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Science and Problem Solving in a Political World: Insights from Katrina

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ABSTRACT

While as scientists ecological economists pursue objectivity and empiricism, as problem solvers we strive to move our policy solutions to pressing problems onto the political agenda. To what extent is a rigorous scientific understanding of sustainability issues necessary and sufficient for creating more sustainable policies? If it is not, what are the obligations of scientists who understand the threats to sustainability to act on their understanding? We use a case study of Katrina to show that impartial science alone is inadequate to achieve our ends. Ecological economics and market fundamentalism have fundamentally different definitions of the problems leading to and resulting from Katrina, which in turn lead to diametrically opposed policy solutions. The solutions of the market fundamentalists are those currently receiving the most consideration, which exacerbates the problems as defined by ecological economists. As scientists and problem solvers, ecological economists must empirically study the public policy process to learn how to promote our policy solutions. We therefore assess two schools of thought concerning public policy—the market model and polis model. The market model of the public policy process assumes that policy makers rationally analyze the options available to achieve a specific goal then choose the one that maximizes utility. The polis model in contrast assumes that policy makers are not consistently rational but respond instead to the strategic presentation of situations using stories and symbols more than value-neutral facts. We argue that the polis model is a more accurate empirical interpretation of the policy process, and therefore, to be good scientific problem solvers, ecological economists must rely on emotionally charged stories that explain the significance of their scientific research instead of impartial presentation of empirical evidence.

Keywords: Public policy; polis model; hurricane Katrina; scale; distribution

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INTRODUCTION

Ecological economics prides itself on being a problem based, policy oriented field focused on the science and management of sustainability (Costanza, 1991; Farley, Erickson, & Daly, 2005). While the field has an explicitly value driven research agenda focused on a just distribution of resources within and between generations, as scientists, we strive to be both empirical and objective: our hypotheses must be supported by available evidence, and the results of experimental tests of hypotheses should not depend on the values of the scientist conducting them. The question we address in this paper, however, is to what extent is a rigorous scientific understanding of sustainability issues necessary and sufficient for achieving a sustainable society? Related to this first question,

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what are the obligations of scientists who understand the threats to sustainability to act on their understanding?

Some argue that the scientist's role is simply to carry out objective research, and it is the duty of policy makers to act on the resulting knowledge (Gross & Levitt, 1994; Jones, 1984; Pouyat, 1999; Rykiel, 2001; Shackley & Wynne, 1995; Wagner, 1999). This approach however assumes that political decision makers pay attention to scientific research, know how to distinguish good research from bad, and are willing to act rationally on the resulting knowledge to further the common good. The supporting evidence for these assumptions is not good. For example, Molina and Rowland discovered the ozone depleting properties of chlorofluorocarbons (CFCs) in 1973 (Molina & Rowland, 1974), yet a global agreement to begin phasing out ozone depleting compounds was not ratified until 1989. Though the size and depth of the Antarctic ozone hole broke records in 2006 (Gutro, 2006), India and China are rapidly increasing their production of ozone depleting chemicals (Bradsher, 2007) and a total phase out is not expected before the middle of the century (World Meteorological Organization, 2003). Policies to address global climate change have still not made it on to the federal agenda in the US.

One explanation is that scientists are failing to communicate their results to policy makers. Many scientists argue that environmental problems demanded a new social contract for science: scientists must not only conduct research that will help create a more ecologically sound, economically feasible and socially just society, but they must also effectively communicate this research to policy-makers and the public (Costanza, 2001; Lubchenco, 1998; Mooney & Ehrlich, 1999; Wagner, 1999). The question is, should scientists impartially communicate their knowledge to policy-makers (Pouyat, 1999; Wagner, 2001), or should they be active advocates of particular policies (Costanza, 2001; Mooney & Ehrlich, 1999)?

The objective of this article is to show that empirical science is necessary but not sufficient to move policy solutions to sustainability problems onto the political agenda. In order to be effective problem solvers, ecological economists must learn how the public policy process works then use this knowledge to turn their policy proposals into reality. A companion article (Farley et al., 2007) suggests what ecological economists might do to promote the implementation of their policy proposals.

Our approach is to use the response to Hurricane Katrina as a case study to show that effective policy solutions to the sustainability problem require a solid scientific understanding of the problem, but that this understanding alone will not move these solutions on to the political agenda. We begin by summarizing how ecological economists define the problems presented by Katrina, and how the problem definitions determine policy solutions. We next briefly contrast this ecological economic view with the problem definition and policy recommendations of market fundamentalists, the laissez-faire version of neoclassical economics (Soros, 1998; Stiglitz, 2002, 2004). We choose to present this extreme version of neoclassical economics for three reasons. First, the market fundamentalist vision currently seems to have the most influence on policies for addressing the aftermath of Katrina. Second, market fundamentalists present themselves as a purely objective scientists, with mathematical models providing value-neutral decision rules, and often charge heterodox economists (including ecological economists) with a lack of scientific rigor (Cohen, 2007; Lee, 2004). Third, the resulting policies are almost diametrically opposed to those of ecological economics, which suggests that both policies cannot be supported by an objective scientific interpretation of the same sets of facts.

