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INTEGRATIVE FRONTIERS IN ENVIRONMENTAL POLICY THEORY AND RESEARCH

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Abstract

Environmental policy research continues to advance toward a more Kuhnian "normal" science where theory and empirical tools are brought to bear on real-world policy systems to better understand social processes and determine the context in which policies work best. Traditional environmental policy tools now involve more flexible market-based instruments, voluntary agreements, and information provision tools like ecolabels and sustainability indicators. Policy process theories continue to be refined through hypothesis testing and are evolving into more integrative and multidisciplinary frameworks. Interdisciplinary methods are also being employed to better measure and analyze environmental outcomes, which has always been a major challenge in environmental policy research. These research tools are being explored in emerging policy approaches like collaborative partnerships and with novel environmental issues like climate change adaptation, pharmaceuticals and personal care products, and nanotechnology.

Keywords: Policy tools, policy process, integrative policy frameworks, policy outcomes, emerging environmental issue, collaborative policy

Introduction

This paper provides an overview of environmental policy research focusing mostly on the last five years but including several earlier, seminal works. Policy research is transitioning into a phase of what Kuhn (1996) would call "normal" science, where multiple theories guide empirical hypothesis testing. At the same time, policy sciences seek to investigate applied implications and develop policy recommendations. This paper discusses these broader changes in how policy sciences have played out in environmental policy theory and empirical applications. A cross-cutting theme of our discussion is *integration*, where synthetic theoretical frameworks and multidisciplinary approaches are being developed to understand the linkages between the social and ecological systems inherent in environmental issues.

Recent environmental policy research continues the tradition of economic analysis of policy tools, with a particular focus on market-based instruments. Concurrently, attention is directed to behavioral and political variables through development and testing of theories of the policy process like Institutional Rational Choice (IRC) and the Advocacy Coalition Framework (ACF). Theoretical approaches are benefiting from more interdisciplinary collaboration within the social sciences, as well as with natural and physical scientists, to explore the coupled dynamics between social and ecological systems. The call for empirical research on environmental outcomes remains strident, especially in the context of emerging, complex environmental problems like climate change. The dialog between theory and empirics drives the policy sciences forward in classic Kuhnian fashion.

This theoretical and empirical research is further complemented by important methodological advancements. Space limitations prevent a thorough discussion here, but at the heart of these advances is an attempt to better observe causal processes in policy settings. Policy research is plagued by the lack of "counter-factual" observations (Winship & Morgan, 1999; Ferraro, 2009), and approaches like randomized interventions (Duflo, Glennerster, & Kremer, 2007) and matching methods (Ferraro, McIntosh, & Ospina, 2007) are being used to attack these problems.

The next section discusses theoretical frontiers in environmental policy research, followed by a section on emerging empirical research. The distinction between theory and empirics is not meant to be sharp given the constant feedback between different aspects of the scientific process. The organization of our paper merely reflects our judgment about whether the theoretical or empirical aspect of the research is more interesting at the current time. We conclude by offering perspectives on the future of research in environmental policy theory and applications.

Theoretical Frontiers in Environmental Policy Research

Environmental policy research benefits from the application of social science theories that identify how policies affect individual behavior and, in turn, how those policies are influenced by collective decisions. Environmental policy theory is now explicitly integrating a broader range of disciplines to better understand the linkages between human and natural systems.

Policy Tools

Policy tools research is a well-established tradition in environmental policy with origins in the economics of market failures. Interlinked with broader policy trends, early research focused on command-and-control regulation or pollution taxes as ways to reshape incentives (Keohane, Revesz, & Stavins, 1998; Hahn & Stavins, 1991). However, some early policy tools were considered inefficient for solving a number of environmental problems (Fiorino, 2006). For

example, though command-and-control regulations have addressed point source water pollution, they have been less successful in dealing with non-point source pollution. The combination of new and unresolved problems, along with criticisms of existing tools, has fueled the development and analysis of new, more "flexible" policy tools (Tews, Busch, & Jorgens, 2003; Fiorino, 2006). Such tools have often been implemented outside the gridlocked Congressional legislative process (Klyza & Sousa, 2008) and are increasingly used in private sector collaborations (Eisner, 2006). Here we focus on market-based instruments, voluntary agreements, and information-based tools, each of which attempt to realign economic incentives with individual choice and information, rather than relying on mandatory behaviors backed by enforcement.

