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A modest proposal: global rationalization of ecological footprint to eliminate ecological debt

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In the context of ecological overshoot, extreme poverty, and profligate consumption, we propose using ecological footprint analysis (EFA) to regulate and rationalize material consumption worldwide. EFA quantifies human-consumption flows relative to renewable natural capital stocks given specified levels of technology. Worldwide, 1.8 global hectares (gha) of bioproductive land exist per person, yet the human population is currently consuming 2.2 gha per person. Given global overshoot and the radically uneven distribution of consumption, we propose a global regime of cap-and-trade of ecological footprint. Under the terms of our modest proposal, all nations would be allocated population-based ecological footprints of an “earthshare” of 1.8 gha per person. Nations with large per capita footprints would be obligated to make reductions through some combination of reduced consumption, resource-productivity gains, population decreases, ecological restoration, and purchase of footprint credits. In contrast, countries with small per capita footprints could sell footprint credits to finance modernization along ecological lines. Mathematical simulation of our proposal indicates global convergence of nations’ ecological footprints in 136 years. In our view, the obscenity of contemporary ecological degradation and human suffering is perhaps rivaled by the audacity of our proposal to commodify biocapacity worldwide. We leave it to the reader to compare our response to institutional failure and the problem of distributive justice to the remedy Swift offered in 1729.

KEYWORDS: geopolitics, international trade, environmental equity, incentives, sustainable development, economics, resource conservation

Introduction

Over the past fifty years, human alteration of earth’s ecosystems has accelerated and diversified markedly, degrading the natural capital and related ecosystem functions on which we depend. The Millennium Ecosystem Assessment (MEA) undertaken by the United Nations from 2001-2005 inventoried the state of the world’s ecosystems and quantified the effects of human activities on them. The analysis was designed to “establish the scientific basis for actions needed to enhance the conservation and sustainable use of ecosystems and their contributions to human well-being” (MEA, 2005). According to its findings, approximately 60% of the ecosystem services evaluated are being degraded or used unsustainably (MEA, 2005). This statistic is, of course, a measure of the “overshoot” that environmentalists have long identified as a failure to recognize and heed the limits to growth (Catton, 1980).

Linked to this ecological crisis, we face a poverty crisis and a related ethical dilemma rooted in con-

cern for distributive justice. Without sufficient access to natural resources, humans cannot survive and certainly cannot thrive. Meeting our basic human needs requires water, food, shelter, clothing, and other goods derived from nature. With incomes of less than one dollar a day, close to a billion people currently live in “extreme economic poverty” and, by definition, lack access to essential natural resources to meet basic needs (World Bank, 2008). The profligate use of resources by the rich within and across nations degrades natural resources and limits access, exacerbating problems of the poor who often rely directly on such resources for income generation and sustenance. Impoverished people, with scant alternatives and a foreshortened planning horizon, further degrade local environments, deepening their hardships and further eroding local potential for socioeconomic development. Roberts (2003) has referred to the ecological degradation that accompanies a lack of economic opportunity as the “pollution of poverty.”

From an ecological perspective, poverty remediation is not unproblematic. As is increasingly

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well understood, improvement of the economic status of the world's poor could, over time, result in unintended and devastating side effects. If developing nations adopt first-world consumption patterns and dominant technical designs, emissions—including greenhouse gases from private automobiles and nitrogen from inorganic fertilizers—would overwhelm ecosystem-buffering capacity at local and global scales (Tilman, 1999; Galloway, 2000). In this context, people are seeking to expand what is now an unacceptable choice set: to take no action to alleviate systemic desperate poverty and the accompanying resource degradation or, alternatively, to cope with the pollution, ecological disorganization and overshoot that would result from adding billions of people to today's global middle class.

In the contemporary political economic context much of the energy and optimism directed at finding an alternative to this pair of poor choices focuses on so-called “leap-frog technologies,” radical innovations that will allow rapidly developing nations to avoid the negative socioeconomic and ecological consequences of modernization while imparting competitive advantages (e.g., hydrogen-based transportation, regenerative agriculture). While we share a certain measure of respect for innovation dynamics as a central element of progressive strategies, in our analysis we emphasize institutional processes regulating the pace and nature of technical change (Berkhout, 2002). We regard technologies as responses to scarcity and changes in factor prices, and factor prices are subject in part to social controls (i.e., politics). Our commitment to social controls (i.e., a retreat from voluntarism and an embrace of regulations and externally imposed limits) is a principle element of the immodesty suggested by the title of this article.

Our proposal is a policy instrument to address the social and ecological challenges that humanity confronts. We propose to regulate and rationalize material consumption at the global level through establishment of a system of cap-and-trade of consumption rights. Like Jonathan Swift in his essay of 1729, our interest lies in advancing a public dialogue focused around our shared problems. We leave it to the reader to compare our proposal to Swift's remedy to the dual problem of social inequity and how to live within our means.

An Institutional Analysis of Ecological Overshoot

As identified in the MEA, resource degradation is largely a consequence of a failure to develop institutions that account for the world's natural capital in supporting our welfare. Ecosystem services—

valuable functions performed by natural systems, including purification of air and water, pollination of crops, stabilization of climate and habitat (NRC, 2005)—are often not valued or are undervalued in the marketplace, in policy-making processes, in organizations, and at the household level (Daly & Cobb, 1989; Costanza et al. 1997; Balmford et al. 2002). As a consequence of institutional failure, ecosystems' contributions to socioeconomic systems are targets of chronic under-investment (Wackernagel & Rees, 1997).

