Contemporary Journal of Anthropology and Sociology

The Treadmill of Destruction and Ecological Exchange in Comparative Perspective: A Panel Study of the Biological Capacity of Nations, 1961-2007

John Hamilton Bradford, Ph.D.
Assistant Professor of Sociology, Mississippi Valley State University
john.bradford.mvsu@gmail.com

&

Alexander M. Stoner, Ph.D.
Assistant Professor of Sociology, Salisbury University
amstoner@salisbury.edu

Abstract: This article seeks to explain how militarism and export dependence influence the biosphere's ability to meet the consumption-based demands placed upon it by human populations. The authors examine key predictors of per capita Biological Capacity, an estimate of the resources utilized in the production of final goods and services, in order to assess two broad areas of literature. First, the "Treadmill of Destruction" argument suggests that an increase in military spending and armed conflicts causes environmental degradation, reducing Biological Capacity. Second, the "Ecologically Unequal Exchange" approach indicates that underdeveloped states with higher levels of export dependence will also have reduced Biological Capacity. Our findings largely confirm both hypotheses. Results also indicate that diminished Biological Capacity plays a key role in explaining the negative association found in previous studies between export dependence and domestic consumption among low income countries.

Keywords: Ecologically Unequal Exchange, unequal exchange, militarism, Ecological Footprint, Biocapacity, natural resources, Treadmill of Destruction, Treadmill of Production

INTRODUCTION AND OVERVIEW

In recent years a growing number of scholars have begun to examine the connections between militarism and the environment. These scholars have brought attention to the harmful pollutants that are generated from the manufacture of military weaponry as well as the massive quantities of resources that are depleted in order to sustain militaries' permanent preparedness for war (e.g., Hooks & Smith, 2005, 2012; Jorgenson, Clark, & Kentor, 2010; Jorgenson & Clark, 2009; Rice, 2007). Politicians and international organizations in the past decade have expressed increasing concern over resource scarcity and the related possibility of armed conflict (Theisen, 2008). Moreover, conflict scholars such as Homer-Dixon (1999) argue that the increasing scarcity of key resources relative to global demand renders more likely an increase in the frequency, intensity, and duration of military conflicts over their control.

This study analyzes cross sectional time series data to examine two prominent political economy approaches to studying society-environment relationships: Treadmill of Destruction and Ecologically Unequal Exchange, which examine the environmental impacts of militarism and export dependence, respectively. More specifically, we seek to explain how militarism and export dependence affect per capita Biological Capacity, or Biocapacity. Biocapacity is an estimate of the quantity of ecosystem resources utilized in the production (rather than consumption) of final goods and services and is therefore one measure of material throughput.[1] Previous studies that quantitatively assess the Treadmill of Destruction and Ecologically Unequal Exchange have focused on explaining variation in the Ecological Footprint and carbon emissions (Jorgenson & Clark, 2009; Jorgenson, Clark, & Kentor, 2010). These studies estimate the consumption-based demands placed on the biosphere by human populations. To date, however, our study is the first attempt that we know of to explain the variation between and within nations in the productive capacity of the biosphere to meet those demands. In addition, whereas most conflict scholars examining the environment-conflict link have focused primarily on how environmental factors influence the likelihood of conflict (e.g., Kaplan, 1994; de Soysa, 2002; Reuveny, 2007), our study deepens and extends this strand of research by examining the reverse causal pathway: namely, how global conflicts impact the bio-productivity of the environment.[2]

Our findings support central tenets of Treadmill of Destruction theory and partially support Ecologically Unequal Exchange theory. First, we find that increases in military spending and armed

[1] Biocpacity provides an estimate of material throughput, although we acknowledge that it is not generally interpreted in this manner. We believe this confusion arises because the term "Biocapacity" is somewhat misleading. Despite its name, Biocapacity does not measure capacities or potentials. Measurements of Biocapacity contain no assumptions about how productive land types might be or could be used. Estimates of Biocapacity are instead derived exclusively from actual, measurable land area required in a given country and year to supply over 60 categories of commodities, including primary products and the manufactured goods derived from them. For more information, please see the research note contained in Appendix A.

[2] The evidence that environmental factors such as resource constraints and global climate change directly influence global conflict is thus far weak (cf. Salehyan 2008), but it is likely that environmental factors exert strong indirect influences and also that the causal pathway between our dependent and independent variables is reciprocal rather than unidirectional. The environment both affects and is affected by our explanatory variables such as war, military spending, trade, and GDP, for example. We do not deny these bidirectional causal pathways, but because of their complexity, they remain outside the scope of the present study.

conflicts cause environmental degradation, reducing Biocapacity available in these states. Second, states with higher levels of export dependence will also have reduced Biocapacity. Results indicate that diminished Biocapacity plays a role in the negative association found in previous studies between export dependence and domestic consumption among low income countries. Specifically, we demonstrate that the negative association found in previous studies between export dependence and domestic consumption among low income countries is partially a consequence of diminished Biocapacity: low income countries with relatively higher levels of export dependence not only consume fewer resources in the form of final goods and services, but also produce fewer domestic goods and services to consume.

In the following sections, we first review the specific theories of relevance for our panel analysis. We then describe our estimation procedures and methods before turning to the results of our analysis. And finally, we conclude by summarizing our main findings and explaining their theoretical relevance.

Political Economy of the Environment
Treadmill of Destruction

A burgeoning literature within the field of environmental sociology explores how militaries and armed conflicts contribute to environmental degradation. Hooks and Smith (2004, 2005, 2012) refer to the unique environmental impacts of militarism and war as the 'Treadmill of Destruction,' in order to distinguish these effects from those produced by economic forces such as the pursuit of profit and the expansion of capital. The latter forces mediating the economy and the environment are commonly referred to as the 'treadmill of production' (Schnaiberg, 1980; Schnaiberg & Gould, 1994).

Militaries generate massive withdrawals of energy and resources. In the United States, the military is the largest consumer of fossil fuels (Santana, 2002). Militaries generate massive amounts of carbon dioxide waste (Dycus, 1996) as well as toxic waste (LaDuke, 1999; Shulman, 1992). According to Hooks and Smith (2005), militaries exert negative environmental effects even when they are not actively engaged in warfare. Moreover, the environmental effects of militarism and warfare cannot be explained solely in terms of economic motives (Hooks & Smith, 2005, p. 21). For example, in contrast to competitive firms, militaries have displayed little concern for controlling costs (Hooks & Smith, 2005, p. 23-24).

The development of weapons of mass destruction (WMDs), including nuclear, chemical, and biological weapons, dramatically transformed war in the second half of the twentieth century. Today, the extent of environmental damage inflicted by militaries depends more on the technological sophistication of the weapons they employ than on the number of soldiers and other personnel that militaries possess (Hooks & Smith, 2012; Kentor & Kick, 2008). Whereas most wars fought throughout human history brought about environmental degradation indirectly, WMDs are intentionally designed to make ecosystems uninhabitable by humans (Hooks & Smith, 2005).[3] Jorgenson and Clark (2009), in their analysis of panel data for 53 developed and less-developed countries, find a positive association between per capita ecological footprints and military expenditures per soldier. They interpret this as evidence that more capital intensive militaries place additional strains on the environment

[3] It is important to note that while many nation-states have WMDs, the usage of these is quite rare. In fact, there are only a few instances of either chemical or biological weapons (and obviously none for nuclear) being used in war during the period under study.

(Jorgenson & Clark, 2009, p. 640). Downey et al. (2010) find evidence of a significant positive relationship between resource extraction and armed violence, suggesting an intricate and complex web of industrial production and state power. Jorgenson et al. (2010) find that the ratio of military expenditures to the number of military personnel as well as the ratio of military personnel to the total population significantly effects total and per capita carbon dioxide (CO2) emissions and Footprint per capita.

Military spending can decrease a nation's Biocapacity indirectly, by allocating scarce resources within a nation away from productive uses, and directly, by funding operations that destroy the ecological productivity of that nation's land and sea areas. We therefore hypothesize that military expenditure is negatively associated with per capita Biocapacity. Treadmill of Destruction theory also predicts a negative correlation between war and Biocapacity because of the mass ecological destruction that wars generate.[4]

Ecologically Unequal Exchange

The Ecologically Unequal Exchange approach draws upon various theoretical traditions, most notably development economics, neo-Marxian theory (e.g., Emmanuel, 1972), Dependency Theory (e.g., Baran & Sweezy, 1966; Cockroft, Frank, & Johnson, 1972) and World-Systems Theory (e.g., Hopkins & Wallerstein, 1977). The concept of *unequal exchange* arises out of post-war theories of underdevelopment, in which advanced capitalist economies were seen by some neo-Marxian theorists, Dependency Theory scholars, and development economists as preventing or reversing development in the Global South. The notion that formally voluntary market exchange could be unequal and have socially deleterious consequences arises historically only after market exchange became the prevailing mode of social interdependence. Indeed, much of the impetus of classical economics derived from its critique of the exploitative character of feudal exchange in which the social relationships that prescribe the exchange, rather than the exchanged objects, were regarded as fundamentally unequal (cf. Roemer, 1986).

