

K. A. TAIPALE

JUNE 2003 V.O.5B

[HTTP://WWW.ADVANCEDSTUDIES.ORG/PAPERS/AGENTOFCHANGE.PDF](http://www.advancedstudies.org/papers/agentofchange.pdf)



**INFORMATION TECHNOLOGY AS AGENT OF CHANGE
IN ENVIRONMENTAL POLICY**



CENTER FOR ADVANCED STUDIES WORKING PAPER NO. 05-2003

INFORMATION TECHNOLOGY AS AGENT OF CHANGE IN ENVIRONMENTAL POLICY

CAS WORKING PAPER No. 05-2003 • JUNE 2003 v.0.5B
[HTTP://WWW.ADVANCEDSTUDIES.ORG/PAPERS/AGENTOFCHANGE.PDF](http://www.advancedstudies.org/papers/agentofchange.pdf)



ABSTRACT

ARTICLE: 32,000 WORDS

INCREASED DISSATISFACTION WITH THE EFFICACY, EFFICIENCY AND EQUITY OF THE EXISTING COMMAND-AND-CONTROL SYSTEM FOR ENVIRONMENTAL REGULATION HAS LED TO AN INCREASED CALL FOR NEW APPROACHES TO ENVIRONMENTAL PROBLEMS, IN PARTICULAR, DECENTRALIZED ENVIRONMENTAL REGULATION INCORPORATING ECONOMIC INCENTIVE MECHANISMS.

THIS ARTICLE EXAMINES SOME OF THE STRUCTURAL CHARACTERISTICS, STRENGTHS AND WEAKNESSES OF THE EXISTING SYSTEM OF COMMAND-AND-CONTROL REGULATION; COMPARES THOSE WITH THE FEATURES EXHIBITED BY ECONOMIC INCENTIVE STRATEGIES; AND IDENTIFIES HOW SUCH STRATEGIES MIGHT BE ENABLED BY THE EMERGENT DIGITAL INFORMATION TECHNOLOGIES.

IT IS THE THESIS OF THIS ARTICLE THAT INFORMATION TECHNOLOGY CAN ACT AS AGENT OF CHANGE IN ENVIRONMENTAL POLICY, IN PARTICULAR, BY IMPROVING INFORMATION FLOWS FOR IDENTIFYING AND MONITORING ENVIRONMENTAL HARMS, MODELING CAUSATION, AND LOWERING TRANSACTION COSTS FOR INCENTIVE-BASED MECHANISMS AS WELL AS FOR TRADITIONAL REGULATORY AND COMMON LAW METHODS.

WE CONCLUDE THAT CENTRALIZED FEDERAL RESOURCES SHOULD BE FOCUSED INCREASINGLY ON ENHANCING INFORMATION FLOWS (BY INVESTING IN AND DISSEMINATING ENVIRONMENTAL INFORMATION AND SCIENTIFIC RESEARCH AS WELL AS TECHNOLOGIES FOR IDENTIFYING, MONITORING AND UNDERSTANDING ENVIRONMENTAL PROBLEMS) AND TO LOWERING TRANSACTION COSTS FOR COOPERATIVE OR PRIVATE LAW RESOLUTION (BY ENCOURAGING THE CREATION OF DECENTRALIZED MECHANISMS WITH AN EMPHASIS, WHERE APPROPRIATE, ON LETTING MARKETS EXIST AND SET PRICES FOR ENVIRONMENTAL HARM, BENEFIT AND ABATEMENT).

ABOUT THE AUTHOR

K. A. TAIPALE

B.A., J.D. (NEW YORK UNIVERSITY), M.A., M.ED., LL.M. (COLUMBIA UNIVERSITY)

EXECUTIVE DIRECTOR, THE CENTER FOR ADVANCED STUDIES IN SCIENCE AND TECHNOLOGY POLICY
SENIOR FELLOW, WORLD POLICY INSTITUTE

ACKNOWLEDGEMENTS

THE AUTHOR WOULD LIKE TO THANK PETER LEHNER, CHIEF OF THE ENVIRONMENTAL PROTECTION BUREAU, OFFICE OF THE NEW YORK STATE ATTORNEY GENERAL, [OTHERS IN FORMATION] FOR THEIR COMMENTS.

COPYRIGHT NOTICE

COPYRIGHT K. A. TAIPALE © 2003.

TABLE OF CONTENTS

| | | |
|-----------|--|----|
| PART I. | <u>INTRODUCTION</u> | 1 |
| PART II: | <u>FROM COMMON LAW TO THE REGULATORY STATE</u> | 11 |
| PART III: | <u>ECONOMIC INCENTIVE SYSTEMS</u> | 22 |
| | PIGOUVIAN MECHANISMS | |
| | COASIAN MECHANISMS | |
| PART IV: | <u>INFORMATION TECHNOLOGY AS AGENT OF CHANGE</u> | 47 |
| | MONITORING | |
| | ANALYZING | |
| | DISTRIBUTING | |
| | MANAGING MARKETS | |
| | COALITION BUILDING | |
| | INFORMATION TECHNOLOGY AS AGENT OF CHANGE? | |
| PART V: | <u>CONCLUSION</u> | 69 |



INFORMATION TECHNOLOGY AS AGENT OF CHANGE IN ENVIRONMENTAL POLICY



I. INTRODUCTION.

It is by now cliché to assert that environmental regulation is necessitated by market failures in accounting for externalities and for the consumption of common goods. Externalities shift pollution costs from the producer to others¹ and the unfettered consumption of common goods can lead to the so-called “tragedy of the commons”.²

* B. A., J.D. (New York University) M.A., M.Ed., LL.M. (Columbia University)
Executive Director, Center for Advanced Studies in Science and Technology Policy.
Email: papers-aoc@advancedstudies.org • Bio: <http://taipale.info/>.

¹ The concept of externalities can be defined in conventional neoclassical economics as follows:

An *economic externality* may be viewed as an economic gain or loss accruing to one or more recipient agents as a result of an economic action initiated by another agent – with the gain or loss not being reflected in the market price.

Bernard Huber, Modern Public Finance, Homewood, IL: Richard D. Irwin (1979) quoted in Nicholas Mercurio, Franklin A. Lopez and Kristen P. Preston, Ecology, Law and Economics: the Simple Analytics of Natural Resource and Environmental Economics at 3, Lanham, MD: University Press of America (1994).

Thus, an externality exists when the action of one party enters the utility or production function of some other party. Ibid. at 4. Externalities lead to a misallocation of resources because they allow one party to shift costs (or benefits) to another party (or society as a whole) by not fully accounting for private or social costs or benefits in pricing. Ibid. 5-17. [NB: Although we use the term 'victim' throughout this article to refer to the party to whom the externality or burden of pollution is shifted, in terms of pure economic efficiency, a socially optimal allocation of harms, benefits, and costs may require some 'disutility' on the part of victims.]

² In the consumption of common goods (that is, goods not subject to individual property rights), each individual consumer receives all the gains from their individual consumption, while receiving only a fraction of the gains from conservation, thus every individual's incentive favors over-consumption, even though this course leads to collective disaster. See Garrett Hardin, “The Tragedy of the Commons,” 162 Science 1243, 1243-48 (1968) available online at <http://www.sciencemag.org/cgi/content/full/162/3859/1243>. Interestingly, some commentators have quibbled with Hardin's use of the commons as metaphor suggesting instead that he more properly should have used “open access”. As Susan Cox and others have argued, there was no “tragedy of the commons” in the real commons, that is, in the historic grazing areas of medieval Europe that Hardin used as example, as these were effectively managed for resource conservation through complex community norms. See Susan Jane Buck Cox, “No Tragedy on the Commons,” 7 Envtl. Ethics 49 (1985).

Under neoclassical economic theory, competitive markets are the preferred method of allocating scarce resources efficiently so as to maximize overall social value.³ However, market mechanisms only function properly if all social costs and benefits are fully reflected in pricing.⁴

Under traditional systems of economic accounting, environmental goods and harms are not fully valued in development, production and waste disposal decisions thus leading to the externalization of environmental costs through pollution and the over-consumption and/or degradation of common resources.⁵

During the course of the 20th century, common law mechanisms for remedying problems of environmental externalities based on equitable enforcement of property rights through courts by

³ "The environment is a scarce resource. This means that it cannot provide all the desired quantities of all its services at the same time. ... Thus, the use of the environment involves trade-offs. ... Economics is about how to manage the activities of people and the ways we use the environment to meet our material needs and wants in the face of scarcity." A. Myrick Freeman, "Economics, Incentives, and Environmental Regulation," in Norman J. Vig and Michael E. Kraft, eds. Environmental Policy: New Directions for the Twenty-first Century, Fourth Edition, Washington, DC: CQ Press (2000), at 190.

For a general overview of natural resource and environmental economics, see Mercurio, *supra* footnote 1. And see Robert N. Stavins, Economics of the Environment: Fourth Edition, New York: W. W. Norton (2000).

⁴ See Mercurio, *supra* footnote 1, at 3-18 (discussing the concept of "market failure"). And see generally Part II in Arthur C. Pigou, The Economics of Welfare, New Brunswick: Transaction (2002) (originally published by Macmillan & Co., 1952, first edition 1920) (in particular, Chapter IX, "Divergences Between Marginal Social Net Product and Marginal Private Net Product," at 172-203).

Market failures generally result from the existence of externalities (arising from, among other things, imperfect information, barriers to entry or exit, lack of buyers or sellers, uniqueness of individual goods, etc.) and lack of or failure to enforce rights (the problem of open access). See generally Mercurio, *supra*.

⁵ It is a fundamental premise of this article that environmental externalities result largely from information failures – environmental benefits or harms are not fully valued because information is unavailable or too costly, or because available information is distributed asymmetrically. We believe that advances in information technology – particularly wide-area networks and distributed computing resources – can significantly mitigate these failures. See generally Part IV *infra*. The classic article on information failures is Friedrich Hayak, "The Use of Knowledge in Society," 35 Am. Econ. Rev. 519 (1945).

For a general discussion of costs and benefits of environmental protection, see Stavins, *supra* footnote 3 at 139-216 and 217-316. For a discussion of the issues involved in economically valuing environmental assets, see Gail Bingham, et al., "Issues in Ecosystem Valuation: Improving Information for Decision Making," 14 Ecological Economics 73-90 (1995). For an example of how nation-states fail to appropriately account for environmental assets, see Robert Repetto, "Accounting for Environmental Assets," Scientific American (June 1992) at 41-45. For a general discussion of the economics of natural resources, see Mercurio, *supra*, at 103-147.

For a general discussion of externalities and information failures as justification for government regulation, see Stephen Breyer, Regulation and Its Reform at 23-28, Cambridge: Harvard University Press (1992).

individual property-owner victims gave way to statutory mechanisms based on command-and-control strategies and regulatory entitlements administered through a vast federal bureaucracy.⁶

Although air and water quality have improved over the past three decades under the existing regulatory scheme,⁷ other problems, including waste management, hazardous releases and fishery depletion, have not⁸ and significant inefficiencies and other problems with the current

⁶ See generally, Richard N. L. Andrews, Managing the Environment, Managing Ourselves: A History of American Environmental Policy 201-254, New Haven and London: Yale University Press (1999) ("The Rise of Modern Environmentalism" and "Nationalizing Pollution Control"). And see Part II infra.

⁷ Some commentators have argued that such improvements have come despite federal regulation and that both air and water might have improved as much or more without such regulation. See, for example, David Schoenbrod, "Protecting the Environment in the Spirit of the Common Law," Roger E. Meiners and Andrew P. Morris, eds., The Common Law and the Environment: Rethinking the Statutory Basis for Modern Environmental Law 3-23 New York: Rowman and Littlefield (2000) ("pollution was being reduced at least as quickly before the early 1970s as afterward, when the administrative state took over," *ibid.* at 3).

Others say that the existing system deserves much of the credit for environmental improvements since the 1970s. See, for example, Jerry Anderson, "The Environmental Revolution at Twenty-five," 26 Rutgers L. J. 395, 398 (1995) ("we are far better off than we would have been without the Clean Water Act, the Clean Air Act, and other weapons of environmental law's first arsenal") and Howard Latin, "Ideal Versus Real Regulatory Efficiency: Implementation of Uniform Standards and 'Fine-Tuning' Regulatory Reforms," 37 Stan. L. Rev. 1267, 1273 (1985) ("Despite its imperfections, command-and-control regulation has fostered significant improvements in environmental quality"). See also Andrews, *supra* footnote 6, at 280, "[f]or all the criticism and political conflict that were directed toward [federal] regulations, in reality they were extraordinarily successful in reducing pollution, at least from major industries and municipal sources."

Still others argue that progress even in air and water quality has been sporadic and improvements have only been achieved in limited, highly visible circumstances, such as industrial waste from point discharges into major waterways and certain "smokestack" emissions, but that more diffuse sources (for example, storm and agricultural run-off, or climate change) or diffuse harms (for example, urban air toxicity, or loss of habitat and biodiversity) have been ignored. See generally Braden R. Allenby, et al. "Overview and Perspectives" in Deanna J. Richards, et al., Information Systems and the Environment, 1-12, 2, Washington, DC: National Academy Press (2001) ("Although adequate for their limited purpose of providing clean air, water and land, these approaches [i.e., remediation of specific sites and end-of-pipe emissions standards] increasingly are recognized as inadequate to deal with the more global perturbations of natural systems – climate change; loss of habitat and biodiversity; and depletion and degradation of soil, water, and atmospheric resources.").

Additionally, new dangers (for example, hormone and antibiotic build-up in water supplies from agribusiness) have been identified and are raising concern. There is ample evidence that despite progress, unacceptable levels of air and water pollution remain from a variety of sources. For example, the EPA estimates that 40% of all surveyed waterways fail to meet existing federal clean water standards. See generally NRDC Reports, "Clean Water & Oceans: Water Pollution: In Depth," National Resources Defense Council, available online at <http://www.nrdc.org/water/pollution/depth.asp> and "Clean Air and Energy: Air Pollution" available online at <http://www.nrdc.org/air/pollution/default.asp>.

⁸ "Economic Man, Cleaner Planet," The Economist, 29 September 2001, at 73 (hereinafter, "Economic Man"). Available online at http://www.economist.com/opinion/displayStory.cfm?Story_id=797431.

system are apparent.⁹ Dissatisfaction with the efficacy, efficiency and equity of the current approach is now found among a broad range of interests, including business executives, environmental analysts, environmental justice groups, and state and local government officials.¹⁰

As a result of such dissatisfaction, there has been an increasing call for new approaches to environmental problems.¹¹ In particular decentralized environmental regulation incorporating economic incentive mechanisms has gained much currency.¹²

⁹ J. Clarence Davies and Jan Mazurek, *Pollution Control in the United States: Evaluating the System*, at 269, Washington, DC: Resources for the Future (1998) ("... the fragmented system is seriously broken. Its effectiveness in dealing with current problems is questionable, it is inefficient, and it is excessively intrusive.") Summary of findings available online at http://www.rff.org/multipollutant/books/summaries_old/pollute_control.htm. And see footnote 11 infra.

¹⁰ Norman J. Vig and Michael E. Kraft, "Environmental Policy from the 1970s to 2000: An Overview," in *Environmental Policy*, supra footnote 3, at 1, citing Davies and Mazurek, supra footnote 9; National Academy of Public Administration (NAPA), *Setting Priorities, Getting Results: A New Direction for EPA*, Washington, DC: NAPA (1995); and Ken Sexton, Alfred A. Marcus, K. William Easter, and Timothy D. Burkhardt, eds. *Better Environmental Decisions: Strategies for Governments, Businesses and Communities*, Washington, DC: Island Press (1998). See also footnotes 11 and 70-80, infra, and accompanying text.

See also, Adler, supra footnote 12, at 660, "[t]hese problems in environmental policy have gradually produced a consensus on the need for significant reform. With few exceptions, environmental analysts recognize that changes must be made in order for environmental gains to continue into the twenty-first century."

