

# Reflections—In Praise of Consilience

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## Introduction

Specialization, one of the keys to achieving economic efficiency, is of immense importance in explaining why markets have come to occupy such a central role in the modern economy. To choose an example from my own field of interest, cap-and-trade programs owe their success in part to specialization. The flexibility inherent in such programs has the effect of shifting the responsibility for choosing the emissions control method from a government bureaucrat to an environmental manager in a regulated facility. That local manager is likely to have a much better sense of the control options than a less specialized bureaucrat who has responsibility for overseeing a host of facilities that can be quite different in size, in production processes, or even in local conditions. While cap and trade narrows down the choice set to those strategies that are compatible with the policy objective, it does leave the ultimate choice within that set to the specialist.

Educational institutions have long recognized the value of human capital specialization, and graduate programs have thus become more narrowly focused. While the field of economics used to be a part of philosophy, economics graduates now specialize in various sub-fields, such as financial economics, econometrics, and energy economics.

Disciplinary specialization, however, also poses certain challenges. For example, it encourages the development and use of a specialized language (“jargon”). While jargon certainly facilitates communication among those who speak that language, it makes it more difficult to communicate with those who don’t, namely those who have a different specialty.

While specialization does not necessarily imply isolation, I would conjecture that too narrow of a focus could, in principle, pose a threat to innovation. Consider a biological metaphor. Biologists note that species can go extinct even when a breeding population exists if the gene pool contains too little genetic diversity. Inbreeding produces lower survival rates and eventually the nondiverse population dies off.

Now replace genes in this metaphor with ideas. Talking only to our fellow specialists can reduce the diversity of ideas (intellectual inbreeding) and runs the risk that the vitality of the stock of ideas in the specialty will diminish over time.

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We economists, of course, routinely talk about “the marketplace of ideas,” where ideas compete and those that command the most support rise to the surface. But that interaction is different from the one that forms the basis for this “Reflections” column.

Here, I am raising the simple question of whether, given a fixed amount of time, crossing disciplinary boundaries can make sense or whether time is always better spent digging deeper within the boundaries of the specialty. Obviously, both approaches are valuable, and I don’t want to try to force a false dichotomy here. But I do have the sense that historically speaking, crossing disciplinary boundaries is treated with less respect than a deeper, narrower focus. My own personal experience suggests that boundary crossing can be very productive.

The title of this “Reflections” derives from this sense of the value of the cross-fertilization of ideas across disciplinary boundaries. In this context, “consilience” refers to the linking together of principles from different disciplines to form new constructs. In this column I examine the role of consilience in bringing new ideas to the management of natural resources and the environment and the extent to which it has influenced modes of analysis and policy. Ultimately, I find that the cross-fertilization of ideas has been quite important in creating a number of innovative new methodologies, new perspectives, and even new policy instruments. Using a host of specific examples, I examine not only how economics has been enriched by ideas that originated in other disciplines but also how economics has enriched other disciplines concerned with the management of natural resources and the environment. I close by sharing some thoughts on the conditions under which consilience can prosper as well as some thoughts on the future.

## How Other Fields Have Enriched Economics

Over the course of my career I have observed several very useful additions to our field that originated in other disciplines.

### Mathematics

The most profound, widespread, and durable contributions to economics have come from mathematics. Works by Samuelson (1947), Hicks (1946), Arrow and Debreu (1954), Kantorovich (1939), and Koopmans (1957), for example, were all grounded in mathematics. Their work allowed for the formalization and generalization of economic propositions in a manner that identified the necessary and sufficient conditions for efficiency to be achieved, for dynamic models of economic growth to be developed, and for empirical methods to be derived that were capable of teasing meaningful relationships out of uncontrolled, real-world data. With the new math, it became possible to characterize general equilibrium outcomes rather than partial equilibrium outcomes, and once computing power rose sufficiently, it also laid the groundwork for the computable general equilibrium models that are now common in the field.

The importance of these individuals’ contributions cannot be overemphasized, as evidenced not only by the fact that they were all awarded Nobel Prizes in economics<sup>1</sup> but also by the fact that the ranks of the early winners of the Nobel Prize in Economics were

<sup>1</sup>The Nobel Prize in Economics is known formally as the Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel. I shall use the more common, popular reference here.

dominated by those trained at least somewhat in mathematics (or physics). The diffusion of these new insights and methodologies throughout the field of economics occurred not only because some pioneers took the time (and the risk) to cross the boundary between mathematics and economics to apply these new techniques but also because they had the wisdom and foresight to discern how and where these novel methods could be profitably employed within the set of ideas commonly examined by economists.