Market-Based Instruments

Market-based instruments, including pollution charges, marketable permits, deposit refund systems, and offset markets (Hahn & Stavins, 1991), have developed in response to the inefficiencies of traditional command-and-control regulation. In theory, market-based incentives facilitate technology innovation (Jaffe & Stavins, 1995) and increase net benefits by reducing compliance costs and increasing flexibility in achieving environmental goals (Olmstead, 2010). Though market-based instruments were historically utilized for air pollutants like sulfur dioxide, they have more recently been applied to water-quality (Stephenson & Shabman, 2011; Breetz et al., 2005), nutrient trading (Barry et al., 2010), and carbon offset programs (Mooney et al., 2004a, 2004b).

Market-based instruments have had some notable early successes. It is widely recognized that the United States sulfur dioxide emissions trading program significantly reduced emissions (Kruger, 2007; Schmalensee et al., 1998). As well, bottle deposit refund programs have increased recycling rates in many municipalities throughout the United States (Bell, Huber, & Viscusi, 2010; Walls, 2011).

However, market-based instruments have also received considerable criticism. The European Union carbon trading program has not reduced overall greenhouse gas emissions in part because it allowed for free allowances and individual country allocation, which resulted in an oversupply of permits and a low carbon price (Newbery, 2011). Limited participation in market-based programs can be significantly affected by non-financial barriers such as trust in third parties and other group participants (Breetz et al., 2005). Market-based instruments may have multiple tradeoffs, such as having to compromise cost-effectiveness, which may be alleviated through hybrid approaches or multiple instruments (Goulder & Perry, 2008). Future research should address not only the success and efficiency of the instrument, but also tradeoffs and how program design influences participation and environmental quality.

Voluntary Agreements

Voluntary agreements (VAs), or "green clubs," are growing in popularity among industries for going "beyond compliance" to improve environmental conditions (Prakash & Potoski, 2007, 2006). Different types of VAs feature integration with existing regulations and agency processes (OECD, 2003), but a consistent criticism of VAs is that a lack of enforcement can reduce effectiveness (Glachant, 2007). Much of the research has focused on how to facilitate effective VAs, as well as what causes firms to participate. Studies on participation have found that firms are more likely to participate if they perceive a net benefit (Alberini & Segerson, 2002), there is a threat of regulation (Lyon & Maxwell, 2002; Khanna et al., 2007; Brouhle, Griffiths, & Wolverton, 2009; Alberini & Segerson, 2002), and if they operate in states surrounded by states with existing VAs (Daley, 2007). Other variables that have influenced firms to participate include industry group membership, the level of environmental funding in a state, and neighborhood characteristics (Brouhle et al., 2009). Though some research has found that stakeholder influence has no effect on industry participation in VAs (Khanna et al., 2007), more recent work found that business

participation in voluntary environmental programs was positively influenced by stakeholder perspectives of their company (Darnall, Potoski, & Prakash, 2010), and others have highlighted the need for companies to engage with stakeholders in the VA development process (Murdock, Wiessner, & Sexton, 2005).

There remains debate over the effectiveness of VAs; while they can be more efficient than other types of policies because enforcement is often undertaken by third parties and paid for by participants (McEvoy & Stranlund, 2010), they can be ineffective in dealing with large scale environmental issues if their scope is local in nature (Press, 2007). VAs are more effective if they minimize collective action problems like free riding and shirking by accruing most benefits to participants and requiring a minimum abatement level (Prakash & Potoski, 2007; Brau & Carraro, 2011; Prakash & Potoski, 2006). Emerging efforts are trying to combine VAs with other policy tools to reduce free riding behavior and maximize financial opportunities to participating firms (Oikonomou et al., 2009; Arimura, Hibiki, & Katayama, 2007), but new tools are needed to monitor VA impacts (Lyon & Maxwell, 2007). Recent empirical research also found that VA effectiveness may depend on the nature of the environmental issue. Business participation in ISO 14001 certification, the most common environmental VA, resulted in reductions for air pollutants but not water pollution, suggesting the need for additional research to understand the influence of VAs on multiple types of pollution (Prakash & Potoski, 2011).

Information Provision Tools

Information provision tools aim to reduce information asymmetry, which occurs when consumers do not have full information about the products they are purchasing, resulting in inefficient choices. In the context of environmental policy, one of the best-known examples of information disclosure is the Toxics Release Inventory (TRI) "right to know" clause requiring companies to release information about toxic chemical release (42 U.S.C. Sec. 116, 1986).

Research on the TRI suggests some overall decrease in emissions, but the impact was not uniform across sources and was likely influenced by other policies (Kraft, Stephan, & Abel, 2011; Bui, 2005). Reacting to criticisms about how information tools are integrated into decision-making (Weil et al., 2006), more effort has been devoted to communicating environmental information directly to consumers who want to buy environmentally friendly products or to producers to help them make decisions and develop a reputation for improved environmental management.