¹¹ See Richard B. Stewart, "A New Generation of Environmental Regulation?" 29 *Cap. U. L. Rev.* 21 (2001) at 21:

The criticisms of the "first generation" system of centralized federal command- and-control regulation are by now familiar. It has been criticized on the grounds that it is unduly rigid, cumbersome, and costly; fails to accommodate and stimulate innovation in resource-efficient means of pollution prevention; fails to prioritize risk management wisely; is patchwork in character, focusing in an uncoordinated fashion on different environmental problems in different environmental media and often ignoring functional and ecosystem interdependencies; and relies on a remote centralized bureaucratic apparatus that lacks adequate democratic accountability. While acknowledging its past accomplishments, critics of the command central planning system maintain that it is reaching its inherent limits and is no longer capable of ensuring sustainable environmental progress at tolerable social cost.

The proposed cures for these failings have also been widely discussed: measures to improve the command system through better balancing of regulatory costs and benefits, improved risk analysis and management and greater flexibility; use of market-based regulatory instruments, including environmental taxes and tradable permits in lieu of command requirements; development of information-based systems to encourage internalization of environmental norms by business and other organizations; and integrated approaches to environmental planning and management nationally and at the ecosystem level. Proponents of these "second generation" strategies would use them to thoroughly restructure the existing environmental regulatory system in the United States and replace many uses of command instruments with alternatives.

¹²*Ibid.* The primary difference between command-and-control regulation and economic incentive mechanisms are that centralized command systems seek to limit, directly or indirectly, the quantity of environmental harm or pollution that each producer may generate, while economic incentive mechanisms

seek to establish, directly or indirectly, a price that must be paid for environmental harm or pollution but leave the producer free to decide the level of harm or pollution that they generate. *Ibid.* at 94. See also footnote 81 and accompanying text *infra*.

Beyond the adoption of regulatory economic incentive mechanisms to simply improve efficiencies of allocating externalities, some commentators advocate a renewed evaluation of common law remedies based on renewed property rights as a substitute for administrative regulation. See, for example, Roger Meiners and Bruce Yandle, "Common Law and the Conceit of Modern Environmental Policy," 7 George Mason L. Rev. 923, 952 (1999) and see footnote 20 *supra*.

The most extreme proponents of using private markets, property rights and common law as an alternative to command regulation for environmental protection comprise the "free market environmentalism" movement, see, for example, Terry L. Anderson and Donald R. Leal in 1991 in the original edition of Free Market Environmentalism, New York: Palgrave Macmillan (rev. ed. 2001, 1991). See also, Jonathan H. Adler, "Free and Green: A New Approach to Environmental Protection," 24 Harv. J.L. & Pub. Pol'y 653, 667-677 (2001). Advocates of this approach believe that private law and a system of strong, alienable property rights in environmental resources can solve most environmental problems without any federal government regulation. "Environmental problems ... are essentially property rights problems which [sic] are solved by the extension, definition, and defense of property rights in environmental resources." Adler, *supra*, at 668.

Although we fully support the introduction of market-based mechanisms and increased reliance on tort-based common law as a viable decentralized enforcement mechanism, it is unlikely that relying solely on private markets and property rights alone can deal with many of the "more serious [and complex] environmental problems, such as the pollution of air sheds and large water bodies, improper disposal of hazardous wastes, and protection of biodiversity and large-scale natural resources of high aesthetic and ecological value. ... [A]ggregation of individual market actors' preferences is not an appropriate method for establishing a polity's environmental policy." Stewart, *supra*, at 98.

Further, critics of economic incentive mechanisms are concerned that economic efficiency alone is not an appropriate (or desirable) goal for environmental policy. See, for example, Kenneth J. Arrow, et al., "Is There a Role for Benefit-Cost Analysis in Environmental, Health and Safety Regulation?" and Steven Kelman, "Cost-benefit Analysis: An Ethical Critique," in Stavins, *supra* footnote 3, at 319-324 and 355-364, respectively. And see, Robert C. Paehlke, "Environmental Values and Public Policy," in Vig and Kraft, *supra* footnote 3, at 77-97, and Paul W. Taylor, "Respect for Nature: A Theory of Environmental Ethics," in Revesz, *infra* footnote 22, at 32-43. Or even that such mechanisms perform better or more efficiently, see Latin, *supra* footnote 7, at 1273 ("Critics of uniform standards should therefore be required to demonstrate with reasonable assurance that 'fine-tuning' approaches [including incentive mechanisms] can be successfully implemented, and will actually perform better, before the current regulatory system is 'reformed.'")

Nevertheless, even such staunch Malthusian supporters of centralized regulation as the Worldwatch Institute have adopted the rhetoric of market-based solutions. See generally David Malin Roodman, The Natural Wealth of Nations: Harnessing the Market for the Environment, New York: W.W. Norton/Worldwatch Environmental Alert Series (1998).

Attempting to reconcile the divergent views between the ecological and economic perspective is the concept of 'natural capitalism' introduced in Paul Hawkins, Amory Lovins and L. Hunter Lovins, Natural Capitalism, Boston: Little Brown (1999) in which internalization of environmental values in industrial production leads to "the next industrial revolution," "organized not around lifeless abstractions of neoclassical economics and accountancy but around biological realities of nature," in which "all forms of capital, including human and natural capital" are fully valued in production decisions. *Ibid.* at 9. But cf. Jay Foster, "Between Economics and Ecology: Some Historical and Philosophical Considerations for Modelers of Natural Capital," 86 Envtl. Monit. & Assess. 63-74 (July/August 2003) (suggesting that economic and ecological assumptions are antithetical and cautioning against confusing the issue of whether or not economic models accord with ecological models with the issue of whether or not economic activity accords with ecological reality.)

It is beyond the scope of this article to fully address the polarity between free market and ecological values as a basis for environmental policy. But see footnote 78 *infra*. However, it is a fundamental premise of this article that environmental externalities arise from information failures, regardless of mechanism, see footnote 5 *supra*, and that developments in information technology can help alleviate these failures. See footnote 19 *infra*. For our purposes, we consider command regulation and common law mechanisms as

Economic incentive mechanisms involve pricing environmental externalities either by direct government fiat or through market determination of value for assigned rights or obligations.¹³ In either case, accurate information flows and reliable monitoring are required for effective implementation and enforcement. Further, to the extent that these mechanisms create new regulatory property-like rights (for example, tradable credits or permits) or lifecycle financial responsibilities for manufactured products (for example, product take-backs), the ability to define and track those rights or responsibilities is also required.¹⁴ Current advancements in information technology can help facilitate the development of these alternative regulatory systems.¹⁵

special examples of economic incentive mechanisms that have failed to effectively price externalities because of information failures. See footnote 81 *infra* discussing the economic incentive aspects of command-and-control and footnote 34 *infra* detailing the development in common law enforcement of traditional property rights. See also the text accompanying footnote 87 *infra*, discussing common law remedies as hybrid economic incentive mechanisms.

¹³ Additionally, environmental externalities can be allocated by courts enforcing negotiable property rights, that is, where injunctive relief backstops a strong "tradable" property right (see discussion of Coasian mechanisms in Part III, *infra*) or liability for damages establish a "price" for environmental harm (see discussion of Pigouvian mechanisms in Part III, *infra*). See text accompanying footnote 87. But see Part II *infra* (discussing the evolution of common law remedies in the environmental context, in particular, see footnote 34). For a general overview of the role of the courts in environmental policy, see generally Lettie McSpadden, "Environmental Policy in the Courts," in Vig and Kraft, *supra* footnote 3, at 145-164.

Note that proponents of the "Chicago school of economics" (see Nicholas Mercurio and Steven Medema, Economics and the Law: From Posner to Post-modernism at 51-83, Princeton: Princeton University Press (1997) discussing "Chicago Law and Economics"), such as Ronald Coase (see Part III *infra*) and Richard Posner argue that the development of the common law, in particular tort law, can best be explained as if its goal were to maximize economic efficiency, that is, as if judges were making decisions to promote efficient resource allocation. See Richard A. Posner, Economic Analysis of Law at 19-21, Boston: Little Brown (4th ed. 1992, 1972) and see William M. Landes and Richard A. Posner, "Causation in Tort Law: An Economic Approach," 14 J. of L. & Eco. 109, 109-134 (1983). And see Mercurio, *supra* footnote 1, at 167-171.

Although we concur with this analysis generally, we believe that common law mechanisms (like command-and-control mechanisms, see footnote 81 *infra*) have generally mis-priced environmental externalities because of asymmetries or other discontinuities in information flows or other distributional failures (thus, we find ourselves in agreement with the "New Haven school," which recognizes that legal-economic policy should account for both allocative and distributional impacts, see Mercurio, *supra*, at 80). See footnotes 34 and 40 *infra*. Although this article is primarily concerned with information technology affects on economic incentive mechanisms, it is a central thesis herein that developments in information technology can improve information flows and achieve more efficient pricing of externalities regardless of mechanism. See footnote 19 *infra*.

¹⁴ For example, with regard to regulatory property rights, see Carol M. Rose, "The Several Futures of Property: Of Cyberspace and Folk Tales, Emission Trades and Ecosystems," 83 Minn. L. Rev. 129, 167 (1998) ("property rights [mechanisms] in environmental law can only exist where our governmental institutions have the capacity to run the regimes – to define total allowable use, to allocate rights, to keep track of trades and subsequent uses, and, ultimately, to enforce the quotas.")

¹⁵ See generally the discussion in Part IV, *infra*.

This article examines some of the structural characteristics, strengths and weaknesses of the existing system of command-and-control regulation; compares those with the features exhibited by economic incentive strategies; and identifies how such strategies might be enabled by the emergent digital information technologies. Throughout, the underlying thesis of this article is that improved information flows enable hidden externalities to be accounted for, whether through direct regulatory mechanisms, common law approaches or market action.¹⁶

Part II is an overview of the historical evolution of environmental regulation with a focus on how institutional technologies¹⁷ -- that is, the legal and administrative institutions and supporting rules -- intended to address environmental externalities have evolved to the present state. It then identifies some of the weaknesses of the current system.

Part III examines the theory and potential advantages of economic incentive systems for pricing environmental externalities, including a comparison of Pigouvian mechanisms, such as pollution taxes or charges, with pseudo-Coasian mechanisms, such as tradable permits, credits or development rights.¹⁸

¹⁶ See footnote 19 *infra*. See also, the discussion of information disclosure strategies in the text accompanying footnotes 136-148 *infra*. However, information and disclosure strategies themselves can also result in increased social costs and inefficient allocation of resources unless properly designed and managed. *Ibid*.

¹⁷ For a discussion of law as technology, see Bruce Yandle and Andrew P. Morris, "The Technologies of Property Rights: Choice Among Alternative Solutions to the Tragedies of the Commons," 28 *Ecology L. Q.* 123, 127-130 (2001).

¹⁸ As more fully discussed below in Part III (see footnote 86 *infra*), we use the term pseudo-Coasian to distinguish those economic incentive systems that use market-based mechanisms to establish price from those that use governmental assignment of price (we term the latter Pigouvian). See, Yandle and Morris, *supra* footnote 17, at 124-125, "If the recommendation follows the Pigouvian tradition, it will call for government taxation or regulation, and the politically determined rules will form a public or regulatory property regime. A recommendation in the Coasean [sic] tradition, on the other hand, will rely on markets and a system of private property rights to solve the tragedy." (footnotes omitted)

[NB: curiously, American common usage seems to be "Coasean" although reference to R. W. Burchfield, ed., *Fowler's Modern English Usage*, Oxford: Oxford University Press 750-752 (3rd ed. 1996, 1926) leads us to conclude that "Coasian" is the more correct. So too, "Pigouvian" and "Pigovian" seem both to be in general usage, indeed, Coase himself uses "Pigovian," see Coase, *infra* footnote 103 at 149. However, our view is that the former is more correct. See Fowler, *ibid*. Therefore, we use "Coasian" and "Pigouvian" throughout this article. For those interested in this question of usage, see also Google Answers: English

Part IV examines briefly how developing information technology might enable adoption of the mechanisms discussed in Part III, in particular by improving information flows for identifying, measuring and monitoring environmental harms and exposing externalities, modeling causation, and lowering transaction costs for trading and enforcement.¹⁹

This article concludes in Part V by proposing a hybrid infrastructure of command-and-control and economic incentive-based regulatory mechanisms to manage environmental issues in the twenty-first century. The proposal is for an evolutionary, not revolutionary, progression that matches the costs, burdens and advantages of each approach to the particular nature of different environmental problems.²⁰

Language Usage (posted 12-13 June 2003) available online at <http://answers.google.com/answers/main?cmd=threadview&id=216407>

¹⁹ As noted throughout this article (see, for example, footnotes 5, 12, 13, 16, 20, 34, 40, 78, 107, 146 and 220), we believe that improved information flows not only enable certain incentive based strategies described in Part III *infra*, but can also enhance the efficiency and efficacy of traditional mechanisms for allocating externalities, including common law remedies as well as command-and-control regimes by lowering transaction costs, distributing enforcement efforts and exposing hidden externalities, thus more effectively pricing externalities. "A surprising number of environmental problems are caused, at least in part, by inappropriate prices for some of the goods and services that people buy and by barriers to the effective functioning of markets." Freeman, *supra* footnote 3, at 206-207.

²⁰ Re-evaluating property-based environmental protection enforced through common law remedies must also be considered as an available policy option in thinking about 'new' approaches to environmental problems. Although not addressed directly in this article, we believe that common law mechanisms, including nuisance, trespass, and the public trust doctrine, are viable methods for improving environmental regulation and are enhanced through developments in information technology. As noted in footnote 13 *supra*, common law mechanisms can be considered economic incentive mechanisms in which the threat of injunctive relief enhances the victims bargaining position (a Coasian mechanism, see Part III *infra*) or liability for damages establishes a 'price' for environmental harms (a Pigouvian mechanism, see Part III *infra*). See text accompanying footnote 87 *infra*. And see footnote 13 *supra* discussing the common law as an efficiency-seeking economic allocation mechanism.

For our purposes, there are two parts to rethinking common law property mechanisms – (1) re-assertion and enforcement of strong property rights as a matter of law, and (2) using information technology to improve efficiency and efficacy in asserting and protecting these rights:

First, recent developments in property rights law, including dicta in the takings cases, in particular, Lucas v. South Carolina, 505 U.S. 1003, 1015 (1992) (where there is a physical invasion, "no matter how minute the intrusion, ... we have required compensation"), and Tahoe-Sierra v. Tahoe Regional Planning, 535 U.S. 302, 322 (2002) (physical intrusion is a categorical taking "no matter how small"), can be coupled with the reasoning in the Martin v. Reynolds Metals, 135 F. Supp. 379 (D.C. OR 1955), *aff'd*, 258 F.2d 321 (9th Cir.), *cert denied*, 358 U.S. 840 (1958) (gaseous fluoride contamination as trespass), Borland v. Sanders Lead, 369 So.2d 523, 529 (Ala. 1979) (whether invasion is tangible or intangible is not relevant, smoke found to be trespass), Bradley v. American Smelting, 709 P.2d 782, 788-789 (Wash. 1985) (microscopic particles give rise to trespass), Ream v. Keen, 838 P.2d 1073, 1075 (Or. 1992) (smoke as trespass), and Wilson v. Interlake Steel, 32 Cal.3d 229, 233-234 (Ca. 1982) (California Supreme Court intimates that sound waves

Under this approach, centralized federal resources should be focused increasingly on enhancing information flows (by investing in and disseminating environmental information and scientific research²¹ as well as technologies for identifying, monitoring and understanding environmental problems) and to lowering transaction costs for cooperative or private law resolution (by encouraging the creation of decentralized mechanisms with an emphasis, where appropriate, on letting markets exist and set prices for environmental harm, benefit and abatement).

To facilitate optimal allocation of resources and enforcement and insure equitable outcomes, regulatory property rights, statutory presumptions for common law remedies, assignment of ownership rights in natural resources, “private attorney general” status and class action reform, and other decentralizing instrumentalities should also be considered to achieve greater overall

may result in trespass) line of cases to reaffirm strong property right protection in pollution cases – both for intrusions on the victim's property and extrusions from the polluter's property. See, generally, Meiners and Yandle, *supra* footnote 12, and Meiners and Morris, *supra* footnote 7.