The initial foundation laid down by mathematics was followed by the development of the theory of cooperative and noncooperative games (as recognized by the 1994 Nobel Prize awarded to John C. Harsanyi, John F. Nash Jr, and Reinhard Selten, and the 2005 prize awarded to Robert J. Aumann and Thomas C. Schelling). This in turn was followed by the development of mechanism design theory<sup>2</sup> (as recognized in the 2007 Nobel Prize awarded to Leonid Hurwicz, Eric S. Maskin, and Roger B. Myerson).

### Modeling Spatial Relationships

During the early 1970s, spatial relationships in pollution control were mainly implicit in economic models. For example, the impact of emissions from a particular polluter on concentration levels downstream depends, among other things, on the location of the emitter vis-à-vis the location of the target concentration. The models at that time captured this relationship by using a transfer coefficient that depended on the relative location of the emissions. Spatial relationships were embedded implicitly in those coefficients, but otherwise the models did not include spatial characteristics for the emitting facilities.

Fast forward to today with our increasing reliance on geographic information systems (Bateman *et al.* 2002) and spatial econometrics (Anselin, Florax, and Rey 2004), which explicitly model spatial relationships. These technological advancements were made possible in no small part by software and data management systems originally designed for other disciplines. This more sophisticated treatment of space has added considerably to fields of inquiry associated with land use (Geoghegan, Wainger, and Bockstael 1997), fisheries management (Holland *et al.* 2004), and valuation (Bockstael *et al.* 1995), among many others.

In some subfields of environmental and resource economics, models that use a richer treatment of spatial relationships produce results that differ from those produced by models that ignore spatial relationships (Paterson and Boyle 2002). While it is certainly true that not every methodological innovation produces “better” results, the fact that the results are different is valuable in and of itself because it opens the door to discussions about the sources of those differences and whether they are meaningful enough to change or augment the way we analyze issues and problems.

### Psychology

Our field has obviously also been influenced in a major way by psychology. Two prominent examples include the influence of psychologists on the booming subfield of nonmarket valuation and the rise of behavioral economics. One psychologist in particular, Daniel

<sup>2</sup>Mechanism design is a field within game theory that examines solution concepts for a class of private information games. Applications of mechanism design theory have led to breakthroughs in a number of other areas of economics as well, including regulation, corporate finance, and the theory of taxation.

Kahneman, won the Nobel Prize in Economics for his contributions to these fields.<sup>3,4</sup> His work on prospect theory (Kahneman and Tversky 1979) and framing (Tversky and Kahneman 1981) was influential in shaping the way economists think about decision making under uncertainty. In the nonmarket valuation context, Kahneman's work was influential in showing how the framing of questions in stated preference approaches can affect responses (Alevy, List, and Adamowicz, 2011).

In behavioral economics, Kahneman's work was influential in helping to explain how the outcomes from human choices can deviate in important ways from the expectations created by the standard economic model of rational choice. One commonly cited example, "the loss aversion principle," finds that, contrary to conventional expectations, the disutility of giving up an object is greater than the utility associated with acquiring it (Kahneman, Knetsch, and Thaler 1991; Benartzi and Thaler 1995). Another example, the "status quo bias" (Samuelson and Zeckhauser 1988), notes that individuals have a strong tendency to resist change because the disadvantages of change seem larger than the advantages.

These insights are being used to develop new approaches (or "nudges") to facilitate decisions where consumers may not act in their own best interest. Behavioral approaches have now been developed to facilitate decision making in such diverse fields as finance and health care, and have even been proposed as one pathway for improving marriage (Thaler and Sunstein 2008).

Perhaps of more interest to the readers of this journal is a recent review illustrating the use of behavioral nudges to promote energy efficiency. In one example, Allcott and Mullainathan (2010) describe how a private company, working with a utility, designed and sent home energy use reports to electricity and gas consumers that not only explicitly compared the household's energy consumption with that of similar households but also provided energy conservation tips. According to the authors, randomized, controlled trials involving hundreds of thousands of utility customers across the United States have found that making this specific information available to consumers is a cost-effective way to reduce electricity consumption.