In the post-war era of decolonization, radical development economists such as Raul Prebisch and the United Nations Economic Commission for Latin America (ECLA) argued that peripheral countries suffered from declining *terms of trade*, defined as the value of a country's imports divided by its exports both because competition to produce commodities supplied by peripheral countries is more intense than for those supplied by countries in the center and because the income elasticity of demand is higher for goods produced by the center, so that as income increases in the center, proportionally less of that income is spent on commodities exported by peripheral countries. In the neo-Marxist tradition, Arghiri Emmanuel (1972), defined unequal exchange as the exchange of commodities with unequal quantities of embodied labor time, measured

[4] Although Treadmill of Destruction theory acknowledges that the preparation for and anticipation of war can be a boom for the armaments industry and thus for economies in which the armaments industry plays a central role, this positive relationship is not expected to be exclusively coterminous with the actual operations of war. Therefore, if this relationship did hold, we would expect to find it between military spending and per capita GDP, not between Biocapacity and War. We control for per capita GDP to filter any indirect effects that military spending or war may have on Biocapacity via economic development. In addition, this relationship would only be expected for significant arms exporters such as the United States, in which wars have seldom been fought in the latter half of the twentieth century.

by capital-labor ratios. More recently, Wallerstein (2005) and other World-Systems Theory (WST) scholars have similarly argued that because competition and profits are inversely related, peripheral production processes yield lower rates of return, and thus, a lower rate of "development" for those countries in which these processes prevail. Countries that enjoy the higher rates of return reinvest these profits, thereby reinforcing their economic advantages in a vicious feedback loop. As a consequence of the theory of declining terms of trade, many peripheral countries, particularly in South America, adopted the policy of import substitution industrialization (ISI), which was widely maintained until the rise of neoliberalism in the 1980s and 1990s.

Dependency Theory and WST can be traced to Paul Baran's *Political Economy of Growth* (1957) in which he argues that a systematic transfer of surplus from the periphery to the center inhibited development outside of Europe. Baran's central insights were later extended and reformulated by Dependency Theory scholars such as André Gunder Frank (1966), who explicitly criticized Rostow's theory of Modernization and the neoclassical theory of international trade. Dependency Theory has either evolved into or been supplanted by WST, the leading exponent of which is Immanuel Wallerstein. With a few notable exceptions (see, e.g., Bunker, 1984), however, WST scholars did not begin to pay systematic attention to the environment until the mid-1990s. In particular, Bunker (1984, 2003; see also Bunker & Cicantell, 2005) shows how rapid accumulation of capital in the core, unbalanced energy flows from the periphery, and the contradiction between 'economies of scale' and 'economies of space' reproduce global inequality within the capitalist world-system.

Ecologically Unequal Exchange posits that countries with higher levels of export dependence will consume fewer resources than countries with lower levels of export dependence because the former export away the resources they would have otherwise consumed. Previous studies indicate a positive association between exports and carbon dioxide emissions (Jorgenson, 2007). In a cross-sectional analysis, Jorgenson and Rice (2005) report an inverse relationship between exports as a percentage of GDP and per capita Ecological Footprints. Using panel data, Jorgenson (2009) has also reported that among low-income countries, exports to high income countries negatively impact per capita ecological footprints. Other studies have found that foreign direct investment (FDI) in the manufacturing sector positively affects organic water pollutant emissions (Jorgenson, 2006) and per capita noxious gas emissions in low income countries (Jorgenson et al., 2007).

The policy implications of these findings, however, remain unclear. On the one hand, low Ecological Footprint scores (i.e., those below the global average which is the stipulated standard of sustainability) are correlated with high infant mortality rates and other forms of underdevelopment. On the other hand, a low Ecological Footprint has been conventionally interpreted as an indication of low 'consumption-based' ecological impacts and thus, intuitively, as environmentally beneficial. Moreover, as Jorgenson et al. (2010) acknowledge, the findings of earlier models regressing the Ecological Footprint on exports are undermined because levels of exports are already included in the Footprint estimates (but not in Biocapacity estimates).

Finally, in bivariate regressions, export dependence is positively associated with both per capita GDP and per capita Ecological Footprints. The negative association reported between export dependence and the Ecological Footprint arises only after adding per capita GDP as a control. These results are therefore equivocal because they indicate that export dependence has both a direct negative and an indirect positive (via GDP) effect on Footprint scores, and regression coefficients alone cannot tell us which effect is larger.

Ecologically Unequal Exchange theory makes no determinate prediction of how export dependency will affect Biocapacity, which again is an estimate of the resources utilized in the production of final goods and services. Ecologically unequal exchange is in fact compatible with the hypothesis that export dependence *increases* per capita Biocapacity, so long as the *terms of trade* (expressed in biophysical units) decline more rapidly than Biocapacity increases. However, in light of the discussion above, it is reasonable to expect that export dependency, at least for low income countries, is negatively associated with Biocapacity. We therefore hypothesize that poor countries with higher levels of export dependence are less economically developed on average than those countries with lower levels of export dependence, where 'less developed' means utilizing less efficient and less capital-intensive technologies and generating less output than 'more developed' countries. Countries with higher levels of export dependence should therefore, according to Ecologically Unequal Exchange theory, have lower per capita Biocapacity than other countries.

EMPIRICAL ANALYSIS

Data Set

Data consist of point estimates at 1-year intervals of political-economic variables predicting per capita Biological Capacity for 142 countries from 1961 to 2007. Our initial year, 1961, is the first year in which Biological Capacity data are available. The use of panel data (i.e., cross sectional time series data) greatly improves our ability to infer causal relationships. Analyses derived from panel data can often yield results that conflict with or contradict less robust inferences drawn from cross-sectional analyses restricted to one time period (Frees 2004). We utilize both fixed-effects (FE) and Prais-Winsten (PW) regression models of panel data to estimate the standardized and unstandardized predictor variable coefficients. To maximize the use of available data, we allow panels to be unbalanced. The panel analyses are conducted using the xtregar and xtpcse suite of commands, respectively, in Stata (ver. 12) software.[5]

We report unstandardized coefficients and use the logged values of per capita Biocapacity to minimize skewness. Because the predictor variables are also logged, the unstandardized coefficients are elasticity coefficients, representing the percent change in per capita Biocapacity given a one percent increase in the predictor variable. Observations per country vary from 2 to 20. The total number of observations for the FE AR(1), and PW models are 4722, and 4865, respectively. Appendix B lists all countries included in the study.

For substantive and methodological reasons, we first estimate for our panel data a fixed effects (FE) model. The FE model controls for time-constant, unobserved effects (α_i) that are correlated with the explanatory variables by utilizing time-demeaned data, such that for each cross sectional unit *i*, the average over time is subtracted from each time period. The

[5] For the xtregar command, we use the "fe" option to specify a fixed-effects model. Because the same time periods are not available for all panels, for the xtpcse command, we use the options "pairwise" which utilizes all time periods common to the two panels contributing to the covariance. To correct for AR(1) autocorrelation structure, we use the option "correlation(ar1)."

fixed-effects estimator, also known as the *within estimator*, ignores variation between units and analyzes only within-unit change. The primary advantage of restricting analysis to within-unit variation is that the FE estimator controls for all possible variables even if they are not explicitly included in the model, so long as they do not change over time. The FE estimator thus greatly reduces the risk of omitted variable bias, which can be especially high in non-experimental, observational studies involving macro-level data. Utilizing per capita Biocapacity as our dependent variable in a fixed effects model reflects that our primary interest is whether, and to what extent, the predictor variables we have selected contribute directly to those variations in ecological productivity not attributable to time-invariant natural and cultural factors.

The results of the Hausman test statistic (all significant at $p<.001$) confirm that the FE model is preferable to the random-effects (RE) model, in which the unobserved effects are assumed to be uncorrelated with the explanatory variables. To ensure that our findings are not an artifact of the fixed-effects estimation procedure, however, we re-estimated all appropriate models with RE panel regression. The RE models all produced similar findings to those discussed below, and when different, the RE models generally inflated the size and significance of the predictor variable coefficients. Additionally, because we are more concerned with analyzing the observed cases than with generalizing to unobserved cases, we report only the findings from the more conservative FE procedure in Table 2 (Models 1 and 2).

Because of the likely presence of first-order serial correlation in the idiosyncratic errors of the explanatory variables indicated by the Wooldridge test ($p<.05$), our estimation procedures correct for AR(1) disturbance in the residuals. Models correcting for AR(1) transform the data prior to performing the de-meaning FE transformation or the quasi-differencing PW transformation, in effect eliminating trends so that the time-series data exhibit stationarity. We report models that correct for AR(1) disturbance in two ways. In the FE models, we utilize the Baltagi and Wu (1999) algorithm to remove the AR(1) component. Table 2 also reports Models 3 and 4 which correct for AR(1) disturbance using a time-series cross-sectional Prais-Winsten (PW) with panel-corrected standard errors (PCSE) and autoregressive errors. The PW model is a form of feasible generalized least-squares (FGLS) that corrects for first-order serial correlation and heteroskedasticity and has been used in previous studies of society-environment interactions utilizing a political-economy framework (e.g., Jorgenson & Clark, 2012). Instead of transforming the data by subtracting the panel-specific time average as in the FE model (or some fraction of the panel-specific time average as in the RE model), the PW procedure uses quasi-differenced data, subtracting some fraction (ρ) of the variables' lagged values, (Y_{it}-ρY_{it-1}, X_{it} - ρX_{it-1}, etc.) where ρ is the estimated autocorrelation coefficient. The primary advantage of the PW model is that it enables us to analyzes both within-country and between-country variation. We also employ PCSE because using the most common feasible generalized least-squares estimator for panel data sets with fewer time periods than panels can generate biased standard errors (Beck & Katz, 1995). These results largely confirm the results obtained in our FE models.