However, availability of common law remedies to victims of environmentally harmful activities has been limited through preemption by federal environmental law. See, for example, *Illinois v. Milwaukee*, 731 F.2d 403 (7th Cir. 1984) (Federal Water Pollution Control Act, 33 U.S.C.S. § 1251 et seq., and not state law governed in a nuisance claim against defendant cities); *Conner v. Aerovox, Inc.*, 730 F.2d 835 (1st Cir. 1984) (plaintiff's maritime tort claim was preempted by the Federal Water Pollution Control Act, and the Maritime Protection, Research, and Sanctuaries Act of 1972, 33 U.S.C.S. § 1401 et seq., to the extent it would have afforded a damage remedy for pollution of navigable waters based on a common-law nuisance theory). Thus, an important environmental reform necessary in order to rely more on private tort actions would be to end this form of preemption.

Second, for the same reasons argued in this article with respect to regulatory incentive based systems, information technology has the potential to improve the efficiency and efficacy of use of common law mechanisms by lowering the transaction and information costs associated with their employ, in particular in identifying, monitoring and modeling harms and causation, and organizing and managing groups of plaintiffs. See generally Part IV *infra*.

See also footnote 34 *infra*. However, to reconsider common law mechanisms for environmental regulation requires recognizing their existing failures as market allocation mechanisms in this context. In the main, common law has failed to provide adequate protection for environmental concerns because of a failure to enforce rights through injunction and the existence of information asymmetries has created procedural barriers for 'victims'. See generally Mercurio, *supra* footnote 1 at 15-17 discussing lack of rights enforcement and information asymmetries as sources of market failure. In addition, where common law courts have tried to price externalities directly through damages, inadequate information and restrictive recognition of harms has resulted in under-pricing. See, for example, footnote 38 *infra*. Finally, as noted above, federal regulation has preempted common law in certain instances.

²¹ Taking into account the requirements discussed in the text accompanying footnotes 136-148 *infra* (that is, that risk disclosure must be managed to avoid "information cascades" and other problems that can themselves result in misallocation of resources).

efficiency (measured both in terms of economic efficiency and achieving socially beneficial environmental goals).²²

²² Our basic premise is that information and rules of general applicability (particularly procedural rules) should be developed (and enforced) centrally, but that application, negotiation and, to some extent, private enforcement, of rules to achieve specific outcomes (that is, the "pricing" of environmental externalities) should occur within (or as close as possible to) the community or polity that bears both the costs and derives the benefits from any particular activity.

(Sound environmental resource stewardship depends on accurate and timely information being available to entities and individuals making decisions about the use of such resources. Thus, our premise is grounded on an assumption that developments in information technology, particularly, wide area networks and distributed computing resources, militate against the efficiency of scale rationalization for centralized information to be concentrated in the hands of 'experts' and requiring centralized regulation.)

One of the biggest complaints about the current federalized command-and-control system is that it "involves unattached interest groups: one side represents the benefits of environmental cleanup with little thought to the costs; the other represents the costs with little emphasis on the benefits. But efficient pollution control requires weighing the benefits and costs; for many problems, this can better be done at the state and local levels, where individuals and small groups can accomplish the balancing that efficiency requires more directly." Barry C. Field, "If It's Broken, Fix It," reviewing Davies and Mazurek, *supra* footnote 9, in 23 Regulation, No. 1, at 68 (1998), available online at <http://www.cato.org/pubs/regulation/regv23n1/field.pdf>. Also, see generally, "Richard B. Stewart, "Pyramids of Sacrifice? Problems of Federalism in Mandating State Implementation of National Environmental Policy," in Richard L. Revesz, Foundations of Environmental Law and Policy 183-191, New York: Foundation Press (1997).

However, adoption of decentralizing methodologies can only succeed where symmetrical information flows and general information availability obviates the need for economies of scale, and eliminates disparities in effective representation and the shifting of externalities to others. *Ibid.* and see Mercurio, *supra* footnote 1, at 15-17 discussing asymmetric information distribution as a source of market failure.

To be effective, of course, such decentralizing strategies also require legal mechanisms for "private justice" enforcement (i.e., allowing for decentralized enforcement by victims or representational organizations through statutory or common law actions), including citizen suit and public nuisance standing, *qui tam* proceedings, and class action reform, to insure that adequate representation of social and environmental interests can be asserted. It is beyond the scope of this article to examine these issues in detail. See also Mercurio, *supra* footnote 1, at 15-17 discussing the full enforcement of rights as a requirement of competitive markets. Additionally, as noted *supra* in footnote 20, in order for common law mechanisms to be used, preemption by federal environmental laws must be overcome.

For an interesting discussion of direct environmental standing for representative environmental organizations see Karl S. Coplan, "Citizen Suits and the Future of Standing in the 21st Century: From Lujan to Laidlow and Beyond: Direct Environmental Standing for Chartered Conservation Corporations," 12 Duke Env. L. and Policy F. 183 (2001), but cf. Jonathan H. Adler, "Citizen Suits and the Future of Standing in the 21st Century: From Lujan to Laidlow and Beyond: Stand or Deliver: Citizen Suits, Standing, and Environmental Protection," 12 Duke Env'tl. L. & Pol'y F. 39 (2001) (arguing for a more stringent "injury in fact" standard for standing).

For a discussion of "public good" private justice mechanisms generally, see Pamela H. Bucy, "Private Justice," 76 S. Cal. L. Rev. 1, 31-54 (2002) (calling explicitly for an expansion of the *qui tam* Federal Claim Act [31 U.S.C. §§3729-33] model to cover protection of the environment. *Ibid.* at 76-80). See also Myriam E. Gilles, "Representational Standing: U.S. ex rel. Stevens and the Future of Public Law Litigation," 89 Calif. L. Rev. 315 (2001).

For a discussion of public nuisance standing, see Dennis E. Antolini, "Modernizing Public Nuisance: Solving the Paradox of the Special Injury Rule," 28 Ecology L.Q. 755 (2001).



II. FROM COMMON LAW TO THE REGULATORY STATE.

Prior to the emergence of the modern regulatory structures beginning in the 1930s and then greatly expanded in the 1970s,²³ environmental protection was based on a combination of common law, state and local rules, and a few federal rules.²⁴ Early common law enforcement was based on Blackstonian concepts of absolute possession of physical property enforced through tort actions of trespass and nuisance.²⁵ In the main, these property rights were premised on an exclusive right to possession and enjoyment of one's own property.²⁶ Violation of these rights by another were actionable and, more importantly, enjoicable at equity.²⁷

Trespass required the physical invasion of property and early courts applied a "dimensionality" test in order to find trespass.²⁸ Thus, what "couldn't be seen" was not trespass but might be actionable as nuisance. However, unlike intentional trespass, where liability would attach without the showing of harm, nuisance required the showing of significant harm.²⁹ Therefore, the

²³ See generally, Richard N. L. Andrews, *supra* footnote 6, at 154-178 and 201-226.

²⁴ For example, the Rivers and Harbor Act of 1899, 33 U.S.C. §401.

²⁵ Sir William Blackstone, Commentaries on the Laws of England (1765). And, see, Joel F. Brenner, "Nuisance Law and the Industrial Revolution," 3 J. Legal Studies 403, 416-25 (1974).

²⁶ "Property is the exclusive right of possessing, enjoying, and disposing of a thing: it is 'the right and interest which a man has in lands ... to the exclusion of others;'" McKeon v Bisbee, 9 Cal. 137, 142; 1858 Cal. LEXIS 81 (1858) (citation omitted).

²⁷ John G. Sprankling, Understanding Property Law, New York: Lexis (2000).

²⁸ "If the intruding agent could be seen by the naked eye, the intrusion was considered a trespass. If the agent could not be seen, it was considered indirect and less substantial, hence, a nuisance. See, e.g., 1 Harper & James, Torts, § 1.23 (1946) (where the dimensional or the tangible/intangible test is included in an earlier definition of trespass and nuisance)." Borland v. Sanders Lead Co., 369 So. 2d 523, 527 (Ala. 1979).

²⁹ Robert V. Percival, et al., Environmental Regulation: Law Science and Policy, New York: Aspen (2000) at 73-77 (discussing private nuisance).

In addition, common law recognized an action for public nuisance. However, for a private plaintiff to bring an action for public nuisance generally required the showing of some harm or injury that is "special, particular, or peculiar" (defined as "different-in-kind" not just "different-in-degree" from the impact on the general

environmental plaintiff found themselves on the horns of a dilemma – to find trespass required more than smoke or gas and to find nuisance required a showing of significant harm and causation.³⁰

This was a rather draconian all-or-nothing system and was not entirely satisfactory to either party – either the victims were not able to meet the standard for proving trespass or nuisance and were thus denied relief for the imposition of the externality on them, or, if the standard were met, the polluter was enjoined from productive activity regardless of the social benefit or investment involved, or, in the case of trespass, the amount of harm done.³¹

Needless to say, the economic implications of this situation did not stand the test of industrialization. While private nuisance actions offered some theoretical basis for relief for pollution damage, by the end of the nineteenth century their promise was mostly illusory, particularly when damage was the result of significant industrial activity.³²

The physicalist, absolute conception of property earlier espoused by Blackstone gave way in the late nineteenth and early twentieth centuries to the “modern” view of property as a “bundle of rights.”³³ This not only helped facilitate a growing economy based on intangible wealth but also

public). See Dennis E. Antolini, "Modernizing Public Nuisance: Solving the Paradox of the Special Injury Rule," 28 *Ecology L.Q.* 755, 761 (2001).

³⁰ But see *Martin v. Reynolds*, 221 Ore. 86, 342 P.2d 790 (Ore. 1959) (gaseous fluoride as trespass); *Borland v. Sanders Lead*, 369 So.2d 523 (Ala. 1979) (smoke as trespass); and *Bradley v. American Smelting*, 709 P.2d 782 (Wa. 1985) (microscopic particles as trespass). See also footnote 20 supra.

³¹ See, for example, *McClung v. North Bend Coal*, 1 Ohio Dec. 187 (C.P. Hamilton 1892), affirmed, 9 Ohio C. C. 259 (1895) (injunction issued). See also *Susquehanna Fertilizer Co. v. Malone*, 73 Md. 268 (1890) rejecting a balancing approach:

"The law, in cases of this kind, will not undertake to balance the conveniences, or estimate the difference between the injury sustained by the plaintiff and the loss that may result to the defendant from having its trade and business, as now carried on, found to be a nuisance. No one has a right to erect works which are a nuisance to a neighboring owner ..."

³² Brenner, supra footnote 25 at 419 (the law simply “was not being applied in industrial towns”).

³³ See generally Wesley N. Hohfeld, "Fundamental Legal Conceptions as Applied in Judicial Reasoning," 26 *Yale Law Journal* 710-770 (1917) and Benjamin Cardozo, *Paradoxes of Legal Sciences*, New York: Columbia University Press (1928), reprint, *The Lawbook Exchange* (2000), at 129.

provided the basis for limiting private property rights – first against individuals seeking redress against industrialization, but later as the very basis for the sorts of governmental regulation that ultimately arose to protect the environment.³⁴

³⁴ See Craig A. Arnold, "The Reconstitution of Property: Property as a Web of Interests," 26 Harv. Envtl. L. Rev. 281, 282 (2002). Thus, the paradox that the very evolution in property rights legal theory that denuded the common law remedies of trespass and nuisance as instruments available to victims for remedying environmental pollution would later be used to rationalize government regulation of polluters (who might have developed alternative, environmentally sounder means of production had common law remedies constrained their activities in the first place, see discussion of Commoner, *infra* this footnote).

The earlier absolutist (but egalitarian) doctrine that conferred on a property owner the absolute right to prevent others from using their property in an injurious manner regardless of the social benefit of the offending conduct gave way, with the emergence of industrialization, to a more limited property right requiring a recognition of the social utility of the offending conduct. As industrialization took hold, the balancing of reciprocal rights and duties manifest in the early industrial period in turn increasingly gave way to an overriding right of the industrial landowner to engage in conduct detrimental to other property owners but shielded by arguments of "great utility."

See Robert J. Goldstein, "Green Wood in the Bundle of Sticks: Fitting Environmental Ethics and Ecology into Real Property," 25 B. C. Envtl. Aff. L. Rev. 347, 358 (1998) citing Morton J. Horwitz, The Transformation of American Law 1780-1860 (1977) and Morton J. Horwitz, The Transformation of American Law 1870-1960 (1992). See also Lawrence Meir Friedman, A History of American Law, New York: Simon and Schuster, 2d ed. (1986). But, cf., Alan Watson, "The Transformation of American Property Law: A Comparative Law Approach," 24 Ga. L. Rev. 163 (1990), also cited in Goldstein, *supra* (taking issue with Horwitz's analysis of legal evolution).

This abstraction of property as a bundle of rights divorced from possession of or relationship to a 'thing' or 'object' undermines the primary requisite principles of environmentalism – (1) the connectiveness between human beings and their physical environment, and (2) the unique character of individual natural things or objects. See Arnold, *supra* at 281-282. And see Aldo Leopold, A Sand County Almanac, and Sketches Here and There, at 204, New York: Oxford University Press (1987, 1948) for an early expression of this 'land ethic' based on connectiveness and uniqueness. And see, Paul W. Taylor, Respect for Nature: A Theory of Environmental Ethics, in Revesz, *supra* footnote 22, at 32-43.

Barry Commoner has argued that this disconnectedness has resulted in the perception of "two worlds" – the natural and the developed and that the environmental crisis is a result of the clash between these two worlds. Barry Commoner, Making Peace With the Planet, at 19, New York: The New Press (1992, 1975). He argues that efforts to control pollution over the past several decades have failed to a large extent because existing regulatory schemes that attempt to "balance" between these two worlds have not resulted in changes to the "technologies of production" but only marginal changes in behavior. In his view, only outright prohibition through regulation (or common law injunction) would have forced producers to develop new technologies of production to avoid environmental damage. Administrative regulation of pollution has resulted only in "end-of-pipe" technologies being developed with marginal improvements in performance. *Ibid.* at 41-55 ("Prevention versus Control"). See also Barry Commoner, The Closing Circle: Nature, Man, and Technology, New York: Random House (1971). Compare Hawkins, *supra* footnote 12, calling for a reintegration of the "two worlds" within a system of "natural capitalism", but see Foster, *supra* footnote 12, cautioning that ecological and economic values may be antithetical.

The problem in our view, however, is not so much with the concept of 'balancing' between competing interests per se but in the information failures and resulting limitations of the balancing mechanisms used to appropriately price externalities. Historic approaches to force accounting for environmental externalities have been ineffective because the mechanisms do not generally fully account for harms (or benefits) or transaction costs outweigh resolution benefits. Mandated command-and-control regimes price harms through government fiat and are subject to legislative and regulatory capture and high enforcement costs while court awarded damages based on provable 'economic losses' do not fully compensate for intangible

In *Madison v. Ducktown Sulphur*³⁵ the court refused to enjoin the defendant's operations even after finding a nuisance, lamenting that to do so would be:

"[T]o protect by injunction several small tracts of land, aggregating in value less than \$1,000, [by] destroy[ing] other property worth nearly \$2,000,000, and wreck[ing] two great mining and manufacturing enterprises, that are engaged in work of very great importance, not only to their owners, but to the State, and to the whole country as well."³⁶

In *Boomer v. Atlantic Cement Co.*³⁷ the NY Court of Appeals balanced the burden of injunctive relief with the actual harm suffered and used a conditional injunction to force the polluter to pay the victims for the "permanent damages to plaintiffs which would compensate them for the total economic loss to their property present and future caused by defendant's operations."³⁸

harms or unrepresented interests. From the regulated industries' points of view, these same mechanisms often seem arbitrary and unrelated to actual benefits to be achieved or costs incurred.

The central thesis of this article is that new information technologies can improve information flows thus enabling better accounting for externalities regardless of the mechanism for enforcement. See footnote 19 *supra*. The distinction between command-and-control and incentive based mechanisms, and between Pigouvian and Coasian methods (see Part III *infra*), revolves around where and how harms (and benefits) are to be evaluated and priced – that is, whether through public or private mechanisms, political or market determination, and before or after the fact. Developments in information technology enable adoption of more complex or nuanced strategies that depend on improved information flows to be effective and efficient.