Some interesting insights about how ideas in one discipline can be successfully transplanted to, and indeed flourish in, another discipline can be found in Daniel Kahneman's (2010) autobiography, which is available on the Nobel Prize Web site.<sup>5</sup> First, his seminal paper on prospect theory was published in *Econometrica*, where it would gain more exposure to economists than it would have had it been published in a psychology journal. Second, as his research continued, he was able to connect with economists who would be very influential not only in the diffusion of the basic ideas of prospect theory but also in their refinement, particularly in an economic context. Kahneman specifically names Richard Thaler and Jack Knetsch as economists who not only inspired him but also demonstrated some of the deeper implications of his models for economic analysis.

<sup>3</sup>The 2002 prize was shared with Vernon Smith for his pioneering work on designing economic experiments, another area where consilience seems to have played a role.

<sup>4</sup>Kahneman's acknowledged partner in the discoveries that led to his Nobel Prize (Amos Tversky) did not share in the prize because by that time he was deceased and the prize is no longer awarded posthumously.

<sup>5</sup>[http://nobelprize.org/nobel\\_prizes/economics/laureates/2002/kahneman-autobio.html](http://nobelprize.org/nobel_prizes/economics/laureates/2002/kahneman-autobio.html) (accessed July 30, 2010).

## How Economics Has Influenced Other Environmental Fields

While other disciplines have had important effects on economics, this is only part of the story. Economic thinking has also crossed boundaries to influence other disciplines.

### Law

One of the main areas where economic ideas have enriched other disciplines is in the field of law. One of the most obvious signs of this influence is the fact that most, if not all, prominent law schools now have one or more economists on the faculty.

The field of economics has a long history of making contributions to the law. The “institutional economics” school, which began to take shape with the writings in Thorstein Veblen’s *The Theory of the Leisure Class: An Economic Study of Institutions* (1899), focused more specifically on law and economics after the publication of John R. Commons’s influential book *Legal Foundations of Capitalism* (Commons 1924). This school emphasized that legal institutions are an important part of the evolution of the economy. At that time, legal institutions were a black box to most economists, but the institutionalist school attempted to open the box, a field of inquiry that ultimately laid the foundation for 2009 Nobel Laureate Oliver Williamson’s pioneering work on firm decision making (Williamson 1985).

The main early emphasis of the field of law and economics was on traditional economic questions in which lawyers had some interest. These included the regulation of natural monopoly, taxation, antitrust legislation, and so on. In these fields, the legitimacy of bringing economic thought to the table seemed self-evident.

More recent foci in the field of law and economics have not abandoned these traditional questions as much as they have enlarged the scope of inquiry to include a host of questions traditionally considered out of the domain of economics, such as allocating liability for accidental or intentional harm, the efficiency of various types of legal procedures, explaining the proper balance between regulation and common law approaches to risk management, and suggesting ways in which the legal system could be reformed (Shavell 2004). Whereas in its early years the field of law and economics focused mainly on administrative law or statutes, more recently the emphasis has shifted to include the common law.

### The Common Law

The common law consists of a set of adjudicatory principles that have been derived from rulings in specific cases. In this bottom-up process for rule formation, the principles emerge from specific conflicts in court cases involving very specific fact situations through a process known as *stare decisis*. In this legal doctrine, earlier rulings from equal or appellate courts in the same jurisdiction carry precedent value—that is, the judges subject to the precedent are expected to give it considerable deference in their rulings. Precedent does not have to be blindly followed, however. When, for example, the current case features a differentiating fact situation or context, the judge may create a refinement or an exception to the precedent. Judges in jurisdictions other than the one where the precedent was decided are not bound by that precedent but they may still find it persuasive enough to cite in their rulings.

Readers are certainly entitled to wonder what insights economics can contribute to the common law. At first glance, any attempt to smoothly integrate the rather different

worldviews of economics and the common law would appear to be fraught with peril. After all, the common law in tort cases<sup>6</sup> (e.g., an oil spill) involves fact situations where the consequences of an accident have already been determined (as opposed to a regulation or statute, which attempts to specify behavior in advance). Furthermore, while the common law principles are derived from a bottom-up process, normative economic analysis involves the application of a top-down criterion—economic efficiency. And finally, while the courts are seen as dispensing justice, the efficiency criterion of economics attempts to allocate resources to their highest and best use.

These differences, while profound, are not definitive. Let's examine more closely each of the above differences between the common law and economics.