If empirical science alone failed to generate appropriate policies in the case of Katrina, then our role as scientists and problem solvers demands that we scientifically study the public policy process to learn how to promote our policy solutions. The article therefore assesses two schools of thought concerning public policy—the market model and polis model (Stone, 2002) to assess which offers the most valuable insights into the policy process.

We offer two conclusions. First, problem solving on the scale necessary to achieve a sustainable, just and desirable future requires more than science and statistics: objective science is necessary, but not sufficient. If we apply the scientific method to the policy making process itself, we learn that policy discourse uses ordinary, everyday language, in which no distinction is made between facts and values (Norton, 2005). In complex systems, a single set of facts can be used to tell a number of equally true stories and present a number of equally plausible futures (Allen, Tainter, Pires, & Hoekstra, 2001). Moving our policies onto the political agenda requires that we communicate our research results through passionate narratives that use ordinary language integrating facts and values, identify stakes and tradeoffs for the public, and advocate for particular goals, problem definitions and policies.

Second, while we must integrate facts and values to get our policies implemented, once we have done so we should return to the empirical testing of conventional science. Policies implemented in situations of uncertainty, designed to affect evolving and unpredictable complex systems, should be looked at as scientific experiments capable of falsifying our initial theories. Critical data in this exercise include the values and opinions of stakeholders who affect and are affected by the problem. When our policies fail to work as planned, we must adapt them accordingly—the process of adaptive management (Norton, 2005). As good scientists, we can never let theory (or ideology) trump empirical evidence.

ECOLOGICAL ECONOMICS AND KATRINA: COUPLING PROBLEM AND POLICY

A problem can be defined as the discrepancy between a goal and the existing reality. The goal of ecological economics is to achieve a high quality of life for this and future generations, which requires a sustainable scale of the economy in relation to the ecosystem that contains and sustains it, just distribution and efficient allocation (Daly, 1992). This section describes how the problems leading to and resulting from Katrina can be defined in terms of scale, distribution and efficiency, and how these problem definitions lead to specific policy recommendations.

Katrina and Scale

Scale, as defined by ecological economists, is the physical size of the economic system relative to the ecosystem that sustains and contains it. Sustainable scale is exceeded when human activities overwhelm the regeneration capacity of ecosystems or their ability to provide critical life support functions. For renewable resources, this occurs when resource extraction exceeds resource renewal rates, when waste emissions exceed absorption capacity, or when so much of a critical ecosystem is destroyed by economic uses that what remains can no longer provide the ecosystem services on which humans (and other species) depend. For non-renewable resources, scale becomes unsustainable when a resource is being used faster than renewable alternatives are being developed (Daly, 1990). Desirable scale is exceeded when the marginal costs of ecosystem loss and degradation caused by economic growth outweigh the marginal benefits of that growth Uncertainty regarding ecosystem function and technological, evolutionary and cultural adaptation means that we cannot precisely define either sustainable or desirable scale (Daly, 1992; Lawn, 2001; Malghan, 2006). Nonetheless, there is compelling evidence that excessive scale contributed to the Katrina disaster in at least four different ways.

First, research suggests that global climate change caused by greenhouse gas emissions in excess of planetary absorption capacity is increasing the severity of hurricanes and other natural disasters around the world (Goldenberg, Landsea, Mestas-Nuñez, & Gray, 2001; Kerr, 2005; Knutson, Tuleya, & Kurihara, 1998; Webster, Holland, Curry, & Chang, 2005). It is impossible to say for certain that global warming contributed directly to Hurricane Katrina, but it is equally impossible to deny some probability that it did so.

Second, human activities are degrading and destroying wetlands, sandbars and islands faster than they can restore themselves (Costanza & Farley, 2007; Day et al., 2005; LCWCRTF and WCRA, 1999). Katrina led to a dramatic breakdown of remaining wetlands, with sofa-size clumps of wetland material blown around the landscape (Dean, 2005), indicating a loss of resilience to natural shocks. Since 1930, Louisiana has lost 4,800 km^2 of coastal wetland (Day et al., 2005); research by the US Army Corp of Engineers suggests that every 4.4 km of wetland can reduce storm surge by 30 cm (U.S. Army Corps of Engineers, 1961). Wetland loss driven by economic forces has also contributed to a precipitous decline in seafood production, destabilization of coastal oil pipelines, loss of Cajun culture and the loss of habitat for migratory birds and other wildlife (LCWCRTF and WCRA, 1999).

Third, in the wake of Katrina New Orleans was inundated in a "toxic gumbo" (Frickel, 2006). The EPA documents over 200 toxic release inventory sites in New Orleans (figure 1) (United States National Library of Medicine, 2006), 24 superfund sites affected by Katrina, and another 28 affected by Rita (EPA, 2005). Toxic compounds were being released faster than the local ecosystem could absorb them.