Ecological modernization theorists argue that the core contemporary political, social, and economic institutions of late modernity have the potential to address the current ecological crisis (Crowley, 1999; Marx, 2000; Mol & Sonnenfeld, 2000; Mol, 2000, 2001, 2003). Specifically, they argue that hyperindustrialization—radical resource productivity gains—will limit throughput, reducing inputs, waste, and attendant ecological degradation (Hawken et al. 1999). As part of this material transformation, ecological rationality is incorporated into economic logic, social organization, and politics. In this framework, socioeconomic development and environmental protection are seen as complementary, rather than contradictory, goals. As an integrated social-scientific analysis and policy prescription, ecological modernization points to institutional change—defined to include formal coordination mechanisms such as rules and prices as well as cognitive structures such as conceptions of fairness, justice, and personal identity—as capable of transforming circuits of production and consumption and attendant ecological disorganization. In keeping with this generic prescription of multi-scaled institutional innovation, we introduce a policy proposal in which ecological footprint analysis (EFA) would be used to measure, monitor, and manage consumption of natural resources in pursuit of sustainable development.

EFA seeks to provide a unified, comparable measure of human ecological impact known as the “ecological footprint” (Loh & Wackernagel, 2004). This footprint can serve as an indicator of sustainability (York et al. 2003; Loh & Wackernagel, 2004). Human consumption greater than available biocapacity—i.e., productive capacity of earth's renewable natural resources to produce goods and services on a sustainable basis—constitutes ecological overshoot (Venetoulis et al. 2004). We outline a globally scaled environmental agreement to reduce and redistribute consumption as represented by ecological footprint. Our policy is designed to ensure against global ecological overshoot and to raise the material standard of living of the world's poor to an equitable level.

In keeping with general tendencies in governance (e.g., Mazmanian & Kraft, 1999), we employ a

property rights or market-based approach to protect natural capital, including a cap-and-trade scheme. This proposal conforms to the general logic of a system of tradable environmental property rights, as outlined by Carley & Spapens (1998). In its global scope, its reliance on nation states as units of analysis, the centrality of cap-and-trade logic, and its focus on inducement of technological change, our proposal mimics key aspects of the Kyoto Protocol.¹

This agreement will serve the following functions.

1. Limit the extent of nations' ecological footprints and provide incentives to reduce footprint by phasing in increasingly stringent controls over time.
2. Provide incentives for product and process innovations and system redesign resulting in heightened eco-efficiency and ecological restoration (i.e., increased biocapacity).
3. Transfer resources to relieve poverty and to support sustainable development of poor nations.
4. Provide incentives to rapidly industrializing nations such as China and India to pursue sustainable development paths.

The following section justifies the regulatory controls we propose through historical and ethical arguments. We then review the mechanics of EFA and our policy proposal in detail. We mathematically simulate how our proposition would affect ecological footprints across the globe as we move toward convergence of ecological requirements of all nations on earth. The final section reflects on the implications of our analysis.

Critique of the Unilateral Appropriation of Natural Resources

In seeking to rationalize consumption and progress toward sustainability, we must simultaneously address both excessive consumption and insufficient access to natural resources and investment capital. While it is likely inaccurate to argue that lifestyles of the rich explain the misery of the poor, these problems are connected; more importantly, they imply a unified strategy to promote sustainability.

Severe disparities in income and consumption exist between developed and less developed regions, and this stratification is increasing.

The income gap between the fifth of the world's people in the richest countries and the fifth of the world's people in the poorest was 74 to 1 in 1997, up from 60 to 1 in 1990 and 30 to 1 in 1960. By 1997, the richest 20% captured 86% of world income, with the poorest 20% capturing a mere 1% (Wallach & Woodall, 2004).

Throughout his or her lifetime, the average American "accounts for the consumption of 540 tons of construction materials, 18 tons of paper, 23 tons of wood, 16 tons of metal and 32 tons of organic chemicals" (Carley & Spapens, 1998). Examinations of aggregate consumption estimate that people in high-income countries consume, on average, six times as much as people in low-income countries (Loh, 2002). Rich nations are largely responsible for ecological overshoot and the consequent drawdown of natural capital. While seldom contemplated and nowhere made explicit, drawdown of natural capital is an expression of a property claim. The consumption of a disproportionate share of the world's natural capital constitutes *unilateral appropriation of natural resources* (Pogge, 1998).

Although accepting that all inhabitants of the earth ultimately have equal claims to its resources, defenders of capitalist institutions have developed conceptions of justice that support rights to unilateral appropriation and discretionary disposal of a disproportionate share of resources. They argue that a practice permitting unilateral appropriation of disproportionate shares is justified if all are better off under this practice than they would be if such appropriation were limited to proportional shares (Pogge, 1998).

According to the "Lockean Proviso," in a state of nature people are subject to a moral constraint in that unilateral resource appropriation is justifiable only if "enough, and as good" remains for others (Pogge, 1998). That is to say, shares must be proportional for all. This provision can be lifted "only if everyone will be better off under the new rules than under the old, that is, only if everyone can rationally consent to the alteration" (Pogge, 1998). Pogge argues that this conditional requirement is not fulfilled today because hundreds of millions of people are born into and remain in extreme poverty. While it is possible for these people to rent out their labor, the compensation they receive is often not enough to meet their basic needs.