Clearly, the fact that tort cases commonly involve situations where the consequences have already been manifested means that the ruling cannot undo or prevent that specific harm; in this case, the ruling merely allocates the financial responsibility for that harm. The entry point for economics emerges from the ability of this ruling to create a precedent that, once established, will provide strong incentives for future behavior. For example, if an oil company understands (due to the precedent) that causing an oil spill triggers a legal requirement to compensate harmed parties, it has an incentive to take precautions. Thus, because of *stare decisis*, tort cases do not simply allocate fixed costs; they create precedents that affect future resource allocation incentives.

Similarly, top-down and bottom-up processes do not inherently lead to principles that are incompatible. While compatibility is certainly not assured, neither is incompatibility. Whether these specific processes produce compatible principles can be determined through experience.

Finally, as Guido Calabresi, a lawyer who ultimately went on to become the dean of the Yale Law School, pointed out in his classic early book *The Costs of Accidents: A Legal and Economic Analysis* (Calabresi 1970), economic analysis can be used to examine whether the precedent creates incentives that are compatible with an efficient allocation of the risk of an accident. The rules that emerge from this efficiency analysis turn out to be quite compatible with the actual rules that have emerged from the *stare decisis* process, despite its presumed focus on justice.

The reason for this compatibility between the rules prescribed by justice and those prescribed by efficiency, despite their quite different perspectives, becomes more apparent upon closer inspection. A focus on justice typically leads courts to place responsibility on the party causing the harm. A focus on efficiency leads economists to internalize the externality. Internalizing the externality is normally accomplished by forcing the responsible party to bear all the costs, including the harm from its actions.

Interestingly, a ruling that is “just” in the sense that it allocates responsibility to the party causing the harm can also be efficient in the sense that (due to its precedent value) it can create incentives that minimize the total expected costs from accidents by providing an efficient balance between the costs of precaution and any remaining expected damages.

If these two rather different approaches lead to similar prescriptions, then why bother with applying economic principles to the law? Professor A. A. Leff (1974), in an early (highly critical) review of the path breaking text by Richard A. Posner (1972), *Economic Analysis of Law*,

<sup>6</sup>Tort law involves civil (as opposed to criminal) proceedings to provide relief to plaintiffs who have experienced a harm caused by an action or actions by the defendant.

suggests that some lawyers have responded positively to this new economics approach to the law because it gets away from an age old problem introduced by the legal positivists—the haunting realization that justice is what the judges say it is. Rather than the more comfortable situation in which judges apply universal standards so that everyone with an equal acquaintance with those standards would reach the same decision, the legal profession has been faced with the charge that judges are imposing their values on others. This, states Leff, is disquieting for the legal profession. As he put it in his review:

There arose a great number of schools of ethics—axiological, materialistic, evolutionary, intuitionist, situational, existentialist, and so on—but they all suffered the same fate: either they were seen to be ultimately premised on some intuition (but-tressed or not by nose counts of those seemingly having the same intuitions), or they were even more arbitrary than that, based solely on some “for the sake of argument” premises. I will put the current situation as sharply and nastily as possible: there is today no way of “proving” that napping babies is bad except by asserting it (in a louder and louder voice), or by defining it as so, early in one’s game, and then later slipping it through, in a whisper, as a conclusion. (p. 454)

Then Professor (now Judge) Richard A. Posner and others entered the scene with a powerful set of tools that rationalizes many of the common law principles by finding them consistent with a universal standard—economic efficiency. This standard also provides a pathway for reforming the principles in those cases where they might be found to impose unnecessary costs on society. Leff (1974) suggests that some believe that this approach appears to get the legal profession out of its bind. While many authors, including Leff, find this appearance misleading or at least incomplete, this disciplinary fusion has nonetheless produced some revealing new insights and some useful new policy constructs.

### **Property Law**

Property law has also benefited from a cross-fertilization of ideas from economics. In particular, the evolution of the concept of a property right from a rather simple legal recognition of ownership to a multiattribute bundle of entitlements held by the owner has paved the way for a number of new policies (Schlager and Ostrom 1992). One innovation drawn from economics involves separating the various attributes of property and allowing them to be traded independently from the master property from which they were derived. Another involves the creation of new legal property rights for attributes of property that had never before been treated as property themselves.<sup>7</sup> Yet a third, pioneered by Elinor Ostrom (1990, 1998, 2009), 2009 Nobel laureate in economics (and a political scientist), involves examining how the specific structure of property rights, both formal and informal, affects the way that shared resources are governed and used. These new approaches are discussed in more detail below.