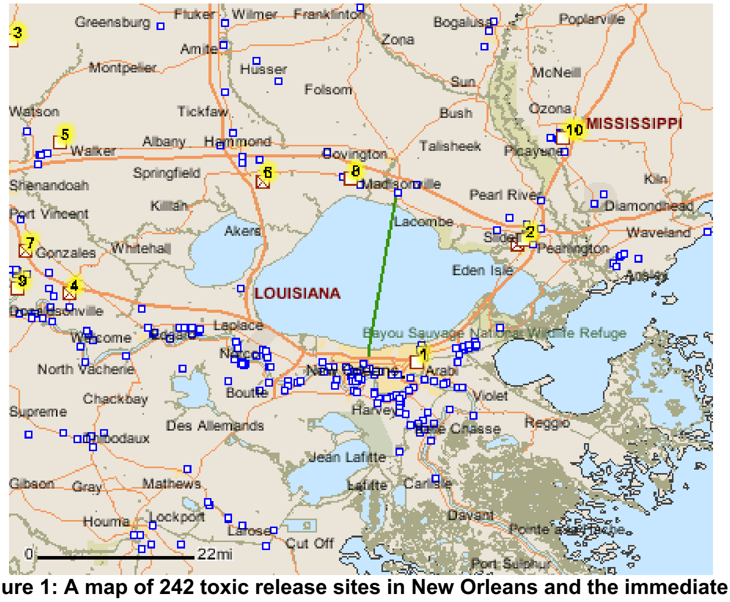

Figure 1: A map of 242 toxic release sites in New Orleans and the immediate vicinity. Superfund sites are numbered. (United States National Library of Medicine, 2006)

Lastly, the spike in oil, gas, and natural gas prices following Katrina underscored how our current standard of living, and possibly even survival, depends on consuming fossil fuels (Heinberg, 2003) as it is impossible to do work without the use of low entropy energy (Georgescu-Roegen, 1971). The proximate cause of the prices spikes was Louisiana's substantial contribution to national energy supplies (Louisiana Department of Natural Resources, 2005). The ultimate cause is that we are using our finite fuel supplies faster than we can develop renewable alternatives while developing new uses, or complements, faster than we develop substitutes.

Policies for addressing the scale problem

Defining these problems as examples of both unsustainable and undesirable scale generates a series of policy options for solving them. It is a basic tenet of ecological economics that policies should allow a margin of error when dealing with biophysical systems that are both poorly understood and susceptible to irreversible and/or unpredictable change (Daly & Farley, 2004) and that we should not rely on yet-to-be developed technologies as remedies for environmental degradation and absolute resource scarcity (Erickson, 2002; Georgescu-Roegen, 1971). Policies should thus apply the precautionary principle (Raffensberger & Tickner, 1999), especially in light of research showing that people are willing to pay more to reduce the probability of losses than they are to increase the probability of equal gains (Kahneman & Tversky, 2000). The losses from exceeding sustainable scale are likely to be catastrophic and irreversible. In contrast, even a 2/3 decrease in economic output would only return the US to a 1969 level of real per capita GDP (Bureau of National Economic Accounts, 2007). We assume that returning to a 1969 standard of living would not be catastrophic, suggesting that considerable investments to reduce the probability of catastrophe are warranted.

With respect to global warming, the precautionary principle demands that we immediately halt additional increases in carbon emissions and move quickly to reduce them. At the margin, reducing carbon emissions through conservation and efficiency may even have negative marginal costs (Nordhaus, 1994), but there is increasing agreement that we will need to reduce emissions by at least 80% by 2050 if we wish to avoid potentially catastrophic impacts (Kallbekken & Rive, 2007; Stern et al., 2006). Either a cap and auction scheme or carbon taxes would theoretically reduce emissions while stimulating technological innovations, and both approaches have their advantages (Baumol & Oates, 1989; Pearce & Turner, 1990). As prices adapt to ecological constraints faster than ecosystems adapt to economic variables, it may be safer to let scale (e.g. caps) determine prices than to let prices (e.g. carbon taxes) determine scale (Daly, 1997).

With respect to wetland loss, it might be possible to substitute the storm protection service of wetlands with built capital, but the latter depreciates, while the former can be made self-sustaining. The precautionary principle therefore demands that we act immediately to halt continued degradation of wetlands then begin restoring what has been lost. First we should halt perverse subsidies that provide incentives for destroying remaining wetlands and shifting barrier islands (Bagstad, Stapleton, & D'Agostino, 2007), then ban activities that continue to degrade the wetlands, or tax them at a rate sufficient to generate the revenue needed to counteract the damage. When there is uncertainty on the impacts of specific activities on wetland loss, those responsible should post financial assurance bonds adequate for restoring any possible wetland loss (Costanza & Cornwell, 1992; Costanza & Perrings, 1990).