In this context, it is not true that "all strata of humankind, and the poorest in particular, are better

¹ In some respects, our proposal is an extension of climate change mitigation schemes such as Aubrey Myer's proposed program of global contraction and convergence of greenhouse gas emissions. Thanks to Maurie Cohen for this reference.

off with universal rights to unilateral appropriation and pollution than without the same” (Pogge, 1998). Thus, the Lockean proviso remains in force (Pogge, 1998). Unilateral appropriation of natural resources would only be justified if there were some form of compensation from the benefit of this appropriation. Following this logic, Pogge (1998) calls for a “Global Resources Dividend” to compensate the world’s poor for unjust unilateral appropriation of natural resources.² In recent years, the idea of “ecological debt” has been used to describe debt accumulated through unilateral appropriation of natural resources and by extension the global commons (Sachs, 2004). Simms (2005) argues that this cumulative process, which began hundreds of years ago under Western colonialism, is largely responsible for the economic successes of the world’s rich nations. In the context of ecological overshoot and extreme poverty, Simms (2005) contends that rich nations have accumulated an ecological debt far greater than the questionable financial debt of poor nations.

While reparation payments have not been widely contemplated, existing international environmental agreements have incorporated notions of equity and distributive justice. Precedents recognize differences in rights and responsibilities across nations. For example, the 1987 Montreal Protocol “differentiated between rich and poor countries” and the 1992 Convention on Biological Diversity refers to the need for “equitable sharing” of the agreement’s costs and benefits (Beckerman & Pasek, 2001). The United Nations Framework Convention on Climate Change (UNFCCC), signed at the Río Conference in 1992, states, “the parties should protect the climate for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities” (Beckerman & Pasek, 2001). Further, the Kyoto Protocol differentiates responsibility in that “countries with higher per capita emission rates are expected to accept bigger cuts from the levels of their emissions in 1990” (Attfield, 1999). Kyoto proponents justify this provision with the argument that “while everyone has a right to develop, only some nations have in fact developed sufficiently. Those that are not yet sufficiently developed are therefore entitled to continue with their own development and not expected to divert resources in the mitigation of climate change” (Shue, 1995). Recognizing these precedents and the moral requirements

underlying them, our proposal allocates responsibility to adapt (and presumably cost) in proportion to national consumption.

Ecological Footprint Analysis

As part of an analysis of the ecological implications of economic throughput, in the early 1970s Paul Ehrlich and John Holdren developed the IPAT model ($I = P \times A \times T$) in which human environmental *Impact* equals *Population* multiplied by *Affluence* (i.e., quantity and quality of consumption) multiplied by *Technology* (i.e., efficiency of production and waste assimilation) (Rees, 2000). This framing of the material problem draws our attention to a set of relationships that define opportunities for intervention at multiple scales.

In the tradition of critical analysis of natural resource consumption and a failure to “tread lightly on the earth,” EFA estimates the areal extent of biologically productive land and water ecosystems required to support some specified individual, activity, organization, territory, or even the planet as a whole (Chambers et al. 2000). For a given individual, the ecological footprint is the amount of bioproductive land and water area, of average quality, needed to support his or her particular lifestyle as proxied by types and amounts of consumption (i.e., A = affluence) and the efficiency of local processes of material transformation and waste assimilation (i.e., T = technology). Multiplying average values of these factors for a given country by the number of citizens in that country (i.e., P = population) yields an estimate of the nation’s ecological footprint.

Worldwide, the average ecological footprint of a human being is estimated to be 2.2 global hectares (gha). While calculations suggest that average per capita ecological footprint has been slightly declining since 1980, this decrease has been overshadowed by the aggregate increase stemming from population growth (Venetoulis et al. 2004). As Loh & Wackernagel (2004) explain, “global Ecological Footprint changes with population size, average consumption per person, and resource efficiency. Earth’s biocapacity changes with the amount of biologically productive area and its average productivity.” In this framework, ecological footprints are tallied as debits, while biocapacity constitutes assets (thus, ecosystem services are analogous to interest). EFA is thus a means of evaluating our balance sheet and conducting an ongoing critical accounting of the world’s renewable natural capital.

Global biocapacity is calculated by placing the world’s available land and water into a set of ecological categories (Wackernagel et al. 2005). Six categories are recognized as productive: arable land,

² Hancock (2003) goes further and argues that access to natural resources is a basic human right guaranteed under international human rights declarations such as the Universal Declaration of Human Rights (UNDHR) and International Covenant on Economic, Social, and Cultural Rights (ICESCR) (United Nations, 1948, 1976).

pastureland, forested land, productive sea space, built land, and carbon land.³ These general categories are further differentiated into subcategories for purposes of compiling a resource inventory of bioproductive area. Bioproductivity coefficients are assigned to each land and sea type based on a synthesis of scientific information. These coefficients are predicated upon “equivalence factors (capturing the productivity difference among land-use categories) and yield factors (capturing the difference between local and global average productivity within a given land-use category)” (Wackernagel et al. 2005). Application of these coefficients to resource-inventory data generates an area-weighted average to represent global renewable ecological capacity.

After subtracting 12% of available bioproductive area from the global total for the sustenance of non-human species, 11.3 billion gha of biocapacity remain (Holmberg et al. 1999; Loh & Wackernagel, 2004).⁴ For a population of 6.302 billion people (2003 estimate), approximately 1.8 gha are available per capita (GFN, 2006). Wackernagel and Rees refer to the amount of bioproductive land and sea of average quality available per capita worldwide as an “earthshare” (Chambers et al. 2000). The relationship between an earthshare and an individual’s footprint is a measure of sustainability. Ratios greater than 1.0 indicate living within means. Ratios less than 1.0 signal overshoot. Similar estimates can be produced at the level of individual nations or the globe as a whole.