See also, Nathaniel O. Keohane, Richard L. Revesz and Robert N. Stavins, "The Choice of Regulatory Instruments in Environmental Policy, 22 *Harv. Envtl. L. Rev.* 313, 313 (1998) ("The design of environmental policy requires answers to two questions: (1) what is the desired level of environmental protection?; and (2) what policy instruments should be used to achieve this level of protection?").

³⁵ 113 Tenn. 331, 83 S. W. 658 (1904).

³⁶ *Ibid.* at 366.

³⁷ 26 N.Y. 2d 219, 257 N.E. 2d 870 (1970) ("Court granted plaintiffs an injunction to be vacated upon defendant's payment of permanent damages to plaintiffs for continuing, recurrent nuisance, because economic costs of removal of nuisance were too great" Lexis Summary).

³⁸ *Ibid.* at 225. Note that in *Boomer* the court remanded to the lower court to determine the "total economic loss". Had the injunction been granted, the plaintiff might have been able to bargain for their full economic loss in a Coasian sense. See text accompanying footnotes 103-113 *infra*.

However, the actual "permanent damages" awarded in *Boomer* were limited to monetary loss calculated by the court primarily with reference to diminution in market value for the properties in question. See *Boomer* trial court opinion, 287 N.Y.S.2d 112 (1967). And see Raymond D. Hiley, "Comment: Involuntary Sale Damages in Permanent Nuisance Cases: A Bigger Bang from *Boomer*," 14 *B. C. Envtl. Aff. L. Rev.* 61, 86-

Essentially, the earlier balancing test (which had already undercut the common law protection of victim's property rights) now gave further way and became what was effectively a right of private condemnation.³⁹ In dicta, the court also suggested that the appropriate body for balancing these interests was not the courts but the legislature.⁴⁰

Other perceived problems with common law remedies for environmental protection were that they: (i) operated after the fact (because a case was generally not filed until after the harm had already occurred they were not effective at preventing pollution);⁴¹ (ii) were not effective in

91 (1986). Thus, in Boomer, plaintiffs were not compensated for intangible losses, such as general health, psychological or emotional harm (or "hedonic damages"), nor was there any compensation for any harm to others. For a general discussion of hedonic damages, see Andrew Jay McClurg, "It's a Wonderful Life: The Case for Hedonic Damages in Wrongful Death Cases, 66 Notre Dame L. Rev. 57 (1990).

³⁹ Cf. Justice Jason, dissenting in Boomer, supra footnote 37, at 230. "This kind of inverse condemnation may not be invoked by a private person or corporation for private gain or advantage. Inverse condemnation should only be permitted when the public is primarily served in the taking or impairment of property."

Compare also the majority holding in Boomer with the same court's previous opinion in Whalen v. Union Bag, 101 N.E. 805, 806 (N.Y. 1913) (injunction upheld where paper mill employed 500 and estimated damages to plaintiff were only \$312). In Whalen the court held:

"Although the damage to the plaintiff may be slight as compared with the defendant's expense of abating the condition, that is not a good reason for refusing an injunction. Neither courts of equity nor law can be guided by such a rule, for if followed to its logical conclusion it would deprive the poor litigant of his little property by giving it to those already rich."

Interestingly, this method of private condemnation can be "gamed" against pre-existing but disfavored land uses in certain circumstances. See, for example, Spur Industries v. Del E. Webb, 494 P.2d 700 (Ariz. 1972), in which a prior existing feed lot was permanently enjoined in favor of a real estate developer who "came to the nuisance". The real estate developer sued and was "required" to pay the enjoined feed lot operator who was forced to move or shut down.

⁴⁰ Boomer, supra footnote 37 at 223. It is here that the Boomer court highlights the primary issue underlying all environmental policy. As noted in footnote 34 supra, the fundamental issue in environmental policy is essentially the question of in which forum (legislative or regulatory polity, court case, or private market) and through what mechanism (government fiat, court 'balancing', or market bargaining) the cost of externalities are to be determined and imposed on the offending party. Although this article examines information technology in the context of incentive based mechanisms, it is our core thesis that improved information flows and disclosures in themselves create the opportunity for improved accounting for such externalities regardless of forum or mechanism. See also footnote 19 supra, but see the discussion in the text accompanying footnotes 136-148 infra (discussing some of the problems associated with simply relying on information disclosure strategies without adequate support structures).

⁴¹ See Missouri v. Illinois, 180 U.S.208, 248 (1901) (injunction for anticipated nuisance requires showing of danger to be "real and immediate"):

"We fully agree with the contention of defendants' counsel that it is settled that an injunction to restrain a nuisance will issue only in cases where the fact of nuisance is made out upon determinate and satisfactory evidence; that if the evidence be conflicting and the injury be doubtful, that conflict and doubt will be a ground for withholding an injunction; and that, where interposition by injunction is sought, to restrain that which it is apprehended will create a nuisance of which its

situations with diffuse harms or multiple sources due to high transaction costs and difficulties in showing significant harm or causation;⁴² and (iii) often involved great disparities in available resources and economic power between parties resulting in predictable outcome.⁴³

A perception that the pre-1970 legal structure was insufficient to deal with environmental problems together with a series of highly publicized environmental 'horrors', ranging from the cranberry and irradiated milk scares in the late 1950s, to the burning Cuyahoga River in 1969 and the notorious Love Canal in 1980 provided the basis for political and public support for the nationalization of environmental regulation.⁴⁴

At the same time, following the publication in 1962 of Rachel Carson's Silent Spring,⁴⁵ which alerted the citizenry to the possibility of pesticide accumulation in the food chain, increased environmental awareness led to the formation of the Environmental Defense Fund⁴⁶ and the National Resources Defense Council.⁴⁷ These groups began to use the courts to try to require federal agencies to be more responsive to environmental concerns.⁴⁸

complainant may complain the proofs must show such a state of facts as will manifest the danger to be real and immediate."

⁴² See Richard A. Posner, Economic Analysis of Law, New York: Aspen Law and Business (2d. ed. 1977), at 46-47. See, also, Brenner, *supra* footnote 25 at 425. But cf. Meiners and Morris, *supra* footnote 7 (arguing that common law was effective and preferable to reliance on statutory regulation).

⁴³ See Boomer, *supra* footnote 37 (use of "conditional" injunction results in private condemnation), but compare, Whalen, *supra* footnote 39 (rejecting balancing test). Although not central to this article, we believe that an effective information policy can help mitigate against this disparity through information sharing and disclosure strategies. However, effective use of such information requires defined property rights and access to the legal mechanisms discussed in footnote 22 *supra* (victim or representational standing in court) to enforce those rights.

⁴⁴ See Andrews, *supra* footnote 6, at 227-254. And see Cass R. Sunstein, Risk and Reason: Safety, Law and the Environment, New York: Oxford University Press (2002) ("there is no doubt that publicity about Love Canal was crucial to enactment of [the Superfund] law in 1980" at 81).

⁴⁵ Rachel Carson, Silent Spring, Boston: Houghton Mifflin (2002, 1962).

⁴⁶ Formed in 1967 by a group of scientists who sought to have the pesticide DDT banned. See, generally, <http://www.environmentaldefense.org/aboutus.cfm?subnav=aboutus>.

⁴⁷ Formed as a result of activity in the mid-1960s to prevent the licensing of an electric power project at Storm King Mountain in New York.

⁴⁸ Such litigation, intended to force the federal government itself to include environmental considerations in its actions, also helped set the stage for the later federalization of environmental regulation by making the

Federalization of environmental law⁴⁹ began in earnest on January 1, 1970, when President Nixon signed the National Environmental Policy Act⁵⁰ on national television. Also in 1970, President Nixon created the Environmental Protection Agency (EPA) by executive order.⁵¹ In the decade that followed, Congress enacted a flurry of legislation, including: the Clean Air Act (1970);⁵² the Federal Water Pollution Control Act (Clean Water Act) (1972);⁵³ the Federal Insecticide, Fungicide, and Rodenticide Act (1972);⁵⁴ the Marine Mammal Protection Act (1972);⁵⁵ the Marine Protection, Research, and Sanctuaries Act (1972);⁵⁶ the Noise Control Act (1972);⁵⁷ the Coastal Zone Management Act (1972);⁵⁸ the Endangered Species Act (1973);⁵⁹ the Safe Drinking Water Act (1974);⁶⁰ the Toxic Substance Control Act (1976);⁶¹ the Resource Conservation and Recovery Act (1976);⁶² the Soil and Water Resources Conservation Act (1977);⁶³ the National Ocean Pollution Planning Act (1978);⁶⁴ the Fish and Wildlife Conservation

federal government a “public player” in the environmental arena, which had previously been more of a state concern. See, generally, Andrews, *supra* footnote 6, at 221, and Richard B. Stewart, “The Reformation of American Administrative Law,” 88 *Harv. L. Rev.* 1667 (1975).

⁴⁹ See generally Percival, *supra* footnote 29, at 101-113, and see Andrews, *supra* footnote 6, at 201-254.

⁵⁰ 42 U.S.C. §§4321-4347.

⁵¹ Reorganization Plan No. 3 of 1970, 84 Stat. 2086 (1970).

⁵² 42 U.S.C. §§7401-7671q.

⁵³ 33 U.S.C. §§1251-1387.

⁵⁴ 7 U.S.C §§136-136y.

⁵⁵ 16 U.S.C. §§1361-1407.

⁵⁶ 33 U.S.C. §§ 1401-1445a.

⁵⁷ 42 U.S.C. §§4901-4918.

⁵⁸ 16 U.S.C. §§1451-1464.

⁵⁹ 16 U.S.C. §§1531-1544.

⁶⁰ 42 U.S.C. §§300f-300j –26.

⁶¹ 15 U.S.C. §§2601-2692.

⁶² 42 U.S.C. §§6901-6922k.

⁶³ 16 U.S.C. §§2001-2009.

Act (1980);⁶⁵ and the Comprehensive Environmental Response, Compensation, and Liability Act (1980) ("CERCLA").⁶⁶

So began the modern era of the environmental regulatory state.⁶⁷ By 2001, according to a report released by the Office of Management and Budget 70% of the cost of new federal government regulation was directly attributable to environmental rules promulgated by EPA.⁶⁸ The report estimated that total annual costs to the national economy associated with all major environmental regulation by federal agencies were between \$120bn and \$203bn.⁶⁹

The current system, referred to by critics as the "mandate, regulate, and litigate" approach⁷⁰ is increasingly subject to criticisms from all sides of the political spectrum. Three principal failings are cited: "yesterday's failed ambitions, today's large price tag and tomorrow's even harder targets."⁷¹

⁶⁴ 33 U.S.C. §§1701-1709.

⁶⁵ 16 U.S.C. §§2901-2911.

⁶⁶ 42 U.S.C. §§9601-9675.

⁶⁷ For a more detailed description of these developments, see Paul R. Portney, "EPA and the Evolution of Federal Regulation," in Paul R. Portney and Robert N. Stavins, Public Policies for Environmental Protection, Washington, DC: Resources for the Future (2000), at 11-30; Norman J. Vig and Michael E. Kraft, *supra* footnote 3, at 1-31; Richard N. L. Andrews, *supra* footnote 6, at 201-284.

⁶⁸ See Office of Management and Budget, Draft Report to the Congress on the Costs and Benefits of Federal Regulation, available online at <http://www.omb.gov/inforeg/8stevensdraftmemoMarch18.pdf>.

⁶⁹ Total benefits were estimated at \$120 to \$1,783 billion for a net benefit of between -\$83 and \$1,663 billion. *Ibid.* at 110, Table 11. See also Meiners and Yandle, *supra* footnote 11, at 952 ("By EPA's own estimates, federal environmental regulations cost as much as \$200bn per year in current dollars," citing EPA, The Cost of Clean (1990) in n. 177), and Adler, *supra* footnote 12, at 657 ("In 1999, environmental regulations cost an estimated \$206 billion").

⁷⁰ "Economic Man," *supra* footnote 8, at 73. See also comments of Lynn Scarlett, U.S. Assistant Secretary of the Interior for Policy, reported in John Tierney, "Trying for Balance at the Interior Department," N. Y. Times A:26 (June 9, 2003) available online at <http://www.nytimes.com/2003/06/09/politics/09NORT.html> (describing the current system as "based on prescription, punishment, process – have permit, pass go – and piecemeal decisions pitting one [environmental concern] against another. We want [a new incentive-based approach] that encourages innovation.")

⁷¹ "Economic Man," *ibid.* See also footnote 11 *supra*.

Additional criticisms of the EPA and recent environmental policy include: (i) an over-reliance on command-and-control systems that engender a legalistic, inflexible culture at odds with its constituencies, (ii) fragmentation and lack of focus in priorities, (iii) overlap and inconsistencies due to the patchwork nature of environmental laws, (iv) a disparity between resources and responsibilities resulting in unfunded mandates to the states and significant burdens to industry, and (v) a lack of high quality scientific and economic (cost-benefit) analysis and information.⁷²

Proponents of public choice theory⁷³ have also raised issues of regulatory capture and bureaucratic and interest group rent-seeking.⁷⁴ However, for our purposes we are mainly concerned with the inefficiencies resulting from the existing system's over-reliance on command-and-control mechanisms to price externalities.⁷⁵

⁷² See Davies and Mazurek, *supra* footnote 9, and see footnote 11 *supra*.

⁷³ Public choice theory is the economic analysis of non-market decision-making – the process whereby individual decision-makers engage in a complex social construction that results in political outcomes. Mercurio, *supra* footnote 13, at 84. See generally, George Stigler, "The Economic Theory of Regulation," 2 *Bell Journal of Economics and Management Science* 335 (1971).

⁷⁴ See, for example, Corrine Larrue, "The Political (Un)feasibility of Environmental Economic Instruments. In B. Dente (Ed.), Environmental Policy in Search of New Instruments, Chapter 3, at 37-54. Dordrecht: Kluwer Academic Publishers (1995); and generally Achim Korber, The Political Economy of Environmental Protectionism, Cheltenham: Edward Elgar (2000).

The two issues of prime concern to proponents of public choice analysis are the economic misallocation and waste resulting from (i) the bureaucracy's interests not being coterminous with maximizing social welfare (that is, the bureaucracy is motivated by its own quest for power, prestige, budget, etc., see Mercurio, *supra* footnote 13, at 93) and (ii) rent-seeking behavior.

'Rent seeking' is "the resource wasting activity of individuals in seeking transfers of wealth through the aegis of the state", *ibid.* at 96, quoting James M. Buchanan, et al., eds., Toward a Theory of the Rent-seeking Society at ix, College Station: Texas A&M University Press (1980). This inefficient investment by special interest groups in the political process in order "to gain a competitive advantage through manipulation of the regulatory process ... is facilitated by the fact that firms have the ability to receive concentrated benefits through government action, whereas the costs are dispersed throughout the whole society." Adler, *supra* footnote 12 at 666, citing Todd J. Zywicki, "Environmental Externalities and Political Externalities: The Political Economy of Environmental Regulation and Reform," 73 Tul. L. Rev. 845 (1999) (discussing rent-seeking in environmental policy).

⁷⁵ To a large extent, these inefficiencies result in a "mis-pricing" of environmental externalities (see footnote 81 *infra*) due to limitations of the bureaucratic mechanisms used for determining priorities and standards, asymmetries in information flows and other distributional inequities. Note that these same issues affect 'pricing' through common law mechanisms, see footnote 13 *supra*.

For a discussion of the problems associated with information failures in the regulatory standard setting process, see Breyer, *supra* footnote 5, at 109-122 and 263-271.

Under current practice, the federal command-and-control regime⁷⁶ uses regulation, permits or licensing to impose quantitative limits on environmentally harmful behavior -- mainly limitations on the amount of residuals that each producer may generate or discharge. Such regulation may be based on the level of control that can be achieved using currently available technology (technology-based regulation) or at a level needed to achieve some environmental or health quality goal or aggregate pollution loading on a common resource (standards-based regulation). In practice, most command-and-control regulations use uniform standards of performance based on technological feasibility.⁷⁷

Weaknesses of command-and-control are: (i) inflexibility, in that such systems impose a uniform standard (absent a waiver) on performance regardless of particular conditions, costs or relative benefits in a given circumstance,⁷⁸ (ii) a tendency to establish a floor (or ceiling) for

⁷⁶ EPA and the state environmental protection agencies under delegated federal rules.