<sup>7</sup>Due to space limitations, only a sampling of the possibilities will be discussed here. One little known but important omission is ISO New England’s Forward Capacity Market, which uses a bidding process to integrate energy efficiency and generation expansion into future plans for meeting expected electrical energy demand (Peterson *et al.* 2006).

## Emissions Trading

One example of the creation of new property rights is, of course, emissions trading or its current formulation, cap and trade. By the late 1950s, both economists and policy makers had formed quite well developed and deeply entrenched visions of how pollution control policy should be conducted. Unfortunately, these two visions were worlds apart.

The mainstream economic view at the time viewed the world through the eyes of Pigou (1920), who had argued that in the face of an externality, such as pollution, the appropriate remedy involved imposing a per-unit tax on the emissions from a polluting activity. The tax rate would be set equal to the marginal external social damage caused by the last unit of pollution at the efficient allocation. Faced with this tax rate on emissions, firms would internalize the externality. By minimizing their own costs, firms would simultaneously minimize the costs to society as a whole. Thus, according to the mainstream economic view in the late 1950s and 1960s, rational pollution control policy involved putting a tax on pollution.

On the other hand, U.S. policy makers in the 1950s and 1960s preferred to control pollution through a series of legal regulations, ranging from controlling the location of polluting activities to the specification of emissions ceilings (Kneese and Schultze 1975).

The result was a standoff in which policy makers focused on quantity-based policies while economists promoted price-based remedies (Kneese and Schultze 1975). During the standoff, the legal regimes prevailed, and hence taxes made little headway.

The situation changed in 1960, when Ronald Coase, also a Nobel laureate in economics, published a remarkable article in which he sowed the seeds for a rather different mindset (Coase 1960). Arguing that Pigou's analysis had an excessively narrow focus, Coase proposed that by making property rights explicit and transferable, the market could play a substantial role, not only in valuing these rights but also in assuring that they gravitated to their highest and best use. To his fellow economists, Coase pointed out that a property rights approach allowed the *market* to value the property rights (as opposed to the *government* in the Pigovian approach). To policy makers, Coase pointed out that the legal regimes in effect at the time provided no incentives for the rights to flow to their highest valued use, and hence pushed compliance costs higher than necessary.

The appeal of emissions trading comes from its ability to create incentives that are compatible with achieving a prespecified environmental target at minimum cost even in the absence of any regulator information on control costs. As long as marginal abatement costs of complying emitters differ, incentives for trade exist. Firms with high marginal abatement costs buy permits from firms with low marginal costs until the market clears and the demand for permits equals the fixed supply.

Emissions trading is an idea that has had a considerable impact on policy. From its use to control the phasedown of lead in gasoline (Nussbaum 1992; Newell and Rogers 2007), both the sulfur (Stavins 1998; Keohane 2007) and the nitrogen oxide emissions (Farrell, Carter, and Raufer 1999; Farrell 2001) responsible for acid rain, California smog (Harrison 2004), and, finally, carbon dioxide emissions in Europe and the United States (Tietenberg 2010), emissions trading has been a key component of a number of air pollution control programs.

### Renewable Energy Credits

The creation of renewable energy credits (RECs) provides another example of both of the novel aspects of property law mentioned in the opening of this section. A generator of electricity from a renewable source (such as wind or photovoltaics) can produce two saleable commodities. The first is the electricity itself, which can be sold to the grid, while the second is the REC that turns the environmental attributes (such as the fact that it was created by a qualifying renewable source) into a legally recognized form of property that can be sold separately.<sup>8</sup>

The demand for these credits comes from diverse sources, but the most prominent are (1) voluntary markets, involving consumers or institutions that altruistically choose to support green electricity, and (2) compliance markets, involving electricity generators that must comply with a renewable energy standard.

Some states with restructured electricity markets authorize voluntary markets in which households or institutions can directly buy green power, if offered (typically at a higher price) by their generator, or purchase RECs if their current provider does not offer green power. This allows consumers or institutions to lower their own carbon footprint since the REC they purchase and retire represents a specific amount of avoided greenhouse gas emissions. Educational institutions, for example, are incorporating the purchase of RECs into their strategies for achieving the goal of carbon neutrality that was adopted after signing onto the American College and University Presidents' Climate Commitment (2010).