Ecolabels are one type of information provision tool that describes some aspect of an environmentally-friendly product or industry behavior. Some ecolabels are based on scientific analysis of environmental criteria or sustainability tools like life cycle analysis (LCA). Examples of ecolabels include organic, biodegradable, and carbon footprint labels, among others. There are varying levels of regulation with ecolabels; the US EPA Energy Star ecolabel as well as the EU ecolabel initiatives (Baldo et al., 2009) are government sponsored initiatives, while others are individual company creations not independently verified by a third party (Tews et al., 2003). Reacting to these inconsistencies, several consumer groups like the Environmental Working Group (*Skin Deep Cosmetics Database*, 2011) and Consumers Union (*Greener Choices Eco-Labels*, 2011) have developed their own databases to evaluate ecolabels.

Ecolabel research has analyzed their effectiveness in changing consumer and producer behavior. Economic models have found that ecolabels can reduce pollution if consumers are willing to pay for environmental quality; however, ecolabels alone cannot eliminate all externalities (Ibanez & Grolleau, 2008). While ecolabels can encourage green behavior, financial policies, in the form of incentives and penalties, can be more effective (Coad, de Haan, & Woersdorfer, 2009). In part, this may be because conscious consumers utilize ecolabels in their purchasing decisions, while price oriented consumers are less affected (Schumacher, 2010).

Sustainability tools and indicators are another information provision tool that mostly have assisted companies and governments to understand the environmental impact of their products and policies (De Smedt, 2010). Rabl and Holland (2008) note the differences of multiple sustainability tools including impact pathway analysis (IPA), LCA, and multi-criteria analysis (MCA). Recent advancements of the LCA method termed "dynamic life cycle analysis" consider both the carbon mitigation potential and the embodied carbon emissions of a practice or technology, which can assist in policymaking by prioritizing low-emission technologies (Kenny, Law, & Pearce, 2010). Despite their prevalence, sustainability tools face technical challenges such as lack of data, uncertainty about future scenarios, and non-linear impacts (Rabl & Holland, 2008). In addition, the definition of the term sustainability remains vague and contentious, increasing the potential for symbolic rather than substantive use of indicators.

Policy Process

Theories of the policy process expand beyond the economic basis of the policy tool perspective to integrate political and behavioral components into policy analysis. The past twenty years have seen the emergence of a number of policy process theories such as the ACF, IRC, policy diffusion, and punctuated equilibrium, among others (Sabatier, 2007) that have been applied to environmental contexts. In Kuhnian fashion, research has turned to further refining these theories by testing competing hypotheses and synthesizing theories.

Testing Theories of the Policy Process

Sabatier (2007) summarizes the most common policy process theories and shows how each is based on different assumptions and focused on different questions (see also Schlager and Blomquist, 1996). Recent empirical environmental research utilizes these theories in three ways: 1) testing hypotheses from a single theory; 2) testing competing hypotheses from different theories; and 3) attempting to combine elements of existing theories into a more synergistic framework.

Below we provide examples from the ACF and IRC, which are arguably the two policy theories most actively (but not exclusively) applied to environmental policy.

ACF scholars continue to expand the theory's geographic scope and apply it to different environmental policy issues. In the comparative politics tradition, Sabatier and Weible (2007) argue that the degree of consensus needed for major policy change and openness of political systems in different countries affects the process of coalition formation. Tests of the ACF in a number of environmental policy subsystems have produced supporting evidence for hypotheses involving policy change, learning, and coalition stability (Weible, Sabatier, & McQueen, 2009; Ellison & Newmark, 2010; Huntjens et al., 2011; van Overveld, Hermans, & Verliefde, 2010). One of the most important recent findings is evidence that policy beliefs drive actual political cooperation among members of coalitions (Henry, Lubell, & McCoy, 2011; Weible, 2005), instead of previous research that identified coalitions as actors with similar beliefs without measuring behavior.

IRC theory, especially Ostrom's Institutional Analysis and Development (IAD) Framework, has also advanced its approach by moving from case studies to more large-N, comparative research. A leading example is the International Forestry Resources and Institutions (IFRI) program, which tests hypotheses about common-pool forest management among many sites across multiple spatial scales. This research has found that monitoring and rule enforcement, group rules, and local autonomy significantly affect forest quality (Lavertu & Weimer, 2009). Continued large-N research through IFRI has more recently shown that property rights (Coleman, 2011) and the percent of women in a community (Mwangi, Meinzen-Dick, & Sun, 2011) significantly affect adoption of sustainable forest practices. Further advancement of the theory can be achieved by

examining the effect of cross-scale and cross-sector linkages, power structures, and social inequalities (Tucker May, 2010).