⁷⁷ See Thomas W. Merrill, "Innovations in Environmental Policy: Explaining Market Mechanisms," 2000 U. Ill. L. Rev. 275, 275-276 citing Wendy E. Wagner, "The Triumph of Technology-based Standards," 2000 U. Ill. L. Rev. 83 (2000). See also, Bruce A. Ackerman and Richard B. Stewart, "Reforming Environmental Law," in Revesz, *supra* footnote 22, at 150-157, 150. ("The existing system of pollution regulation ... is primarily based on a Best Available Technology (BAT) strategy.")

However, while uniform performance standards based on existing technology are the most common, there are other approaches as well. For example, standards can also be based on the perceived impact on the ambient environment (as with Clean Water Act point discharge standards, see 33 U.S.C. 1313(d)(4) (1994)), or a percentage adjustment from some base level of past performance (see, new motor vehicle standards of Clean Air Act of 1970, 42 U.S.C. §7521 (1994)). Merrill, *supra*, 276 n. 1.

⁷⁸ As noted earlier, such uniform standards tend toward economic inefficiency by equalizing performance regardless of marginal cost or benefit:

The impracticality of simple uniform standards [results from] ... (1) the complex [nonlinear] relationship between emission removal and pollution reduction, (2) marginal [incremental] costs that rise significantly [as more emissions are reduced], and (3) significant variation in removal costs from source to source

Breyer, *supra* footnote 5, at 263-64. In addition, uniform standards tend to disadvantage small firms and create barriers to entry for new firms. *Ibid.* at 115-116. See also, Ackerman, *supra*, at 151.

Nevertheless, achieving economic efficiency alone is not a universally accepted goal for environmental policy. See Kenneth J. Arrow, et al., "Is There a Role for Benefit-Cost Analysis in Environmental, Health and Safety Regulation?" and Steven Kelman, "Cost-benefit Analysis: An Ethical Critique," in Stavins, *supra* footnote 3, at 319-324 and 355-364, respectively. And see, Robert C. Paehlke, "Environmental Values and Public Policy," in Vig and Kraft, *supra* footnote 3, at 77-97, and Paul W. Taylor, "Respect for Nature: A Theory of Environmental Ethics," in Revesz, *supra* footnote 22, at 32-43.

performance and “lock in” that level of abatement,⁷⁹ and (iii) discouragement of technological innovation.⁸⁰

Accordingly, in our view, economic efficiency has to be balanced with non-economic ecological perspectives, distributional equity and other social welfare concerns in order to avoid certain undesirable outcomes, for example, “hot spots,” “race(s) to the bottom” or other environmental injustices or anomalies of burden shifting that have traditionally rationalized centralized command-and-control regulation. See generally Stewart, *supra* footnote 22, discussing “The Rationales for Centralization,” at 184-191 and see footnotes 83 and 206-208 *infra* and accompanying text.

The issue of whether efficiency alone (that is, aggregate social welfare) or distributional concerns (how harms and benefits are distributed within society) should be considered in setting environmental policy underlies the fundamental polarity in the environmental debate. See Mercurio, *supra* footnote 1, at 98-99. Free market or economic analysis starts with the premise of equal, rational actors in a competitive market in which environmental benefits and harms can be monetized. Advocates of government intervention and direct regulation believe that distributional inequities and other market failures prevent equal bargaining from occurring and that certain environmental harms cannot be adequately compensated. It is not our intention to take sides in this debate.

The underlying thesis of this article is that information failures interfere with the efficient operation of both policy options, thus, improvement in information technologies and their application to environmental problems can improve outcomes under any mechanism. See footnote 19 *supra*.

Nevertheless, we do believe that these improved information flows facilitate adoption of more decentralized mechanisms, particularly those based on positive economic incentives (profit maximizing or cost reducing) to influence private decision making rather than the negative incentives of command-and-control. Further, we believe that such mechanisms are not just economically more efficient but that they result in broader positive environmental effect throughout the private decision-making process. See footnotes 150 and 151 *infra*.

⁷⁹ Resulting in essence in “permits to pollute,” which then become regarded as regulatory entitlements as well as potential pre-emptive shields against other actions, including common law actions. See Meiners and Yandle, *supra* footnote 12, at 952-954. However, regulatory property strategies can also exacerbate this problem, “in part because property introduces a rhetoric and mentality of entitlement.” Rose, *supra* footnote 14, at 172.

In addition, by imposing a uniform performance standard on an entire industry, such rules remove any incentive to innovate in environmental performance beyond current practice as competitive advantage for innovation is stifled and barriers to entry are reinforced. Technology-based standards tend to result in regulatory cartels. Meiners and Yandle, *supra* footnote 12 at 955. And see Breyer, *supra* footnote 5, at 115-116 discussing anticompetitive effects of standards based regulation.

⁸⁰ Both by inhibiting industry competition as discussed in the preceding footnote 79 *supra*, and by “locking in” existing technology solutions thereby creating significant barriers to entry for pollution abatement innovators who will be uncertain that their technological innovations will ever be adopted by regulations within the regulated industries. “[T]he introduction of specific emissions standards may freeze antipollution technology.” Breyer, *supra* footnote 5, at 269 and see 115-116 (discussing “freezing technology” as one of anticompetitive effect of standards based regulation).



III. ECONOMIC INCENTIVE SYSTEMS.

This section discusses economic incentive mechanisms as alternatives to command regulation. The primary difference between command-and-control and economic incentive mechanisms is that command-and-control systems attempt to mandate uniform limits on a particular class of environmentally harmful activity while economic incentive mechanisms attempt to price those activities and let the producer determine their own level of harmful activity.⁸¹

Command-and-control systems tend to equalize output of environmental harms regardless of differences in individual compliance costs or benefits whereas economic incentive systems tend

⁸¹ See Stewart, *supra* footnote 11, at 94-95. To some extent command-and-control regulations also act as an "economic incentive" mechanisms as any individual producer is free to engage in prohibited activity by internalizing the cost of the penalty or punishment (discounted by the chance of enforcement and the time-value of the penalty compared to the economic gain of the illegal behavior). See Timothy F. Malloy, "Regulating By Incentives: Myths, Models, and Micromarkets," 80 *Texas L. Rev.* 531, 531 (2002) ("Environmental regulation is all about using incentives to control behavior. Under direct command-and-control regulation, the government creates specific obligations and generally relies upon negative incentives of civil and criminal penalties to motivate individuals or organizations to comply with those obligations.")

In theory, violation of command-and-control regulation is intended to result in punitive 'costs' and therefore the cost of violation should in all cases exceed the benefits. In practice, unfortunately, fines are often set by statute and rarely relate to the actual harms or benefits in any particular case. In addition, due to resource constraints, enforcement is sporadic and selectively applied. "[T]he uncertainty of punishment for noncompliance can lead firms to violate the statute where the expected value of the fine is less than the cost of compliance." Breyer, *supra* footnote 5, at 267.

Further, as noted above (see footnote 78), command-and-control regulation tends to equalize performance regardless of marginal cost or benefit. Thus, an additional general criticism of command-and-control in practice might be that it under-prices environmental harms for violators and over-prices compliance costs for non-violators.

Another distinction often drawn between command-and-control systems and incentive systems by advocates of the latter is that command-and-control systems tend to use set limits of activity with 'costs' incurred only if such limits are exceeded, thus establishing regulatory entitlements (permits providing rights to pollute up to the proscribed limits), whereas economic incentive systems apply a continuous cost to the point of zero pollution (that is, to the extent that environmental costs are internalized there is always economic incentive to continue to reduce harmful behavior to eliminate such costs). However, certain market-based regulatory mechanisms (particularly those based on artificial scarcity or regulatory property) themselves use artificial limits or thresholds, thus also resulting in a 'permissible' (or regulated) level of harmful activity to continue. See footnote 100 *infra* discussing the relative differences in economic character between charge mechanisms and trading mechanisms.

to equalize the marginal cost of abatement.⁸² Economic incentive systems provide producers of environmental harm a great deal of flexibility in determining cost-effective ways of reducing pollution, which in turn allows a given level of harmful activity to be achieved at the lowest overall cost.⁸³ Thus, it is argued, incentive based systems are more economically efficient in that no one

⁸² See Stewart, *supra* footnote 11, at 95.

⁸³ However, economic efficiency alone may not be sufficient for optimal environmental outcomes (optimal social welfare in economic terms). An 'efficient' allocation of resources in any given circumstance is contingent on the initial and unique assignment of rights and obligations within which market forces operate. Mercurio, *supra* footnote 13 at 17-18. Thus, where market imperfections, distributional inequities or unequal bargaining power exists a priori, 'efficient' mechanisms can lead to inequitable (or non-optimal social welfare) results. Adoption of economically efficient mechanisms must therefore be tempered, and their use must be monitored, to avoid burden shifting where externalities are shifted to other victims due to discontinuities in information access, disparities in economic resources or biases in rights enforcement. "Each social welfare contour defines a politically determined, subjective tradeoff between the utilities [of individual actors within the system]." *Ibid.* at 43.

A particular problem that can arise from the application of market-mechanisms in the environmental context is the problem of "hot spots", which can occur when market-mechanisms treat residual(s) (that is, pollutants) covered by the system as fungible for regulatory purposes but they are not for environmental purposes. "For some pollutants, an additional unit of pollution in a location that already has a high level of pollution may do more damage than in a location with a lower level. Accordingly, standard tax [or charge] and trading systems can potentially result in local pollution 'hot spots.'" Stewart, *supra* footnote 11 at 101.

A related problem with the strict application of social welfare economics in the environmental context is that the economic solution to these "optimal but not best result" outcomes (i.e., outcomes based only on economic efficient allocation) involves transfer payments between profit maximizing and utility maximizing participants to equalize social welfare in what is known as the "compensation principle." *Ibid.* at 45. The problem here is that a solution based on transfer payments assumes that all environmental harm is monetizable – in other words it is premised on the non-uniqueness of environmental assets and objects (and that all harms can be fully compensated by transfer payment). Compare this assumption with the view of Commoner and Leopold, *supra* footnote 34 (expressing an environmental ethic based on connectiveness between man and nature and the uniqueness of individual natural things or objects). See also Adam Fenech, et al., "Natural Capitalism in Ecology and Economics: An Overview," 86 *Envtl. Monit. & Assess.* 3-17 (July/August 2003) (arguing that a successful natural capital model may require economic theory to be recast to include non-monetary social preferences and values). And see Taylor, *supra* footnote 34.

A further concern is whether economic incentive mechanisms in practice are actually more efficient than command-and-control imposed uniform standards. For example, Latin, *supra* footnote 7 at 1268-1271, argues that uniform standards may be a preferable "second best" strategy:

[P]rominent legal scholars such as Bruce Ackerman, Steven Breyer, and Richard Stewart have concluded that command-and-control regulation is inefficient and should be replaced by more flexible strategies. Their principal criticisms may be summarized as follows: Uniform standards do not reflect the opportunity costs of environmental protection, they disregard the individual circumstances of diverse conflicts, they do not achieve environmental protection on a "lowest-cost" basis, and they fail to provide adequate incentives for improved performance.

In response to these alleged deficiencies in the present system, advocates of "regulatory reform" argue that environmental controls should be tailored to particularized ecological and economic circumstances, regulatory benefits weighed against the costs of environmental protection, and increased reliance placed on economic incentive mechanisms, such as taxes on environmentally destructive activities or transferable pollution rights. Professor Stewart, for example, recently advocated "a more individualized or 'fine-tuning' approach to regulation." Critics of command-and-control standards differ on suggested "fine-tuning" prescriptions, but there is widespread agreement that *some* alternative must be preferable to the current regulatory system.

is worse off (social costs are the same since the overall amount of harmful activity is the same)⁸⁴ and some are better off (fewer resources are used to comply with limits and thus are available for other uses).⁸⁵

This article contends that the academic literature on "regulatory reform" reflects an excessive preoccupation with theoretical efficiency, while it places inadequate emphasis on actual decision-making costs and implementation constraints. Any system for environmental regulation must function despite the presence of pervasive uncertainty, high decision-making costs, and manipulative strategic behavior resulting from conflicting private and public interests. [emphasis added] Under these conditions, the indisputable fact that uniform standards are inefficient does not prove that any other approach would necessarily perform better. In a "second best" world, the critical issue is not which regulatory system aspires to ideal "efficiency" but which is most likely to prove effective. [see also footnote 107 infra, quoting Coase, "the proper procedure is to compare the total social product yielded by these different arrangements."]

In recognition of severe implementation constraints on environmental regulation, this article identifies numerous advantages of uniform standards in comparison with more particularized and flexible regulatory strategies. These advantages include decreased information collection and evaluation costs, greater consistency and predictability of results, greater accessibility of decisions to public scrutiny and participation, increased likelihood that regulations will withstand judicial review, reduced opportunities for manipulative behavior by agencies in response to political or bureaucratic pressures, reduced opportunities for obstructive behavior by regulated parties, and decreased likelihood of social dislocation and "forum shopping" resulting from competitive disadvantages between geographical regions or between firms in regulated industries [i.e., spillovers, hot spots, burden-shifting and races-to-the-bottom]. [emphasis added] A realistic implementation analysis indicates that "fine-tuning" would prove infeasible in many important environmental contexts; indeed, the effectiveness of environmental regulation could often be improved by reducing even the degree of "fine-tuning" that is currently attempted.

[citations omitted]

Although we agree generally with Professor Latin's argument, it is the fundamental premise of this article that developments in information technology change the very conditions and constraints – that is, high information costs and 'hidden' burden-shifting or political manipulation – that Professor Latin sets out above, thus, enabling the consideration and adoption of more nuanced mechanisms for fine-tuning (that is, pricing externalities), including specifically, incentive based mechanisms. We believe that information technology can act as agent of change in environmental policy by lowering information and transaction costs and by exposing hidden externalities, burden-shifting and political manipulation. See generally footnotes 154, 187 and 206-208 infra and accompanying text.

⁸⁴ At least where regulatory scarcity is imposed through a cap on harmful activity (pseudo-Coasian mechanisms, see infra) or where the tax or charge imposed (Pigouvian mechanisms, see infra) exceeds the marginal cost of abatement.

⁸⁵ This formulation is a restatement of the theory of Pareto Optimality. As articulated by Vilfredo Pareto:

We will say that the members of a collectivity enjoy maximum ophelimity in a certain position when it is impossible to find a way of moving from that position very slightly in such a manner that the ophelimity enjoyed by each of the individuals of that collectivity increases or decreases. That is to say, any small displacement in departing from that position necessarily has the effect of increasing the ophelimity which certain individuals enjoy, and decreasing that which others enjoy, of being agreeable to some, and disagreeable to others.

Vilfredo Pareto, Manual of Political Economy. (1906) 1971 translation of 1927 edition, New York: Augustus M. Kelley, at 261. See also Mercuro, supra footnote 13, at 27-30 discussing the concept of "exchange equilibrium" and "Pareto optimum", at 30. And see Figure A-3, *ibid.* at 28.

There are many forms of economic incentive mechanisms that might be applied to environmental problems. For our purposes we divide them into two groups: Pigouvian (or “polluter pays assigned cost”) mechanisms and pseudo-Coasian (or “market bargaining allocates cost”) mechanisms.⁸⁶

Pigouvian mechanisms include pollution taxes or charges, subsidies or credits, and certain liability schemes. Pseudo-Coasian mechanisms include tradable quotas or credits, transferable development or consumption rights, and information disclosure systems.

Additionally, certain property right mechanisms can be either Pigouvian in nature, for example where tort liability is imposed on the polluter for nuisance or trespass, or pseudo-Coasian, where

⁸⁶ We distinguish Pigouvian mechanisms as those in which government prices externalities directly and pseudo-Coasian mechanisms as those in which some private bargaining, that is, some market force, sets pricing. See, footnote 18 *supra*, and see, also, Yandle and Morris, *supra* footnote 17 at 124-125.

As discussed below in the text accompanying footnotes 103-113, a 'pure' Coasian mechanism would entail an absolute property right on the part of either the victim or the polluter and perfect market conditions, including perfect information flows, no transaction costs and equal bargaining resources, to function. In practice, most "market based" or "economic incentive" schemes devised or advocated for environmental purposes require some ongoing government intervention or regulation to set the limits or rules within which the market mechanism can then function to price certain behavior(s) (i.e., some regulation beyond simple assignment or enforcement of property rights). (Coase himself identifies as central to Pigou's concern "what additional State action is required [to deal with ongoing imperfections]", Coase, *infra* footnote 103, at 135.)