Two prominent methods are used to estimate ecological footprints: national footprint accounting (NFA) and input-output analysis. For a given nation, NFAs are calculated for a series of categories of material goods that capture core dependence on natural resources. National imports are added to domestic production and exports are subtracted (Wackernagel et al. 2005; GFN, 2006). For each category of goods, this measure of net material consumption is translated into a spatial measure. In conducting this translation, commodities consumed from croplands, pasturelands, and forests, for example, are differentiated into primary and secondary products. Primary products are unprocessed, for example corn. Secondary products are the goods derived from primary products, for ex-

ample high fructose corn syrup. For primary products, ecological footprint calculations are based on global yield estimates. For processed secondary products, calculations are based on national conversion coefficients representing the efficiency of national production and waste-assimilation processes (Wackernagel et al. 2005).

Aggregating the spatial measures derived for each category, as described above, yields a nation’s ecological footprint. Per capita footprint is calculated by dividing national footprint by national population. Obviously, focusing on average levels of consumption obscures vitally important variance within a population (Sachs & Santarius, 2007). The NFA approach also fails to accurately reflect all resource uses associated with international trade (i.e., services), and does not inform whether impacts occur within or outside a country due to the aggregation of imports and domestic production (Lenzen & Murray, 2001, 2003; Turner et al. 2007; Wiedmann et al. 2007a, 2007b).

In recent years, input-output analysis has been applied to obtain more robust ecological footprint estimates at national, regional, and local levels (Bicknell et al. 1998; Lenzen & Murray, 2001, 2003; Wiedmann et al. 2006). Environmental input-output analysis captures resource flows through inter-industrial monetary transaction data (Lenzen & Murray, 2003). Multiple approaches, including a basis in land condition (i.e., accounting for losses in ecological functionality of land that is altered from a pristine state), have been introduced for calculating input-output based ecological footprints (Lenzen & Murray, 2001, 2003). There is, however, no standardized method of ecological footprint accounting based on input-output analysis, making different methods incompatible (Wiedmann et al. 2006). Given current objectives, we will rely on NFA data for development and assessment of our policy proposal.

A Property Rights Approach to Managing Ecological Footprint

Past international environmental agreements have focused on specific ecological risks stemming from discrete pollution streams. The Montreal Protocol, for example, confines itself to the reduction and elimination of ozone-depleting substances such as chlorofluorocarbons (CFCs). The Kyoto Protocol focuses on the reduction of greenhouse-gas emissions such as carbon dioxide (CO₂) to prevent or slow climate change. While these agreements suggest that international cooperation is possible (Speth & Haas, 2006), they are limited in their ability to engage with the overarching problems of ecological overshoot and inequitable resource distribution.

³ Carbon land is the area required to sequester greenhouse gas emissions. This footprint component now accounts for approximately one half of the global ecological footprint, a nine fold increase from 1961 (GFN, 2007).

⁴ Allocating 12% of biocapacity for biodiversity conservation is derived from rather informal estimates of conservation biologists as to habitat required to avert catastrophic acceleration of extinction rates (Chambers et al. 2000).

