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THE ECOLOGICAL DYNAMICS OF ENVIRONMENTAL LAW AND POLICY

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Abstract: Environmental laws and policies influence the direction of environmental science in complex ways. An emphasis on static efficiency in the design and implementation of law and policy creates incentives for scientists to ask questions that are narrowly focused on the most predictable and measurable environmental variables. Policies designed to protect or restore the emergent properties of ecosystems encourage scientists to ask questions about ecosystem dynamics and the relationship between human activities and the loss or degradation of ecosystem services. Answering such questions is essential for the ecological sciences to advance. This essay addresses three manifestations of policies that can improve understanding of ecological dynamics: the precautionary principle, adaptive management, and the ecosystem approach to environmental management.

INTRODUCTION

Typically in environmental law and policymaking we ask economists to tell us if what we are considering is the most efficient use of scarce resources. To accomplish this, economists carry out various forms of comparative cost-benefit analyses in hopes of identifying the most economically efficient means to a given environmental end. A great deal of simplification must occur to accomplish these analyses. Administration and compliance costs must be predicted and their costs estimated and compared to predicted outcomes whose value also must be stated in monetary terms. To reduce the uncertainty and increase the reliability of the results, economists must focus on those costs and benefits that are the most predictable and quantifiable. One result of this approach is to encourage environmental scientists to produce results that fit into the cost-benefit paradigm, what David Driesen calls "static efficiency."[1] Because of the conflict apparent in so much envi-

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[1] DAVID M. DRIESEN, THE ECONOMIC DYNAMICS OF ENVIRONMENTAL LAW 11, 13 (2003).

ronmental policymaking, stakeholders tend to challenge vigorously each other's assumptions and the science on which they are based. It is in this context that we so often hear one people's "sound science" being contrasted with their opponent's junk science. In this atmosphere, science, like economics, gets pulled toward caution, to focusing on the already known, the obvious, and the simple. Though it may be obvious that sound science is necessary for the development of good environmental law and policy, I would argue that sound law and policy is also necessary for good science. The focus on static efficiency not only limits our ability to protect our environment effectively, it also slows the progress of the environmental sciences by creating incentives to focus on the kinds of simplifications most suited to efficiency analyses.

David Driesen urges us to go beyond static efficiency to consider the economic dynamics of environmental law and policy, to understand the effects of such laws and policies as a complex system of incentives and disincentives that steer economic behavior in ways that benefit or harm the environment. Driesen changes the economic question from how do we meet environmental goals in the most efficient manner—static—to how do we use economic dynamics to achieve our environmental goals. He doesn't reject static efficiency arguments, he just recognizes their limitations.

Using much the same logic, I argue that we also need to inform environmental law and policy with our best understanding of ecological dynamics to better understand the impacts of our actions. To understand both economic and ecological dynamics requires systems thinking and an intellectual honesty about our ability to predict the costs and benefits of our laws and policies. What a focus on economic and ecological dynamics does, is shift society's attention toward how best to produce conditions in which people prosper in the least disruptive and most supportive ways for protecting and restoring the ecological dynamics of the natural systems upon which all prosperity depends.

In this essay I address three manifestations of this focus on ecological dynamics: the precautionary principle, adaptive management, and the ecosystem approach. These and others are ways of basing environmental laws and policies on ecological dynamics. In doing so, they encourage scientists to focus on these system dynamics rather than on the more mundane accounting relied on when static efficiency is the goal. The criticisms frequently leveled at these policies are that they are too complicated and the concepts on which they are based too poorly defined.[2] But that may be exactly why they are good for science—they require that we continually improve our understanding of the ecological dynamics that govern the natural world. They raise bigger and better questions. How we frame environmental policy questions has enormous implications for environmental science.

I. Framing Environmental Policy

As Walters and Holling have pointed out, the "resource managers will perhaps always operate in a twilight of uncertainty about the relative importance of their actions as opposed to the effects of uncontrolled environmental and ecological factors."[3] As a result, narrow efforts to establish the sort of persuasive causal links between policies and outcomes required by cost-benefit analyses are likely to fail. The best we can hope for is to appraise policy options from the perspective of ecological dynamics. But because our ability to model complex ecosystem dynamics fully and to predict ecological change confidently are limited, such appraisals are often resisted as a departure from sound science.