Finally, we include a regression of per capita Biocapacity on the 'first differences' (of the standard deviations) of our independent variables, an alternative to AR(1) correction. Figure 6 plots the effects on the expected value of per capita Biocpacity of a change from one standard deviation below the mean to one standard deviation above the mean, for each independent variable.[6] These results provide additional support for our regression analyses.

Independent Variables[7]

Military expenditure (current LCU) (1961–2007).

Military expenditure data are available from the Correlates of War (COW) "National Material Capabilities (v4.0)" dataset (Singer et. al. 1972; Singer 1987). Included in this measure are expenditures on armed forces, peace-keeping forces, defense ministries and other government agencies engaged in defense projects; paramilitary forces trained and equipped for military operations; military operations in space; military research and development; military aid (of donor countries); wages, pensions and social services for current military personnel. Excluded from these data are veterans' benefits, destruction of weapons, and all other current expenditures for previous military activities. These data are logged to minimize skewness. To minimize collinearity, we 'residualize' military expenditure by regressing the logged values of these data on the logged values of GDP per capita. We use the residuals of this regression in the reported models to assess the effects of military expenditure on the per capita Biocapacity of nations, entirely independent of economic development.[8]

War

'War' is a binary ('dummy') variable indicating whether or not a country is in a state of war in a given year. These data were compiled from two 'Correlates of War' datasets: the Intra-State War Data (v4.0) and Inter-State War Data (v4.0). The former dataset encompasses wars that primarily occur between factions located within the recognized territory of a single state, whereas the latter dataset includes wars that take place between two or more states. Because we are primarily interested in the biological and environmental effects of war in geographical regions where war is fought, we do not regard as 'in a state of war' high income countries that fight wars in non-contiguous, low income countries. In other words, in conflicts between low income countries and high income countries, where conflicts takes place exclusively within the

[6] In Figure 6, we first use *estsimp* from the CLARIFY suite of commands for Stata (King et. al. 2000, 2003), on an ordinary least squares regression of our full model. We then use Boehmke's (2008) *plotfds* command.

[7] In analyses not reported here, we also included as predictor variables *GDP per unit of energy use (constant 2005 PPP $ per kg of oil equivalent)*, a measure of efficiency derived from the World Bank; the *Democracy Index* as reported in Vanhanen's (2003) *Democratization and Power Resources* (2003) dataset; and *Total land area.* Incorporating *GDP/Energy* as a variable drastically reduced our sample size by over 80 percent to 360 observations across 82 countries. Moreover, the addition of *GDP/Energy* substantially reduced the overall r-squared of our models to 0.01 or below. Finally, we could not include *Total land area* in our FE models because it is invariant over time. We did include this variable in our PW regressions, but to our surprise, the geographic size of countries is not a significant predictor of Biocapacity per capita. The pairwise correlation coefficient for the logged values of Biocapacity per capita and land area is less than 0.02. None of the three variables were significant, and their exclusion did not alter our findings.

[8] This method has been commonly used in studies testing political-economic theories of environment-society relationships in which the predictor variables exhibit high degrees of multicollinearity (e.g., Jorgenson & Clark, 2009). All other predictor variables, with the exception of the dummy variable 'War' and GDP per capita itself, are likewise residualized by using the residuals of the regression of the logged values of the predictor variable on the logged values of per capita GDP. In analyses not reported here, we also employed the non-residualized independent variables. The non-residualized data produced extremely large variance inflation factors but did not substantively affect our results.

geographical boundaries of the low income countries, we do not count the high income countries as in a state of war.[9] For example, during the Invasion of Iraq of 2003, we regard Iraq as being in a state of war, but not Australia, the United Kingdom, and the United States.

Exports of goods and services (% of GDP)

To assess the predictions of Ecologically Unequal Exchange theory (e.g., Jorgenson & Clark, 2009) we include as a predictor variable the percentage of gross domestic product derived from the exports of goods and services. We refer to this variable as export dependence. These data are logged to minimize skewness and residualized on GDP per capita (ln) in order to test the effect of exports independently of development.

Ecologically Unequal Exchange theory posits that countries with higher levels of export dependence will consume fewer resources than countries with lower levels of export dependence because the former export to the latter the resources they would have otherwise consumed without being sufficiently compensated for their losses. Previous studies indicate a positive association between exports and carbon dioxide emissions (Jorgenson, 2007). Other studies report a negative association between exports and per capita Footprints (Jorgenson & Rice, 2005), and between per capita Footprints and indices of export flows weighted by GDP per capita, which quantify the extent to which countries export to more developed countries. For this negative association between export dependence and consumption to occur, exchanges, measured in terms of resources, must be unequal.

High Income x War

We include as predictor variables in our analyses two interaction terms. The first is an interaction between two dummy variables: High income and War. 'High income' is a dummy variable in which all high income countries (i.e., countries with the top quartile of per capita GDP's as estimated by the World Bank) are coded as one and all other countries as zero. This dummy variable is then multiplied by the variable 'War.' This interaction term is intended to capture the differential effects of war on high income countries compared to all other countries. The coefficient of this variable is the effect that war has on Biocapacity per capita for high income nations. The variable 'War' then becomes an estimate of the impact of war on Biocapacity for all other nations. We expect that in models utilizing the interaction term, the coefficient for the interaction term will be positive and the coefficient for 'War' will be negative. This prediction reflects the fact that, since World War Two, wars in which high income nations are involved have rarely been fought on their own soils and also that war can intensify domestic production.

Low income x Exports

To better estimate the influence of export dependence on Biocapacity, we include in our analyses a multiplicative interaction term between the dummy variable 'low income' and export dependence. 'Low income' is a dummy variable in which all countries belonging to the lowest quartile of

[9] Countries are categorized as low or high income by the World Bank according to their 2012 gross national income (GNI) per capita. The GNI per capita for low income countries is $1,035 or less and for high income countries is $12,616 or more. These groups constitute the lower and upper income quartiles, respectively. By 'low income' we mean those countries that are sometimes called developing, less-developed, industrializing, peripheral, or Third World, and which are often located in the Global South. Likewise, 'high income' countries include developed, industrialized, core, or First World countries. Per capita GNI's, of course, do not convey information about within-country distributions of wealth or income.

economic development as estimated by the World Bank are coded as one and all other countries as zero. The use of this interaction term better tests Ecologically Unequal Exchange theory, which contends that the effects of export dependence will be different for low income and high income countries. Ecologically Unequal Exchange theory predicts that the effect of export dependence on Biocapacity for low income countries will be negative, for reasons explicated above, and that there will be either no relation or a positive relation between export dependence and Biocapacity for middle and high income countries.

Control Variables

We include GDP, GDP-squared, and urbanization in our models primarily as controls to ensure that any observed effects of military expenditures, war, or export dependency on per capita Biocapacity are not spurious associations. Although not the focus of this study, our inclusion of these variables also enables us to partially assess some of the claims made by Ecological Modernization theory and Treadmill of Production theory.

Gross Domestic Product (GDP) per capita (constant 2005 US$)

We obtain countries' per capita gross domestic products (*GDP per capita*) from the World Bank (2007) as a measure of economic activity and affluence. These data are logged to minimize skewness and are measured in constant 2005 U.S. dollars. GDP is commonly used as a proxy measure of standard of living. More accurately, GDP is a flow variable quantifying the total market value of final goods and services produced in a country at a given time. Although an increase in GDP is commonly referred to as 'economic growth,' it is important to remember that this is not the growth of a stock of material wealth, but rather, an increase in the intensity or rate of monetary exchanges.

GDP per capita squared

To test for curvilinear relationships between development and per capita Biocapacity, we include the quadratic (i.e., the square) of GDP per capita as an explanatory variable. Specifically, the inclusion of the quadratic of GDP per capita tests for the existence of an Ecological Kuznets Curve (EKC) as predicted by Ecological Modernization theory. The EKC describes a relationship in which economic activity and environmental degradation are positively correlated and then negatively correlated after crossing a given threshold of development. When plotted on a graph in which GDP per capita is the X-axis and some measure of pollution is the Y-axis, an EKC exhibits an inverted-U shape. An EKC is thought to exist if $\beta_1>0$ and $\beta_2<0$, in which β_1 and β_2 are the regression coefficients for GDP per capita and GDP per capita squared, respectively. To minimize collinearity between GDP per capita and GDP per capita squared, we residualize the latter by using the residuals from a regression of the logged values of GDP per capita squared on the logged values of GDP per capita.

Urban population (% of total)

To test the hypotheses of urban political economy perspectives, we include as a predictor variable in our analyses the percentage of a country's total population living in urban areas. These data are logged and residualized to minimize skewness and collinearity. [10] Urban political economy

[10] Due to significant levels of collinearity, we transform urban population data by regressing the logged values of these data on both the logged values of GDP per capita and the logged values of GDP per capita squared and use the residuals in the reported models.

approaches generally predict positive associations between urbanization and carbon dioxide emissions as well as urbanization and per capita Ecological Footprint estimates (e.g., Molotch 1976; Dickens 2004). Prior research has confirmed these predictions (e.g., Jorgenson and Clark 2012; Roberts and Parks 2007). We infer from these studies that urbanization will be positively correlated with per capita Biocapacity.