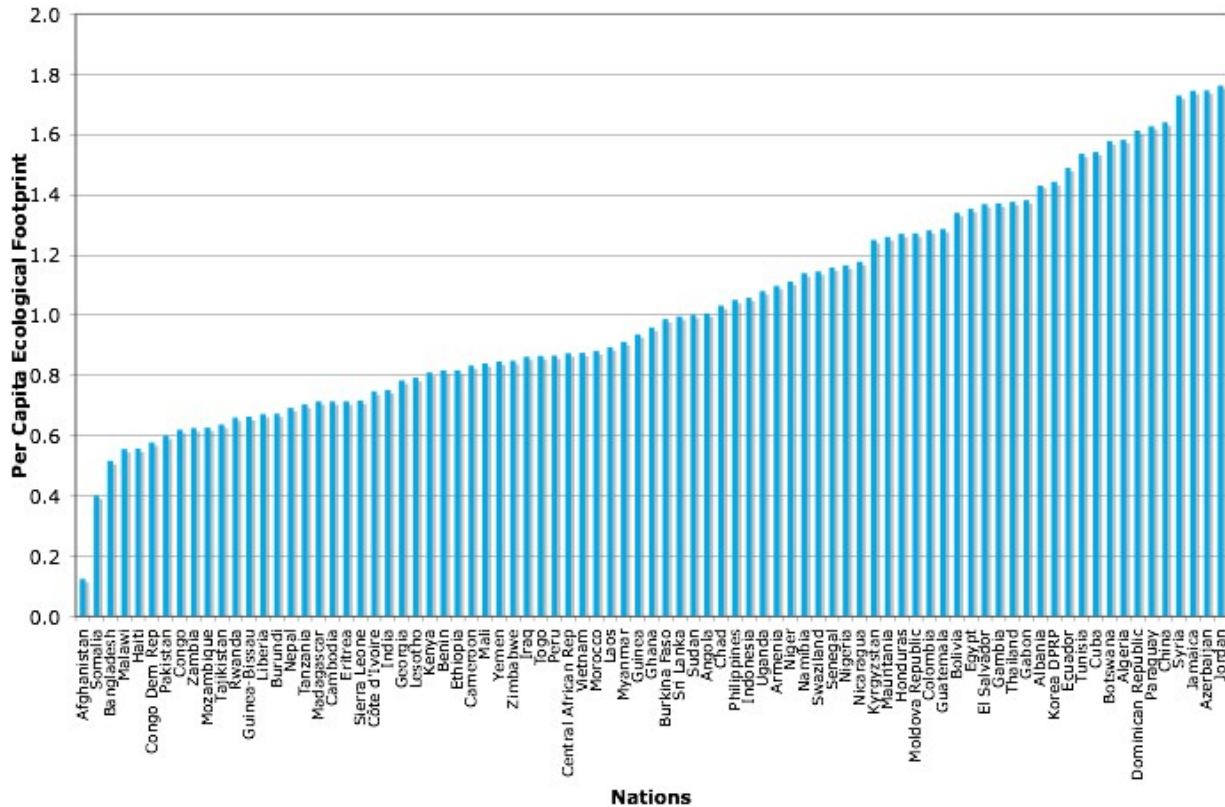


Figure 1 Creditor or Surplus Nations (GFN, 2006).

In seeking ways to address our current situation, we are drawn to a property rights-based approach. We propose to allocate ecological footprint to nations (and by extension, their citizens) and then place controls on national footprints while simultaneously creating exchange mechanisms. National footprints are to be allocated on the basis of population (national population x earthshare).⁵

As stated earlier, current estimates define an earthshare as 1.8 gha per capita (Loh & Wackernagel,

2004). Currently, of the 147 nations included in the Global Footprint Network database, 83 have per capita ecological footprints below or equal to 1.8 gha (GFN, 2006; Hails, 2006) (Figure 1). These nations are consuming, in terms of per capita averages, at levels below their allocation of earthshare. We refer to this group of countries as “surplus” or creditor nations, as under our proposed agreement they are positioned to sell consumption rights (i.e., extend ecological footprint credit) to “debtor” nations.

The remaining 64 nations have ecological footprints greater than 1.8 gha per capita (Figure 2). In the present term, these are “debtor” nations. Under our proposed agreement, they are responsible for reducing consumption and/or purchasing ecological footprint credits to meet their global obligations. To progress toward global sustainability and equity, our proposition aims to ensure that, over time, debtor nations reduce their per capita footprints to levels below or equal to an earthshare. Creditor nations would be obligated to maintain per capita footprints at or below an earthshare.

⁵ Alternative approaches for the initial allocation of consumption rights could be contemplated. For example, it is easy to imagine the grandfathering of high consumption nations, awarding them additional consumption allowances according to the logic that they should be permitted to retain privileges gained under the old standard of “first come, first served.” Alternatively, national consumption allowances could be tied to national biocapacity according to the logic that this will result in spatial rationalization of population and investment relative to ecological endowments. In defending our decision to allocate rights irrespective of development status and biocapacity, we reject the first argument categorically. We also dismiss the second argument because such a strategy would ignore global interdependencies and counteract efforts to protect existing biocapacity from over-exploitation. Critics of our approach may contend that a population-based allocation rewards nations with large populations and high population growth. While population pressures are clearly part of the IPAT framework, we argue that as nations reach consumption convergence through the international agreement outlined here, population growth in developing nations will likely decline.

