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Extending market allocation to ecosystem services: Moral and practical implications on a full and unequal planet

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ABSTRACT

Both economists and conservationists are calling for expanded use of market-based instruments (MBIs) to address worsening environmental problems, but the lack of MBIs at the scale required to solve major global problems makes it difficult to empirically evaluate their effectiveness. This article indirectly evaluates MBIs for essential ecosystem services by examining market allocation of another essential resource that is allocated by markets and which has experienced dramatic price increases: food. In an unequal world, markets respond to price increases by reducing food allocations to the destitute and malnourished, but not for the affluent. MBIs would increase the prices of ecosystem services and the commodities whose production degrades them, forcing the impoverished to reduce consumption by more than the wealthy. Furthermore, most MBIs would be prone to speculation and price instability, be incompatible with the satisfaction of individual preferences, or would not maximize economic surplus. Most environmental problems can be characterized as prisoner's dilemmas, which are best solved through cooperation, not competition. Society must create economic institutions that promote cooperation and ensure that the burdens of reducing throughput are not borne disproportionately by the poor.

1. Introduction

A growing number of studies suggest that the continually expanding human economy threatens potentially catastrophic destabilization of planetary life support functions, with specific threats ranging from climate chaos to the irreversible domination of oceanic ecosystems by jellyfish (Gershwin, 2013; IPCC, 2013; Millennium Ecosystem Assessment, 2005; Rockstrom et al., 2009). If the field of economics is to remain relevant to human society it must acknowledge and address these emerging challenges.

Conventional microeconomics[1] (also known as price theory) has long defined environmental problems as externalities, with the implication that solving these problems requires the internalization of these externalities into the market system via monetary penalties for activities that harm the ecosystem and monetary rewards for activities that benefit it (Baumol and Oates, 1989; Pearce and Turner, 1990; Pigou, 1932). For the purposes of this article, we define a market as an institution in which private sector parties offer goods and services to other private sector parties in voluntary exchange for money. Prices adjust to and balance supply and demand. Market-based instruments (MBIs) are incomplete markets in which the government or some other institution determines supply, demand or price, while the other two are determined through voluntary exchange. With environmental taxes, the government determines a major component of the price, and supply and demand adjust; with cap and trade or cap and auction systems, governments typically determine the supply, and demand and price adjust. In most examples of payments for ecosystem services, governments or other forms of collective action determine the demand and/or the price, and allow supply to adjust.[2] These mechanisms allow individual agents to balance the costs and benefits of a given activity at many different margins (e.g. shifting consumption to substitutes, improving efficiency, and developing new technologies), which in theory can minimize the cost of achieving particular environmental goals.

In recent years both conservationists and economists have been calling for even greater use of MBIs to achieve environmental goals

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[1] By 'conventional microeconomics', this article refers to neoclassical economic theory as taught in the vast majority of economics programs in the US, Europe, and many other nations. Its core features include the assumptions (i) that economic behavior is driven by individual preferences with the goal of maximizing preference satisfaction, and (ii) that analysis should start from the axiomatic imposition of equilibrium (Arnsperger and Varoufakis, 2006).

[2] In some cases, such as Costa Rica's payment for environmental service program, landowners are essentially compensated for complying with existing law, so there is an element of government-determined supply as well (Daniels et al., 2010).

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(McCauley, 2006; Spash, 2008). One result has been a dramatic surge in payment for ecosystem service schemes (See for example three special issues in Ecological Economics on PES: Engel et al., 2008; Farley and Costanza, 2010; Muradian et al., 2010). Leading academic proponents of these schemes explicitly seek to model them after conventional markets, and argue that private sector initiatives show the greatest success (Engel et al., 2008; Wunder et al., 2008).

However, market-like approaches have also drawn serious criticism. One standard criticism is that many ecosystem services are both non-excludable and non-rival: markets do not function for non-excludable resources, and are inefficient for non-rival ones (Farley and Costanza, 2010; Randall, 1993; Samuelson, 1954). Another major criticism is that MBIs are grossly unfair: the planet's richest inhabitants have done the most harm to the global environment, but MBIs might force the poorest people to reduce their consumption the most. A partial list of other criticisms include the high level of irreducible uncertainty involving natural systems (Faber et al., 1998; Limburg et al., 2002; Vatn, 2005), the argument that nature's values are incommensurable with market values (Martinez-Alier et al., 1998), and the lack of confirmation that MBIs actually work (Pattanayak et al., 2010).

A careful evaluation of the empirical evidence regarding MBIs for ecosystem services would help inform efforts to expand their use. Such an evaluation should include not only conventional economic criteria such as impacts on cost-effectiveness, efficiency and utility, but also fairness: will those who caused the problem pay the costs? The evaluation should also carefully define the criteria so that decision makers can better assess their suitability. However, using MBIs to address major problems like climate change, excessive nitrogen emissions or biodiversity loss will require changes to market signals beyond the scale of past or current experience, which makes empirical evaluation very difficult, especially if responses to price or quantity restrictions are non-linear.

The objective of this paper is to evaluate the potential desirability and effectiveness of MBIs in allocating the most important ecosystem services, defined as those for which there is a high likelihood that beyond some threshold, the marginal loss of the service or of the ecosystem that generates it would have unacceptable impacts on human welfare. Such ecosystem services are essential and non-substitutable, and if an economic instrument is going to allocate any resources correctly, it should be those that are essential. Given the lack of empirical data on MBIs that that have major impacts on essential ecosystem services, we will use as a proxy an essential market resource that has undergone dramatic price increases, and for which there is abundant data on the outcomes: staple foods. We will evaluate these outcomes in terms of market efficiency, utility maximization, and justice, but also assess the desirability of market efficiency as a criterion for allocating essential resources in the presence of extreme income inequality. This approach ignores whether or not it is possible to apply MBIs to ecosystems to focus instead on whether it is desirable. We will therefore also assess the extent to which the physical characteristics of essential ecosystem services affect the ability of MBIs to achieve efficient outcomes, then suggest alternatives to market instruments allocating ecosystem services and other essential resources.