The compliance market, which is apparently larger than the voluntary market (Holt and Bird 2005), has arisen because some states have imposed renewable energy standards on generators. Requiring that a certain percentage of electricity in the jurisdiction be generated from qualified renewable power sources, these standards can be met either by actually generating the electricity from qualified sources or by purchasing a sufficient number of RECs from generators that have produced a higher percentage from those sources than the mandate. By providing flexibility in how the mandate can be met, RECs lower the compliance cost, not only in the short run (by allowing the RECs to flow to the areas of highest need) but also in the long run (by making renewable source generation more profitable than it would otherwise be in areas not under a renewable energy mandate).

As of 2010, some thirty-eight states and the District of Columbia had a renewable energy standard (North Carolina State University 2010) and a majority of those included REC programs. Clearly, this is an innovation that has penetrated the policy arena on quite a large scale.

### Transferable Development Rights and Conservation Easements

Moving on to an entirely different area of property law, two relatively new rights, transferable development rights (TDRs) and conservation easements, are aimed at preserving land and involve separating one attribute of land ownership—the right to develop—from the land itself. TDRs allow a development right derived from one location to be used in another, while conservation easements allow the transfer of the right to develop to an organization (usually a land trust) that will retire it (thereby preserving the land).

<sup>8</sup>Generally, renewable generators create one REC for every 1,000 kWh (or, equivalently, 1 MWh) of electricity placed on the grid.

Owners of land are typically opposed to zoning ordinances designed to promote preservation, even if efficiency suggests that the land should be preserved, because they bear all the costs of preservation while society as a whole reaps the benefits. TDRs attempt to change this dynamic.

TDR programs are a method for shifting residential development from one portion of a community to another, whereby local units of government identify *sending areas* (where development is prohibited or discouraged) and *receiving areas* (where development is encouraged). Landowners in sending areas are allocated development rights based on criteria identified in adopted plans. Generally, the allocation depends upon the number of developable sites available on the landowner's property in the absence of the zoning law. Developers seeking to develop a parcel in a receiving area must first buy a certain quantity of development rights from landowners in a sending area. In principle, the revenue from selling these rights compensates the sending area owners for their inability to develop their land and, hence, makes them more likely to support the zoning restrictions. TDRS are thus viewed as a means of preserving land without burdening the public budget and without imposing an unfair distribution of the costs. The price of these rights is determined by the market, although the market is certainly affected by such administrative decisions as how many rights are granted to each sending landowner and how many are required for development in the receiving areas.

Conservation easements are another increasingly popular approach to preserving land. A conservation easement is a legal agreement between a landowner and a private or public agency that limits uses (usually including, but not necessarily limited to, the right to develop that land) of a specified parcel of land in order to protect its conservation values. In essence, this document turns the right to develop the land into a form of property that can be separated from the land to which it refers. By acquiring and holding that right, the land trust denies current or subsequent owners of the property the right to develop that land.

Once created, conservation easements can be either sold or donated. If the donation is deemed to benefit the public by permanently preserving important resources and meets other federal tax code requirements, it can qualify as a charitable tax deduction. The tax-deductible amount is the difference between the land's value with and without the easement.

Separating out the development rights may allow the value of the entire bundle of rights to the land to be increased, while simultaneously preserving the land. Conservation easements are voluntary transactions, with consent required for any transfer. Thus, no one is forced to part with his or her development rights. Moreover, by focusing only on the development rights associated with the land, this approach allows land trusts to preserve land from development much more cheaply than would be possible if the only option were to purchase the land itself.

## Ecology and Biology

Perhaps it is not surprising, especially given their common prefix, that ecology and economics have been able to achieve a symbiotic relationship. Indeed, the fusion of economics with ecology and related fields, such as conservation biology, seems to offer such great promise that it has spawned both a professional association (the International Society of Ecological Economics) and its own journal (*Ecological Economics*). The journal was founded by a systems

ecologist (Robert Costanza), but its current editor-in-chief is an economist (Richard Howarth).<sup>9</sup>

### Valuing Ecosystem Services

One of the first major efforts that emanated from the joint field of ecological economics was an attempt to derive the aggregate value of global ecosystem services (Costanza *et al.* 1987). Although both the methods used and the magnitudes derived generated their share of controversy (Toman 1998), the general notion that ecosystem services are economically valuable has persisted.

One of the subfields of biology that has vigorously followed up on this notion that ecosystem services are economically valuable is conservation biology, a field that focuses on the science and practice of conserving the Earth's biological diversity. Specifically, if payment mechanisms could be designed so that these ecological services would actually receive revenue from beneficiaries that reflected their true economic contribution, then that revenue could provide the funding for increasing, preserving, and/or protecting those services.