Table 1. Univariate Descriptive Statistics for Regression Variables (1961-2007)

	N	Mean	SD	Min	Max	Skew	Kurtosis
Biological Capacity per capita (ln)	6274	0.718	1.074	-3.507	3.975	0.2	3.24
Military expenditures (ln), residualized	5061	0	1.921	-6.863	7.042	0.148	3.75
War	6978	0.095	0.293	0	1	2.762	8.63
GDP per capita (ln)	5375	7.598	1.568	3.913	11.314	0.342	2.094
GDP per capita squared (ln), residualized	5375	0	0.042	-0.322	0.042	-1.2	5.018
Exports (% of GDP) (ln), residualized	5097	0	0.619	-2.105	1.673	-0.379	3.023
Urban population (ln), residualized	5374	0	0.422	-2.004	2.683	-1.181	7.896

RESULTS

Interpreting the coefficients of our regression analyses is far from straightforward. Statistical results are frequently sensitive to model specification, and for this reason we have included two sets of models: the fixed-effects regressions, which analyze only within-country variation over time, and the Prais-Winsten regressions, which enable us to make inferences regarding between-country variation in per capita Biocapacity over time. Models 1 and 2 in Table 2 provide the results for our fixed effects panel regression model correcting for AR(1) serial correlation; and Models 3 and 4 in Table 2 provide the results for our PW regression model with panel-corrected standard errors (PCSE) and corrections for AR(1) disturbance. For each type we estimate restricted and full models, in which the interactions terms are, respectively, excluded and included. The overall R-squares are approximately 15 percent for Models 3 and 4, and less than 1 percent for Models 1 and 3, indicating that much of the per capita variation in Biocapacity within and between countries is not attributable to the variables we have selected for analysis.

Table 2. Unstandardized Coefficients for the Regression of Per Capita Biological Capacity on Selected Predictor Variables: Fixed Effects and Prais-Winsten with panel-corrected standard errors (PCSEs) estimates, utilizing AR(1) correction for 142 countries, 1961-2007

VARIABLES	(1) Fixed Effects	(2) Fixed Effects	(3) PCSE	(4) PCSE
Military expenditures (ln)	-0.0153***	-0.0154***	-0.0388***	-0.0374***
	(0.00425)	(0.00425)	(0.00649)	(0.00639)
	[1.31]	*[1.32]*	*[1.31]*	*[1.32]*
War	-0.0146**	-0.0174**	-0.0168	-0.0196
	(0.00731)	(0.00764)	(0.0122)	(0.0125)
	[1.12]	*[1.16]*	*[1.12]*	*[1.16]*
GDP per capita (ln)	0.00658	0.00488	0.147***	0.146***
	(0.0162)	(0.0163)	(0.0161)	(0.0164)
	[1.07]	*[1.07]*	*[1.07]*	*[1.07]*
GDP per capita squared (ln)	-1.723***	-1.701***	1.725***	1.683***
	(0.462)	(0.464)	(0.463)	(0.470)
	[1.09]	*[1.11]*	*[1.09]*	*[1.11]*
Exports (% of GDP) (ln)	-0.0282***	-0.0135	-0.0245*	-0.0102
	(0.00952)	(0.0118)	(0.0139)	(0.0169)
	[1.16]	*[1.42]*	*[1.16]*	*[1.42]*
Urban population (ln)	-0.494***	-0.494***	0.0891	0.0858
	(0.0452)	(0.0454)	(0.0609)	(0.0612)
	[1.17]	*[1.23]*	*[1.17]*	*[1.23]*
High Income x War		0.0345		0.0327
		(0.0259)		(0.0328)
		[1.04]		*[1.04]*
Low income x Exports		-0.0422**		-0.0405
		(0.0199)		(0.0248)
		[1.38]		*[1.38]*
Constant	0.677***	0.689***	-0.362***	-0.358**
	(0.0218)	(0.0217)	(0.139)	(0.141)
Observations	4,722	4,722	4,865	4,865
R-squared (overall)	0.0020	0.0026	0.153	0.152
R-squared (within)	0.0380	0.0391	--	--
R-squared (between)	0.0178	0.0196	--	--
Number of id	142	142	143	143

Coefficients flagged for statistical significance. Standard errors in parentheses. Variance Inflation Factors are in italics and brackets. Two-tailed tests: *** p<0.01, ** p<0.05, * p<0.1

Military Spending and War

Our most important finding is that across all models the coefficient of military expenditures is negative and statistically significant utilizing two-tailed t-tests. Countries with higher levels of military spending on average have lower per capita Biocapacity than countries with lower levels of military spending. The negative impact of military spending on Biocapacity persists even after controls are included and this finding is robust to differences in model specification. Most importantly, this effect on domestic Biocapacity is independent of purely economic effects, such as GDP per capita and GDP per capita squared. This finding supports the Treadmill of Destruction perspective, according to which militarism and warfare can produce environmental effects that are related, but irreducible to, those effects deriving from the Treadmill of Production (i.e., the economy).

In all models the coefficient of 'War' is negative. Although these coefficients are only statistically significant in the fixed effects models, we contend that all of these results are nevertheless substantively important. [11] In Models 1 and 2, which correct for first-order serial correlation in the residuals, the coefficients for War is -.015 and -.017, respectively, and are statistically significant at $p<.05$. A one percent increase in the frequency of wars fought in low income countries is associated with a decline in per capita Biocapacity of approximately .02 percent. The AR(1) correction for all models effectively filter out any effects that wars fought in a previous year may have on Biocapacity in a subsequent year. This makes the reported coefficients all the more convincing since wars can be expected to have cumulative and lagging ecological effects.

In addition, the inclusion of the interaction term, 'High income x War', which estimates the effect that war has on per capita Biocapacity for high income countries, is positive and consistent with our predictions in all models. Models 2 and 4 include the interaction term High Income x War and show that the effect of war on per capita Biocapacity is substantially different for high income countries compared to middle income and low income countries. Although we cannot reliably generalize this finding to unobserved countries, for the data at hand the positive coefficient for the interaction term means that this generally negative effect on per capita Biocapacity for low and middle income countries is actually positive for those high income countries included in our analysis. Specifically, our results show that war leads to .03 percent higher increase in per capita Biocapacity for high income countries. Moreover, this effect on Biocapacity is independent of the indirect effects that war may have on Biocapacity via growth in GDP.

In our regression models, we use a dummy for the income constitutive term for both of our interaction variables. This greatly eases the interpretation of our regression models, but restricts our comparisons to only two income groups. To provide for a more detailed examination of

[11] Recall that tests of significance estimate the likelihood of obtaining these observed coefficients from an unknown population of coefficients with a mean coefficient of zero (the null hypothesis). Because social processes can often produce power-law distributed cross-sectional data and clusters of volatility in time-series data, we cannot assume that there exists an underlying, fixed frequency distribution (i.e., with a defined mean and variance) from which our data are sampled (cf. Moss and Edmonds 2005). More intuitively, generalizing to unobserved cases is of secondary importance in this study. We cannot use these data for purposes of prediction or retrodiction, nor can we use these data to infer the value of coefficients for unobserved cases. We interpret the tests of significance in this study primarily to compare the relative sizes of coefficients and to flag those that are far from a normally distributed mean value of zero.

how the effects of war and export dependence on Biocapacity are mediated by GDP, we include in Figures 3-6 a graphical illustration of these interactive effects using Boehmke's (2008) 'grinter' command for Stata. To obtain these graphs, we ran our previous regression Models 2 and 4, replacing High Income x War and Low Income x Exports with two new interaction terms utilizing the raw, continuous data for GDP per capita (ln): GDP x War, and GDP x Exports.

The new interaction term ('GDP x Exports') using continuous GDP data is depicted in Figures 3 and 5, which show the marginal effects of War on per capita Biocapacity conditional on per capita GDP for the fixed effects and Prais-Winsten estimations, respectively. Figure 3 shows a clearly negative association between War and Biocapacity for countries with per capita GDP's less than the inter-country mean GDP, approximately $1978 in constant 2005 dollars, or ln(1978.31) = 7.59. Above the mean income level, the correlation breaks down as the confidence interval always includes zero. Similar results are obtained in Figure 5. The fact that military spending and war show consistent results across all models utilizing three distinct estimation procedures is further confirmation that our results are robust against differences in model specification, that is, that our findings are not artifacts of any one particular model.