As the environmental philosopher Kristin Shrader-Frechette has argued, the types of quantification usually considered "sound science" and used to support environmental policies are narrow but precise, such as dose response relationships between animal exposure to some toxic chemical in a laboratory and a particular measurable health outcome, or the relationship between water flow through a dam and electricity production and so on. The "ecological sciences," however, tend to be holistic and broad. "The advantages and disadvantages of the animal-toxicity paradigm (of ecosystem management)" she writes, "stem from its being simple to use and easy to understand."[4] The problem, she points out, is that while the relationship works best for exposures to single chemicals in a controlled setting, most of what typically stresses ecosystems are multiple stressors—chemical, physical, and biological—that never act alone in the real world, an uncontrolled setting. Adopting an animal-toxicity paradigm leads science to a simplification of the relationship between environmental degradation and health, both human and environmental.

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[2] *See* Wayne A. Morrissey, *Science Policy and Federal Ecosystem-Based Management*, 6 Ecological Applications 717, 717 (1996).

[3] Carl J. Walters & C. S. Holling, *Large-Scale Management Experiments and Learning by Doing*, 71 Ecology 2060, 2066 (1990).

[4] *See* Kristin S. Shrader-Frechette, *What Risk Management Teaches Us About Ecosystem Management*, 40 Landscape & Urb. Plan. 141, 143 (1998).

Law and policies derived from a static efficiency paradigm therefore lead to a science of supporting stake-claiming and case-making in a process where the environment is understood to be one of several interests making claims on scarce resources. Treating the environment as an "interest" among competing interests significantly weakens the environmental case, which is fundamentally that the need to protect the environment is a responsibility and a constraint on all interests that use the resources the environment provides. Treating the environment as an interest leads to the bad environmental science of defining and defending the "interests" of the environment in poorly thought out monetary terms, or interest satisfaction curves and other overly simple metrics for use in multi-objective decision models. These decision-support models are often hyped as "objective," which they are not. Embedded in the structure of the model are assumptions about the interests involved and their relationships to each other.

Law and policies derived from ecological dynamics reject the notion that the environment is an "interest" making claims on resources, but rather, is the fundamental resource on which all economic interests depend. What needs most understanding is how to minimize the ways in which each interest's claims deplete and impoverish the environment. This requires a fuller understanding of the relationship between economic and ecological dynamics. In this framework economic development can be appraised according to whether or not it increases our capacity to meet human needs, while decreasing environmentally damaging energy and material throughput. Good environmental laws and policies should be:

- Based on manipulating economic dynamics in order to create economic incentives to decrease energy and material throughput and ecosystem disruptions;
- Clear in purpose, directed to both public welfare and environmental protection;
- Preventative;
- Adaptive, capable of change as new information and better understanding of ecological dynamics emerges; and
- Holistic—based on a full understanding of ecological dynamics.

Widespread adoption of dynamic, clear, preventative, adaptive, and holistic policies will stimulate much important scientific activity. Good policy is based on an understanding of the links between ecological and economic dynamics. Such policies give impetus to science by facilitating the asking of different and important questions.

For example, Stirling and Gee point out that precautionary policies, where adopted, have led to: (1) increased research and monitoring of environmental change and its relationship to public and ecosystem health; (2) research into a wider range of mechanisms of environmental degradation and a need for multi-disciplinary approaches to understanding effects; (3) increased participation in science based policymaking, including a broadened definition of who is considered an interested and affected party; (4) the development of potential substitutes for environmentally destructive activities and substances; and (5) the development of whole new fields of risk reduction technologies such as "green chemistry."[5]

Massachusetts's Toxics Use Reduction Act (TURA), is an example of these policies.[6] The law created a Toxics Use Reduction Institute and an Office of Technical Assistance to assist industry to discover ways to reduce its use of toxic substances.

II. Manifestations of Policy

A. *Precautionary Principle*

At the conclusion of the 1992 World Conference on Environment and Development in Rio de Janeiro, widely known as the Earth Summit, the world's governments adopted the Rio Declaration on Environment and Development. It states that, "[w]here there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation." In the decade since the Earth Summit there has been considerable discussion of the meaning of the so-called precautionary principle and its implications for environmental law, policy, and science.

The principle recognizes two key features of ecosystem dynamics. First, the complex interactions that characterize ecosystems in the real world often make it almost impossible to establish with scientific certainty cause and effect relationships between a given activity or substance and a decline in environmental health or integrity. Second, the same limitations on our understanding of ecosystem dynamics and the extreme difficulty and high costs of repairing or restoring de-

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[5] *See* Andy Stirling & David Gee, *Science, Precaution, and Practice*, 117 Pub. Health Rep. 521, 526–28 (2002).