Generally, use of economic incentive mechanisms requires the internalization (pricing) of environmental externalities. Thus, in the absence of a pre-existing property right (and enforcement mechanism), government regulation must be used to either (1) assign an arbitrary cost to harmful activity (Pigouvian mechanisms), (2) assign responsibility regardless of cost (hybrid-Pigouvian mechanisms, for example, CERCLA clean-up costs, see text accompanying footnotes 100-102, or hybrid-Coasian mechanisms, for example, extended product responsibility schemes, see footnotes 93-94 and 102 *supra* and accompanying text), or (3) enforce artificial 'scarcity' (for example, by granting regulatory property rights) within which markets can determine pricing for harmful behavior (pseudo-Coasian, for example, tradable credits or quotas, see text accompanying footnotes 114-127) (without artificial limits or assigned rights, that is, to the extent that there is an unlimited right to pollute, no market price will be set as there is no pressure to internalize environmental costs). See the discussion of relative economic efficiency in pricing between Pigouvian mechanisms and pseudo-Coasian mechanisms, *infra* footnote 100.

Transferable development and consumption rights, discussed in the text accompanying footnotes 128-135 *infra*, come closest to 'pure' Coasian mechanisms, however, in many cases they involve either regulatory property (e.g., zoning or tradable consumption rights) or property right transfers (deed-restrictions or conservation easements) subsidized by regulatory tax or other policy.

Information and disclosure strategies, discussed in the text accompanying footnotes 136-148 *infra*, also require either direct or indirect regulatory intervention to provide or force information disclosure that exposes externalities to the general market for the subject enterprise's products or services.

the existence of a strong property right (including a regulatory property right or court granted injunction) gives the right holder the incentive to invest in or negotiate for protection and enhancement of the environmental resource “owned”.⁸⁷

PIGOUVIAN MECHANISMS

Mechanisms that apply a direct charge (or subsidy) to the polluter (so-called “polluter pays” mechanisms) are often referred to as Pigouvian mechanisms, after Arthur C. Pigou,⁸⁸ an early proponent of the idea that government intervention was called for when there was a divergence in cost of private and social value resulting from a particular activity.⁸⁹ In considering the problem of environmental externalities, Pigou argued that pollution generates a net social cost that the government should impose on the polluter through a system of taxes, bounties and regulations.⁹⁰ For our purposes, we consider three mechanisms under this heading:

⁸⁷ Common law property rights mechanisms are not discussed in detail in this article, but see footnote 20 supra. See also footnote 13 supra, discussing common law mechanisms as efficiency-seeking allocation mechanisms:

The courts do not always refer very clearly to the economic problem posed by the cases brought before them, but it seems probable that in the interpretation of words and phrases like “reasonable” or “common or ordinary use” there is some recognition, perhaps largely unconscious and certainly not very explicit, of the economic aspects of the question at issue.

Coase, *infra* footnote 103, at 123-124.

⁸⁸ Arthur Cecil Pigou (1877-1959) British economist [pronounced pi’gOO, thus, pi’gOO-vian, not pi’gO-vian].

⁸⁹ See Pigou, *supra* footnote 4, at 172-203, and see generally Arthur C. Pigou, Wealth and Welfare, London: Macmillan (1912) in which Pigou first sets out his framework for analyzing the divergences between private and social interests previously identified by Henry Sidgwick, The Principles of Political Economy, London: Macmillan (1901) (Sidgwick argued that self-motivated economic pursuits do not always result in ideal or efficient outcomes and identified areas in which government action could increase optimal total welfare).

⁹⁰ Pigou, *supra* footnote 4, at 192 (“It is ... possible for the State ... to remove the divergence [in social and private net product] by ‘extraordinary encouragements’ or ‘extraordinary restraints’ ... the most obvious forms [of which] are, of course, those of bounties and taxes.”). Broadly interpreted, Pigouvian logic underlies any system of government intervention, including command-and-control regulation, strict liability statutes, traditional tort damages, etc. See footnote 81 *supra* and text accompanying footnote 87 *supra*.

For an economic analysis of Pigouvian charges and subsidies, see Mercurio, *supra* footnote 1, at 179-185.

- ◆ First, are taxes, fees or other charges on pollution, waste, residuals or other environmentally harmful activity that impose a direct charge on each unit of harm generated, discharged or engaged in by an actor. An example of such a Pigouvian tax would be a “carbon tax” to reduce carbon dioxide emissions.⁹¹ New tax imposition or tax-shifting strategies have not been widely accepted in the United States because of a general opposition to taxes but they have been somewhat more successfully adopted in Europe.⁹²

"Extended product responsibility" ("EPR") strategies, in which manufacturers are made responsible for not only the production phase of their products but also for their end-of-cycle reuse or disposal costs, are another example of a Pigouvian charge mechanism.⁹³ EPR has had limited success in the United States (for example, voluntary programs for batteries and carpets, and mandatory bottle return laws) while enjoying wider adoption in Europe and Japan (for example, mandatory electrical and electronic equipment take-back).⁹⁴

⁹¹ In 1993, the Clinton administration proposed a massive BTU tax to reduce CO2 emissions. Opposition from Congress was fierce and the proposal was defeated. Calls for a carbon tax continue, see, for example, Paul Krugman, "Reckonings; Sins of Omission," New York Times, Op-Ed, (November 29, 2000).

In practice, "the closest that any charge system [in the United States] comes to operating as a Pigovian [sic] tax is the unit-charge approach to financing municipal solid waste collection, where households (and businesses) are charged the incremental costs of collection and disposal." Robert N. Stavins, "Market-based Environmental Policies," in Portney and Stavins, *supra* footnote 67, at 41.

⁹² For a discussion of tax-shift strategies, see, Lester R. Brown, Eco-Economy, New York: Norton (2001), at 236-239. Also, see Bernie Fischlowitz-Roberts, "Restructuring Taxes To Protect the Environment," Eco-Economy Updates, Earth Policy Institute (July 25, 2002-10), available online at <http://www.earth-policy.org/Updates/Update14.htm>.

See also, the discussion of insurance premium taxes, sales taxes and tax differentiation in Stavins, *supra* footnote 91, at 46-50.

In practice and until recently, in places where environmental taxes were used, they were primarily used for revenue raising purposes and were generally set too low to produce significant abatement of environmental harms. See Stewart, *supra* footnote 11, at 112-113.

For a comparison of the economic effect of uniform standards versus a tax or charge mechanism, see Mercurio, *supra* footnote 1, 183-185.

⁹³ For a comparison of alternative EPR cost recovery mechanisms, including manufacturer "take-back" provisions, product taxes, recycling subsidies as well as user fees, see Karen Palmer and Margaret Walls, Extended Product Responsibility: An Economic Assessment of Alternative Policies, Discussion Paper 99-12, Washington, DC: Resources for the Future (1999) available online at http://www.rff.org/proj_summaries/99files/palmer_extended_product_responsibility.htm.

⁹⁴ For a discussion of extended product responsibility strategies, including a comparison of United States and foreign approaches, see generally Gary A. Davis and Patricia S. Dillon, Extended Product

- ◆ Second, direct and indirect subsidies, including tax credits, price supports and other such mechanisms can be considered. Under a direct subsidy scheme, the government could entertain bids from polluters for pollution abatement and then purchase directly the desired level of reduction.⁹⁵ However, because there is strong political opposition to overt payments to polluters not to pollute such a system does not seem politically feasible. In practice, most direct government subsidies actually support or encourage environmentally destructive actions and the removal of such subsidies would seem the political priority for environmental policy here.⁹⁶ Direct subsidies for abatement, unless conducted through a very transparent information structure, would also be subject to classic regulatory capture and rent-seeking

Responsibility: A New Principle for Product-oriented Pollution Prevention, Washington, DC: Environmental Protection Agency Office of Solid Waste (1997).

For international developments in electronics product stewardship, see "EPA Home: Wastes: Product Stewardship: Products: Electronics: International Initiatives," EPA Web Page available at <http://www.epa.gov/epaoswer/non-hw/reduce/epr/products/eintern.html>. For more on the Japanese initiative, see the Japanese Law for Recycling of Specified Home Appliances, enacted in 1998 and fully implemented in April 2001 (requiring manufacturers and importers to take-back the discarded products they manufacture or import and recover specified percentages of components and material for recycling) (see summary from Foreign Press Center/Japan, available online at <http://www.fpcj.jp/e/shiryo/jb/0106.html>) and, for more on the European Commission initiative, see the European Union (EU) Directive on Waste Electrical and Electronic Equipment (WEEE Directive) COM (2000) 347, adopted by the European Commission in 2000 (available online at http://europa.eu.int/comm/environment/docum/00347_en.htm). See also footnote 102 infra (discussing the different approaches used in the Japanese [user fees] and European [manufacturers pay] system to recover end-of-cycle costs).

Adoption of these laws has spurred innovation in the "methods of production" (see Commoner, supra footnote 34) by providing both economic incentives for reducing waste (i.e., to lower the cost to be borne by manufacturers) and direct regulation of percentages of recyclable material to be recovered. See, for example, "The impact of environmental legislation on electronics and electrical product design and assembly," The Welding Institute UK (2002), at http://www.twi.co.uk/j32k/protected/band_3/ksnrs003.html. And see the discussion in Davis and Dillon supra.

For a discussion of deposit-refund systems see the references in footnote 102 infra.

⁹⁵ See Stewart, supra footnote 11, at 98. For an economic analysis of subsidy mechanisms, see Mercurio, supra footnote 1, at 182-183.

⁹⁶ See Brown, supra footnote 92, at 240-244, citing an Earth Council study finding \$700bn in environmentally destructive subsidies worldwide per year. See, also, David Malin Roodman, Paying the Piper: Subsidies, Politics, and the Environment, Washington, DC: Worldwatch Institute (1996). Numerous examples of environmentally destructive subsidies exist in the United States, including agriculture supports, depletion allowances, national timber sales, mining leases, government land sales, etc. See also, Stavins, supra footnote 91, at 55-56 ("U.S. Experience with Reducing Government Subsidies" discussing below-cost timber sales and fossil fuel energy subsidies). Again, we believe that effective information strategies can help expose the hidden environmental externalities implicit in these subsidies resulting in improved policies.

behavior.⁹⁷ Indirect or partial subsidies, particularly tax incentives such as accelerated depreciation and credits, low interest loans and incentive grants for investment in pollution abatement equipment have been marginally effective in targeted circumstance. On the state level such strategies have also been used to encourage investment in alternative energy sources.⁹⁸

- ◆ And, third, liabilities imposed for environmental damage by tort law or statutory scheme (such as CERCLA) can also be thought of as a Pigouvian environmental incentive system because they impose a charge on conduct that causes environmental harm or loss.⁹⁹ Of course, as previously mentioned above in footnote 81, even traditional command-and-control regulation can be thought of in Pigouvian terms since they effectively impose a cost -- a fine or penalty for non-compliance -- on environmentally harmful behavior much like tort liability.

For analytical purposes, we distinguish here between the mechanisms described above, where government imposes an arbitrary price or fixed remedy ("Pigouvian"), from those discussed below in which some "market bargaining" determines outcome costs ("pseudo-Coasian").¹⁰⁰ We

⁹⁷ See footnote 73-75 supra and accompanying text (discussing public choice theory).

⁹⁸ For example, New York State provides a solar energy tax credit and assures homeowners access to the electric grid to sell their surplus power. See "Governor Announces Incentives for Residential Solar Power," Press Release, January 31, 2000, available online at http://www.state.ny.us/governor/press/year00/jan31_1_00.htm

⁹⁹ See Stewart, supra footnote 11, at 97. For an economic analysis of common law tort mechanisms, see Mercurio, supra footnote 1, at 165-171. And see footnote 13 supra, discussing the common law as an efficiency-seeking economic mechanism.

¹⁰⁰ See footnote 86 supra.

For a direct comparison of the relative regulatory efficiencies of Pigouvian charge mechanisms and pseudo-Coasian trading mechanisms, see Breyer, supra footnote 5, at 273:

While both [charges] and marketable rights promote efficiency (by encouraging those for whom it is cheapest to curtail pollution to do so first), these systems may produce quite different results in a world of uncertainty. An administrator operating a [direct charge] system, and firms operating within it, know fairly well what ceiling the system has placed on their costs. They will have to pay the [charge] multiplied by their actual emissions. Insofar as they curtail emissions, they will pay less. Yet without knowing the individual cost schedules, technology, and demand facing every firm, no one can be certain in advance to what extent firms will curtail emissions or choose to pay the [charge]. The cost ceiling is known, the future pollution level is not.

include certain liability schemes, such as CERCLA and certain other strict liability statutes (such as the Oil Pollution Act ¹⁰¹), as hybrid Pigouvian, where the actual price is not fixed ahead of the activity but the certainty of “clean-up costs” are imposed. ¹⁰²

An administrator of a marketable rights system faces a converse problem. Since the number of rights is within his control, he knows fairly well the maximum emissions that will be produced. He cannot know, however (without detailed cost information about each firm), how much firms will have to pay to achieve that emissions level. He cannot know in advance the price that the marketable right will fetch at auction. The pollution level is known, the future cost of achieving it is not.

For this reason, advocates of [incentive]-based systems claim that the choice between [charges] and marketable rights depends on one's estimates about the way in which emissions and abatement costs are related to the damage caused by pollution. [citation omitted] If one believes that pollution harm increases gradually as emissions increase but that abatement costs take a radical jump upward at a certain abatement level, one might favor a [charge mechanism], since a small mistake in the [amount of the charge] would not lead to an enormous increase in pollution or impose enormous unknown costs. A small mistake in the number of authorized marketable rights, however, might cause substantial cost increases by passing the "high abatement cost" threshold with little compensating benefit in the form of reduced pollution. On the other hand, if one believes that pollution's harm increases suddenly and dramatically as a threshold level is passed but that abatement costs rise gradually, one might favor marketable rights. It would be important to guarantee that the threshold pollution level not be reached, while a mistaken estimate of the cost of reducing pollution to that level would not be enormously important.

Thus, in principle, the preference for a particular system should vary depending upon the estimated clean-up costs.

Breyer, *supra* footnote 5, at 273. See also, Tom H. Tietenberg, "Economic Instruments for Environmental Regulation," in Stavins, *supra* footnote 3, at 373-395 and Keohane, *supra* footnote 34, at 315-316 ("[E]conomic theory suggests that the optimal choice between tradable permits and emissions taxes is dependant on case specific factors."). And see generally the discussion comparing effluent charges and marketable permits in William J. Baumol and Wallace E. Oates, "The Theory of Environmental Policy," in Revesz, *supra* footnote 22, at 157-160 (in addition to the differences cited above, they discuss the effect of inflation on fees, the economic impact of grandfathering versus auctions for initial allocation of permits, hot spot/upstream-downstream issues, and the ease of transition from the existing permit system to tradable permits).

¹⁰¹ 33 U.S.C. §§2701-2761.

¹⁰² For analytical purposes, we consider traditional tort liability (in addition to such statutory strict liability mechanisms) also to be Pigouvian in nature. See footnote 12 and text accompanying footnote 87 *supra*.

In addition, certain Pigouvian mechanisms can be considered hybrid-Coasian. For example, the EPR strategies, discussed above in footnotes 93-94 and the accompanying text, are hybrid mechanisms since the actual costs of recycling or disposal are in the end determined by market forces and the regulation just forces internalization of whatever that cost may be. Compare the bottle deposit return approach where an arbitrary fixed amount per unit of waste is fixed by regulation (a more 'pure' Pigouvian pricing mechanism). See generally Peter Bohm, "Deposit-Refund Systems: Theory and Applications to Environmental, Conservation, and Consumer Policy," in Revesz, *supra* footnote 22, at 160-163 ("A deposit refund system is essentially a combination of a tax and a subsidy." *Ibid.* at 160). And see the discussion of deposit-refund systems in Stavins, *supra* footnote 91, at 42-45.