Figure 3. Marginal effect of War on Biocapacity, conditional on GDP. Fixed Effects, Model 2

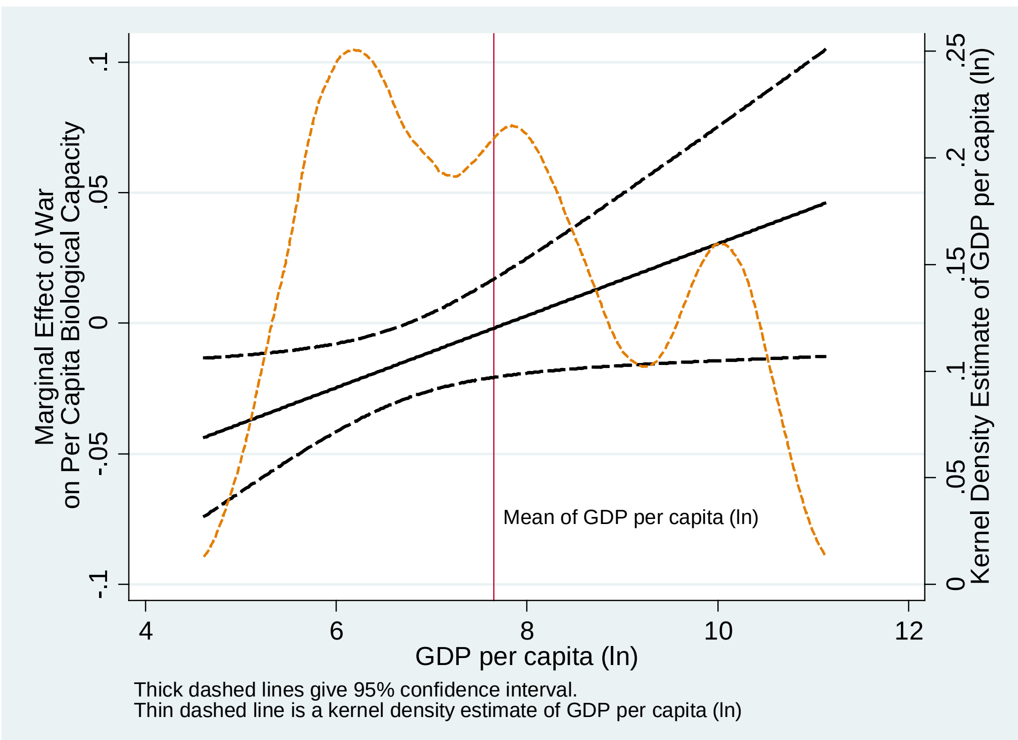


Figure 4. Marginal effect of Exports on Biocapacity, conditional on GDP. Fixed Effects, Model 2

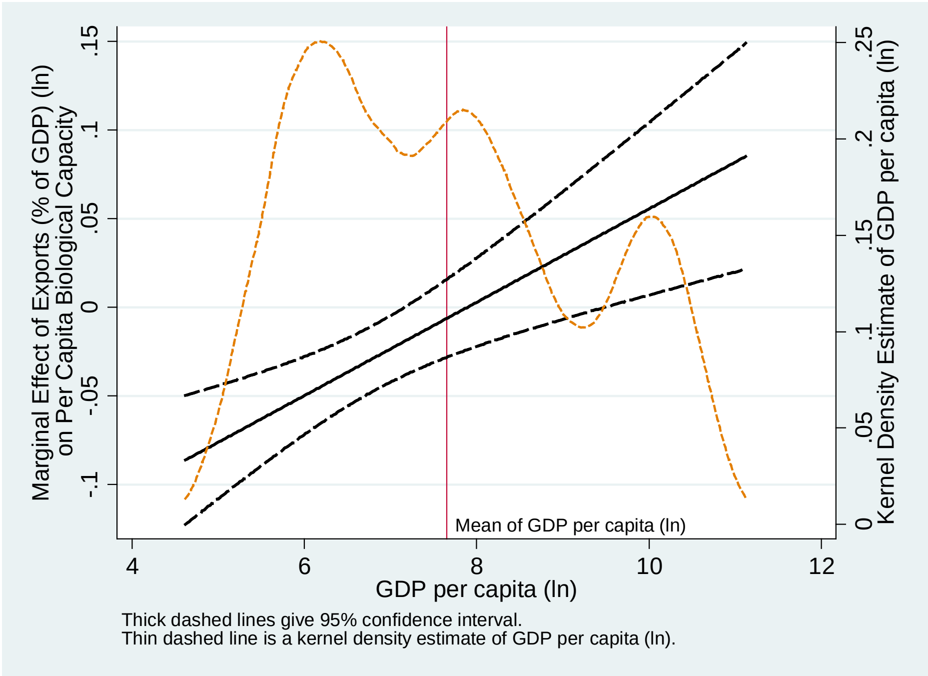


Figure 5. Marginal Effect of War on Biocapacity, conditional on GDP. Prais-Winsten, Model 4

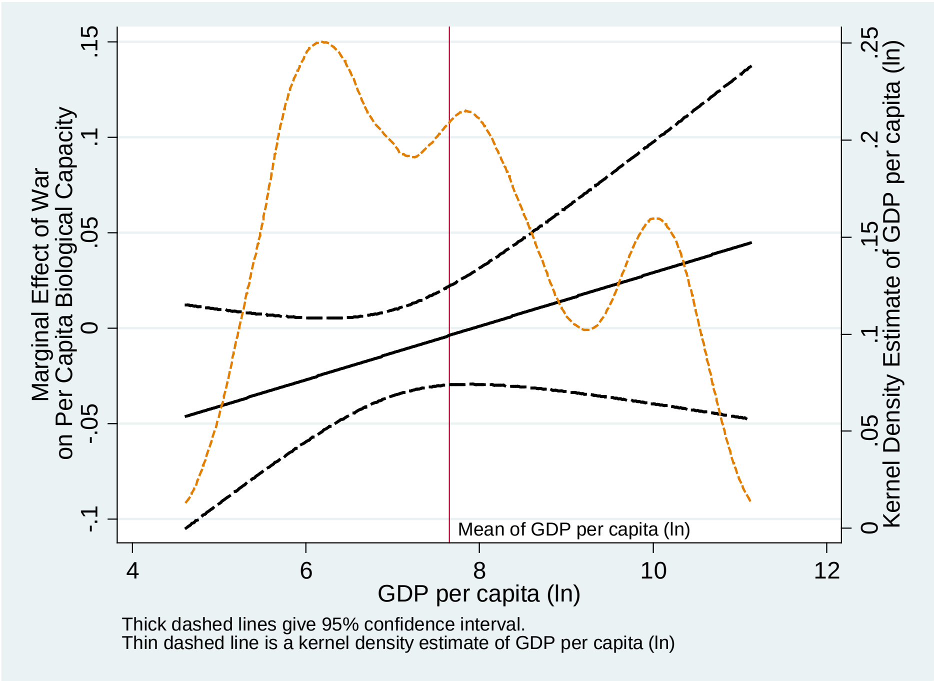
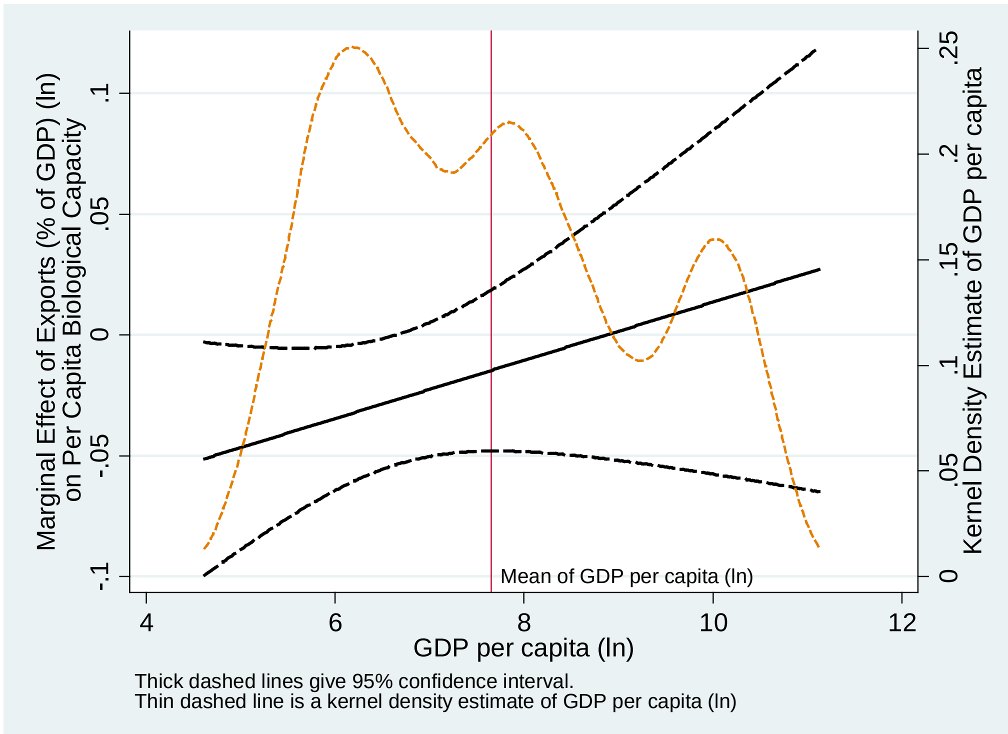


Figure 6. Marginal Effect of Exports on Biocapacity, conditional on GDP. Prais-Winsten, Model 4



Export Dependence

All of our models report a negative association between per capita Biocapacity and export dependence, at least for low income countries. Only in Models 1 and 3, however, is export dependence statistically significant at $p<.01$ and $p<.1$, respectively. Two interpretations are consistent with a negative association between Biocapacity and export dependence: countries are either export dependent because they are resource-poor, or countries become resource-poor as a result of being export dependent. Models 1 and 2 exclude from consideration variation in Biocapacity due to time-invariant factors such as geography or resource endowments. Thus, a negative association between export dependency and Biocapacity in those models provides strong support for the latter interpretation, namely, that export dependency generates, directly or indirectly, a relative decline in per capita Biocapacity, *ceteris paribus*. A negative association between per capita Biocapacity and export dependence indicates that export dependent countries both produce and consume fewer final goods. The coefficient for the multiplicative interaction term, 'Low income x Exports,' is negative across both Models 2 and 4 and statistically significant in Model 2. For the countries and years we have analyzed, it appears that for low income countries, export dependence negatively impacts Biocapacity per capita, whereas for high income countries, the effect on Biocapacity by export dependence is negligible.