Section two of this paper discusses the economics of essential, non-substitutable resources and describes how they are allocated by markets in an unequal world. Section three explains how the resulting allocations are defined by conventional economists as efficient or optimal, and discusses the desirability of this criterion for essential resources. Section four examines how markets might allocate ecosystem services if market allocation were possible. Analysis in the first sections focuses on the economics of essential resources. Section five in contrast explains how the physical characteristics of ecosystem services pose serious challenges to their market allocation, with the result that MBIs in ecosystem services will not even satisfy the criteria for efficient outcomes discussed in section three. Most environmental problems have the characteristics of prisoner's dilemmas, and solving them requires institutions that promote cooperative and other-interested behaviors (Henrich et al., 2001; Nowak and Highfield, 2011; Sober and Wilson, 1998; Wilson, 2007), not competition and self interest. Section six suggests that rather than trying to force environmental problems into market institutions, we must instead develop economic institutions tailored to the physical characteristics of the environmental problems, the goals society wishes to achieve, and our best understanding of human behavior. Section seven offers some brief conclusions.

2. The Economics of Essential, Non-Substitutable Resources

A resource is essential if humans require it to survive, such as food, water, energy, and life sustaining ecosystem services. Ecosystem services have been defined in numerous ways (Fisher et al., 2008), but we use a definition derived from Georgescu-Roegen's (1971) seminal work, in which he distinguishes between stock-flow and fund-service resources. Stock-flow resources, such as timber, seafood, oil, and water for irrigation, are materially transformed and used up in the act of production. A tree for example is transformed into a house, and oil into work, dissipated heat, greenhouse gasses and particulate matter. We can decide how fast to harvest stock flow resources, and we can stockpile them if we choose to do so. We define stock-flow resources provided by nature as *ecosystem goods*.

A fund-service or fund-flux resource, in contrast, results from a particular configuration of stock-flow resources that interact to generate a flux of services over time. Both labor and built capital are fund-service resources. In the case of natural systems, a particular configuration of plants, animals, water, minerals, atmospheric gasses and so on creates an ecosystem fund that generates a flux of *ecosystem services*. Funds are not materially transformed into the services they generate, but rather are worn out over time. Human made funds can be maintained with a constant flow of stock-flow inputs, while ecosystems continually renew themselves by capturing solar energy. A fund generates services at a rate over time that is determined by the size and health of the fund, and services cannot be stockpiled for later use. For example, a forest is not physically transformed into something else when it regulates water flows, it can regulate a certain maximum flow per hour, and the regulation capacity cannot be stockpiled. By this definition, provisioning services are the reproductive capacity of ecosystems, not the stock of raw materials they contain (Daly and Farley, 2010; Farley and Costanza, 2010; Malghan, 2006).

All economic activity involves the use of energy to transform raw materials into economic products. Many of those raw materials alternatively serve as the structural building blocks of ecosystems funds, and their removal or reconfiguration coupled with waste emissions affects the fund's ability to generate services, including its ability to reproduce. Economic production inevitably affects ecosystem function, and so-called externalities are completely internal to the economic process. This is basic ecological economics.

For a resource to be truly essential, it must be extremely difficult or impossible to obtain a substitute. Many economists argue that ecosystem goods and services are neither essential nor non-substitutable. Several classic publications on essential resources assume that resource scarcity is reflected in rising prices, creating incentives to use the resources more efficiently or develop substitutes (Barnett and Morse, 1963; Dasgupta and Heal, 1974; Solow, 1974)—in which case the resources are not truly essential.[3] A recent review on the economics of scarcity and growth acknowledges that markets often do not exist for the ecosystem services and thus may fail to signal scarcity, but nonetheless the "majority opinion is that even in relatively short periods—years, even months—substitution possibilities obviate resource scarcity" (Simpson et al., 2005, p. 6). At the extreme, some economists have

[3] It is worth noting that both Dasgupta and Heal explicitly acknowledge that human life depends on ecosystem services, and these services are seriously threatened (Dasgupta, 2008; Heal, 2014).

even argued that climate change will have negligible economic impacts because it primarily affects agriculture, which accounts for a small percentage of GDP (e.g. Beckerman, 1995; Schelling, 2007): presumably, from this perspective even food has substitutes.

We assume that it is likely impossible to develop substitutes for complex, interdependent services, especially at a large scale. Even with major energy subsidies, Biosphere 2 proved unable to reproduce vital ecosystem services at a cost of $9,000,000 per person per year (Avise, 1994). It would be foolhardy to bet the future of human civilization on the development of future technologies that might provide substitutes.

For practical purposes, substitutability cannot be divorced from affordability. It is often possible to develop substitutes for certain specific life sustaining ecosystem services, such as dikes and chlorine to replace the storm surge protection and water filtration provided by wetlands. However, the world's poorest are frequently the most dependent on ecosystem services for their survival (Dasgupta, 2005), and if they cannot afford substitutes, then the services are essential to them.

Essential resources—whether essential for an individual, human society as a whole, other species or entire ecosystems—have distinct economic characteristics. By definition, a shortage of an essential resource has catastrophic consequences, and as we approach the catastrophe threshold, the marginal value of the resource as measured by its contribution to well-being must become immeasurably large—at least to the people or species for whom they are essential (Farley, 2008; Limburg et al., 2002).

