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Editorial

Why aren't contemporary ecologists and economists addressing resource and energy scarcity: The major problems of the 21st century?

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1. Introduction

Human society is facing huge, and in some cases intractable, problems due to growing populations, resource scarcity and its impact on the economy (e.g. Dilworth, 2009). These problems were well identified in the 1950s, 1960s, and 1970s by pioneering ecologists along with geologists, economists, and engineers who identified and in some cases, predicted accurately many important resource problems having to do with the interrelated issues of growing scarcity of cheap high-quality energy and other resources. These were exacerbated by growing populations and a pervasive and perverse economic paradigm that is becoming less and less able to address, and is in many cases the source, of many of the problems (Hall and Klitgaard, 2012). This suite of problems is fundamentally ecological in nature because they are about the relation of organisms, including humans, to their essential resources. But ecologists now rarely address the increasing scarcity of the resources of greatest importance to humans. We wonder why and will address this question later in the paper.

In this editorial we present a brief history of these issues and chart some possible ways forward. We argue that there must be recognition of the overwhelming and immediate importance of resource scarcity issues and the way they impact the biosphere, the economy, and society at large. These issues are exacerbated and made more challenging to resolve by climate change and human impact on ecosystems. In this editorial, we discuss why ecologists and economists are not generally addressing what we consider the most important issue of our times.

2. Our mentors

When we were in graduate school in the late 1960s and early 1970s, we were strongly influenced by ecologists such as Garrett Hardin, Paul Ehrlich, Howard and Eugene Odum, David Pimentel, Kenneth Watt and George Woodwell, economists Kenneth Boulding and Herman Daly, and computer scientist Jay Forrester and his students Dennis and Donella Meadows. They spoke clearly and eloquently about the growing collision between increasing human numbers and their increasing material aspirations and the finite resources of the planet. Garret Hardin's "Tragedy of the Commons" (1968), Paul Ehrlich's "The Population Bomb" (1968), Kenneth Boulding's "Spaceship Earth" (1966), Herman Daly's "Steady State Economics" (1977) and many subsequent writings discussed resource constraints and problems with conventional economics. H.T. Odum, our own mentor, especially, emphasized the resources that humans were dependent on. His book, Environment, Power and Society (1971) showed that the basic energy and ecological laws of nature applied to all systems including those dominated by humans and that economics was underlain by energy. What was astonishing for us was the realization that these principles we were learning and applying to rivers and estuaries of North Carolina could be equally applied to human-dominated systems and the biosphere as a whole.

Meadows et al. (1972) predicted in the "Limits to Growth" model that human population growth and resource use, combined with the finite nature of resources and pollution, would lead to a serious decline in the quality of life and even numbers of humans. Hubbert (1969) predicted that U.S. conventional oil production in the U.S. would peak in1970 and globally in the first decade of the 21st century. He was derided at the time but both predictions have come true. We call these scientists collectively "resource constraintists" and they can be compared with those at the other extreme, which we call "technical and economic cornucopians". Until recently, discussion of resource scarcity, especially energy, largely disappeared from public and scientific discussions. Many believe that technology and market economics have resolved these issues, and that "the limits to growth", in both its specific (e.g. Meadows et al., 1972) and its general meaning, has been completely invalidated. For example, in the plenary session on "Mineral Resources" at the 33rd International Congress on Geology held in Oslo in 2008, Neil Williams mentioned that the Limits to Growth model, which was part of his graduate education and that had once influenced him similarly to us, had been shown to have basically failed. Many still believe this. There continue to be reassuring pronouncements that the US will become a net oil exporter again and that human creativity alone will solve all problems. Thirty to forty years ago, academia was brimming with discussions and concerns about the relation of human populations to global resources. For the several subsequent decades, however, this perspective disappeared from most teaching, research, and public discourse. In particular ecologists

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now rarely dwell on these issues and are often unaware of these concepts. For example, energy was essentially not considered in an issue of Frontiers in Ecology and the Environment (February 2005), dedicated to "Visions for an ecologically sustainable future". "Resources" and "human population" were also barely considered. Population growth has become a taboo subject, smothered by political and politically correct perspectives (Bartlett, 1998).

Given the general failure of most contemporary thinkers, including those focusing on "sustainability", to consider these resource scarcity issues either at all or certainly with any particular degree of sophistication, we think it important to review their evolution, the evidence for their importance, the larger resource and societal context, and the sociology of the response to them. We believe that the failure to consider and debate intelligently the potential importance of these original arguments over the past half century, especially in light of recent events, can be described most accurately as *folly* in the grand tradition of historian Barbara Tuchman's 1984 book The March of Folly. We think that future generations will look at our failure to think about, discuss intelligently, or prepare for the implications of peak oil, depletion of high-grade reserves of many critical metals, and continued population growth, as grand folly (e.g. Dilworth, 2009).