Finally, the new interaction term ('GDP x Exports') using continuous GDP data is depicted in Figures 4 and 6, which show the marginal effects of export dependence on per capita Biocpacity for the fixed effects and Prais-Winsten estimations, respectively. The relationship between exports as a percentage of GDP and per capita Biocapacity is negative for countries with below-average per capita incomes, thus supporting our earlier hypotheses.

Assessing the Effect of GDP-squared and Urban Population on Biocapacity

The effects of GDP, GDP-squared, urbanization, population distribution, and population intensity are not the focus of this study. To test for the existence of a 'Biocapacity Kuznets Curve,' we include in all of our models the quadratic of GDP per capita as a predictor variable. The coefficient for the residualized values of GDP per capita squared is positive and statistically significant across all models at $p<.01$. Our models also show conflicting results on the effect of urban population on Biocapacity. In Models 1 and 2 the coefficient is negative and statistically significant at $p<.01$, whereas in Models 3 and 4 the coefficient is positive and statistically insignificant. Although outside the scope of this paper, we suspect that the change in coefficient is due to the different transformation procedures used to eliminate AR(1) serial correlation in the residuals.

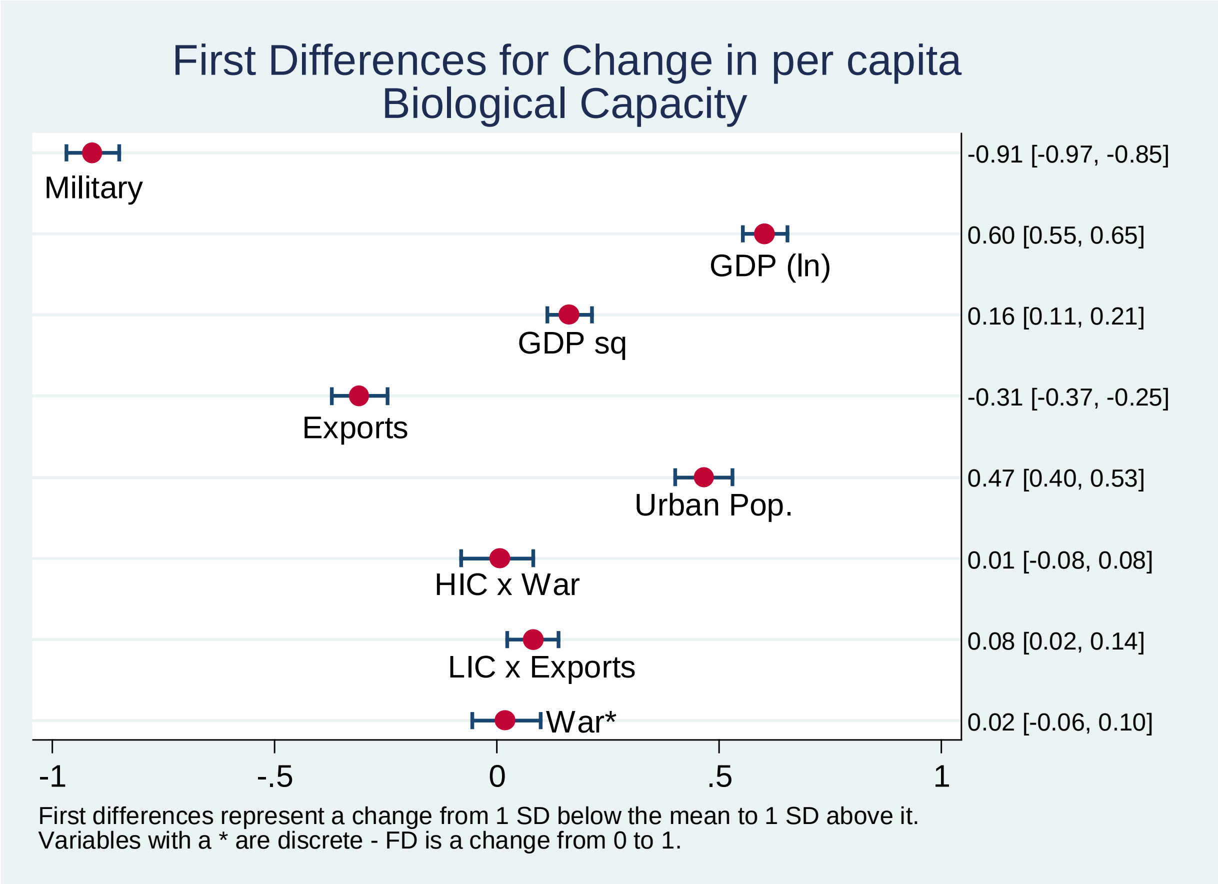
Assessing the Effect of GDP per capita on Biocapacity

Across all models the coefficient for GDP per capita is statistically significant and has the largest standardized coefficient of any variable. The coefficients for GDP per capita are positive across all models, but are statistically significant only in Models 3 and 4 at $p<0.01$. This positive association obtains after the *average linear increase in GDP per capita as well as the average linear decrease in Biocapacity per capita have been removed*. The positive coefficients reported in Models 3 and 4 explain both the variation within and between countries, and therefore show that countries with higher GDPs also have higher per capita Biocapacity, on average. In Models 3 and 4, a one-percent increase in GDP per capita is associated with an increase in Biocapacity of .15 percent. These results suggest that economic activity induces, rather than inhibits, material throughput as measured by Biocapacity, which is unsurprising. It is important to point out, however, that Biocapacity is a flow variable, not a measure of the stock of material wealth that is drawn down over time by economic activity. Although global economic activity draws down these resources, this will not be captured by Biocapacity measurements.

CONCLUSION AND DISCUSSION

This study contributes to our understanding of society-environment relationships within a political economy framework in two ways. First, the results of our analysis provide strong empirical support for the Treadmill of Destruction: military spending and armed conflicts cause environmental degradation, reducing per capita Biocapacity. Models 1 and 2 show that, holding per capita GDP constant, increases in military spending over time negatively impacts Biocapacity within countries. Models 3 and 4 in addition, show that countries with greater increases in military spending experience greater declines in per capita Biocapacity, relative to other countries that have smaller marginal increases or reductions in military spending. This negative association is confirmed in our analysis employing a regression of Biocapacity on the 'first differences' (of the standard deviations) of our independent variables, illustrated in Figure 7.

Figure 7. The effect on Biocpacity of standard deviation changes in the independent variables



In addition, our results support the contention that modern warfare has a more dramatic effect on the Biocapacitiy of low and middle income countries than on high income countries. In regressions of per capita Biocapacity, the coefficient for warfare is positive for high income countries, but negative for low and middle income countries. Moreover, as shown in Figures 3 and 5 utilizing continuous GDP data, for countries with below-average per capita incomes, the marginal effect of war on per capita Biocapacity is negative, whereas for countries with above-average per capita incomes, no general relationship can be inferred.

Second, our findings help specify the mechanisms by which export dependency engenders and reinforces material inequalities both within and between nations. Not only do export dependent nations produce wealth which is subsequently exported away in unequally compensated material exchanges, export dependence also inhibits the very ability of these nations to produce material wealth. The negative coefficient in Model 2 for the multiplicative interaction term, 'Low income x Exports' shows that, holding per capita GDP constant, increases over time in the percentage of GDP derived from exports diminishes Biocapacity within low income countries. Although we cannot generalize the coefficient reported in Model 4 to unobserved countries or years (due to a lack of *statistical* significance), the negative association between export dependency and per capita Biocapacity indicates that a slightly negative association between export dependency and per capita Biocapacity also holds *between* the low income countries included our analyses. These results are confirmed in Figure 7. Moreover, our regression analysis depicted in Figures 4 and 6 of the multiplicative interaction term using continuous GDP data confirms that the effect of export dependence on Biocapacity is differentially distributed according to income level: export dependency primarily diminishes Biocapacity for low income countries, whereas for high income countries, the effect of export dependency on per capita Biocapacity must be determined on a case-by-case basis.

Previous studies have found that export dependency diminishes the per capita Ecological Footprint (of consumption) scores of low income nations. This study furthers this research by distinguishing between ecologically unequal exchange, in which low income countries export more of their material wealth (quantified in global hectares) than they receive in imports, and processes by which export dependence inhibits Biocapacity directly. Our results indicate that export-dependent, low income countries consume fewer material resources in part because they produce, *priorto exchange*, fewer domestic goods and services to consume.

To explain our findings, we have suggested that war, military spending, and export dependency reduce per capita Biocapacity through forms of environmental degradation that directly impinge upon biophysical productivity. In short, we posit an inverse relationship between environmental degradation and Biocapacity. Biocapacity, however, is not inversely related to *all* forms of environmental degradation, pollution, or resource depletion. For example, Biocapacity is positively correlated with both carbon emission levels and with indicators of economic growth such as GDP. Although tentative, we regard these findings as substantively important to the study of the political economy of the environment. Biocapacity, as an estimate of material throughput, measures only the ability of populations to withdraw and utilize material resources for productive purposes, and toxic additions to the environment do not always negatively impact this ability. Thus, the specific means by which the Treadmill of Destruction and export dependency negatively impinge upon Biocapacity via environmental degradation warrant future research.