A catastrophic threshold can be physiological or ecological. A catastrophic physiological threshold is a limit beyond which humans cannot survive, for example as the result of inadequate food or clean water. Physiological thresholds are relatively predictable. An ecological threshold is "the point at which there is an abrupt change in a quality (for example, wood production, the maintenance of a particular species), property or phenomenon or where small changes in a driver (for example, pollutant input, landscape fragmentation) may produce large responses in the ecosystem." (Groffman et al., 2006, p. 1) From an anthropocentric perspective, such a threshold is catastrophic when it results in the loss of human life sustaining ecosystem services. For example, excessive deforestation may prevent the Amazon forest from recycling adequate rainfall to sustain its regeneration, potentially resulting in drought, fire, and decreased forest cover in a positive feedback loop that could eventually flip the forest into an alternate state. The release of stored carbon would make it exceptionally difficult to stay below the two degree centigrade change in global climate that is widely cited as a catastrophic threshold (Coe et al., 2013; Lima et al., 2013; Nepstad et al., 2008; Nobre and Borma, 2009). Ecological thresholds are very difficult to predict ahead of time, and may not even be evident for some time afterwards due to time lags in response to drivers (Groffman et al., 2006).

In the vicinity of thresholds, marginal analysis fails as marginal changes in quantity can have non-marginal outcomes, such as a small reduction in daily caloric intake resulting in death, or a small increase in timber harvest resulting in ecosystem collapse. The marginal value (or price, for a market good) of an essential resource will increase dramatically as we approach this threshold (Farley, 2008). In terms of the diamond–water paradox, water becomes more valuable than diamonds, but if we are ignorant of where the threshold lies, which is often the case for ecosystem services, we will be unaware of the rising value.

When essential resources are traded in markets, total expenditure increases as quantity declines, which is the definition of price inelastic demand. Inelastic demand explains why the price of staple grains doubled or tripled during the 2007–2008 food crisis in response to small declines in supply (FAO et al., 2011).[4] The physiological threshold for staple foods is the minimum required to sustain life, and as an individual nears that point, his or her willingness to pay for food skyrockets together with the food's marginal contribution to survival.

Ecosystem services are rarely priced, most people are unaware of their importance, there may be significant time lags between an ecosystem stressor and the resulting impact, and there is high uncertainty concerning the exact location of ecological thresholds (Muradian, 2001), all of which make it extremely difficult to estimate a demand curve. Ecosystem services such as pollination, climate regulation, and nutrient cycling are essential to agricultural systems (Zhang et al., 2007), and therefore are as essential as agriculture. If it were possible to integrate essential ecosystem services into the market, presumably their demand curves would be quite similar to the demand curve for food, an obvious market good for which there are abundant empirical data on price and consumption.

Estimating an individual's demand curve for staple foods requires a wider range of prices and quantities than most individuals experience in their lives. As a physiological need, we assume that the demand for staple foods is reasonably similar across individuals, and points on an individual's demand curve can therefore correspond to different individuals facing different prices for food. Global data supplies the broadest range of prices and consumption levels. A basic principle in microeconomics is that the cost of something is what you give up to get it (e.g. Mankiw, 2009), or opportunity cost. Therefore the real price an individual pays for food is what she has to give up in order to purchase another unit (e.g. calorie) of food. The best measure of opportunity cost is the share of income dedicated to food consumption: a person spending 70% of her income on food must sacrifice the consumption of other very important commodities for the marginal unit of food, while someone spending only 1% of income gives up very little at the margin. In other words, the opportunity cost of food is a better measure of its marginal value to an individual than its market price.

The average percentage of household income spent on food consumed at home varies from about 6.7% in the US (USDA Economic Research Service, 2012) to over 70% in some of the world's poorest countries (Anker, 2011; Seale et al., 2003). However, these estimates include costs of processing, packaging and retail markups. In the poorest countries, households consume largely unprocessed foods. In wealthier countries, unprocessed food represents only a small share of food expenditures. In the US for example, only 11.6% of total food expenditures go to farmers and agribusiness (Canning, 2011), which suggests that the proportion of income spent on unprocessed foods is less than 1%. We hazard a rougher guess that unprocessed food might account for 50% of income in poor countries.

Unfortunately, only a handful of African countries show up on available data-bases reporting the share of income spent on food. Since these are some of the poorest countries on the planet with the lowest per capita levels of consumption, they should not be left out when calculating a demand curve. Engel's law however states that as income falls, the proportion of income spent on food increases, even as overall food expenditures decrease; though first formulated in 1857, numerous subsequent studies have verified the results (Anker, 2011). We do not claim any fixed relationship between Engel's curves and demand curves in general, only that for the special case of food, the inverse of per capita incomes adjusted for purchasing power parity (PPP) is a suitable proxy for the opportunity cost and hence marginal value of food.

Fig. 1 therefore uses the inverse of per capita incomes (PPP) as a proxy for price on the Y-axis and calories consumed per capita as a measure of quantity on the x-axis to derive an individual's demand curve for food. Calories of course are a poor proxy for food consumption, especially in a world where people are increasingly obese and malnourished at the same time, and the fact that markets allocate so many resources toward the production of unhealthy calories is itself problematic. We nonetheless found an R-squared of 0.60 when using Excel to fit a power function curve to the data. Though a very crude estimate, the demand curve clearly fits our expectations that demand becomes

[4] The reduction in grain supply for food markets likely resulted from a combination of drought, increased ethanol production, and speculation (Lagi et al., 2012).