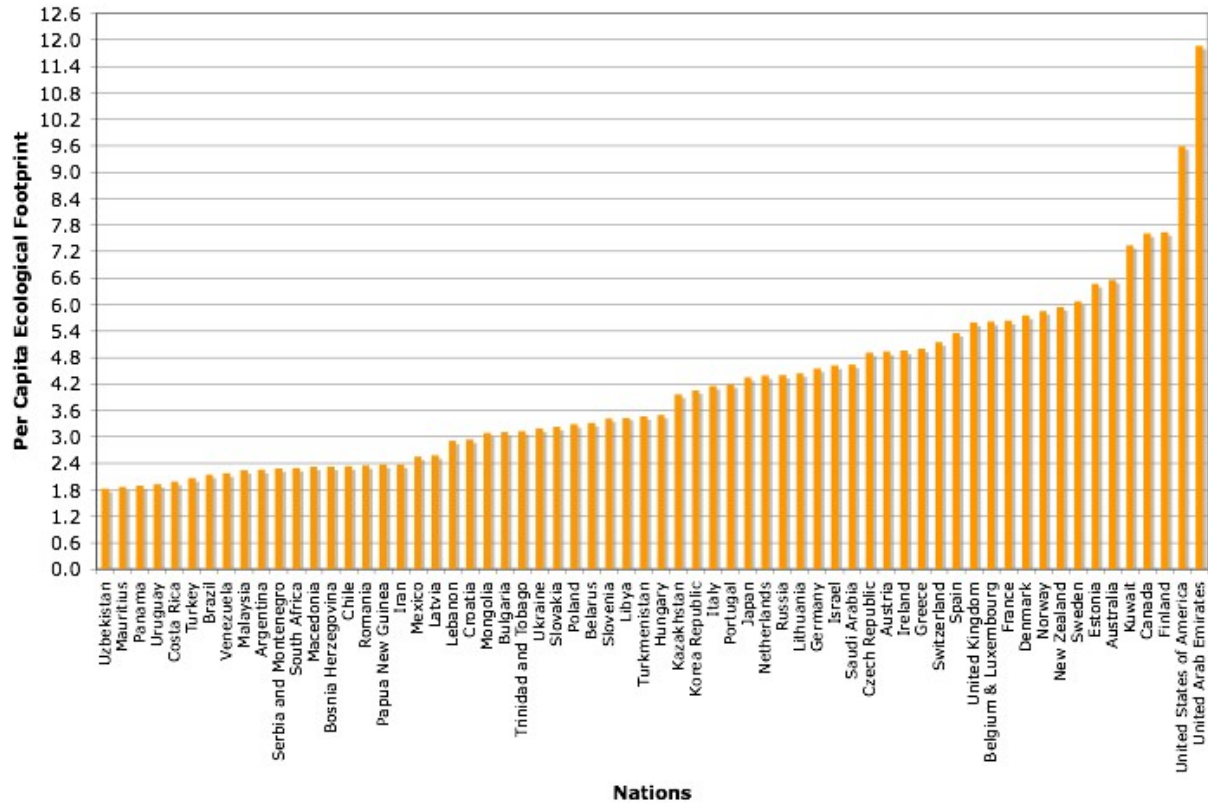


Figure 2 Debtor or Deficit Nations (GFN, 2006).

Cap-and-Trade of Ecological Footprint

Such controls and immodest aims would need to adhere to several policy principles. Nations with large per capita ecological footprints would not be able to adapt overnight due to technical, economic, social, and political constraints. Thus, implementation of this proposal would need to be phased in over some substantial time period. In the spirit of relying on incentives and incorporating flexibility into regulatory structures, we propose to implement a cap-and-trade strategy. Nations consuming beyond their footprint allocation would be free to meet their obligations through a combination of reductions in ecological footprint and purchase of footprint from creditor nations. Creditor nations would be free to sell “consumption credits” to debtor nations. The dynamics of this market would, of course, structure the price of credits and the nature and rate of investment in footprint reduction.

Such an agreement would need to incorporate substantial flexibility to allow countries to pursue implementation consistent with their values, strategies, and assets. While significant opportunities for low-cost improvements in resource efficiency and biocapacity (i.e., ecological restoration) are available

in industrialized societies (Hawkin et al. 1999), improvements are often cheaper in developing nations (Grubb et al. 1999; Oberthur & Ott, 1999; Illum & Meyer, 2004). Consistent with the Kyoto Protocol, we allow for Joint Implementation (JI), a mechanism that permits a recipient country to “receive additional funds, modern technology and know-how, whereas the investing country would acquire (CO₂) credits at a lower cost than taking action at home” (Oberthur & Ott, 1999). Presumably, JI would support reductions in consumption at the global scale at lower aggregate cost and would accelerate technology transfer to developing nations.⁶

Our proposal includes a mechanism for annual update of each nation’s rights and responsibilities based on changes in their 1) consumption, 2) technology, 3) population, and 4) biocapacity (i.e., ecological restoration that results in expanded carrying capacity). These updates represent feedback loops such that unsustainable investments and patterns of behavior are costly, while progress toward sustainability yields rewards.

⁶ JI is further supported by the uneven global distribution of biocapacity. For example, biodiversity “hotspots” are essential resources and should be maintained.

We propose that controls on footprint be phased in over time. Deficit nations will be required to reduce their deficit footprints by 5% per year until they reach a sustainable level of consumption. Creditor nations, in other words nations with a per capita footprint of less than an earthshare, will be required to stay within the limit of an earthshare per person. Such nations could expand resource usage up to that threshold, but not exceed it without incurring debtor-nation responsibilities.

Simulation

We developed a mathematical model to simulate convergence of ecological footprints of debtor and creditor nations under the proposed agreement. The simulation is structured as follows.

1. All nations' footprints are normalized in terms of deviation from the allotted 1.8 gha earthshare per capita.⁷ For example, the United States has an average per capita ecological footprint of 9.6 gha, which results in a +7.8 gha deviation from the allotted 1.8 gha per capita. Similarly, Cambodia with a per capita footprint of 0.7 gha has a deviation from a per capita earthshare of -1.1 gha.
2. Average per capita consumption converges across the globe at the level of nation states on the basis of annual incremental changes. All nations eventually reach and maintain consumption at the rate of an earthshare per capita, defined as a per capita national average ecological footprint of 1.8 gha. This expectation applies to both deficit nations (that are consuming above 1.8 gha per capita) and surplus nations (that are consuming below 1.8 gha per capita).
3. Debtor nations are required to reduce deficit ecological footprint by 5% annually. In each year, 2.769% of this 5% obligation will be achieved through real, material reductions and 2.231% will be achieved through purchase of consumption credits. These specific values derive from our mathematical simulation (see below), but our intention is to require rich nations to meet roughly half of their annual obligations in the initial years of the agreement through real internal reductions rather than by simply purchasing credits.⁸ Real reductions can occur in consumption,

population, and/or via higher productivity (i.e., efficiency of production and consumption).

4. JI is not considered in this simulation and we treat population and biocapacity as constants.
5. The sale of an ecological footprint credit provides an offset to the purchasing nation and income to the selling nation for a period of 20 years. This 20-year contract provides flexibility for deficit nations to reduce consumption (through long-term internal reduction strategies) and creates an annual income stream to surplus nations to support sustained investment in security, infrastructure, human capital, and other resources required for economic development and ultimately increased consumption. While the real reduction or increase of ecological footprint following the sale of credits will be realized over the 20-year contract period, as an accounting convention we record footprint increases and reductions in the year following the sale of the credit.