Acknowledgements
The authors thank Clayton Thyne, Ryan Schroeder, Eric Rittinger, and the anonymous reviewers at *Contemporary Journal of Anthropology and Sociology* for their invaluable and helpful suggestions.

REFERENCES

Baran, P. (1957). *The Political Economy of Growth*. New York, NY: Monthly Review Press.

Baran, P., & Sweezy, P. (1968). *Monopoly Capitalism: An essay on the American economic and social order*. New York, NY: Monthly Review Press.

Beck, N., & Katz, J. N. (1995). What to do (and not to do) with time-series cross-section data. *American Political Science Review,* 89(3), 634-647.

Boehmke, F. J. (2008). "GRINTER: A STATA utility to graph interaction effects after regression models. (Version 1.5)." Iowa City, IA: University of Iowa.

Boehmke, F. J. (2008). "PLOTFDS: A Stata Utility to plot the marginal effect of independent variables. (Version

1.1).” Iowa City, IA: University of Iowa.

Brenner, R. (1977). The Origins of Capitalist Development: A Critique of Neo-Smithian Marxism. *New Left Review,* 104, 25–92.

Brulle, R. J., & Pellow, D. (2006). Environmental justice: human health and environmental inequalities. *Annual Review Public Health*, 27, 103-124.

Bunker, S. (1984). *Underdeveloping the Amazon: Extraction, unequal exchange, and the failure of the modern state.* Chicago, IL: University of Chicago Press.

Bunker, S., & Ciccantell, P. (2005). *Globalization and the Race for Resources.* Baltimore, MD: JHU Press.

Catton, W.R. Jr. (1982). *Overshoot: The Ecological Basis of Revolutionary Change.* Champagne, IL: University of Illinois Press.

Clark, B., & Jorgenson, A. K. (2007). The economy, military, and ecologically unequal exchange relationships in comparative perspective: A panel study of the Ecological Footprints of nations, 1975–2000. *Social Problems*, 56(4), 621-646.

Clark, B., & Jorgenson, A. K. (2012). The Treadmill of Destruction and the Environmental Impacts of Militaries. *Sociology Compass*, 6(7), 557-569.

Cockroft, J., Frank, A. G., & Johnson, D. (1972). *Dependence and underdevelopment.* New York: Anchor.

Dickens, P. (2004). *Society and Nature.* Cambridge, UK: Polity Press.

Downy, L., Bonds, E., & Clark, K. (2010). Natural Resource Extraction, Armed Violence, and Environmental Degradation. *Organization and Environment,* 23, 417-445.

Dycus, S. (1996) *National defense and the environment*. Hanover, NH: University Press of New England.

Emmanuel, A. (1972). *Unequal Exchange: A Study of the Imperialism of Trade*. (B. Pearce Trans.). New York & London: Monthly Review Press.

Frank, A. G. (1966). *The Development of Underdevelopment*. New York, NY: Monthly Review Press.

Frees, E. W. (2004). *Longitudinal and Panel Data: Analysis and Applications in the Social Sciences.* New York, NY: Cambridge University Press.

Hewitt, J. J., Jonathan, W. & Gurr, T. R. (2008). *Peace and Conflict*. Boulder, CO: Paradigm.

Homer-Dixon, T. (1999). *Environment, Scarcity and Violence.* Princeton, NJ: Princeton University Press.

Hooks, G. & Smith, C. L. (2004). The Treadmill of Destruction: National Sacrifice Areas and Native Americans. *American Sociological Review*, 69(4), 558-575.

Hooks, G. & Smith, C. L. (2005). Treadmills of Production and Destruction Threats to the Environment Posed by Militarism. *Organization & environment*, 18(1), 19-37.

Hooks, G. & Smith, C. L. (2012). The Treadmill of Destruction Goes Global. In: Gouliamos, K. and Kassineris, C. (eds) *The Marketing of War in the Age of Neo-Militarism.* New York, NY: Routledge, pp., 60-86.

Hopkins, T. K. & Wallerstein, I. (1977). Patterns of Development of the Modern World-System. *Review (Fernand Braudel Center),* 1(2), 111-145.

Jorgenson, A. K. (2005). Unpacking International Power and the Ecological Footprints of Nations: A

Quantitative Cross-National Study. *Sociological Perspectives,* 48, 383-402.

Jorgenson, A. K. (2006). The Transnational Organization of Production and Environmental Degradation: A Cross-National Study of the Effects of Foreign Capital Penetration on Water Pollution Intensity, 1980-1995. *Social Science Quarterly,* 87, 711-730.

Jorgenson, A. K. (2007). Does Foreign Investment Harm the Air We Breathe and the Water We Drink? A Cross-National Study of Carbon Dioxide Emissions and Organic Water Pollution in Less-Developed Countries, 1975 to 2000. *Organization and Environment,* 20(2), 137-156.

Jorgenson, A. K. (2009). The Sociology of Unequal Exchange in Ecological Context: A Panel Study of Lower Income Countries, 1975-2000. *Sociological Forum,* 24, 22-46.

Jorgenson, A. K., & Burns, T. J. (2007a). Effects of Rural and Urban Population Dynamics and National Development on Deforestation in Less-Developed Countries, 1990-2000. *Sociological Inquiry,* 77, 460-482.

Jorgenson, A. K. & Burns, T. J. (2007b). The political-economic causes of change in the ecological footprints of nations, 1991–2001: a quantitative investigation. *Social Science Research,* 36(2), 834-853.

Jorgenson, A. K., Dick, C., & Mahutga, M. C. (2007). Foreign Investment Dependence and the Environment: An Ecostructural Approach. *Social Problems,* 54, 371-394.

Jorgenson, A. K. & Clark, B. (2009). The Economy, Military, and Ecologically Unequal Exchange Relationships in Comparative Perspective: A Panel Study of the Ecological Footprints of Nations, 1975-2000. *Social Problems,* 56(4), 621-646.

Jorgenson, A. K, Clark, B., & Kentor, J. (2010). Militarization and the environment: A panel study of carbon dioxide emissions and the ecological footprints of nations, 1970–2000. *Global Environmental Politics,* 10(1), 7-29.

Jorgenson, A. K., & Clark, B. (2012). Are the Economy and the Environment Decoupling? A Comparative International Study, 1960–2005. *American Journal of Sociology,* 118(1), 1-44.

Jorgenson, A. K., & Rice, J. (2005). Structural Dynamics of International Trade and

Material Consumption: A Cross-National Study of theEcological Footprints of Less-Developed Countries. *Journal of World-Systems Research,* XI(1), 57-77.

Kick, E., Davis, B., & Kentor, J. (2006). A Cross-National Analysis of Militarization and Inequality. *Journal of Political and Military Sociology,* 34(2), 319-337.

King, G., Michael T., & Wittenberg, J. (2000). "Making the Most of Statistical Analyses: Improving Interpretation and Presentation." *American Journal of Political Science* 44(2): 347-61.

Kentor, J., & Kick, E. (2008). Bringing the Military Back In: Military Expenditures and Economic Growth 1990 to 2003. *Journal of World-Systems Research,* XIV(2), 142-172.

LaDuke, W. (1999). *All Our Relations: Native Struggles for Land and Life.* Boston, MA: South End Press.

Litell, R., Stroup, W., & Freund, R. J. (2002). *SAS for Linear Models (4th edition).* Cary, NC: SAS Institute, Inc.

Molotch, H. (1976). The City as a Growth Machine: Toward a Political Economy of Place. *American Journal of Sociology*, 82(2), 309-332.

Moss, S., & Edmonds, B. (2005). Sociology and Simulation: Statistical and Qualitative Cross-Validation. *American Journal of Sociology,* 110(4), DOI: 10.1086/427320.

Network, Global Footprint. (2010). Ecological footprint. Available at: http://www.foot-printnetwork.org/en/index.php/GFN/page/carbon_footprint (accessed 5 November 2013).

Parks, B. C., & Roberts, J. T. (2010) Climate Change, Social Theory and Justice. *Theory, Culture & Society*, 27: 134-166.

Rice, J. (2007). Ecological unequal exchange: international trade and uneven utilization of environmental space in the world system. *Social Forces*, 85(3), 1369-1392.

Roberts, J. T., & Parks, B. C. (2007). *A Climate of Injustice: Global Inequality, North-South Politics, and Climate Policy.* Cambridge, MA: MIT Press.

Roemer, J. E. (1986). *Analytical Marxism*. New York, NY: Cambridge University Press.

Reuveny, R. (2007). Climate Change-Induced Migration and Conflict. *Political Geography,* 26(6): 656-673.

Salehyan, I. (2008). "From Climate Change to Conflict? No Consensus Yet." *Journal of Peace Research* 45(3): 315–26. doi:10.1177/0022343308088812.

Santana, D. (2002). Resisting Toxic Militarism: Vieques versus the U.S. Navy. *Social Justice*, Spring-Summer, 37-48.

Schnaiberg, A. (1980). *The Environment: From Surplus to Scarcity.* New York, NY: Oxford University Press.

Schnaiberg, A., & Gould, K. (1994). *Environment and Society: The Enduring Conflict.* New York, NY: St. Martin's Press.

Shandra, J. M. (2007). Economic Dependency, Repression, and Deforestation: A Quantitative, Cross-National Analysis. *Sociological Inquiry*, 77, 543-571.