While it is possible that even closing canals, renewing sediment flows and the large scale pumping of sediments into the wetland would be inadequate to restore the wetlands enough to preserve Lousiana's coastline (Committee on the Restoration and Protection of Coastal Louisiana, 2006), numerous studies suggest that the benefits of restoring natural capital justify the costs (Aronson, Clewell, Blignaut, & Milton, 2006; Balmford et al., 2002; Farley & Gaddis, 2007).

Finally, we need policies for reducing toxic waste emissions to within the waste absorption capacity of the environment. Pollutants that are persistent or highly toxic should be phased out. Again, we must remove subsidies on activities that cause pollution, and replace them with taxes, tradable quotas and financial assurance bonds.

Katrina and distribution

The second central focus of ecological economics is a just distribution of resources. What constitutes a socially just distribution is a normative question, but the injustice of the plight of the poor in the aftermath of Katrina was widely acknowledged. Ecological economists do not focus solely on the distribution of monetary income and wealth generated by built and human capital, but also on the fair distribution of natural capital (Costanza, Farley, & Templet, 2002). Distribution is about who owns what; it is a question of property rights and as such is a policy variable (Bromley, 1991).

We suggest three basic principles for a just distribution of resources:

1. People are entitled to what they earn with their own labor;
2. People should not be able to freely take what they do not produce if doing so leaves less for others;
3. Wealth created by nature or society as a whole constitutes the commons, and should be shared equally by all. When people take from or degrade the commons, they should compensate society both for the benefits they receive and the costs they impose on others.

Ecosystem services are clearly created by nature and as such should be part of the commons. These services naturally benefit all who live within the geographical region over which they are distributed. However, under current institutional arrangements, the private sector is often able to capture all the benefits of the activities they engage in that degrade or destroy ecosystem services, but generally share the costs with the society. This was clearly the case in New Orleans (Templet, 1995). This imbalance between the distribution of costs and benefits leads to excessive ecological degradation.

The in-ground value of oil is also created by nature, though the oil industry deserves a fair return on its labor, capital, entrepreneurial ability and risk for extracting it. Currently, Louisiana receives no revenue from federal oil and gas leases beyond the three-mile territorial limit (Schwartz, 2005). The record windfall profits received by the oil sector in the months following Katrina (Romero & Andrews, 2006) show that much of oil's in-ground value is privatized.

Policies for addressing the distribution problem

Again, a problem definition implies a set of policy options. Masozera et al. (2007) call for living wage jobs, equal access to loans and finance, and improved access to transportation as ways to improve distribution New Orleans. In addition, we support the basic principle that the wealth of the commons should be shared equally through a two step process. First, decisions concerning macro-allocation—the share of ecosystem structure that should be converted to economic production and the share that should be left intact to provide ecosystem services—should be based on democratic and not plutocratic (i.e. market) principles. Ideally, those affected by the loss of ecosystem services should make such decisions. Second, once the democratic process has decided on macro-allocation, those who would convert ecosystem structure to economic output and waste must compensate those affected for this privilege. For example, those who benefit from the storm protection services of Gulf Coast wetlands should determine how much of those wetlands should be preserved to provide those services, with those who benefit the most having the greatest say and receiving the bulk of compensation from those allowed to use or degrade the wetlands. In practice of course such guidelines would only be approximate, since political boundaries rarely correspond to ecological boundaries.

This policy principle dovetails nicely with tradable quotas and to a lesser extent Pigouvian taxes, both policies suggested above as a means to achieve desirable scale. Where tradable quotas are used—for example, for sulfur dioxide emissions or fish harvests (Newell, Sanchirico, & Kerr, 2005)—the limits are set by democratically elected governments. Public sector auctioning of quotas would require those who acquire them to compensate society for the privilege. Revenue from Pigouvian taxes and auctioned quotas should be invested in public goods or used to replace regressive taxes

Though fossil fuels and minerals do not directly provide ecosystem services, their emissions do degrade them, and they too are part of the commons. Our principles of just property rights suggest that the in-ground value of Gulf Coast oil should be captured by the local and federal government in the form of steadily increasing royalties supplemented by windfall profit taxes. One option is to distribute royalties equally to all state citizens, or as is done in Alaska, invest the royalties and distribute the resulting returns on the investment equally (Barnes, 2001).

Katrina and efficiency

Katrina also raised a number of issues concerning efficiency. The most obvious inefficiency was the failure to restore wetlands and repair levees prior to the storm. The state government had long requested $14 billion in federal money to carry out these repairs, presciently pointing out that “the government will spend billions now to save the marshes or many more billions later to bail out New Orleans” (Bourne, 2000). Most recent estimates of storm damage in the New Orleans area range from $100-$150 billion (Seed et al., 2006), FEMA alone has spent $19 billion as of June 2006 (Lipton, 2006) and the US Senate has recently (May, 2006) approved another $28.9 billion in hurricane relief, including $4 billion for levee control and flood relief (HR 4939).