Compare also the difference in approach between the Japanese and the European EPR strategies (see footnote 94 and accompanying text *supra*). See, for example, Noako Tojo, "Analysis of EPR Policies and Legislation through a Comparative Study of Selected Programmes for EEE: Based on an In-Depth Study of a Japanese EPR Regulation," *IIEEE Communications* 2000 at 10, summary available online at <http://www.iiee.lu.se/information/library/publications/communications/2000/10nao.html>), discussing the

COASIAN MECHANISMS

In an influential article entitled "The Problem of Social Cost,"¹⁰³ Ronald Coase¹⁰⁴ took issue with the theory of social cost set forth by Pigou. According to Coase, Pigouvian theory will not necessarily optimize social product because it fails to account for (or give sufficient credit to) the reciprocal nature of the externalities problem.¹⁰⁵ The "Coase Theorem"¹⁰⁶ postulates that under true market conditions private cost and social cost will be equal, thus, government intervention is

differences in legislative approaches to assigning financial responsibility for recovery costs. The Japanese regulation obligates end-users to pay fees set by industry for the collection, take-back and recycling at the time of disposal (Pigouvian-like mechanism applied to consumers) whereas the EU Directive assigns financial responsibility to the manufacturer (who may or may not pass on the cost when pricing new products) (pseudo-Coasian). The Japanese approach has led to complaints that manufacturers were setting uniform recovery fees for classes of appliances without regard to differences within classes of disposal cost (Thus, importing some of the inefficiencies of a uniform standard-based regulatory regime). See, for example, the complaint of the Korean Embassy to the Japanese Ministry of Economy, Trade and Industry available online at <http://www5.cao.go.jp/otodb/english/mondai/subject/200200201.html>.

¹⁰³ Ronald H. Coase, "The Problem of Social Cost," 3 *The Journal of Law and Economics*, 1-44 (October 1960), reprinted in R. H. Coase, *The Firm, the Market and the Law*, Chicago and London: University of Chicago Press (1990, 1988) at 95-156.

¹⁰⁴ Ronald H. Coase (1910-). American economist, emeritus professor of law and economics at the University of Chicago and recipient of the 1991 Nobel Prize in Economics.

¹⁰⁵ Coase, supra footnote 103, at 96 and 133-149. Interestingly, Coase points out that Pigou does implicitly recognize the reciprocal nature of environmental externalities in his first (of two) examples of divergence between private and social costs [see Pigou, supra footnote 4, at 183-188]:

Pigou distinguishes between the case in which a person renders services for which he receives no payment ["uncompensated service," Pigou, supra, at 183] and the case in which a person renders disservices and no compensation is given to the injured parties ["uncharged disservice," Pigou, supra at 186]. ... Pigou points out that factory-owners who devote resources to preventing their chimneys from smoking render services for which they receive no payment. The implication ... is that a factory-owner with a smoky chimney should be given a bounty to induce him to install smoke-preventing devices [instead of taxing the smoky chimney as many economists following Pigou would suggest]. ... It seems a pity that economists ... do not seem to have noticed this feature of Pigou's treatment, since a realization that the problem could be tackled in either of these two ways would probably have led to an explicit recognition of its reciprocal nature."

Ibid. at 142-143. Coase's main objection to Pigouvian analysis is that "uncharged disservice" (Pigou's second example) [note that "uncharged disservice" corresponds to the classic environmental 'pollution as externality,' i.e. 'polluter-victim' situation] is not necessarily 'anti-social' and thus may not require government intervention. Ibid. 143. Rather, "[I]t is necessary to weigh the harm against the good that will result." Ibid. at 143-144. In Coase's view, the reciprocal nature of this situation makes private (market) negotiation a better allocation mechanism to weigh these harms than direct government intervention.

¹⁰⁶ Coase did not originate the phrase Coase Theorem, rather it was introduced by George J. Stigler in *The Theory of Price*, New York: Macmillan (Third Edition 1966), at 113.

not necessary since the parties (polluter and victim) will negotiate the socially optimal amount of environmentally harmful behavior.¹⁰⁷

Of course, the Coase Theorem is predicated on perfect market conditions,¹⁰⁸ including zero transaction costs and perfect information, as well as strong and well-defined property rights.

¹⁰⁷ Obviously, Coase's analysis of externalities and his critique of Pigou is much more complex and subtle than as we have stated here. Indeed, Coase himself disputed whether the equivalence of private and social cost is even the relevant economic question. "The comparison of private and social products is neither here nor there." Coase, *supra* footnote 103, at 142.

Analysis in terms of divergences between private and social products concentrates attention on particular deficiencies in the system and tends to nourish the belief that any measure which will remove the deficiency is necessarily desirable. It diverts attention from those other changes in the system which are inevitably associated with the corrective measure, changes which may well produce more harm than the original deficiency.

Ibid. at 153.

When an economist is comparing alternative social arrangements, the proper procedure is to compare the total social product yielded by these different arrangements.

Ibid. at 142.

It is beyond the scope of this article to fully exposit Coase's (or Pigou's) work. For our purposes, the primary difference between Pigouvian mechanisms and Coasian mechanisms is that the former would price environmental externalities by government fiat and the latter by invoking some market mechanism (and private bargaining).

However, even Coase acknowledges that the issue of environmental externalities is not a problem to be solved in terms of pure economic efficiency:

In [The Problem of Social Cost], the analysis has been confined, as is usual in this part of economics, to comparisons of the value of production, as measured by the market. But it is, of course, desirable that the choice among different social arrangements for the solution of economic problems should be carried out in broader terms than this and that the total effect of these arrangements in all spheres of life should be taken into account. ... [P]roblems of welfare economics must ultimately dissolve into a study of aesthetics and morals.

Ibid. at 154.

As previously noted in footnotes 34 and 40 *supra*, the issue of environmental policy remains one of where, by whom and how externalities are to be priced (and allocated) and environmental costs, benefits and harms are to be valued. All the mechanisms discussed – direct government regulation, common law and markets – require accurate and timely information flows to function efficiently and effectively. Thus, improvements in information technology provide new opportunities to reevaluate existing methods and to develop new approaches. See footnote 19 *supra* and Part IV *infra*.

¹⁰⁸ Economists are fond of assuming perfect markets and other things that do not exist:

A physicist, a chemist, and an economist are stranded on an island with nothing to eat. A can of soup washes ashore. The physicist says, "Let's smash it open with a rock." The chemist says, "Let's build a fire and heat it." The economist says, "Let's assume that we have a can opener."

Attributed to Paul Samuelson. See also footnote 110 *infra*.

Under these conditions, the Coase Theorem further predicts that it is irrelevant to which party such property rights are initially assigned as the parties will in either case bargain to the optimal outcome.¹⁰⁹ For example, if the property right belongs to the victim, the polluter will pay the victim to allow pollution. If the property rights belong to the polluter, the victim will pay the polluter to modify their behavior. In either case, according to Coase, the price will settle to the same socially optimal level.

In our view, the Coase Theorem (but not Coasian analysis) fails in managing real world environmental problems (at least with regard to pollution problems) because (i) perfect market conditions do not exist, that is, transaction and contracting costs in the real world are high and information is unavailable or inequitably distributed,¹¹⁰ and (ii) environmental problems are often characterized by diffuse costs imposed on victims and concentrated benefits inuring to the polluter creating additional market distortions.¹¹¹

¹⁰⁹ Coase, *supra* footnote 103, 96-104. See also Guido Calabresi and A Douglas Melamed, "Property Rules, Liability Rules, and Inalienability: One View of the Cathedral," 85 *Harv. L. Rev.* 1089, 1115-1124 (1972).

¹¹⁰ See Guido Calabresi, "The Pointlessness of Pareto: Carrying Coase Further," 100 *Yale L. J.* 1211 (1991) ("distributional issues cannot, even in theory, be avoided," *ibid.* at 1215, and "[transaction costs], no less than existing technology, define the limit of what is currently achievable in society," *ibid.* at 1212).

Under conditions where transaction costs do exist, Coasian analysis would initially assign rights to the party with the highest transaction costs in order to achieve the overall optimal social allocation of resources (that is, the party with the lower transaction costs must bear the burden). See Mercurio, *supra* footnote 1, at 158-161. And see Coase, *supra* footnote 103, at 114-119 ("VI: The Cost of Market Transactions Taken into Account"), and "Notes on the Problems of Social Cost," (Part V. The Influence of Transaction Costs), *ibid.* at 174-179.

¹¹¹ Because of these distributional inequities, the high costs of organizing victims or aggregating harms, and high transaction and contracting costs, Coasian theory generally fails in practice as applied to pollution problems as outlined herein (pollution problems generally corresponding to Pigou's second example, "uncharged disservices", see footnote 105 *supra*). However, there are specific areas, particularly in conservation or consumptive use rights, where at least limited markets seem to be working according to Coasian theory (these tend to correspond more to Pigou's first example, "uncompensated services", see footnote 105 *supra*). See the discussion of conservation easements *infra*, text accompanying footnotes 128-135.

Additional examples of such "Coasian bargaining/contracting" include the wolf fund launched by Defenders of Wildlife, see, "Defenders of Wildlife Launches Fund to Reduce Wolf Deaths," Press Release (December 21, 2000) available online at <http://www.defenders.org/releases/pr2000/pr122100.html> (the fund pays ranchers for livestock losses in return for a "no hunt" pledge), the CAMPFIRE program in Zimbabwe, see <http://www.campfire-zimbabwe.org/> (local villages given the right to market predetermined numbers of elephants and other big game to hunters), and the Oregon Water Trust, see <http://www.owt.org/>, (which acquires consumptive water rights to restore water flows for fish habitats). Further examples include: the Nature Conservancy subsidizing farmer's in Indiana to use low-erosion tillage, environmental groups in

Thus, under real-world market conditions, pollution victims often:

- ◆ have insufficient individual incentive to negotiate, organize or otherwise aggregate their costs (harms) in order to overcome transaction cost thresholds (this is particularly so where action prior to actual harm is sought or desirable),
- ◆ may not have the ability or resources to recognize or quantify their costs (harms),
- ◆ may be unable to monetize their benefits (i.e., they do not have the ability to pay the polluter to not pollute),
- ◆ are subject to insurmountable burdens to prove causation and quantify harms, even in private negotiation, because information is not available or inequitably distributed, and
- ◆ suffer environmental damages that are often not reversible (i.e., when the swimming hole is already polluted it may be too late to try to pay the polluter not to pollute, particularly when clean-up costs may have no relationship to abatement costs or monetized benefits).

Since true Coasian bargaining does not seem to function (at least with regard to pollution externalities) due to market imperfections, insurmountable transaction costs and other limitations of the employed strategies, we use the term pseudo-Coasian to identify those mechanisms discussed below that, unlike the Pigouvian examples above (in which government arbitrarily assigns costs), are Coasian-like in that the price for environmental externalities is set (at least in part) by bargaining among private actors. It should be noted, however, that most "market-based" mechanisms dealing with pollution (particularly those based on regulatory property rights)

Nevada and Utah paying ranchers to keep their herds from grazing on public lands used by hikers, and Environmental Defense paying ranchers in Texas to trap cowbirds (which are detrimental to rare songbirds). See Traci Watson, "Environmental Groups Wielding Power of the Purse," USA Today (February 3, 2000).

Another problem with Coasian analysis as applied to real world environmental problems and often ignored by advocates of market-based solutions in the context of pollution and waste disposal is that of "orphaned" harms where the original polluter (or producer of waste) is not individually identifiable (for example, in the case of diffuse sources as with agricultural run-off or climate change, or where there is a large number of polluters), or is simply no longer in existence. Again, we believe that information technology can help overcome some of these problems (in this case by tracking, remote sensing or modeling causation). See generally Part IV *infra* and footnote 19 *supra*.

implemented, advocated or contemplated to date, such as tradable permits, have prices set by bargaining among polluters, not between polluter and victim.¹¹²

Nevertheless, such markets allow for victims (or groups representing victims or environment concerns) to participate in a "pure" Coasian market by purchasing tradable permits, credits or development rights themselves and then retiring them. In a sense, these mechanisms lower the transaction and information costs for victims to pay polluters not to pollute by creating a market among polluters that sets the marginal cost of abatement in which the victims can then participate. If Coasian economic theory is correct, that marginal abatement cost should equal (or approximate) the social cost that a victim would pay for abatement in a direct negotiation.¹¹³

¹¹² This is a significant weakness of many proposed "market-based" solutions because when polluters negotiate among themselves it only affects or implicates the costs of pollution or abatement but does not reduce the overall amounts of pollution. Thus, while tradable permits or like mechanisms may be economically efficient at allocating abatement costs within the defined realm of regulatory scarcity (see footnote 86 supra) it is not necessarily an efficient allocation of social resources, as the 'market' does not take into the bargaining the true cost to the victims (that is, social harms from pollution or social benefits of abatement are not fully reflected in the negotiated price, which generally only reflects relative abatement costs). Hence, our use of the term 'pseudo-Coasian' to describe these mechanisms.

A true Coasian mechanism (that is, one in which private bargaining would result in optimal pricing where the marginal cost of harm would equal the marginal cost of abatement and all social and private costs and benefits were accounted for) would require that the bargaining be directly between polluter and victim(s). In our view, failure to address this point more fully dilutes the effect of most commentary in favor of applying regulatory property mechanisms to problems of environmental externalities.

Most of the market-based trading programs implemented to date (or those generally advocated) are hybrid regulatory-and-market schemes in which an artificial limit to scarcity is imposed (for example, by granting a regulatory property right) through the political or regulatory process and polluters then negotiate among themselves to allocate abatement costs. (Note that the third defining characteristic of successful hybrid property mechanisms identified by Merrill, see text accompanying footnote 124 infra, is that the standard for acceptable outcome had been independently and definitively established before the market mechanism was put in place.) Nevertheless, while not necessarily environmentally optimal as allocation devices, these mechanisms may be more economically efficient than traditional standards-based regulation at allocating assigned abatement costs (once desired outcomes have been identified). See Keohane, supra footnote 34, at 314 ("market-based instruments minimize the aggregate cost of achieving a given level of environmental protection"). (Of course, in theory, under conditions of effective pricing, tax and charge mechanisms should also achieve efficient allocation. Ibid. at 314 n.4.) (But, cf. Latin, supra footnote 83, disputing whether such mechanisms are actually more efficient in practice.)

In a strict sense, the only 'true' Coasian mechanism would be direct bargaining between victim and polluter with the victim enjoying an absolute (but alienable) property right backed by equitable enforcement through an injunction against the polluting activity (or bargaining between victim and polluter where the polluter enjoyed absolute immunity). In either case, in practice, transaction and contracting costs and information asymmetries interfere with the operation of this pure market. See generally footnotes 110-111 and accompanying text.

¹¹³ Obviously, the more perfect the information flows and the more victims or their representatives that participate in the market as buyers, the more the market price will trend towards Pareto Optimality (see footnote 85 supra and references therein) through operation of the "compensation principle" in which

We identify three categories of pseudo-Coasian incentive mechanisms:

- ◆ The first category includes tradable quotas or credits. These mechanisms are rightly considered as “regulatory property” or “hybrid property” mechanisms.¹¹⁴ According to Professor Merrill, there have been eight fully implemented market-based environmental regulatory programs in the U.S.¹¹⁵ Five of these programs arose under various provisions of the Clean Air Act¹¹⁶ and three under water quality standards mandated by the Federal Water Pollution Control Act.¹¹⁷

transfer payments between utility maximizing (victim) and profit maximizing (polluter) participants optimize pricing (see footnote 83 supra and Mercurio, supra footnote 1 at 45). However, existing market-based trading programs have not experienced significant 'victim' participation so it is unlikely that these programs are actually achieving optimal social pricing. In practice, "retirement" of credits or permits generally only occurs for tax or public relations benefit for polluters with excess credits. However, little research or empirical evidence seems to exist on this particular point.

¹¹⁴ See Carol M. Rose, “The Several Futures of Property: Of Cyberspace and Folk Tales, Emission Trades and Ecosystems,” 83 Minn. L. Rev. 129, 164-169 (1998). The idea for tradable pollution permits originated with John H. Dales in Pollution, Property and Prices, Toronto: University of Toronto Press (1968) and was formalized by W. David Montgomery in “Markets in Licenses and Efficient Pollution Control, 5 J. Econ. Theory 395 (1972). For an economic analysis of transferable permits and emission trading, see Mercurio, supra footnote 1, at 186-189.