Singer, J. David, Stuart Bremer, and John Stuckey. (1972). "Capability Distribution, Uncertainty, and Major Power War, 1820-1965." in Bruce Russett (ed)*Peace, War, and Numbers*, Beverly Hills: Sage, 19-48.

Singer, J. David. (1987). "Reconstructing the Correlates of War Dataset on Material Capabilities of States, 1816-1985"*International Interactions*, 14: 115-32.

Spaargaren, G. (2000). Ecological Modernization Theory and the Changing Discourse on Environment and Modernity. In: Spaargaren, G., Mol. A. P. J., & Buttel, F. H. (eds) *Environment and Global Modernity.* Thousand Oaks: Sage Publications, pp., 41-72.

Theisen, O. M. (2008). Blood and Soil? Resource Scarcity and Internal Armed Conflict Revisited. *Journal of Peace Research,* 45: 801-818.

Tomz, M., Wittenberg, J., & King, G. (2003). CLARIFY: Software for Interpreting and Presenting Statistical Results. Version 2.1. Stanford University, University of Wisconsin, and Harvard University.

Available at http://gking.harvard.edu/ (accessed 5 January 2013).

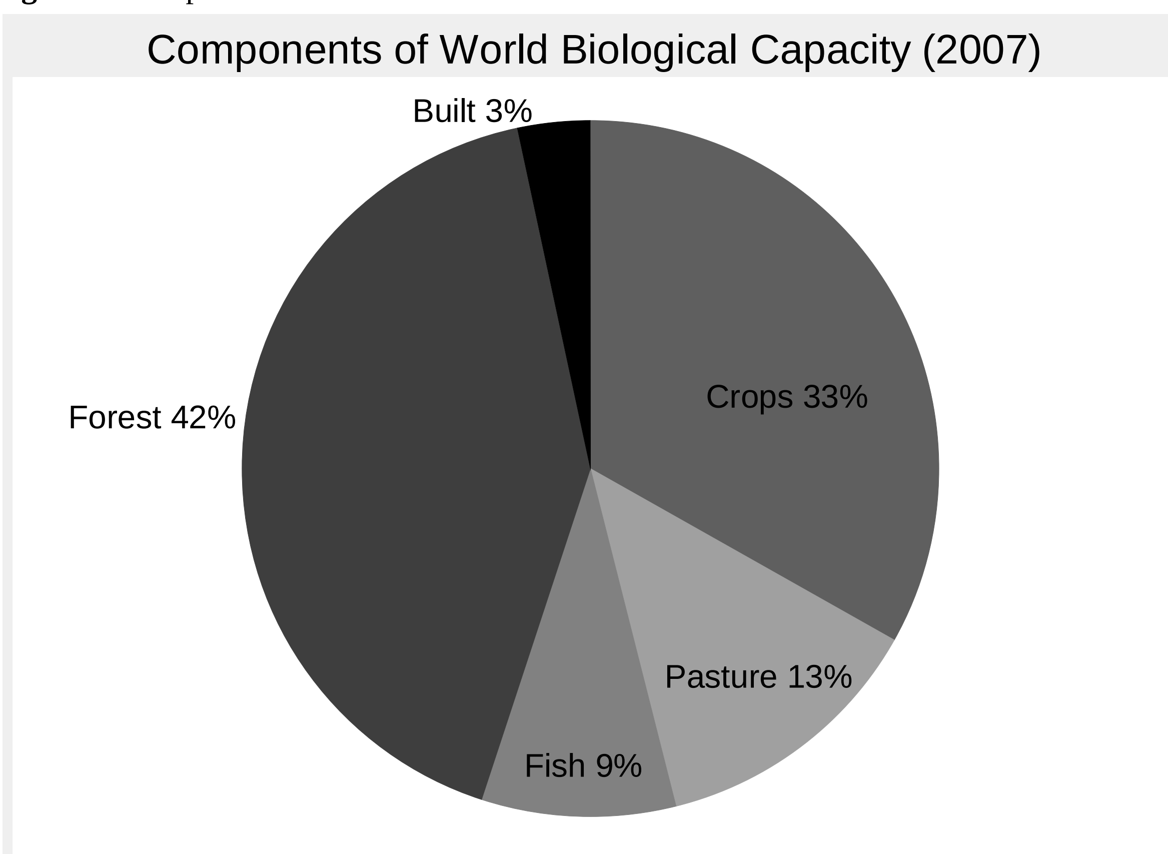
World Bank. (2013). World Development Indicators. Available at: http://databank.worldbank.org/data/views/variableSelection/selectvariables.aspx?source=world-development-indicators (accessed 5 November 2013).

Appendix A:
Research Note on Biocapacity

Biological Capacity and the Ecological Footprint

Biocapacity encompasses area estimates for different land types including cropland, pasture and grazing land, fishing grounds, forests, as well as land occupied by human infrastructure. The percentage components of World Biological Capacity in 2007 are presented in Figure 1. Area estimates for each land type are multiplied by a yield factor to account for national differences and an equivalence factor to standardize different land types into their equivalent units in global hectares of average biological productivity. Biocapacity and the Ecological Footprint are estimated using the same data and are measured and reported in the same units called global hectares (gha): "one gha represents a hectare of forest, cropland, grazing land or fishing grounds with world average productivity" (Global Footprint Network, 2010, p. 4). Conceptually, there are two primary differences between the Ecological Footprint of consumption and Biological Capacity. First, the Ecological Footprint of consumption subtracts the global hectares allocated towards exported goods and adds these hectares to the importing countries. Estimates of Biological Capacity do not make this adjustment. Second, the Ecological Footprint estimates the area of forest land that would be required to sequester carbon emissions, whereas Biological Capacity does not. This can be summarized as follows: Ecological Footprint = Biocapacity + Net Exports + Carbon Uptake Land.

Figure 1. Components of the World



Overshoot and Carrying Capacity

The Footprint Network calculates global "overshoot" as world Ecological Footprint minus world Biocapacity. The difference between the two represents the land area required to sequester unabsorbed carbon emissions. This measure of global 'overshoot' does not attempt to estimate the future loss of productivity growth that may occur with the depletion of non-renewable resources (e.g. petroleum and gasoline) that are necessary to sustain current levels of material throughput and consumption. Biological Capacity does not quantitatively assesses carrying capacity, defined as the maximum population of a species that a given land area can support indefinitely (e.g., Catton, 1980). The Footprint Network in effect assumes the *de facto* sustainability of the global average yield in any given year. Wackernagel explicitly states that: "the present calculations assume that the required land . . . is being used sustainably" (Wackernagel, 1996, p. 52).

Trends in Biocapacity

Although *per capita* Biocapacity has declined from 3.43 in 1961 to 1.78 in 2007, total Biocapacity increased from 10.56 Billion hectares in 1961 to 11.87 Billion hectares in 2007. This increase in Biocapacity is largely attributable to an increase in total crop productivity from 3.05 Billion hectares in 1961 to 3.94 Billion hectares in 2007. Total forest hectares also increased slightly from 4.87 Billion in 1961 to 4.94 Billion in 2007.

Appendix B:
List of Countries

All countries: Afghanistan, Albania, Algeria, Angola, Argentina, Armenia, Australia, Austria, Azerbaijan, Bangladesh, Belarus, Belgium, Benin, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Central African Republic, Chad, Chile, China, Colombia, Congo, Democratic Republic of Congo (Zaire), Costa Rica, Cote D'ivoire, Croatia, Cuba, Czech Republic, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Eritrea, Estonia, Ethiopia , Finland, France, Gabon, Gambia, Georgia, Germany, Ghana, Greece, Guatemala, Guinea, Guinea-Bissau, Haiti, Honduras, Hungary, India, Indonesia, Iran, Iraq, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Republic of Korea, Kuwait, Kyrgyz Republic, Laos, Latvia, Lebanon, Lesotho, Liberia, Libya, Lithuania, Macedonia, Madagascar, Malawi, Malaysia, Mali, Mauritania, Mauritius, Mexico, Moldova, Mongolia, Morocco, Mozambique, Myanmar, Namibia, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Romania, Russia, Rwanda, Saudi Arabia, Senegal, Yugoslavia, Sierra Leone, Slovak Republic, Slovenia, Somalia, South Africa, Spain, Sri Lanka, Sudan, Swaziland, Sweden, Switzerland, Syria, Tajikistan, Tanzania, Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, Uganda, Ukraine, United Arab Emirates, United Kingdom, United States of America, Uruguay, Uzbekistan, Venezuela, Vietnam, Yemen, Zambia, Zimbabwe.

High income countries (OECD and non-OECD): Australia, Austria, Belgium, Canada, Chile, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Israel, Italy, Japan, Republic of Korea, Kuwait, Latvia, Lithuania, Netherlands, New Zealand, Norway, Poland, Portugal, Russia, Saudi Arabia, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Trinidad and Tobago, United Arab Emirates, United Kingdom, United States, Uruguay.

Low income countries: Afghanistan, Bangladesh, Benin, Burkina Faso, Burundi, Cambodia, Central African Republic, Chad, Congo Dem Rep, Eritrea, Ethiopia,Gambia, Guinea, Guinea-Bissau, Haiti, Kenya, Korea, Dem Rep, Kyrgyz Republic, Liberia, Madagascar, Malawi, Mali, Mozambique, Myanmar, Nepal, Niger, Rwanda, Sierra Leone, Somalia, Tajikistan, Tanzania, Togo, Uganda, Zimbabwe.

Figure 2. Biological Capacity per capita by country, 2007