Efficiency demands that society invest in whatever type of capital (built, natural, human or social) and whatever type of good (public or market) offers the highest marginal returns. We have limited resources to invest, and both types of goods (public and private) as well as the 4 types of capital exhibit diminishing marginal utility. Additional investment in any of the four capitals and in public goods and private goods should offer the same marginal benefit (Costanza et al., 2007). Markets favor investment in marketed built capital, which requires the transformation of natural capital, in spite evidence that investments in natural capital and public goods such as levees offer higher returns. For example, Balmford et al. (2002) found that investing in natural capital for certain ecosystems offered a 100:1 rate of return, far higher than almost any private sector investment. Even a study by the office of management and budget conducted in 2003 showed a 5:1 rate of return on environmental regulations (Knickerbocker, 2003)—a type of investment in natural capital—even though economists generally consider regulations less efficient than market mechanisms for achieving the same goals (Pearce & Turner, 1990).

Policies for addressing the efficiency problem

Given our definition of the efficiency problem, a number of policy options emerge. The first and most obvious is the need for government investment in public goods such as natural capital and levees. The government should also invest in research leading to new technologies that help to preserve and provide public goods, such as alternatives to fossil fuels. Technology, being non-rival, is inefficiently allocated by markets, as the marginal cost of additional use is negligible, while prices inappropriately ration use (Daly & Farley, 2004); for example, if a corporation patents a clean, cheap and renewable carbon neutral energy source, China and India might be unable to afford it and continue to burn coal, with serious global consequences. In addition, the proliferation of patents may be slowing the advance of science (Heller, 1998; Heller & Eisenberg, 1998). Patents create incentives, but most scientists are employees of firms, not independent inventors, and there is no reason to believe that salaried scientists work harder for the private sector than the public sector, nor that the public sector would need to pay them more for the work they do (H. Simon, 1991). Publicly funded scientists would be free to share their research, speeding its advance and as the marginal cost of using existing information approaches zero, research results freely available to all would comply with the efficiency criterion of marginal cost pricing.

Government provision of public goods of course requires government revenue, the vast majority of which comes from taxes. Market fundamentalists complain that taxes create a dead weight loss of economic surplus, the definition of inefficiency. However, the capture of rent—values created by nature and society independent of the capital, labor and entrepreneurial ability of individuals or corporations—creates no dead-weight loss, and in many cases reduces it (Daly & Farley, 2004; Flatters & Boadway, 1993). Pigouvian taxes or auctioned quotas reduce negative externalities and therefore increase economic surplus while providing incentives to develop efficiency enhancing technologies. While some economists have worried that using taxes or quotas to limit resource extraction and waste emissions would lead to a loss in jobs, empirical data for Louisiana shows a positive correlation between capital outlays for pollution abatement and job creation (Templet, 1995; Templet, 2003).

Royalties on fossil fuels could also help fund research while simultaneously reducing extraction rates and pollution. In addition, we are currently developing new technologies that rely on fossil fuels more rapidly than we are developing substitute fuels, so the marginal value of fossil fuels is increasing over time, making it more efficient to use them in the future rather than today. Furthermore, the supply of fossil fuels in situ is almost perfectly inelastic (though technological changes do of course increase our ability to extract it). The more inelastic the supply of a resource, the less the deadweight loss from taxes, auctioned quotas, or royalties (Frank & Bernanke, 2003). Finally, when fossil fuels are extracted too rapidly from a given field, the total amount of fuel that can actually be recovered from the field declines (Simmons, 2005), so that once again, slower extraction is likely to be more efficient.

MARKET FUNDAMENTALISTS AND KATRINA: PROBLEMS, POLICIES AND POLITICS

Market fundamentalists have also identified causes of Katrina and have proposed policies designed to address them. These policies are almost the exact opposite of those offered by ecological economists (Farley et al., 2007). What appears to be one of the most influential descriptions of the market fundamentalist vision comes from the Heritage Foundation in a report entitled *From Tragedy to Triumph: Principled Solutions for Rebuilding Lives and Communities* (Meese III, Butler, & Holmes, 2005). As the government has already enacted a number of recommendations from this report, we will use it to provide examples of problem definition and resulting policy solutions.

From Tragedy to Triumph focuses primarily on recovery, but to the extent the report does specify causes of the problem, it blames government environmental regulations. Specifically "the National Environmental Policy Act (NEPA) and the Clean Water Act that have contributed to Katrina's damage. NEPA ….[has] morphed into an all-purpose delaying tactic. Environmental organizations have used NEPA lawsuits to block many types of projects, including levee improvements that might have prevented the flooding of New Orleans. The same is true of the Clean Water Act and its regulations ostensibly designed to preserve wetlands." (p. 3). Implicitly, the report accepts the standard definition of the economic problem as choice under conditions of scarcity in the presence of unlimited wants, to which the 'solution' is anything that increases production. The problems of scale and distribution are completely ignored. By assumption, free markets increase production and government intervention reduces it.