In this editorial, we focus on peak oil, what we believe is the most immediate issue, and on "industrial civilization", including especially the United States, but the same concepts apply to many other resources and to the rest of the world. By industrial society, we mean the energy-intensive, capitalist, growth-oriented and market-driven system that originally developed in the West but that has spread to most of the rest of the world. There are very few ecologists who would list oil as the most, or even a critical resource for sustainability, but to us it is just a fact that is ignored at the peril of those who do. Human numbers and the global economy have increased at rates similar to the use of oil and energy more generally for most of the past two centuries, and given the critical importance of oil (and other fossil fuels) to agricultural production, we see oil as critical to human support as the other basic resources. If oil were removed suddenly from the globe it is likely that a large proportion of humans would die within months. Curiously, most ecologists view oil as leading severe environmental problems (this is true, for example, because burning it leads to climate change), but it is also essential to the survival of our species, at least for the next several decades. Hence any discussion of sustainability must include the issue of sustainability of oil or its replacements.

3. Discussion of resource issues until the early 1970s

Thomas Malthus in his "First Essay on Population" is generally considered to be the first to raise the issue of resource constraints arguing that exponential population growth would ultimately outstrip food production that could increase only linearly. Most, including ourselves, agree that Malthus' predictions have not held up to now but this is not because he was completely wrong, but because cheap fossil fuels applied to agriculture, something he could know nothing about, have allowed food production to keep pace with population growth for much but not all of the world's population. Indeed, the dramatic increases of both population and food, and the economy in general, are all related to fossil energy. There is no way that world population could have surpassed 7 billion without cheap energy that allowed nitrogen fixation (the basis of the agricultural revolution), food and clean water production, health care and more generally wealth for many to advance so rapidly (see Pimentel et al., 1973; Steinhart and Steinhart, 1974; Hamilton et al., 2013).

4. Increasing and then waning interest in resource constraint issues

In 1972 the Limits to Growth was published to a great deal of academic and popular attention. The massive increases in the prices of oil in 1973 and 1979, occasioned in part by the U.S.'s own peak of oil production in 1970, led many to believe that the predictions of the limits to growth models were becoming reality. But beginning in the 1980s, in response to the oil shortages of the 1970s, vast amounts of oil were imported to the U.S., mainly from the Mideast. This led to a drop in the real price of energy and an improvement in the economy. Economists became leaders in addressing resource issues and usually put forth the view that markets had resolved the oil problem. Most had never accepted the idea of scarcity and viciously attacked the Limits to Growth study (e.g. Passel et al., 1972) and believed that the market would solve long-term resource issues (e.g. Boyle, 1973; Simon, 1981; Tierney, 1990; Adelman and Lynch, 1997). It was as if the market could increase the quantity of physical resources in the Earth.

But more recent analyses of the Limits to Growth have come to quite different conclusions about the accuracy and reliability of the models. A number of investigators have revisited the predictions of Limits to Growth and concluded that up until the end of the first decade of the 21st century, the predictions generally agree with reality (Bardi, 2011). Although not meant originally as an explicit predictor, but rather as a tool to understand relations among human populations and various resources, the "limits to growth" model is in fact a rather good example of a successful predictor, at least so far, after 40 years for most of their parameters! Whether the future will bring the violent oscillations the model predicted, we will have to wait and see. Bardi shows that the rejection of Limits to Growth was never based on a rigorous scientific analysis but on economic analyses, which were never tested, and which were then picked up by journalists who repeated the economic objections unquestioningly. For example, we find similarly that journalists often quickly pick up on reports that the US will have large amounts of oil, even enough to export, in the near future (Slater, 2012) rather than use much more sophisticated and scientific reports, which are equally accessible (Hughes, 2013).

5. Turning away from constraintist issues

Meanwhile, in the 1970s and 1980s Ecology as a discipline turned away from these big resource questions that focused on populations, resources, and the human situation, but focused instead on theoretical and sometimes practicable questions about the ecology of natural populations, communities and ecosystems. These topics included "diversity and stability", "how to model populations", "competition structures communities", "top down vs bottom up", and "density dependence". Many of these issues seem to us as ambiguously answered today as then, and the analyses once used to justify their results were frequently found to be erroneous if not duplicitous (e. g. Hall, 1988). Yet many of these principles (for example logistic, Lotka Volterra and Ricker curves as effective predictors and managers of populations) are often taught just as uncritically now as then, even when more explicitly testable procedures for the same questions are available (e.g. Hall et al., 1992; Pastor et al., 1988).

We went on to do ecology for 40 years making our living on more "standard" ecological questions while continuing our interest in constraintist issues on the side. As we look back we think we can say that many of the large theoretical questions in ecology have not been answered, at least in a way that have general reliability and applicability, and that many were not even particularly