Testing competing hypotheses from multiple theories provides a more robust approach to refining theories. Henry (2011) compares perspectives from the ACF and the Resource Dependency Theory (RDT) in a regional planning setting, finding that the ACF hypothesis of shared ideology more accurately describes network collaboration in regional planning than the RDT theory of power-seeking as a driving force for collaboration. Weible (2008) reviews the use of expert knowledge among four policy theories—multiple streams, punctuated equilibrium, social construction, and ACF—across unitary, collaborative, and adversarial policy subsystems. This comparison suggests a number of revisions to existing theories including defining principal and auxiliary coalition members and acknowledgement that conflicts can occur between coalitions from different policy subsystems.

Policy process theory has been criticized for being too elastic and capable of predicting any result through continued refinement of initial assumptions (Meier, 2009). In response, many scholars are combining the strengths and weakness of different theories to build more synthetic frameworks. Lavertu and Weimer (2009) argue that theory of delegation, which predicts policymaking authority, organizational structures, and the level of expertise incorporated into policymaking, should be synthesized into policy process theories like those outlined by Sabatier (2007). Henry (2011) combines the ACF and RDT theories in a land use planning setting to conclude that perceived influence within groups of ideologically similar network actors is positively associated with collaborative ties. Ingold (2011) suggests that combining network structure and actor preferences in climate change research can assist in identifying coalitions and policy output for the ACF. Schneider and Sidney (2009) assert that the future of policy studies

involves the need to combine policy theories with research that is relevant to society. These more integrative approaches may ultimately produce a widely accepted theory linked to multiple disciplines, although theoretical pluralism will persist for the time being and is preferred by some researchers.

Integrative Theoretical Concepts and Frameworks

The increasing recognition that environmental issues involve complex systems across the social and natural sciences has led to a growing amount of integrative, multi-disciplinary research in recent years. Early frameworks in this context include the Pressure State Response (PSR) and Drivers Pressures State Impact Response (DPSIR) frameworks (Tapio & Willamo, 2008). Emerging research has built on existing theories to integrate multiple disciplines and provide more sophisticated views on the role of social learning and networks for linking social and ecological systems.

Social and Policy Learning

Social and policy learning research encompasses disciplines including policy studies, management, sociology, communications, and organization studies (Van Bommel et al., 2009). The multidisciplinary nature of social learning has produced definitions ranging from social conditioning of individuals (Bandura, 1977) to collective learning (Ostrom, 1990). Social learning is an important process in environmental policy, with acknowledgement that it is based on different epistemological assumptions than traditional policy analysis (Van Bommel et al., 2009; Ison, Roling, & Watson, 2007). Theoretical and empirical evidence suggests that institutions that facilitate learning are more adaptable and effective in managing common pool resources (Ostrom, 1990; Gerlak & Heikkila, 2007).

One notable example of social learning research is SLIM (social learning for the integrated management and sustainable use of water at catchment scale), a multi-year European Union (EU)

project on watersheds (Steyaert & Jiggins, 2007). SLIM argued that natural resources are complex systems featuring uncertainty, which requires social learning to understand interdependence between biophysical and social forces (Ison et al., 2007). Collins and Ison (2009b) built upon SLIM to argue that climate change adaptation requires a social learning paradigm.   Other studies have tried to examine the environmental contexts in which social learning can be effective. Social learning can be hampered by distrust and disagreement stemming from unequal power relations (Van Bommel et al., 2009). On the contrary, social learning can be more effective in collaborative groups with decentralized institutions and networks spanning multiple groups as found in the Florida Everglades collaborative ecosystem restoration program (Gerlak & Heikkila, 2011). These studies are beginning to provide more precise definitions of social and policy learning, measure social learning in empirical settings, and identify the conditions under which social learning occurs and influences policy.

Social Ecological Systems

Another integrative framework that draws heavily from the natural and social sciences is the social-ecological systems (SES) framework, which links social, political, and ecological processes using concepts and methods from complex systems (Anderies, Janssen, & Ostrom, 2004). SES frameworks have evolved from the IAD framework, which analyzed the effect of institutions on common-pool resources (Ostrom, 2011; Ostrom & Cox, 2010). Early SES frameworks considered resources, resource users, and public infrastructure coupled with drivers and disturbances to better understand how institutions play a role in governing SES (Anderies et al., 2004). Ostrom (2007) developed a more advanced SES framework, which integrated resources, resource users, and governance systems within the multi-scale socioeconomic, political, and ecological settings in which systems exist. Further revision of this framework has more completely integrated IAD and SES by explicitly including "action situations" such as monitoring, provision,

and policymaking (McGinnis, 2011; Ostrom & Cox, 2010; McGinnis, 2010). SES frameworks have borrowed concepts from natural science, such as sustainability, resilience, and adaptive capacity (Folke, 2006; Folke et al., 2005; Holling, 2001). These concepts often become the key dependent variables in theoretical frameworks, and researchers are debating the best way to define and measure them.