One of the pioneers in this field, Gretchen Daily, the director of the Center for Conservation Biology at Stanford, published a book in 2002 with Katherine Ellison entitled *The New Economy of Nature: The Quest to Make Conservation Profitable*. The book presents a series of cases in which individuals and/or programs use economic principles to promote biological conservation.

For example, in the introduction to the book, Daily relates the story of how, following the passage of the Safe Drinking Water Act, New York City was faced with the possible need to build a \$6–8 billion filtration plant that would involve operating and maintenance costs of \$300–500 million per year. In 1997, the city was able to negotiate a five-year agreement with the U.S. Environmental Protection Agency (EPA) to implement a \$1.5 billion watershed protection program that would enhance the natural ecosystem water protection services sufficiently to obviate the need for the filtration plant. The plan involved buying tracts of land as buffers and upgrading sewage treatment plants. Under this agreement, the EPA would defer a mandate for the filtration plant as long as the water met stipulated standards. Ten years later, in 2007, the EPA announced that it would continue to allow the city to enjoy unfiltered drinking water from the Catskill/Delaware system for an additional ten-year period, provided that the city continued to ensure the excellent quality of the water from this enhanced ecosystem service system.

### Forest Habitat Preservation and Reducing Emissions from Deforestation and Forest Degradation

One of the potentially largest programs in conservation biology that is applying economic ideas concerns using the reduction of greenhouse gas emissions to finance forestry habitat preservation. According to the United Nations, deforestation and forest degradation, through agricultural expansion, conversion to pastureland, infrastructure development, destructive logging, fires, and so on, account for nearly 20 percent of global greenhouse gas

<sup>9</sup>Based on its ISI impact factor, the journal appears to be quite influential. Its five-year impact factor is 2.858, compared to 2.967 for the *Journal of Environmental Economics and Management*.

emissions, more than the entire global transportation sector and second only to the energy sector.

To address this threat, the United Nations has established a program to decrease greenhouse gas emissions by reducing the forest degradation in developing countries that are responsible for them (<http://www.un-redd.org/>). Reducing Emissions from Deforestation and Forest Degradation (REDD) is an effort to create a financial value for the carbon stored in forests, thus offering incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable development. Under this program, countries would receive payments for emission reduction credits that are based on actual reductions in forest emissions measured against agreed-upon baselines (Tacconi 2009). Although the details of the program remain to be worked out, these credits could, in principle, be sold in the international compliance carbon markets (where they could be used in combination with domestic reductions to meet assigned national targets) or in the voluntary carbon markets (where they could be used to pursue other organizational goals, such as lowering a country's carbon footprint or even pursuing carbon neutrality).

The challenges to REDD, however, are far from trivial and include the necessity of establishing baselines that are both fair and effective and assuring that monitoring and verification procedures are sufficiently rigorous to provide accurate measures of actual emissions reductions.

### **Mitigation and Conservation Banking**

One market-based policy instrument designed specifically to preserve wetlands in the face of development pressure is known as wetlands mitigation banking. This program provides incentives for creating off-site “equivalent” wetlands services when adverse impacts are unavoidable and when on-site compensation is either impractical or the use of a mitigation bank is environmentally preferable to on-site compensation. Mitigation banks focus on wetlands, streams, or other aquatic resource areas that have been restored, established, enhanced, or (in certain circumstances) specifically preserved for the purpose of providing compensation or offsets for unavoidable impacts to aquatic resources. According to the EPA, “The objective of a mitigation bank is to provide for the replacement of the chemical, physical, and biological functions of wetlands and other aquatic resources which are lost as a result of authorized impacts.”<sup>10</sup>

A mitigation bank may be created when a government agency, corporation, nonprofit organization, or other entity undertakes mitigation activities under a formal agreement with a regulatory agency. The value of those activities is defined in “compensatory mitigation credits.” In principle, the number of credits available for sale is based upon the use of ecological assessment techniques to certify that the credited areas provide the specified ecological functions (Doyle and Yates 2010). Establishing these banks allows the responsibility for compensatory mitigation to be assumed by someone other than the party who, by causing an adverse impact to a wetland, is required by law to provide mitigation. Thus, mitigation banks involve a form of “third-party” compensatory mitigation.

How has this program performed? As one recent review (Salzman and Ruhl 2006) concludes:

<sup>10</sup><http://www.epa.gov/owow/wetlands/facts/fact16.html>.