Rich nations' commitment to annual 5% footprint reductions drives the dynamic model that we simulate. As stated above, the percentage of reduction that debtor countries (i.e., those with per capita ecological footprints > 1.8 gha) must meet by real, material reductions is fixed, as is the percentage they purchase from surplus nations (i.e., those with per capita ecological footprints < 1.8 gha). These values are determined via *post optimization*, an iterative feedback method for improving parameter convergence. Note that because rich nations reduce their footprint deficit every year, the number of credits that they purchase declines over time. The percentage remains fixed, but the volume of credits changes.

We find that pegging real footprint reduction requirements at 0.02769 every year and allowing "debtor" nations to purchase 0.02231 of their earthshare debt in the form of credits results in convergence. Specifically, all nations achieve average per capita ecological footprints of an earthshare (1.8 gha) in 136 years (Figures 3 & 4). Changes in nations' consumption over the 136-year period are not linear. For example, in the first 26 years of the agreement, deviations from an earthshare for both deficit and surplus nations are reduced by 69%. The curves in the figures derive from plotting every nation's footprints at 25-year intervals. For purposes of clarifica-

⁷ For further details, refer to <http://www.footprintnetwork.org>.

⁸ Note that a policy that did not require real reductions in ecological footprint could simply result in a transfer of wealth from rich to poor nations and thus fail to significantly mitigate overshoot. In contrast, a scheme that rested solely on mandatory real reductions and did not allow for purchase of credits would fail to fuel sustainable development in poor nations. Allowing rich nations to meet

their obligations through variable combinations of real reductions and credit purchases would increase flexibility. Under a modified policy proposal, it is easy to imagine allowing a liberalized trading regime under which rich nations could make real reductions in ecological footprint beyond what is required in a given year and then sell their rights to purchase credits. For present purposes, we hold the purchase and real reduction fractions constant.

tion, the x-axis explicitly identifies the positions of a set of nations consuming at very different levels. Figure 4 zooms in on the later years of policy implementation, as these details cannot be seen at the scale of Figure 3.

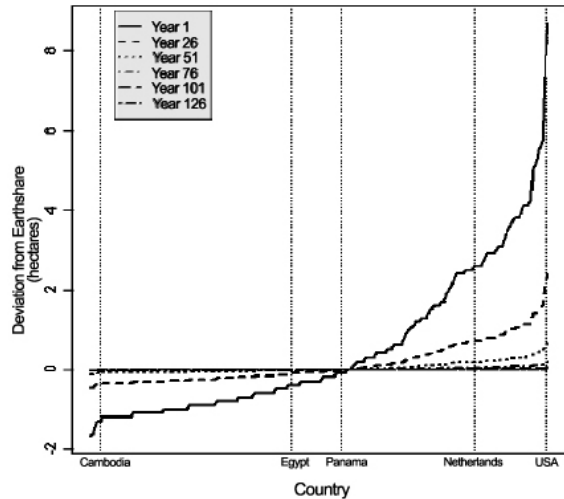


Figure 3 Graphic simulation of convergence of global ecological footprint as demonstrated by plots at 25-year intervals.

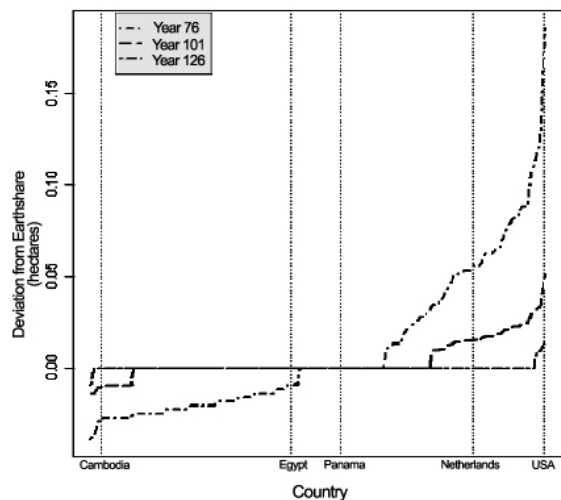


Figure 4 Close up of graphic simulation of global ecological footprint convergence in latter years under proposed agreement as demonstrated by plots at 25-year intervals.

Figure 5 illustrates the dynamic rate of footprint credits for sale by surplus nations over time. In the initial years under the policy, approximately up until year 60, these nations would sell close to 5% of their stock of credits each year, almost certainly resulting in a very significant income stream. Over the following 65-year period, the rate of sales drops off ra-

pidly. In the final years of implementation, the stock of credits approaches zero as surplus nations advance toward consumption at rates approximating an earthshare per capita. Simultaneously, as debit nations approach 1.8 gha per person footprints, they eventually come to a point of purchasing zero credits to meet their annual obligations, yielding a zero rate of sale.⁹

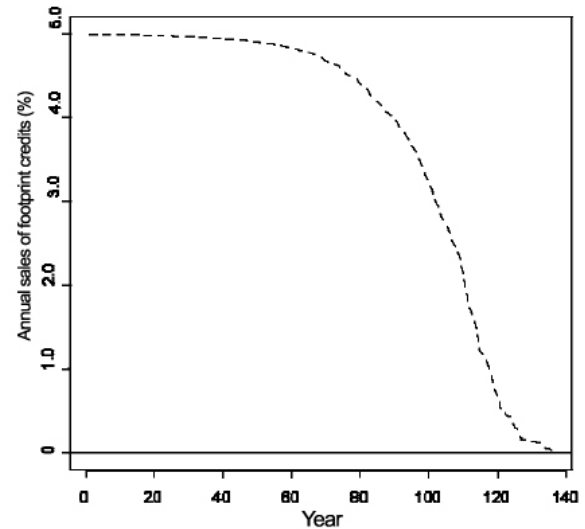


Figure 5 Annual rate of sales of ecological footprint credits as a percentage of total stock of credits initially held by surplus nations.