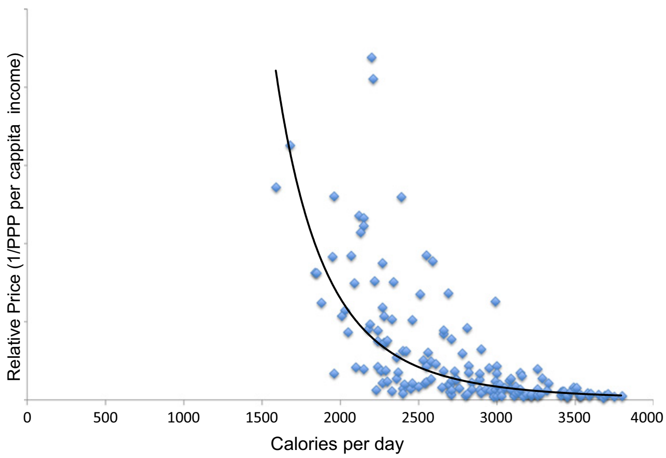

Fig. 1. Individual demand curve for food estimated from per capita income measured in purchasing power parity (World Bank, 2013) and per capita calorie consumption per day (FAO, 2012).

increasingly price inelastic as we reach a physiological threshold of around 1500 cal per day.[5]

A market demand curve is simply the sum of individual demand curves. This individual demand curve seems to suggest that an increase in the price of food would efficiently allocate food away from those who are consuming more than enough calories toward those who are struggling to meet basic needs, as the latter would be willing to pay a much higher price. Market demand curves however are not based on opportunity costs (which differ widely according to income levels), but rather on market price (which in nominal terms are the same for everyone), so the empirical evidence tells a dramatically different story. Americans consume an estimated 3750 cal per day (FAO, 2012). The US exhibits the highest recorded levels of obesity in human history (OECD, 2012), and wastes nearly 40% of its food supply, mostly at the consumer level (Gunders, 2012). The marginal calorie is clearly non-essential. Nonetheless, the price elasticity of demand for food in the United States is estimated at 0.084, which means that a 1% increase in the retail price of food leads to a .084% decrease in consumption (Seale et al., 2003). In contrast, per capita calorie consumption in Zambia is just half that in the US, well below the recommended daily allowance, and malnutrition is responsible for an estimated 80% of the deaths of Zambian children (Panafrican News Agency, 2001). Though the marginal calorie in Zambia is physiologically essential, the price elasticity of demand for food is estimated at 0.628, a fairly typical number for the poorest countries (Seale et al., 2003).

The reason for this seeming anomaly is that the share of income dedicated to a resource heavily influences elasticity of demand. When expenditures on a resource account for only a small share of income, then demand can be inelastic even when a resource is not essential at the margin. Demand for food at the non-essential margin may be particularly inelastic because humans undoubtedly evolved to consume excessive calories in times of abundance to increase resilience against once-common famines. Zambians spend over 60% of their income on primarily unprocessed food (Seale et al., 2003). A paradox occurs as food expenditures approach 100% of income: though the marginal unit of food is likely more essential than ever, demand must approach unitary elasticity, since total expenditures cannot possibly increase with another increase in price. If raw food prices doubled, as happened for rice and corn in the 2007–2008 food crisis, store prices of food in the US would increase by about 18%, in response to which Americans would consume about 1.5% less food. In Zambia, the same doubling of raw food prices would nearly double the price of a food basket, necessarily resulting in a dramatic decline in food consumption. The World Bank estimates that the 2010–2011 surge in food prices drove an additional 44 million people into poverty (Ivanic et al., 2011).

[5] The FAO estimates that the lowest acceptable body weight for a 1.59 m woman is 47 kg, and to sustain this weight with light activity, such a woman must consume 1846 cal a day, while a 54 kg, 1.71 m man undertaking heavy activity should consumer over 3000 cal per day (WHO, 1985). However, many of the countries with the lowest levels of per capita food consumption also have a high proportion of very young people in their population, who are smaller and require less food. The FAO (2012) reports that Eritreans consume only 1570 cal per capita per day, but 43% of their population is under 15.

3. Efficiency and Utility from a Market Perspective

Advocates of market allocation typically claim that markets efficiently allocate scarce resources in a fashion that maximizes well-being or utility, and explicitly refer to the resulting allocation as optimal. But markets allocate more food toward the wealthy and overfed rather than toward the destitute and malnourished. Historical famines in fact have not been the result of insufficient food to feed a given population, but rather of economic institutions that fail to allocate food to those who need it most (Sen, 1981), and can result from markets functioning exactly as they are meant to in societies characterized by extreme inequality in purchasing power. As Sen has pointed out elsewhere, "an economy can be Pareto optimal and still be perfectly disgusting" (Sen, 1970, p. 22). To understand why, we must carefully examine the meanings of efficiency, optimality and utility as used by conventional economists.

Efficiency in general is nothing more than a ratio between benefits and costs or outputs and inputs. Modern agriculture is the most efficient in history if we measure agricultural output per unit of land or unit of labor, but far less efficient than traditional agriculture if we measure food calories produced per calorie of energy inputs (Heller and Keoleian, 2000; Pimentel and Pimentel, 1996). In short, whether or not an activity is efficient depends entirely on how we measure benefits and costs. The goal of modern neoclassical welfare economics is Pareto efficiency, defined as an allocation of resources in which it is impossible to make at least one person better off without making anyone else worse off. The first fundamental theorem of welfare economics states that under certain rigid conditions (including perfect information and no externalities), competitive market equilibriums are Pareto efficient. However, this tells us nothing about what defines 'better off'.