Despite policies mandating that habitat trading ensure equivalent value and function, the experience is that most programs are not administered this way. In practice, most habitat trades to date in wetlands programs have been approved on the basis of acres, in many instances ensuring equivalence in neither value nor function.

This experience is instructive. Effective trading assumes that the tradable commodities are homogeneous. When they are not, the mitigation banking trades may reduce a developer's cost but degrade the environment in the process (Shabman, Stephenson, and Scodari 1998).

Another market-based policy, conservation banking, extends the concept of transferable credits to endangered and threatened species conservation, albeit with a few twists (Wissel and Watzold 2010). While the goal of wetlands mitigation banking is to replace the exact function and values of the specific wetland habitats that would be adversely affected by a proposed project, the goal of conservation banking is to offset the adverse impacts on a specific species.

More specifically, a conservation bank is a parcel of land containing natural resource values that are conserved and managed in perpetuity, through a conservation easement held by an entity responsible for enforcing the terms of the easement. Banks are established for specific species (listed under the Endangered Species Act) and are used to offset impacts on those species that occur on nonbank lands. The values of the natural resources are translated into quantified "credits." Project proponents are, therefore, able to fulfill their conservation requirements through a one-time purchase of credits from the conservation bank.

A survey published in 2005 (Fox and Nino-Murcia 2005) found seventy-six properties in the United States that had been identified as conservation banks, but only thirty-five of these had been established under a conservation banking agreement approved by the U.S. Fish and Wildlife Service. The thirty-five official conservation banks together cover more than twenty-two species listed under the U.S. Endangered Species Act (Fox and Nino-Murcia 2005).

### Concluding Reflections: Fostering Consilience

When and how does the type of consilience examined in this "Reflections" arise? The examples described above suggest a few possibilities. First, of course, the ideas must have value in other disciplines. Second, pioneers who are familiar with both disciplines must not only recognize the value of these ideas in the new context but also facilitate planting them and demonstrating their relevance to the new audience. In part, this involves making sure the new audience is exposed to these ideas by publishing them in journals read by that audience. But that alone is clearly not sufficient. A core of researchers drawn from the new audience must also be sufficiently attracted by these ideas so that they provide a foundation for a durable presence.

Even cross-disciplinary ideas that establish a beachhead in multiple disciplines do not automatically affect, much less transform, policy. My own experience with cap and trade, reinforced by subsequent experience with some of the other examples I have cited here, leads me to believe that those who have the power to shape policy must also be receptive to the changes inherent in these new (and innovative) ideas and methodologies. As with most clichés, the

saying “you can lead a horse to water, but you can’t make it drink” does contain an important grain of truth.

I believe that cap and trade entered the policy arsenal not because everyone was captivated by the idea but rather because it arose at a time when the traditional regulatory system didn’t really know where else to turn. A good sense of timing may turn out to be an important predictor of acceptance, but experience with early versions may matter as well. It is entirely possible, for example, that the experience with earlier emissions trading programs (such as the lead phaseout program and, ultimately, the sulfur allowance program) paved the way not only for international and regional carbon trading but also for quite different programs such as RECs.

While we have no way of knowing whether the optimal amount of consilience is occurring, we seem to have no shortage of pioneers who are willing and able to perform the bridging role that seems so important. From my perspective, that is both a comforting thought and a promising trend.

As indicated by both its prominence in the work of Nobel Prize winners and the degree to which some of these cross-disciplinary ideas have created a sustained following and become enshrined in policy, consilience seems to have impacted both economics and fields related to economics. Nonetheless, I hope this “Reflections” makes clear that, while the policy innovations forged through consilience do add usefully to the menu of policy choices, they certainly do not inevitably dominate more traditional choices. New markets, such as those described above, have both strengths and weaknesses. How well these policy innovations fit into the context where they are applied also matters. The fact that tradable permits work well for certain types of pollution does not mean they will work well for all. And, as the experience with mitigation banking demonstrates, applying tradable permits in an environment where the tradable commodity is much less homogeneous introduces a much higher degree of complexity.

A maturation process is frequently necessary before these new market-based instruments can begin to live up to the early expectations. It is possible that some may never live up to those expectations and that those that do may be appropriate only in specific (perhaps narrow) contexts. Only time will tell whether these innovations will ultimately meet the expectations created by theory, but in any case, the expansion of ideas and options that consilience fosters seems to be a useful end in and of itself.

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