Given this simple definition of the problem, a simple suite of policy solutions emerges, all of which are designed to stimulate growth in the market economy. The report recommends:

1. Reducing or eliminating environmental regulations in the areas damaged by the hurricane to stimulate rebuilding, and for the oil industry to stimulate increased production.
2. Opening new areas to oil drilling, including areas off the continental shelf and the Arctic National Wildlife Refuge, where drilling is currently prohibited.
3. Reducing or eliminating taxes in the hurricane damaged areas to stimulate more economic investment.
4. Repealing the Bacon-Davis act which requires the government to pay prevailing median wage rates.

The problem description and policy solutions are diametrically opposed to those we recommend as ecological economists. The reduction and elimination of environmental regulations will exacerbate the scale problem for global warming, waste emissions and the rapid depletion of fossil fuels. Reducing environmental regulations inefficiently subsidizes polluters and disproportionately affects poor communities (Anderton et al., 1994; Pastor, 2003; Templet, 1995; United Church of Christ, 1987), exacerbating distribution. Opening new areas to drilling in environmentally sensitive areas also has negative impacts on scale. Reducing or eliminating taxes reduces the government's ability to invest in public goods, in spite of evidence cited suggesting their high rate of return on investment. Repealing the Bacon Davis act is likely to worsen income distribution.

Kahneman and Tversky won the Nobel Prize in Economics in 2002 for showing that neoclassical economic assumptions about human behavior are flawed. Ackerlof, Spence and Stiglitz won the Nobel in 2001 for showing that the assumption of perfect information underlying perfect markets never holds true. Empirical science is undermining the central pillars of market fundamentalism (Gowdy & Erickson, 2005). Evidence that changes to global ecosystems induced by economic activity are undermining human well-being continues to mount (Millennium Ecosystem Assessment, 2005; Stern et al., 2006), providing objective scientific support for the problem definition of ecological economists, and there is mounting empirical support for the effectiveness of many of the policy instruments ecological economists propose (Roodman 1998; Sterner, 2003). Nonetheless, it is primarily market fundamentalist policies that are being implemented. To understand why this is so and what can be done about it, we turn to the literature on public policy.

PUBLIC POLICY ANALYSIS: MARKET OR POLIS?

Like ecological economics, public policy is a problem based, interdisciplinary field, but most practitioners come from a specific discipline that favors a matching perspective (Birkland, 2005). The dominant perspective is heavily influenced by neoclassical economics and models of rational decision making (See for example Stokey & Zeckhauser, 1978; Weimer & Vining, 2005), and we refer to it here as the market model. Within this approach the unit of analysis is the individual and the relevant motivation is self-interest. Policy makers identify objectives and alternative courses for achieving those objectives; they evaluate the alternatives, and then choose the one that best realizes the objectives. From this perspective, policy making is a rational, objective endeavor, more science than politics. If this is an accurate description of the policy process, however, objective, well-informed and rational scientists should not arrive at such different problem definitions and policy recommendations as we have described above: the model completely fails to explain the empirical evidence.

The lure of the market fundamentalist decision making model is that it seemingly offers objective decision rules, and objectivity is a hallmark of science. Science however must also be empirical, and if this model of decision making is not an accurate model of how public policy is actually made, then the model is not scientific. Following the empirical research in the field of behavioral economics and recent advances in understanding the evolution of cooperative behavior (Axelrod, 1984; Bowles & Gintis, 2002; Wilson, 2007) most ecological economists have recognized that the assumptions underlying *Homo economicus*—rational, self-interested economic man—are fundamentally flawed as a model of economic behavior and therefore inappropriate (Bowles & Gintis, 2004; Gowdy & Erickson, 2005). The assumptions are even less appropriate as a model of political behavior.

Fortunately, public policy analysts have developed a variety of alternative models of society that more accurately reflect reality than the market model. Stone (2002) for example presents the polis model of society. In this model, policy decisions are made through inherently political processes grounded in the manipulation of the meanings of goals, problems and solutions; using not only science, but emotion, stories and symbolism to influence public opinion. This model explains how orthogonal policy solutions can be proposed for dealing with the same problem, and why objective science may fail to influence which of them is chosen. The contrasts between the polis model and market model deserve elucidation.

While in the market model, the unit of analysis is the individual, in the polis model the unit of analysis is the community, with the public interest as the predominant motivation (though self-interest also plays a role). Within the polis decision-making occurs within a much more complex environment. Decisions are not the result of one individual 'decider', but are rather a system level output involving complex interactions between a diverse array of actors spanning the individual, group, organizational and inter-organizational levels. Each of these actors approaches the public program and solutions through differing points of view that are framed by sometimes differing configurations of goals and policy prescriptions. Policies get made when specific combinations of actors and situations align, which has been dubbed the "garbage can" approach to decision making (Cohen, March, & Olsen, 1972) or the coupling of the problem, policy and politics stream (Kingdon, 1984).