Neoclassical economics emerged from the moral philosophy of classical utilitarianism, which defined utility as pleasure and the absence of pain, and sought to attain the greatest utility for the greatest number. In theory, voluntary production and exchange in competitive markets allows individuals to continue any economic activity until the diminishing marginal benefits are equal to the rising marginal costs, however the individual might define those costs and benefits. Rational individuals will allocate their time, resources, and income in such a way that marginal benefits equal marginal costs across all activities, which is the efficiency condition that maximizes individual utility.

However, the economic principle of diminishing marginal utility suggests that redistributing wealth and income from the rich to the poor can increase total utility, and maximizing individual utility for each individual is therefore not the same as maximizing utility for society as a whole. Furthermore, there are an infinite number of Pareto efficient allocations corresponding to different initial distributions of wealth and income. The second fundamental theorem of welfare economics states that any one of these different Pareto efficient outcomes can be achieved in a competitive market through a lump sum redistribution of resources. How then does one decide which of these possible efficient allocations is actually optimal from the perspective of society? Modern welfare economics assumes that it is impossible to objectively compare utility between individuals, so the only objective criterion for maximizing utility is Pareto efficiency.

Drifting from its classical utilitarian roots, modern neoclassical economics is now based on *choice* or *preference* utilitarianism (O'Neill, 1998) in which "the term utility maximization and choice are synonymous" (Gul and Pesendorfer, 2008, p. 6). Preferences are considered stable, and there is no distinction between needs and wants (O'Neill, 1998; Stigler and Becker, 1977). Preferences are objectively revealed by market choices. The more an individual is willing to pay for something, the greater a contribution it must make to her utility. The market value of goods and services therefore serves as a proxy for utility or replaces it all together (Samuelson, 1938), and the goal of economics becomes the maximization of the monetary value of goods and services net of costs (referred to as economic surplus) given existing distributions of purchasing power. In other words, "the refusal of modern economists to make 'interpersonal comparisons of utility' means in effect that they use wealth rather than happiness as the criterion for an efficient allocation of resources" (Posner, 1985, p. 88). Voluntary markets can be shown to maximize economic surplus under certain rigidly specified conditions. Economists continue to defend markets as the economic institutions that make the greatest contribution to human well-being, but well-being is now explicitly defined as the satisfaction of individual preferences rather than as the greatest good for the greatest number (O'Neill, 1998).

What economists frequently ignore is the fact that markets weight preferences by purchasing power, and monetary value is thus maximized when we allocate the marginal unit of food to an affluent, overfed American who will throw it into the garbage instead of to a destitute Zambian mother who will use it to keep her child from dying of malnutrition, as long as the former is willing to pay more for it. While economists claim that as the price of a particular commodity increases, individuals will stop allocating that commodity toward its least important uses, in the real world, society stops allocating that commodity toward those whom the market implicitly determines are the least important individuals—the poor. Poor families around the world plan 'no food days' in response to price increases (Brown, 2012). MBIs in ecosystem services are likely to function in the same manner (Martinez Alier, 2003; Spash, 2008).

The argument that market allocations are efficient or utility maximizing only works if we make no distinction between preferences and tastes. While it may be true that we cannot know if the utility an apple-lover derives from eating an apple exceeds the utility an orange-lover derives from an orange, it is simple common sense that satisfying objective physiological needs generates greater utility than satisfying an overfed person's preference for the tastiest fruit. How we allocate food among individuals, some of whom are starving while others are overfed, is a question of ethics; it concerns an altogether different type of value from preferences for apples over oranges (Malghan, 2006; O'Neill, 1997; Spash, 2008). If we re-define efficiency as the maximization of human well-being from a given level of inputs, then markets characterized by wide disparities in purchasing power are inherently inefficient when allocating essential and non-substitutable resources.

Unfortunately, disparities in purchasing power are only rising. The Gini coefficient, the most widely used measure of income inequality, has increased in recent decades in China, India, the European Union, the USA and in most other OECD nations, often to record levels (OECD, 2011). The global Gini coefficient exceeds that for most nations (UNDP, 2011). As a result, markets increasingly allocate essential resources toward those with the greatest purchasing power, but with the least physiological need.

4. Extending Market Logic to Ecosystem Goods and Services

The definition of ecosystem goods services offered in Section 2 is based entirely on their physical characteristics, and is not meant to suggest they should be integrated into markets. In fact, the non-rival and non-excludable nature of many ecosystem services make them particularly ill-suited for market allocation. This section however ignores the difficulties in creating markets in ecosystem services, and focuses instead on how markets would allocate them if they could be effectively integrated into markets. We focus here on essential ecosystem services with limited possibilities for substitution such as climate regulation, protection from UV radiation, pollination, the capacity of ecosystems to reproduce themselves and water purification.

Substitutes do exist for many essential ecosystem services, particularly at the local level. For example, water purification plants or bottled water can substitute for water purification services, medicines or mosquito nets can substitute for disease regulation services, and stronger houses can substitute for disturbance regulation, while the capacity to flee to another location can substitute for the loss of almost any locally essential ecosystem service. However, the degree to which many locally provided ecosystem services are substitutable depends on purchasing power. A destitute family may depend entirely on water purification by forests to obtain clean drinking water; on micro-climate regulation, water regulation and pollinators to obtain essential calories; on disturbance regulation to protect them from floods and landslides; and on disease regulation to protect them against life threatening illness (Martinez Alier, 2003). The physiological demand curve for essential ecosystem services may look very much like that for food, approaching the vertical as the service declines to levels that threaten survival. However, if a wealthy family can afford purchased substitutes for the benefits generated by locally essential ecosystem services, then the physiological demand curve for local services will be lower for rich people than for poor people, as depicted in Fig. 2.