As with other policy process theories, SES frameworks are being empirically tested in diverse settings, often facilitated by large-scale funding from the National Science Foundation and other organizations. SES has been applied with success by researchers, policymakers, and managers with different research and management priorities in the Himalayan Mountains (Amatya et al., 2010) as well as in small-scale fisheries (McClanahan et al., 2009). Most recent empirical research is focused on coupling management of social and ecological systems with health and well-being indicators (Bunch et al., 2011). Agent-based models and bioeconomic mathematical models (Sanchirico, Smith, & Lipton, 2008), which involve a number of different actors that interact with each other as well as their environment, are well-suited to analyzing SES frameworks (Matthews et al., 2007; Berger, 2001; Kaufmann, Stagl, & Franks, 2009; Bodin & Crona, 2009). Beyond developing new SES frameworks, future research should focus on more empirical testing of model predictions and validation of parameters, as well as using models for decision-support in real policy settings.

Policy Network Frameworks

Policy networks have become a cross-cutting theoretical and methodological tool applied to multiple environmental policy settings. The basic idea of policy networks is that different types of policy actors (e.g. individuals, organizations, countries) are linked by some type of social relationship (e.g. information sharing) and that the structure of the network influences policy decisions and outcomes. Many policy process theories directly employ network-related concepts,

for example the ideas of coalitions in the ACF and social capital in IRC. Network analysis methods thus provide an empirical tool for evaluating theoretical hypotheses, though network theory can also act as a stand-alone approach to understanding policy and governance (Jones, Hesterly, & Borgatti, 1997). Network analysis has been usefully employed in a number of empirical environmental settings such as natural resource management (Bodin & Crona, 2009; Prell, Hubacek, & Reed, 2009), urban ecosystem services (Ernston et al., 2010; Ernston, Sorlin, & Elmqvist, 2008), small scale fisheries (Marín & Berkes, 2010; Ramirez-Sanchez & Pinkerton, 2009), and watershed management (Schneider et al., 2003).

Despite widespread recognition of the utility of network theory, a consensus has not yet emerged about what network variables are most important for improving environmental policy. The literature commonly employs some vague idea of social "embeddedness" or "connectivity" as having a positive effect on environmental decisions, with empirical measurements focused on network density, reciprocity, and transitivity (friends of my friends). However, a number of scholars have pointed out that the functional role of networks is likely to depend on different contextual variables, for example whether or not the actors are facing coordination or cooperation problems (Berardo & Scholz, 2010). Though some empirical evidence suggests that well-connected and centrally located organizations are more collaborative than smaller, denser networks (Scholz, Berardo, & Kile, 2008), there is a need to further develop and test theories about the conditions under which different types of network variables matter.

Empirical Frontiers in Environmental Policy Research

Below we summarize some emerging frontiers of empirical research in environmental policy. We highlight substantive areas where a large amount of empirical research is currently underway or emerging, which can contribute to theoretical advancements and political

applications. As is obvious from above, there is significant empirical research happening on different theoretical questions, and the empirical research below has theoretical implications.

Policy Outcomes

Measuring environmental outcomes has always been one of the central challenges of environmental policy research, since tangible environmental improvement is a key goal of policy implementation. Environmental policy research is frequently criticized for focusing on process measures like political participation and attitudes, or output measures like policy adoption, plan implementation, and budget expenditures rather than actual environmental benefits. Fully evaluating environmental policies requires analyzing different parts of this causal chain (Rauschmayer et al., 2009), but many environmental outcomes are difficult to measure due to complexity and data scarcity. The emergence of multi-disciplinary research teams offers opportunities to explore these outcomes in more integrated ways. While air pollution has been studied significantly in the development of environmental indicators, (O'Neill et al., 2003) more recent large scale efforts for indicator development include biodiversity and environmental justice.

Biodiversity

Measuring biodiversity and quantifying its benefits can be challenging because of its complex structures and multiple interactions (Noss, 1990). International collaborative efforts to develop biodiversity indicators began in earnest with the Convention on Biological Diversity (CBD) in 2002, which pledged to reduce the rate of biodiversity loss by 2010. Though early efforts to create biodiversity indicators focused largely on ecological parameters, new efforts span multiple scales. The CBD created a framework of indicators ranging in scale from genes to entire ecosystems (Diversity, 2006). More recent efforts include measures for both ecological indicators like habitat extent and condition as well as socioeconomic influences on biodiversity like resource

consumption, overexploitation, governance corruption, and human population density (Butchart et al., 2010; Crafton & Anthony, 2011).