In the rational market model, goals must be both explicit and precise. In contrast, policy goals in real life are often ambiguous, and for good reason. Public policy is built through alliances and coalitions. The more clearly a goal is defined, the harder it is to gain support for the goal among different groups, and in politics coalitions of groups are essential to achieve goals leading to what Stone deems a "policy paradox" (2002). Ambiguous goals also make it easier for policy-makers to claim success in achieving them. Policy goals in the polis model are the "object of political struggle"; the widely shared general goals of equity, efficiency, security and liberty are shared precisely because they can be interpreted in so many different ways, and in politics "provide a language with which contestants in a political battle frame their positions" (Stone, 2002, p. 37).

In the market model, "problem definition is … simply a matter of defining goals and measuring our distance from them" (Stone, 2002, p. 133); policy makers evaluate all possible alternatives, and choose the one that best meets their goals. This requires complete information provided by objective scientists and policy analysts. In the polis model, problem definition and policy making involves "the strategic representation of situations" (Stone, 2002, p. 133): people fight for particular goals, problem definitions and policies. To do so, they select only some of the available information, they interpret this information to favor their views, and present it strategically: “representations of a problem are… constructed to win the most people to one’s side and the most leverage over one’s opponents” (Stone, 2002, p. 133). Even numbers are not cold hard facts, since the choice of what we measure is determined by what we believe is important, and we do not measure what we believe is not. Ecological economists who estimate monetary values of ecosystem services do so to assert their importance, not to suggest that they are for sale (Costanza et al., 1997; Norgaard & Bode, 1998). Measurement requires categorization, and deciding what falls into a particular category can be a political decision. What information is neglected is just as important as the information included (Stone, 2002). From this perspective, information provided by the advocate scientist will carry more weight than that provided by the so-called objective scientist, regardless of the quality of the underlying research.

Finally, in the market model the source of change is exchange, which results in different allocations and distributions of resources as well as technological advance. Exchange is driven by individual choice, and there is no role for scientists as advocates, except perhaps to advocate the free market model. In the polis model, the sources of change are ideas, persuasion, and alliances, driven by the pursuit of power, the pursuit of self-interest and the pursuit of public interest. In this model, passion often has more influence than reason; story telling and metaphor are more powerful than scientific proof (Stone, 2002).

Even from this superficial overview, it is clear that market fundamentalists should have a natural affinity for the market model of public policy and ecological economists for the polis model. For example, both the ecological economic model and polis model assume complex systems with multiple criteria for ranking outcomes in which optimization is a futile pursuit, while in the market models optimization is the goal. While the major conflict in the market models is the self-interest of individuals, in the polis the conflict is between self-interest and public interest. Ecological economics prioritizes ecological sustainability and just distribution, both public interests, over efficiency, which in theory emerges from rational self-interest in a market economy. While collective activity in markets is driven by competition, in the polis it is driven by both cooperation and competition. The central focus of ecological economics, macroallocation, is about the conflict between the competitive use of ecosystem structure to produce market goods for self interest, and the cooperative use of ecosystem structure to produce ecosystem services in the public interest (Daly & Farley, 2004).

Ironically, ecological economists typically strive to advance their cause by integrating insights from the natural and behavioral sciences so that they can present better information to policy makers and the public, as called for by the market model. Influenced by the natural sciences, many frown upon the selective and strategic presentation of information (Lackey, 2001; Wagner, 2001). In contrast, market fundamentalists deny the relevance of the laws of thermodynamics (Gilder, 1989; J. Simon, 1981) and ignore empirical data on human behavior in the assumptions of *Homo economicus* (Bowles & Gintis, 2002; Gowdy & Erickson, 2005); they are adept at selecting and interpreting data that meets their assumptions while discarding that which does not. Market fundamentalists also equate ‘free’ markets with equity, liberty, efficiency and security (Friedman, 1962; Lott, 2007), and, we assume, consciously portray problems in a way that promotes their favored course of action, whether that be large subsidies for the oil industry or an end to environmental regulation (Meese III et al., 2005). In other words, in spite of their natural affinities, ecological economists often act as if the market model of public policy is correct, while market fundamentalists act on the insights of the polis model to push their agenda. If the polis model more accurately represents reality, as the evidence suggests, this would explain why market fundamentalists are more effective in pushing their policies.