Weighting the intense preferences of destitute families for ecosystem services by their purchasing power however would yield negligible market demand, while the lower physiological demand by rich people would conversely translate into greater market demand. Markets for non-excludable ecosystem services would not determine to whom those services flow, but rather whether ecosystem structure is converted into economic products or left intact to provide ecosystem services. In this case, rich people's market demand for timber to build second homes could easily overwhelm poor people's demand for intact forests that generate life sustaining ecosystem services.

A different problem may occur if wealthy individuals want to conserve or restore ecosystems at the expense of agricultural land, as their willingness to pay to conserve non-essential capital (e.g. areas with great scenic beauty) may exceed poor people's ability to pay for agricultural production lost to conservation. Market allocation will then favor conservation. There are in fact numerous examples of people being excluded from protected areas, or of their crops being damaged by protected animals (e.g. Heinen, 1996; Rao et al., 2002; Richardson et al., 2012). This might not be a problem for poor individuals if they were compensated for their loss of crops and farmland. However, on the global scale, the wealthy could potentially pay for so much ecosystem conservation at the expense of farmland that it would reduce food supply and hence dramatically drive up the cost of food. Even if specific

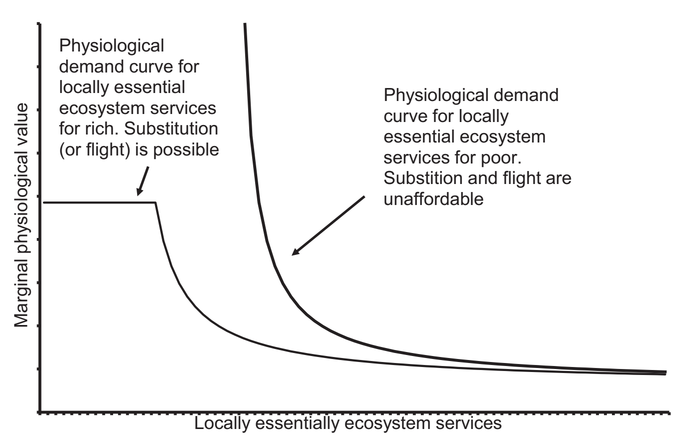

Fig. 2. The physiological demand curve for essential ecosystem services, where substitutes are available at a price that poor families cannot afford (adapted from Farley, 2012).

farmers were compensated for their loss of farmland, higher food prices would force poorer people in countries like Zambia to essentially drop off the market demand curve. This does not mean to imply that society should not be protecting ecosystems or not converting farmlands to conservation, but simply questions the ethics of leaving such allocation decisions up to markets.

5. Further Problems with Market Solutions

Discussion so far has focused primarily on the problems associated with the market allocation of essential resources, of which ecosystem services are but one example. In additional to these problems, the physical and economic characteristics of ecosystem services make it unlikely that MBIs will achieve the equilibrium outcomes, free choice, maximized economic surplus, and Pareto efficient allocations that justify MBI adoption.

A central assumption of neoclassical economic analysis is that the price mechanism drives competitive markets to equilibrium (Arnsperger and Varoufakis, 2006; Vatn, 2005). Rising resource prices however can attract speculative demand, which in turn increases prices in a destabilizing, positive feedback loop leading to bubbles and busts resulting in recessions, misery and hardship (Hudson, 2012; Minsky, 1986). Logically, speculation is more likely to occur under three circumstances: (i) wealth is highly concentrated and a surplus is available for speculative investments; (ii) supply does not increase in response to price signals and (iii) demand does not decrease in response to price signals.

To elaborate, the price mechanism serves as a negative feedback loop leading to equilibrium to the extent that resource scarcity triggers price increases that lead consumers to reduce demand and producers to increase supply or develop substitutes (Simpson et al., 2005). However, when resources are truly essential or they account for only a small share of the consumer budget, demand is highly insensitive to price. For example, wheat consumption in the US actually increased between 2006/2007 and 2007/2008 even though wheat prices nearly tripled (USDA, 2013), which should raise a serious red flag about the potential impacts of internalizing environmental externalities in prices: the poor are likely to reduce consumption, while the rich may scarcely notice. When resource supply is subject to binding biophysical constraints (e.g. food, freshwater, energy and ecosystem services) it will scarcely respond to a price surge, particularly in the short run. For example, from January 2005 to July 2008, the price of oil increased by over 300% while the supply increased by less than 3.4% (British Petroleum, 2012). Oil supply is particularly relevant because cheap energy has fueled our ability to increase market supply and/or develop substitutes for other essential resources, including food and water (e.g. Ayres et al., 2013; Hall and Klitgaard, 2011). In other words, for essential resources on a full planet, neither supply nor demand will be very responsive to price signals.

When both supply and demand are highly price inelastic, any small increase in demand or decrease in supply can trigger a major price increase that attracts speculative demand. Speculators can even initiate the price increase by purchasing then withholding essential commodities from the market in a self-fulfilling prophecy. Land, fossil fuels, and food all exhibit inelastic supply and demand, and saw speculative bubbles burst between 2006 and 2008 (Du et al., 2011; Hudson, 2012; Lagi et al., 2012; Tadesse et al., 2014).

The amount of capital currently available for speculation is unprecedented. According to the BIS, there are currently $5.3 trillion dollars of foreign currency transactions every day, which amounts to 27 times gross world product (Bank for International Settlements, 2013). According to economist Michael Hudson, foreign currencies are held for 30 s on average, and stocks for only 22 s (Hudson, 2011). The speculative economy now dwarfs the real economy, leading to situations in which the price mechanism fuels disequilibrium.