[6] *See, e.g.*, Brian Mayer et al., *Moving Further Upstream: From Toxics Reduction to the Precautionary Principle*, 117 Pub. Health Rep. 574, 574–86 (2002).

graded ecosystems make many kinds of environmental damage essentially irreversible. The term "precautionary principle" "came into English as a translation of the German word *Vorsorgeprinzip*. An alternative translation might have been 'foresight principle' which has the advantage of emphasizing anticipatory action . . . ."[7]

The Great Lakes Water Quality Initiative offers an example of how the precautionary principle works. The Initiative involved reaching agreement among the environmental regulatory agencies from all eight of the Great Lakes states on adopting consistent water quality standards for persistent bioaccumulative toxic substances in the Great Lakes. Certain substances, known as Tier 1 chemicals, would be stringently regulated. Industry representatives argued that a chemical should not be placed on Tier 1 until its toxicity was proven. Environmental activists insisted that any compound whose structure and activity suggested that it might bioaccumulate and concentrate as it passed up the food chain or was persistent and potentially toxic should be listed in Tier 1 until the industries that produced or released the compound showed convincingly that it was harmless. This, they argued, would give industry a clear incentive to carry out the toxicological research needed to demonstrate a chemical's effects in the environment. The environmentalists pointed out that the current system of chemical regulation required months, and sometimes years, to act on a single compound; during the same time industry was producing and marketing hundreds of new compounds that would inevitably be released into the environment with unknown results. It changes the economic incentives for those who introduce new chemicals or technologies. Prior to application of the precautionary principle industries had an interest in avoiding knowledge of the broader implications of their actions out of fear that the more information, the greater the chance of discovering something that might trigger regulation. Under precautionary policies, they would have an incentive to gather as much information as possible to demonstrate the safety of what they propose. Thus, there is a systematic incentive to increase information and understanding.

By shifting the onus of proof of harm from government to industry, precaution can reorient publicly-funded research toward a broader interdisciplinary effort to learn how to redesign the technologies of economic life to make them more compatible with, and less disruptive

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[7] David Kriebel et al., *The Precautionary Principle in Environmental Science*, 109 Envtl. Health Persp. 871, 871 (2001).

to, the complex relationships and cycles of natural systems. As Kriebel and Tickner argued before a congressional hearing:

> Precaution demands more rigorous science to characterize complex risks, clarify gaps in knowledge, and identify early warnings. Application of precaution means using science not only for diagnosis of environmental hazards, but also to effectively identify and develop policy options that can reduce risks and drive innovation towards safer and cleaner materials.[8]

The current system of regulations focuses the scientific community on becoming ever more precise in characterizing risks and defining problems. Switching to a focus on prevention refocuses science on identifying solutions and providing alternative but less inherently disruptive means of achieving the same economic ends. This can stimulate economic activity in the search for cleaner and safer alternatives. It expands the kinds of questions that get asked, encourages tinkering and innovative problem-solving, all of which are positive for the development of creative, socially useful science.

The continual need to improve the characterization of known risks leads science to focus on those chemicals and activities that are already known to be harmful. For example, in the Great Lakes, the environmental sciences tend to focus on the eleven so-called "priority pollutants." These pollutants were designated as priorities in the 1970s by the Science Advisory Board of the Canada-U.S. International Joint Commission, the international organization that oversees management of the boundary waters, including the Great Lakes ecosystem. Substances were selected for the list because: (1) they had been measured in the water in the Great Lakes; and (2) they were known to be harmful. If, therefore, a substance was found but its effects were unknown, or if a substance was known to be harmful but had not yet been measured, it would not be considered a priority. Such a prioritization makes sense for efficiently allocating resources for regulation and cleanup but it makes no sense for science. Yet, for nearly three decades, scientists have been encouraged by the flow of funding to continue to study the priority pollutants in order to characterize the risks they pose and to justify the costs of regulation and remediation. According to Kriebel and Tickner, this pattern of funding leads to "a strong tendency towards

[8] David Kriebel & Joel A. Tickner, Testimony at Congressional Briefing on Science and Precaution in Environmental and Public Health Policy (July 24, 2003) (on file with author).