Domestic Implementation

Up to this point, our discussion has only addressed obligations and opportunities at the nation-state level. Within individual nations, it is possible to imagine allocating rights to an earthshare to each citizen and then implementing a cap-and-trade system in parallel to the global system we have just described. Citizens who exceed an earthshare would be required to conserve and/or purchase surplus footprints from poorer or more frugal fellow citizens. Thus, the distribution of property rights corresponding to an earthshare could result in large monetary transfers between rich and poor individuals within nations. Such transfers could promote domestic poverty alleviation and possibly a significant redistribution of wealth within countries. As every nation would have the ability to determine how it was going

⁹ In computing, sequences that converge to 0 require special treatment. In most cases, dividing small numbers by small numbers iteratively will not yield zero. The values do become infinitesimally small. For our purposes we assigned a value of zero to numbers that drop below 0.009. Our iterative simulation is stopped, and zero values are assigned, when all countries have a per capita footprint deviation from an earthshare of 0.009 or less.

to meet the agreement requirements, elites would likely push the costs of compliance on the poor. A significant element of our proposal's immodesty rests precisely in our not addressing the inequities, repression, and violence that would accompany implementation.

Conclusion

The proposal we outline here would rationalize and equalize global ecological footprint at the level of individual nation states. This proposed international treaty would conserve natural capital by limiting the freedom of rich nations to degrade the environment and amplify global risks. With respect to current and future generations, our proposal advances distributive justice and reduction of ecological debt. Significant infusions of funding into developing nations would reduce the pressure on impoverished people to further degrade their natural capital while providing investment capital to support development. Additionally, the agreement would create incentives for innovations that enhance resource productivity. Such expanded efficiency could fuel sustainable economic development and material wellbeing.

Beyond self-interest in mitigating risks that stem from global environmental degradation, we have argued that concentrated appropriation of natural resources cannot be sustained on ethical grounds. There is no right to withdrawals in cases where they exceed a proportionate share and leave others worse off. On the basis of these arguments, nations consuming more than an "earthshare" per person, as determined by the ecological footprinting methodology, are to bear the costs of the proposed policy.

Our proposal allows us to contemplate how contemporary perspectives on environmental policy play out when applied to overarching environmental issues. It has been suggested that environmental policies capable of addressing such problems must be flexible, efficient and accountable, information-rich, innovation spurring, incentive-based, transmedia (i.e., integrate management across soil, air, and water), and applicable at multiple levels of social organization (i.e., nested) (Kettl, 1998). In keeping with these criteria, our proposal features tradable permits and JI. We reward innovation and provide flexibility to actors to structure their own investment schedule within a regulatory framework premised on clear metrics. Annual updating of rights and responsibilities constitutes critical information signals. In sum, our proposal very much accords with current policy-design principles.

This analysis is obviously limited in many ways; for example, ecological footprinting methodologies do not encompass nonrenewable resource consump-

tion. Further, our policy would create perverse incentives. For example, because conversion of native forestland to pastureland would increase biocapacity and allowable footprint, this approach would sustain the economic-benefit stream from the environment, but it would fail to address all environmental values (Lenzen et al. 2007). Lastly, it is important to note that the NFA methodology that we employ cannot be directly translated into material-consumption rates. While nations' per capita ecological footprints would converge under our policy agreement, differences in the technical efficiency of production and consumption across nations would remain, resulting in varying levels of health and welfare. Further, equalizing the ecological footprints of nation states does not, of course, ensure individuals' equal access to resources. As every country would have the responsibility to determine how to meet the requirements of the agreement, in the absence of controls, there is a significant risk that elites would push the costs and burdens of compliance onto poor, politically marginalized people.

Despite these shortcomings, as a thought exercise, the analysis confronts us with the enormity of the challenge ahead if we take sustainability seriously. At the same time, we are able to begin to explore the material meaning of commitment to sustainability (Blühdorn & Welsh, 2007) and social coordination strategies that would allow us to live within our collective means (Cohen, 2006). Phrased this way, it does not sound like such an immodest proposal.

By making an outrageous suggestion, Swift shocked people of all stripes, thereby raising the visibility of poverty in Ireland and its institutional roots. He gave interest groups with little in common a shared target of mockery and he bounded the solution set, accelerating political processes of negotiation and collective action. We would be pleased if our modest proposal accomplishes any or all of these outcomes. In direct contrast with the intervention Swift proposed, we note that the policy instrument we advocate—establishment of new enclosures and reliance on markets—is increasingly perceived as an efficient and fair solution to problems of social and material coordination and not at all outrageous. In this sense, our proposal could be interpreted to be pragmatic rather than immodest. But, we want to make clear that we are not at all convinced of the wisdom of global commoditization of biocapacity. We are committed to the "ends" we outline, but are quite conflicted with respect to the "means." In our view, the obscenity of contemporary ecological degradation and human suffering is perhaps rivaled by the audacity of this institutional innovation.

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