Numerous critiques of biodiversity indicator development exist both previous to, and in light of, the failure of CBD to meet biodiversity goals. Existing indicators have been criticized for their failure to have a desired end goal for conservation (Mace & Baillie, 2007) and their limited focus on genetic diversity (Laikre, 2010). There is also broad recognition that biodiversity indicator development needs to be coupled with large scale monitoring programs (Scholes et al., 2008) and that indicators should be more incorporated into other types of policy's like land-use planning, agriculture, and economic decision making (Butchart et al., 2010). Overcoming these shortcomings requires biodiversity and other environmental indicator development, monitoring, and evaluation across multiple scales.

Environmental Justice

Environmental justice research focuses on the potentially unequal distribution of environmental outcomes, benefits, and costs across regions, ethnic groups, and income categories (Maguire & Sheriff, 2011). Though environmental justice concerns have become an important policy priority, only recently have environmental justice indicators become more sophisticated and integrated to include multiple measurement tools and disciplines.

There is an increasing need for frameworks and common questions to guide the development of environmental justice indicators. Maguire and Sheriff (2011) suggest a variety of potential tools including GIS, Lorenz maps, concentration curves, inequality indices, and regression to present environmental justice indicators and potential impacts to policymakers. There is also a growing body of empirical research to understand how certain policies have or may affect different populations in the future. Data analysis of sulfur dioxide (SO_2) trading activities in the United States between 1995 and 2009 found that, contrary to the author's hypotheses,

African American and Hispanic communities had fewer imports of SO_2 over time. Instead, SO_2 was concentrated in communities where a larger percentage of adults did not have a high school diploma, suggesting that there are multiple variables to be measured for understanding what types of communities can be adversely affected by pollution (Ringquist, 2011). Efforts are also investigating how government funding could have environmental justice implications. One recent study found that unsuccessful applicants for the U.S. EPA Brownfields grant program are more likely to be non-white, lower income, and in areas with low resource governments (Dull & Wernstedt, 2010). These empirical efforts identify potential problems with existing policies and can provide guidance to policymakers on remediation and indicator development for assessing future policies and programs. Applied research suggests the need for continued cross-disciplinary collaboration to understand how to develop and implement environmental justice indicators that inform policy development to minimize unequal environmental harm.

Collaborative Policy

Collaborative policy, often paired with the concepts of ecosystem and adaptive management, represents an institutional framework for decision-making that has spread to nearly every aspect of public policy, and is especially important in the context of natural resource management. Well-known examples include the Chesapeake Bay Program, CALFED Bay-Delta Program, Comprehensive Everglades Restoration Program, and the Northwest Power and Conservation Council (Heikkila & Gerlak, 2005; Layzer, 2005), but these types of programs can be found in nearly every watershed in the US and most Western democracies, as well as in many developing countries. The basic idea of collaborative policy is to bring together multiple stakeholders to address complex problems that span administrative boundaries, have high levels of uncertainty, involve multiple ecological functions, and have not been effectively managed by traditional policy tools (Lubell, 2004; Weible, Sabatier, & Lubell, 2004; Lubell, 2003; Sabatier,

2005). One important aspect of collaborative policy is that it has become a testbed for policy theory. For example, IRC has used the idea of polycentric governance to understand how collaborative policy operates in the context of cross-scale problems like climate change.   Given the failures of international governance alone, Ostrom (2010) asserts that global policy efforts must be complemented with regional and local programs of mitigation and adaptation.   Other researchers argue collaborative policy reduces the overall transaction costs of cooperation in the context of environmental policy (Lubell, Henry, & McCoy, 2010; Thomas, 2003). ACF research examines whether collaborative policy breaks down the traditional basis for the formation of competing coalitions (Lubell, 2003, 2000) or whether the political forces driving coalition formation continue to operate (Weible, 2006).

Given its widespread use in the real-world, researchers are engaged in a vibrant debate about its effectiveness (Koontz & Thomas, 2006; McCloskey, 2000, 2001).   In a large review of 137 case studies not exclusive to environmental policy, Ansell and Gash (2008) find that history of conflict or cooperation, stakeholder participation incentives, power and resource imbalances, leadership, and design of institutions are the key variables that influence the effectiveness of collaborative governance structures. More recently, Newig and Fritsch (2009) conducted a meta-analysis of 47 environmental case studies throughout North America and Western Europe and found that polycentric governance systems yielded higher environmental outputs than simple monocentric structures. Additional studies have found that a multitude of other factors can affect the overall success of collaborative governance structures including leadership (Heikkila & Gerlak, 2005), stakeholder participation (Johnson et al., 2010), and government agency participation (Weible, 2011). Additional empirical research is needed to better understand these

effects in practice and to further develop the link between multi-level governance and public participation within environmental governance.