TOWARDS MORE EFFECTIVE COMMUNICATION

To achieve their vision of a sustainable, just and desirable future, to be true problem solvers, ecological economists must sway public opinion and decision makers. As scientists, we can study the policy process and learn how this is done; several complex but empirically grounded models of public policy (e.g Birkland, 2005; M. Cohen et al., 1972; Kingdon, 1984; Lindblom, 1959; Stone, 2002) offer a promising start. As problem solvers, we must act on what we learn. We must become advocates for our worldview and values as much in the political world as in academia, even if this means a greater reliance on metaphors, symbols, passion and strategic interpretation of selected facts than on purely empirical science. Advocacy unquestionably requires effective communication skills, which we must also learn. Rather than assuming the public has an obligation to learn scientific jargon, we must learn to communicate in ordinary language, organizing facts into a narrative stressing the relevance of our research to the public and decision makers (Weber & Word, 2001).

There is growing evidence that such an approach is effective. As a dispassionate policy wonk, Al Gore was unable to move climate change onto the political agenda even as Vice-President; as the passionate orator of *An Inconvenient Truth*, which freely mixes facts and values, Gore has managed to do so. With the metaphor of the ecological footprint, Rees made difficult computations of the human capture of biological productivity accessible to the general public, and with clear and simple multi-media communication, Wackernagel's Global Footprint Network has made the concept so widespread that it even became a theme in a July 4th parade in small town Vermont. Though highly controversial within academia, Costanza et al. (1997) have used estimated monetary values of natural capital to effectively communicate its importance, and applications of this approach to ecosystem services of the Puget Sound Watershed has influenced policy makers (Chapter 6 in Green/Duwamish and Central Puget Sound Watershed Water Resource Inventory Area 9 (WRIA 9) Steering Committee, 2005). Gretchen Daily has worked with a Pulitzer Prize winning reporter to do the same (Daily & Ellison, 2002), receiving extensive press coverage as a result.

While many scientists are concerned that engaging in advocacy would threaten their credibility (Pouyat, 1999), they fail to see that the public frequently views them as advocates already (Weber & Word, 2001), to the extent that in the United States at least, belief in science has apparently become a partisan issue (Revkin, 2004). Science is essential to understand the problems we confront; emotion and passion, alliances and cooperation, are equally essential in our efforts to communicate our results and turn our problem definitions and policies into political reality. If we strive to influence the policy debate by impartial communication of the facts alone without a value-laden narrative to frame them, we are needlessly handicapping ourselves.

While scientists must combine subjective and objective elements of science in their narratives, they must be able to justify their interpretations based on the facts (Allen et al., 2001). This is what distinguishes scientists as advocates from ideologues.

SUMMARY AND CONCLUSIONS

Fortunately, like public policy, ecological economics is transdisciplinary, integrating theories and methods from whatever discipline or field is required to solve a given problem (Costanza, Cumberland, Daly, Goodland, & Norgaard, 1997; Farley et al., 2005; Norgaard, 1989). The field of public policy has much to teach us about how to turn our knowledge and goals into policy. As Birkland states “people with political goals study public policy to learn how to promote their preferred policy options” (Birkland, 2005, p. 15).

Birkland points out that the “act of identifying a problem is as much a normative judgment as it is an objective statement of fact; thus, if analysis proceeds from the identification of a problem, and the problem is defined normatively, then one cannot say that any subsequent analysis is strictly neutral” (Birkland, 2005, p. 15). In addition, if a problem is the discrepancy between a goal and reality, then how we define a problem depends on how we define our goals. Ecological economics has the explicitly normative goals of ecological sustainability and just distribution, so our problem definitions must also be normative (Costanza, 2001).

Policy options are determined by how we define a problem (Stone, 2002) and the result is that it is essentially impossible to be a neutral advocate of a particular policy position (Cochran, Mayer, Carr, & Cayer, 2005 as cited in Birkland, 2005). Furthermore, an increasing scientific understanding of the sustainability problem does not inevitably translate into policies that promote sustainability. Turning science into policy involves politics. Politics demands that we actively work to move policies promoting sustainability onto the political agenda.

We conclude that ecological economic problem solving requires normative judgments and advocacy, not simply empirical science and statistical analysis. This does not mean at all that ecological economists should abandon science and statistics, but rather that they should fully embrace the empirical evidence concerning the public policy process. As scientists, ecological economists must draw on physics, ecology, systems thinking and complexity theory to understand the biophysical nature of economic production and its impacts on the sustaining and containing system. We must draw as well on psychology, neurobiology and evolution to understand human behavior within this system. Applying science to public policy, we can learn how policy decisions are made. If we hope to be problem solvers, however, we must act on what we learn to sway decision makers and the public, even if this demands that we strategically present facts and values in a way that makes us uncomfortable as pure scientists. There is unfortunately an inevitable tension at times between science and problem solving in ecological economics.

However, once our desired policies have been implemented, we must test them empirically, and if we succeed in falsifying the underlying hypotheses regarding their suitability and effectiveness, develop new ones. We must navigate the strait between the extremes of "just the facts" and ideological advocacy by subjecting our narratives and policy recommendations to empirical testing and reinterpretation (Allen et al., 2001). Only through this approach of adaptive management will we be able to reduce uncertainty, improve on our science, and formulate better policies for which to advocate.

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