Ecosystem services are in decline (Millennium Ecosystem Assessment, 2005), and increasing the size and health of the ecosystem funds that generate those services is exceptionally challenging in a full world. Furthermore, cap and trade schemes explicitly seek to fix supply. As essential and non-substitutable resources, ecosystem services also have inelastic demand. If we integrate ecosystem services into the market system, they too will become prone to destabilizing speculative bubbles. Financial sector support for MBIs is undoubtedly driven by pursuit of trading profits which actually siphon away resources that could otherwise be invested in solving environmental problems (Spash, 2010).

Another serious problem is that markets only function as theory predicts for rival, excludable resources that generate no externalities (Simpson et al., 2005; Vatn, 2005) but most ecosystem services are non-excludable, non-rival or both. When a resource is non-excludable, markets are essentially impossible, and cooperation is required to protect or provide it. For example, it is impossible to create markets in climate stability in which each consumer independently determines how much to consume. There is no freedom of choice. When a resource is non-rival, using prices to ration access reduces marginal benefits without reducing marginal costs, and is therefore inherently inefficient (Farley and Costanza, 2010; Vatn, 2010). For example, in 2007 Indonesia threatened to sell access to a newly discovered strain of avian flu to the highest bidder (McNeil, 2007) even though restricting scientists' access to the strain would reduce the probability of finding a cure. In its defense, Indonesia was legitimately worried that corporations competing to find a cure (for which the ‘recipe’ is non-rival) would make it excludable with patents in order to sell if for monopoly profits, reducing economic surplus, making the cure potentially unaffordable to Indonesians, and reducing the likelihood of establishing herd immunity. The economic surplus from non-rival resources is maximized at price of zero, at which price markets will not provide them. Cooperation is again required (Farley and Perkins, 2013).

The problem of allocating resources that are non-rival, non-excludable or both presents a prisoner's dilemma. The optimal outcome occurs when individuals put the interests of the group ahead of individual interests, but regardless of what others do, individuals will always come out ahead by putting their own interests ahead of group interests. Prisoner's dilemmas are solved through cooperation (Axelrod, 1984; Nowak and Highfield, 2011).

In some situations, cooperation can pave the way for MBIs. While inherently non-excludable ecosystem services cannot be directly allocated via markets, they are generated by a particular configuration of biotic and abiotic stock-flow resources and degraded by waste emissions. The allocation problem is to decide how much ecosystem structure should be transformed into economic products and waste, and how much left intact to generate ecosystem services. Both stock-flow resources and waste absorption capacity are rival, and through collective action, it is possible to create or reassign marketable property rights to them. For example, the Kyoto protocol made access to the waste absorption capacity for greenhouse gasses partially excludable so that individual emission permits could be assigned to polluters then traded in markets. Pollution taxes are equivalent to creating property rights to waste absorption capacity for governments then charging for use. Payments for non-excludable ecosystem services require collective action to capture payments from service beneficiaries.

Unfortunately, these market-like instruments fail to achieve the outcomes of free choice, maximization of economic surplus, and Pareto efficiency that justify markets in the first place. With markets for pollution or for the structural building blocks of non-excludable services, as with environmental taxes, individuals can decide how much ecosystem structure to consume or how much to pollute, but cannot satisfy their own subjective preferences for the ecosystem services themselves, whose status is determined by collective decisions (caps) or by independent decisions of others (taxes or voluntary payments). Price rationing of non-rival resources (e.g. genetic information) causes artificial scarcity and reduces economic surplus. Finally, on a full planet, economic activity unavoidably alters ecosystem structure and emits waste, whether taxed or permitted by environmental allowances, thus degrading ecosystem services, with inevitable negative impacts on others. In short, when externalities are ubiquitous, all allocations become Pareto incomparable, and Pareto efficiency becomes a useless criteria.

6. Economic Institutions for Allocating Essential Ecosystem Services

Institutions for allocating any resources should be determined by the desired goals, the relevant characteristics of the resources, and human nature. The empirical outcomes for the market allocation of food in a highly unequal world challenge Pareto efficiency as a legitimate criterion for evaluating the allocation of essential resources. A reasonable alternative would be to prioritize the satisfaction of basic physiological needs for this and future generations. In the case of ecosystem services, this means avoiding irreversible ecological thresholds.

Concerning resource characteristics, ecosystem goods and services that are rival and scarce must be rationed to avoid unsustainable use. Price rationing is one possible option, but by definition access to non-excludable resources cannot be rationed. Non-rival resources in contrast should be open access, since rationing access reduces benefits without reducing costs, and adequate provision requires collective action. Cooperation is therefore required to manage the innumerable ecosystem services that are either non-excludable or non-rival.

It would be unwise to design economic institutions based on cooperation if humans were solely capable of competitive and selfish behavior, as economists have traditionally assumed. However, growing evidence from behavioral economics (Fehr and Gachter, 2000; Fischbacher et al., 2001; Gintis et al., 2003, 2005; Henrich et al., 2005), evolutionary biology (Sober and Wilson, 1998; Wilson, 2007, 2012), mathematical biology (Nowak and Highfield, 2011), anthropology (Henrich and Henrich, 2007), neuroscience (Gordon et al., 2011; Kosfeld et al., 2005) and other fields confirms that humans regularly exhibit cooperation, pure altruism and other pro-social behaviors.