Emerging Environmental Policy Issues

One interesting aspect of environmental policy (and policy in general) is how new issues are discovered and incorporated into the policy agenda. Environmental issues are often first recognized by their impact on human health, followed by engagement in the political process, a broader concern about environmental effects, and a growth in environmental policy research. Many of the issues that have emerged more recently have high levels of uncertainty and complexity, with human health and environmental impacts that are hard to measure. In this way they differ somewhat from earlier environmental issues like point sources of air and water pollution, which had acute and visible impacts. We limit our discussion here to three complex issues at different stages of public awareness and scientific attention: climate change adaptation, nanotechnology, and pharmaceuticals and personal care products. Each of these issues involves complex governance and policy structures to deal with their potentially widespread impacts. However, each issue is at a different level of policy development, in part due to the nature of the environmental issue itself as well as the policy and research devoted to specific topics. As a result, these three examples provide perspective on emerging environmental topics at various stages of the policy process.

Climate Change Adaptation

Climate change is a central global challenge that is motivating research in nearly every discipline. While a wide range of research (Pacala & Socolow, 2004; Roughgarden & Schneider, 1999; Metz et al., 2007) has focused on climate change *mitigation*, climate change *adaptation* has recently gained greater emphasis (Aakre & Rübbelke, 2010; Yamin, 2005; Burton et al., 2002; Rabe, 2010). Among the three emerging issues described here, climate change adaptation is the

most advanced in a research context as significant studies and models aim to predict climate change impacts across the globe for the future. As well, many international agreements, national policies, and regional strategies all address adaptation as a key component of climate change and a necessary policy target to reduce future impacts across time and space. Climate change adaptation policies may be fundamentally different from mitigation policies, in part because the private benefits associated with adaptation may increase the likelihood of adoption (Berkhout, 2005). Climate adaptation is also a good context for studying social learning (Adger, 2003; Collins & Ison, 2009a).

There is growing recognition that adaptation will be needed at multiple scales (Adger, Arnell, & Tompkins, 2005), which may require polycentric institutions. Since climate change impacts will be felt at regional and local scales and policy decisions about global issues like climate change are often made at this level, sub-national policies may be an appropriate approach for implementing climate change adaptation efforts (Galarraga, Gonzalez-Eguino, & Markandya, 2011; Ostrom, 2010; Rabe, 2004; Harrison & Sundstrom, 2010). However, multiple climate change initiatives across several different jurisdictions can also create a lack of coordinated effort and overall effectiveness (Selin & VanDeveer, 2009)(Selin & VanDeveer, 2009). Climate change adaptation is also a useful setting for SES frameworks, because the advent of downscaled climate models allows researchers to analyze the links between climate change risk and uncertainty and climate-related behavior and attitudes (Ostrom, 2010; Adger, 2003). However, while these existing theories and research can inform further policy development of climate change adaptation, it will also be important to consider how existing conservation policies can be changed or incorporated into new policies (Hagerman et al., 2010). Future research should continue to couple natural science research on climate change impacts with social science research on appropriate

responses, risk management, and adaptive capacity to understand the multiple ways in which different communities and settings can respond to potential impacts. However, additional research can focus on understanding the policy networks and processes that may be most effective in facilitating adaptive capacity.

Nanotechnology

Nanotechnology is a growing industry that raises a number of ethical, environmental, human health, and policy questions (Bowman & Hodge, 2006). Though nanotechnology has had a significant investment in research, it remains less developed as a policy issue than climate change adaptation because significant uncertainty has delayed the emergence of strong regulations and policies (Wijnhoven et al., 2009; Bosso, 2010). The novel scale of nanotechnology offers new and unprecedented challenges for thinking about human health and environmental impacts and appropriate control (Fiorino, 2010). Environmental advocates and researchers are now calling for faster policy development and searching for appropriate policy tools to address the unique environmental and human health risks of nanotechnology (Panyala, Pena- Mendez, & Havel, 2008; Kaegi et al., 2008; Seaton et al., 2010).

Many scientists have developed frameworks to consider the multiple issues surrounding nanotechnology. In the early stages of an emerging environmental issue like nanotechnology, an open, experimental, and interdisciplinary model is necessary (Macnaghten, Kearnes, & Wynne, 2005). In their regulatory framework based on Australian regulations, Bowman and Hodge (2006) found regulatory gaps between the commercial advancements in nanotechnology and consumer expectations for safeguards with emerging technologies. Similar frameworks have been developed to better understand how to integrate the social and natural sciences with ethics, health, and policy and to understand potential problems that may cross disciplinary boundaries (Kuzma et al., 2008; Linkov et al., 2009).