research within narrow disciplinary boundaries rather than interdisciplinary research on such challenges as the lifelong cumulative effects of hazardous exposure, or the combined effects of simultaneous exposures to several chemicals at once."[9]

B. *Adaptive Management*

Much like the precautionary principle, adaptive management as a paradigm for environmental policy is based on the recognition that our scientific understanding of complex systems is incomplete. But that should not encourage inaction.[10] Like the precautionary principle, it looks to law and policy to lead science rather than be led by it. While debates about the precautionary principle usually focus on potentially harmful chemicals and new technologies like genetic engineering, adaptive management is a term more often heard in the world of wildlife conservation, endangered species protection and resource management in general. Where traditional natural resource law and policies focus on the harvest or mining of products, management focuses on protection and sustainability of the ecosystems within which such products are harvested. The impact on science is to change the questions from how to capture or harvest or mine, to how to cultivate and sustain. These are broader, harder questions, less likely to be undertaken by the industries that mine and harvest.[11]

Kai Lee, whose book *The Compass and the Gyroscope* did much to popularize the notion of adaptive management, talks about it as "implementing policies as experiments."[12] The idea is that even though we don't know enough about ecosystems to be certain of the outcomes of our management actions, we still need to act to prevent declining ecological conditions. Under these circumstances, we need to act based on our best understanding of ecosystem dynamics, continually monitor and be flexible and prepare to change the degree of direction of our interventions as a result of changing conditions. He argues that such an approach "promotes learning to high priority in

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[9] *Id.*

[10] *See generally* ADAPTIVE ENVIRONMENTAL ASSESSMENT AND MANAGEMENT (C.S. Holling ed., 1978); Carl Walters, ADAPTIVE MANAGEMENT OF RENEWABLE RESOURCES (1986). Both sources offer in depth descriptions of how adaptive management has taken account of our incomplete understanding of scientific complexity.

[11] *See* Kai N. Lee, *Appraising Adaptive Management*, 3 CONSERVATION ECOLOGY 3 (Sept. 8, 1999), *at* http://www.consecol.org/vol3/iss2/art3.

[12] *Id.*

stewardship,"[13] clearly a boost for science, requiring a real collaboration between the social and natural sciences. Much emphasis is placed on the development of measurable criteria and indicators to inform management over time. Such criteria and indicators are "information tools in the service of forest management" in the sense that they "can be used to conceptualize, evaluate, implement and communicate sustainable forest management."[14]

C. *Ecosystem Management*

The Ecological Society of America defines ecosystem management as:

> [M]anagement driven by explicit goals, executed by policies, protocols, and practices, and made adaptable by monitoring and research based on our best understanding of the ecological interactions and processes necessary to sustain ecosystem composition, structure, and function . . . . Sustainability must be the primary objective, and levels of commodity and amenity provisions adjusted to meet that goal.[15]

Like the other management paradigms discussed here, ecosystem management adopts ecosystem health, integrity, or sustainability as the primary management goal while expecting human economic activities to be redesigned to be as harmonious with natural flows and cycles as possible. This expectation directs science toward producing the knowledge needed for this kind of engineering. Such knowledge is expected to be derived from both social and natural sciences exploring the dynamics of the interface between ecology and economy.

Conclusion

Each of these management paradigms—precaution, adaptive management, and ecosystem management—are reactive, having arisen in response to a critique of standard practice in environmental law and

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[13] *Id.*

[14] Ravi Prabhu et al., *Between Voodoo Science and Adaptive Management: The Role and Research Needs for Indicators of Sustainable Forest Management, in* Criteria and Indicators for Sustainable Forest Management 40, 41 (R. John Raison ed., 2001).

[15] Hanna J. Cortner & Margaret A. Moote, The Politics of Ecosystem Management 41 (1999) (citing Christensen et al., *The Report of the Ecological Society of America Committee on the Scientific Basis for Ecosystem Management*, 6 Ecological Applications 665, 682 (1996)).

policy. The precautionary principle responds to the apparent recklessness of permitting the continuation of actions whose environmental impacts are potentially large and irreversible because of a lack of scientific certainty about the scope and nature of those risks. Adaptive management responds to the typical lack of ongoing monitoring and assessment about the impacts of conservation actions. Ecosystem management responds to the tendency to manage parts of an ecosystem or individual species while ignoring the dynamic system of ecological relationships that shape and sustain the individual components. Each forces scientists to ask broader questions, to engage in systems thinking. This can only be good for environmental science in general.