Growing evidence also suggests that it is possible to design institutions that promote pro-social behavior or selfish behavior. For example, generosity, trust and a history of reciprocal cooperation stimulates further cooperation, as does punishing people who fail to cooperate or punishing people who fail to punish non-cooperators (Fehr and Gachter, 2000; Fischbacher et al., 2001; Henrich and Henrich, 2007). In contrast, considerable evidence suggests that the market mechanism may trigger selfish behavior and undermine cooperative outcomes. For example, simply cueing subjects in an experiment to think of money can lead them to offer less help to others, solicit less help from others, engage in more solitary activities and accept greater inequality (Caruso et al., 2013; Vohs et al., 2006). Simply studying conventional economics appears to stimulate selfish behavior (Bauman and Rose, 2011; Frank et al., 1993; Kirchgässner, 2005). Offering people monetary incentives to act pro-socially can crowd out intrinsic motivations to act pro-socially to the extent that pro-social behavior is reduced (Bowles, 1998; Frey and Jegen, 2001; Gneezy and Rustichini, 2000). Resources that are best allocated through cooperative institutions should be insulated from markets, not integrated into them.

Furthermore, the goal of market-like solutions to environmental problems is to internalize externalities by forcing prices to reflect full costs. However, the more we atomize the decision making unit (e.g. through individual choice), the more boundaries exist over which externalities can occur, and the greater the transaction costs of resolving them (Vatn and Bromley, 1994). In addition, humans may make very different choices as atomistic consumers with a focus on what is good for themselves than they do as citizens with a focus on what is good for society (Holland, 1997; O'Neill, 1998; Sagoff, 1998). An alternative mechanism for internalizing externalities is to make collective, deliberative decisions at the level of the community affected by the decision's economic, social and ecological outcomes.

Though frequently flawed in practice, democratic processes based on the principle of one person, one vote is one type of collective action with a long history of addressing environmental problems. Rather than seeking to improve deliberative democratic processes, for example by striving to account for future generations or other species (O'Neill, 2001), those who advocate market solutions to the currently unsustainable loss of ecosystem services implicitly call for replacing this decision making process with one based on one dollar, one vote. Giving wealthier individuals more say in the allocation of our shared inheritance from nature is an ethical decision concerning the distribution of power.

There is compelling evidence that MBIs would achieve few of the benefits attributed to competitive markets, would allocate resources to those who gain the least physiological benefit from additional consumption, and could undermine the conditions required to develop cooperative solutions. Furthermore, we believe that deliberative, democratic processes that at least in theory give equal voice to all are inherently preferable to weighting preferences by purchasing power when deciding how to allocate our shared inheritance from nature. Rather than replacing democratic decision making with market forces, we should be working to protect the former from the later (Lessig, 2012).

Going even further, it may be time to reconsider market allocation of essential resources. We suggest two (of many!) possibilities worth considering.

First, technologies required to help solve environmental problems should be publicly financed and open source. Price rationing of green technologies reduces adoption rates to the detriment of all. In contrast, both theoretical and empirical evidence suggest that publicly funded, open source R&D is more likely to provide public goods, accelerate technological progress, and generate higher rates of return than proprietary investments (Alston et al., 2000; Farley and Perkins, 2013; Kolata, 2010). Ideally such research should be funded by a global research consortium, but for practical and ethical reasons, the wealthiest nations that have caused the most harm to the global environment should take the lead. If nations that do not contribute 'free-ride' by adopting the resulting green technologies, those who funded them will still be better off, since a healthy environment is a public good (Farley et al., 2010). Furthermore, giving countries free access to such technologies might stimulate future cooperation, initiating a virtuous circle of reciprocation.

Second, non-price rationing of essential resources to ensure that basic needs are met was done successfully by many countries during World War II and has been proposed for carbon emissions (Cohen, 2011). Brazil suffered an electricity crisis between 2001 and 2002 as a result of drought, and rationed consumer access to reflect the drop in supply, keeping prices largely constant and forcing efficiency gains with negligible economic or political disruption (Rosa and Lomardo, 2004). In contrast, the electricity shortage in California at the same time—partially caused by collusion among electricity producers to reduce supply— led to a nine-fold increase in prices, blackouts, and economic and political turmoil (Weare, 2003). Rationing ensures basic needs are met, minimizes price instability and opportunities for speculation, promotes more efficient use of resources, and reduces environmental impacts. Conventional economists might argue that non-price rationing reduces choice, but this implies that the 75 million additional people who became malnourished from 2003–05 to 2007 (FAO, 2007), and the addition 80 million between 2007 and 2008 (FAO, 2008) simply chose to consume less food.

7. Conclusions

The current ecological crisis may be the most serious challenge humanity has faced in thousands of years. We must recognize that ecosystem goods and services are a shared societal inheritance that must be protected for future generations; decisions concerning their allocation and distribution should also be shared in a deliberative democratic process and preferences should not be weighted by purchasing power. Through democratic processes, basic needs of the many would almost inevitably take precedence over the wants of the wealthy few. Most environmental problems take the form of prisoner's dilemmas, which are best solved through cooperation. We should adapt economic institutions to the nature of the problem. Considerable evidence suggests that MBIs may actually deter cooperation. We should instead focus on creating institutions that build trust, reciprocation and cooperation.

Solving our environmental problems will inevitably demand substantial reductions in throughput and hence consumption. Agriculture and energy use currently pose the greatest threats to the global ecosystems, and solving environmental problems may require particularly significant reductions in agricultural land and energy use (Foley et al., 2011; IPCC, 2013; Rockstrom et al., 2009; Tilman et al., 2011). Using MBIs to reduce total consumption and degradation of ecosystem goods and services would significantly increase the costs of numerous essential goods and services, including food. The likely result would be negligible inconvenience for the wealthy and misery or worse for the poor. Such outcomes are neither morally acceptable nor politically feasible. As Herman Daly has repeatedly argued (Daly, 1992), it would appear that the problems of ecological sustainability and just distribution simply cannot be solved by market forces.

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