Despite academic and practical attempts to create interdisciplinary frameworks (Fisher, 2007; Lee, 2010), most countries have few if any policies in place to deal with nanotechnology from these multiple perspectives (Fairbrother & Fairbrother, 2009; Lee, 2010). The United States National Nanotechnology Initiative is one example of a government program that coordinates efforts to conduct research throughout multiple government agencies; however, only 3.4% of the total 16.5 billion dollar budget over the past decade has been devoted to environmental, health, and safety research (Initiative, 2011). As a result, while the practical applications of nanotechnology have been heavily supported, research to safeguard human and environmental health has been less prominent. Instead of large-scale government policies, voluntary agreements have thus far been the major environmental policy tool employed for nanotechnology. As well, NGOs, including the Wilson Center, have developed inventories to enable information disclosure about products that contain nanomaterials and health and environmental research ("Project on Emerging Nanotechnologies ", 2011). Nevertheless, these initiatives should complement, not substitute, the development of comprehensive government policies (Fiorino, 2010). To facilitate this development, additional research is needed in the natural and social sciences to understand the risk, uncertainty, and potential human health and environmental impacts of nanomaterials, which can inform the development of comprehensive regulations and policies.

Pharmaceuticals and Personal Care Products

Pharmaceuticals and personal care products (PPCPs) have received increasing policy attention related to their potential environmental and human health impacts. (Kannan et al., 2005; Klaschka & Kolossa-Gehring, 2007; Lamas et al., 2009; Peck & Hornbuckle, 2006; Steinemann et al., 2011). In the European Union, an information disclosure policy requires the labeling of 26 particular fragrance chemicals often found in PPCPs with suspected human allergy concerns (Buckley, 2007). The state of California also regulates personal care products for their volatile

organic compound content (Board, 2010). However, in the United States, there are no laws requiring disclosure of the range of chemical products that may enter the environment and human systems (Steinemann, 2009; Steinemann et al., 2011). Among the three emerging issues described here, PPCPs have the least developed research and policy initiatives, potentially as a result of the multiple ingredients involved in such products, adding to their level of complexity. The ubiquity and low dose prevalence of many of these products in the environment present challenges to creating policies and understanding the fate and transport of chemicals.

Empirical research on the effectiveness of existing PPCP policies is still nascent but increasing. The information disclosure approach of the EU "26 allergens rule" does not appear to have had a notable effect thus far. Even though approximately 50% of consumer products contain one of the allergens, the labeling rules have not produced significant change in consumer behavior or industry product ingredient use. A more effective risk management policy could include bans and restrictions of hazardous substances rather than reliance on consumers for risk management in purchasing (Klaschka, 2010). Though there have been numerous articles to examine these policies from a human health perspective (Becerril et al., 2010; De Vader & Barker, 2009), little research has considered the effect of these policies on the environment. As a result, though some initial policies are in place, there has not been the development of larger scale research or policy initiatives at a national scale like adaptation and nanotechnology. Additional scientific research is necessary to better understand the prevalence, fate, and transport of these products to enable the creation of informed, appropriate, and effective environmental policy at a broader scale.

Conclusion

Environmental policy research is coming of age as a subfield of policy sciences. It provides a critical research site for developing economic theories of policy tools and political theories of the policy process. The necessary linkage between human and natural systems provides a platform

for the development of integrative frameworks, interdisciplinary collaboration, and sharing of scientific tools. However, theory can only be advanced through empirical analyses, which continue to broaden in scope and perspective as new problems and policy responses emerge and spread. Methodological advancements, including the better measurement of environmental outcomes, are providing stronger means for hypothesis testing and observation of causal processes.

There will be a continuing demand for environmental policy research, driven, at least in part, by the emergence of new environmental problems. National and international research funding and initiatives increasingly emphasize cross-cutting concepts like sustainability and resilience and call for multidisciplinary teams to address global environmental challenges. Within industry, government, and academia, there is a growing demand for people trained in environmental policy research. Future environmental policy scholars, and the universities, governments, NGOs, and businesses that hire them, need to recognize the importance of this trend. The significant environmental policy researchers of the future will not come from the ranks of students trained narrowly in a single academic discipline. Rather, environmental policy researchers must learn to operate at disciplinary interfaces, borrowing theories and methods as appropriate, while still recognizing how their research contributes to central disciplinary questions. While this is a difficult balancing act, it is one that is necessary to continue the maturation of the environmental policy field in a way that advances knowledge and practice and helps human society solve vexing environmental problems.

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