¹¹⁵ See Merrill, supra footnote 77, at 282, citing Gert Tinggaard Svendsen, Public Choice and Environmental Regulation, 71-132 (1998). See also Stavins, supra footnote 91, at 35-41 (“U.S. Experience with Tradable Permit Programs,” discussing six programs, five clean air and one water [the Dillon Reservoir]).

¹¹⁶ Merrill, *Ibid.* at 283:

The five air pollution programs were adopted at various times starting in 1974 and culminating most recently in 1993. They are: (1) the Emissions Trading Program, which is really four different trading rules - netting, offsets, bubbles, and banking - that apply primarily under the nonattainment provisions of the Clean Air Act [Emissions Trading Policy Statement; General Principles for Creation, Banking and Use of Emission Reduction Credits, 51 Fed. Reg. 43,814, 43,829 (1986)]; (2) the Lead Additives Trading Program that applied to the EPA-mandated phaseout of lead in refined gasoline from 1982 to 1987 [Regulation of Fuel and Fuel Additives, 40 C.F.R. 80.20(d) (1985)]; (3) the CFC/Halon Trading Program that applied during the phaseout of these ozone-depleting substances mandated by the Montreal Protocol [Protection of Stratospheric Ozone, 40 C.F.R. 82 (1988); Montreal Protocol on Substances that Deplete the Ozone Layer, 52 Fed. Reg. 47,489, 47,515-19 (1987)]; (4) the sulfur dioxide trading program under the Acid Rain Program established by the 1990 amendments to the Clean Air Act [Clean Air Act, tit. IV, 42 U.S.C. 7401-7671 (1994)]; and (5) the Regional Clean Air Incentives Market (RECLAIM) program adopted under state regulatory authority in Southern California to achieve compliance with federal guidelines for smog [See generally John P. Dwyer, The Use of Market Incentives in Controlling Air Pollution: California's Marketable Permits Program, 20 Ecology L.Q. 103, 104 (1993)].

¹¹⁷ *Ibid.*:

The three water pollution programs were adopted at various times between 1981 and 1989. They are: (1) a discharge trading program established on the Fox River in Wisconsin in 1981 [See Wis. Admin. Code NR 212.115 (1986)]; (2) a point/nonpoint trading program established in 1982 at the

Merrill's analysis of these market-based strategies looks at the characteristics of existing programs and attempts to provide a theoretical framework to explain how these programs come into being and why they exhibit certain shared characteristics. It is beyond the scope of this work to summarize in full Merrill's analysis but certain pertinent points can be set out.

First, under a wealth-maximization theory¹¹⁸ analysis, Merrill proposes as a general matter that, although there are higher transaction costs to set up and maintain these property systems,¹¹⁹ moving from command-and-control to market-based mechanisms is progressively more effective in controlling rent dissipations and reducing externalities. The combination of these characteristics -- higher management costs but greater effectiveness --

Dillon Reservoir in Colorado [See 5 Colo. Code Regs. 1002-71 (1984)]; and (3) a point/nonpoint trading program established in the Tar-Pamlico River Basin in North Carolina in 1989 [See N.C. Admin. Code tit. 15A, r. 2B.0229 (Aug. 1999)].

¹¹⁸ According to Merrill, the basic insight of the wealth-maximization theory is that:

"property rights emerge and recede in accordance with a criterion of social wealth maximization, in effect a type of cost-benefit analysis. The benefits of a property regime come in reducing wasteful competition to capture the economic rents associated with scarce resources (what the neoinstitutionalists call "rent dissipation") and by making it easier to control the external costs associated with resource use by reducing the number of parties affected by such uses. The costs of such a regime include the costs of defining property rights, identifying the owners of such rights, and protecting the rights against interference by others. According to wealth-maximization theory, if the social benefits of a property regime exceed the social costs of creating and enforcing such a regime, then society will recognize property rights over a resource."

Ibid. at 278.

¹¹⁹ Ibid. at 279, citing Carol M. Rose, "Rethinking Environmental Controls: Management Strategies for Common Resources," 1991 Duke L. J. 1 (1991) and, generally, Rose, supra footnote 114.

"Carol Rose, in a provocative article, has adopted this property rights framework to explain the evolution of different forms of environmental protection. She describes four general control strategies, starting with DO-NOTHING (leaving the problem unregulated), followed by KEEPOUT (prohibiting new polluting sources), then RIGHTWAY (command-and-control regulation), and lastly PROP[ERTY] (market mechanisms). She suggests that, as a general matter, these four strategies are characterized by progressively higher management costs, both in terms of the costs of administrating the system and the costs to users of complying with the system. However, again as a general matter, these strategies are also progressively more effective in controlling rent dissipation and reducing externalities. The combination of these general features - higher management costs but greater effectiveness - means that as a rule, as pressure on resources increases, the political system will tend to shift to progressively more expensive but more effective control mechanisms. "

Merrill, Ibid.

implies that as scarcity increases, the political system will increasingly adopt these higher cost but more effective mechanisms.¹²⁰

Next, Merrill applies a distributional theory¹²¹ analysis to conclude that distributional effects are less likely to effect *when* a market-based mechanism is adopted than *what kind*.¹²²

After examining individual existing programs, the following general characteristics are identified:¹²³

1. The programs existed only in the air and water pollution contexts,
2. The existing programs all relied on “grandfathered” permits – a system of tradable permits in which initial allocations are made to existing polluters without cost to them on the basis of past pollution levels, and
3. All the programs arose in contexts in which the standard for acceptable outcome had independently and definitively been established before the market-mechanism was put in place.¹²⁴

The absolute bias exhibited for mechanisms using tradable permits based on grandfathered rights is strongly supported by a distributional analysis that recognizes the political reality that

¹²⁰ Ibid. at 279-280. Accordingly (and following the thesis of this article), adoption of such mechanisms should also increase as new technologies lower adoption and management costs, see Part IV *infra*.

¹²¹ "The starting point here is not the efficiency of an institutional arrangement but rather its distributional implications. Different policy instruments will favor different social groups, and these groups are assumed to compete in an effort to persuade regulators to adopt those instruments that distribute the greatest wealth to themselves. Moreover, [the influence and effect of such groups will differ depending on factors such as] (1) the costs of organizing the group for political action; (2) the per capita stakes among the members of the group with respect to the particular issue; and (3) whether the interests of the group members are aligned or in conflict with respect to the issue." Ibid. at 280.

¹²² Ibid. at 281.

¹²³ Ibid. at 287-288.

¹²⁴ As noted above in footnote 86 *supra*, market-based allocation mechanisms generally require imposition of regulatory scarcity (for example, by granting a limited number of regulatory property rights) to create the market, thus, a prior political (see Keohane, *supra* footnote 34, describing the political economy of environmental regulation) agreement to an agreed outcome is necessary.

a government grant of new tradable property rights at no cost is preferable to the regulated industry than any other market-based scheme that would impose costs without first granting something of value (i.e., the tradable permit).¹²⁵

Merrill concludes by posing a synthesis of wealth-maximization and distributional theories to explain how and why market-mechanisms come into being and acquire certain characteristics: new environmental control strategies, particularly market-based mechanisms, come into being when the subject resource becomes so stressed or scarce that the cost of adopting the new regime is exceeded by the benefits to be gained (wealth-maximization theory);¹²⁶ however, in order for the new regime to be adopted, existing entrenched interests (for example, the regulated industry) must be satisfied, and, therefore, the choice of particular scheme is greatly influenced by the distributional impact of its characteristics (distributional theory).¹²⁷

- ◆ The second category of pseudo-Coasian mechanisms includes transferable development or consumption rights. These can be imposed by government regulation, for example, in

¹²⁵ "In contrast [to direct tax schemes, which have not been adopted in the U.S. due to political opposition], allocating tradable permits by grandfathering has diffused political opposition to the adoption of trading systems with incentive effects similar to those of taxes." Stewart, *supra* footnote 11, at 115.

Also, the use of grandfathered permits provides additional barriers to entry advantaging existing firms over new entrants. See Keohane, *supra* footnote 34, at 364-365 (discussing the use of grandfathered permits as the exclusive mechanism despite the disadvantage of this allocation method.)

Note that it has been proposed that in future programs such rights should be auctioned not grandfathered. See for example, Peter Cramton and Suzi Kerr, "Tradable Carbon Permit Auctions: How and Why to Auction Not Grandfather," Discussion Paper 98-34, Washington, DC: Resources for the Future (1998), available online at www.rff.org/disc_papers/PDF_files/9834.pdf. See also, Keohane, *supra*, 316 n. 19, discussing the superiority of auction methods of initial allocation.

¹²⁶ As noted earlier in footnote 120 *supra*, adoption of these mechanisms should therefore also occur as new information technologies lower the costs of adoption and management. See Part IV *infra*.

¹²⁷ *Ibid.* at 296-298. This would follow predictions based on public choice theory, see footnote 73-75 *supra*. As noted below in "Coalition Building" in Part IV *infra*, these distributional aspects will also be affected by development and adoption of new information technology enabled strategies as new constituencies of interested parties will be drawn into the process. See footnote 234 *infra*.

requiring offsets¹²⁸ or by zoning,¹²⁹ or can be negotiated entirely between private parties.¹³⁰

Under modern property theory, where property is considered a bundle of rights,¹³¹

landowners can alienate certain rights while maintaining others for their own use. Rights can arise as a government grant or by private disaggregation of existing common law rights, for example by deed-restriction or conservation easement.¹³²

Among the more interesting trends in environmental conservation is the increasing use of conservation easements and development rights acquired from private landowners by various environmental and conservation groups. Such acquisition can occur through direct sale or by donation in return for tax, development variance or other benefits.¹³³

Transferable consumption rights allow the holder to consume some defined amount of a common resource or transfer such right to another. These rights have been used to efficiently allocate water use and to manage depleted fisheries with the assignment of individual transferable quotas of fish catch.¹³⁴

¹²⁸ For example, a private market for offsets under §173 of the Clean Air Act, *supra* footnote 52, has developed in non-attainment areas. See Stewart, *supra* footnote 11, at 104-106.

¹²⁹ In New York City there is a robust market for transferable development "air rights." See, Norman Marcus, "Air Rights in New York City," 50 *Brooklyn L. Rev.* 867 (1984).

¹³⁰ James Tripp and Daniel J. Dudek, "Institutional Guidelines for Designing Successful Transferable Rights Programs," 6 *Yale J. on Reg.* 369, 377-382 (1989) (discussing transferable development rights as a property approach to environmental management). See footnote 111 *supra* for examples of private contract rights being used in the conservation of wolves, elephants, fish habitat, farm land, hiking trails and rare birds.

Privately negotiated conservation based on contract and property rights comes closest to 'pure' Coasian bargaining. See footnote 83 *supra*.

¹³¹ See discussion in Part II *supra*, text accompanying footnotes 33-34.

¹³² See generally Jeffrey Tapick, "Student Note: Threats to the Continued Existence of Conservation Easements," 27 *Colum. J. Envtl. L.* 257 (2002).

¹³³ See, for example, "Success Stories," The Nature Conservancy (2002) available at <http://nature.org/aboutus/success/about/art1814.html>.

¹³⁴ For a description of various water rights trading programs, see "Water Resource Markets," World Bank Group, available online at <http://rru.worldbank.org/Resources.asp?results=true&stopicids=54>. For a discussion of consumption rights to manage fisheries, see Robert Repetto, "A New Approach to Managing Fisheries," *Issues in Science and Technology Online* (Fall 2001) available online at <http://www.nap.edu/issues/18.1/repetto.html>.

Transferable development and consumption rights seem particularly effective in resource conservation efforts.¹³⁵

- ◆ The third category of pseudo-Coasian mechanisms includes information and disclosure approaches.¹³⁶ Typically, such schemes require firms (or government agencies) to disclose information about the environmental impact of their products or activities.¹³⁷

Information disclosure acts as an economic incentive mechanism indirectly. Externalities exist because certain costs can be shifted from the producer to others without being

¹³⁵ See generally Kari Gathen, "Comment: The Use of Conservation Easements to Preserve New York State's Natural Resources," 7 *Alb. L. Envtl. Outlook* 188 (2002). For examples of private contract rights being used for conservation, see footnote 111 *supra* (identifying examples relating to wolves, elephants, fish habitats, farm land, hiking trails, and cowbirds).

¹³⁶ Some commentators consider information disclosure strategies themselves to be a "third wave" of environmental policy (command-and-control being the first, and market-based mechanisms, the second). See Tom Tietenberg, "Disclosure Strategies for Pollution Control," 11 *Envtl. & Resources Eco.* 587-602, 587 (1998). However, we consider them here under "incentive-based" mechanisms as they operate by exposing environmental externalities to market forces. See Stewart, *supra* footnote 11, at 97.

For a general discussion of information disclosure strategies as environmental regulation, see David W. Case, "The Law and Economics of Environmental Information as Regulation," 31 *Envtl. L. Rep.* 10773 (2001) (including a review of economic literature on regulating through information disclosure, *ibid.* 10776-781, and a review of the legal literature on regulating through information disclosure, *ibid.* 10781-789).

See also Bradley C. Karkkainen, "Information as Environmental Regulation: TRI and Performance Benchmarking, Precursor to a New Paradigm?" 89 *Geo. L. J.* 257 (2001) and Mark A. Cohen, "Information as a Policy Instrument in Protecting the Environment: What Have We Learned?" 31 *Env. L. Rep.* 10425 (2001).

¹³⁷ An example of a product disclosure strategy is the 1993 nutritional labeling regulations issued by FDA under the Nutrition Labeling and Education Act of 1990 (NLEA), Pub. L. No. 101-535, 104 Stat. 2353. For a discussion of risk labeling and its economic effects, including guidelines for the design and evaluation of informational strategies, see generally Wesley A. Magat and W. Kip Viscusi, *Informational Approaches to Regulation*, Cambridge: MIT Press (1992).

Examples of activity disclosure include the toxic releases inventory (TRI) program under the Emergency Planning and Community Right-to-know Act (1986), 42 USC §§11001-11050, see <http://www.epa.gov/tri/whatis.htm>, (and see Karkkainen, *supra* footnote 136) and California's Proposition 65, see Percival, *supra* footnote 29, at 520-525 (but see Cass R. Sunstein, "Information Regulation and Informational Standing: Akins and Beyond," 147 *U. Pa. L. Rev.* 613, 627-628 (1999) "California's Proposition 65 ... has in some ways been counterproductive. ... With respect to information, less may be more." See text accompanying footnotes 133-137). See also, Karkkainen, *supra* footnote 136, at 345-348, distinguishing the operative mechanisms of Proposition 65 from those of TRI.

With respect to disclosure relating to federal agency action, see the National Environmental Policy Act, 42 USC §§4321-4370a, §102(2)(c) requiring an environmental impact statement for any major federal action.

accounted for.¹³⁸ Information disclosure exposes this "hidden" cost-shifting and allows consumer, financial and enforcement markets to re-impose these costs on producers through indirect "pricing", that is, market pressures. Thus, for example, disclosure about environmental harms (including health effects) of a particular product can result in a drop in consumer demand for that product.

In general, information disclosure systems exert pressure on firm behavior in five ways:¹³⁹

1. direct consumer effect (consumers will not buy dirty product),
2. indirect consumer effect (consumers will not buy any product from dirty firm),
3. secondary market effects (for example, financial market effect, where financial firms may avoid investment in dirty firms, either because their own customers demand it, or because they price into the investment the potential environmental liability),
4. enforcement effect (disclosure provides market with information that will lead to direct regulation or enforcement action by agency or affected citizens), and
5. political effect (disclosure may result in call for direct regulation of dirty firm or industry).

Information strategies are not always effective and can also impose significant social costs of their own.¹⁴⁰ Examples of these kinds of problems are apparent in the EPA's decision to require schools to disclose asbestos hazards in the mid-1980s¹⁴¹ and the Alar controversy.

¹³⁸ Pigou, *supra* footnote 4, and, generally, Part I, Introduction, *supra*.

¹³⁹ Compare Karkkainen, *supra* footnote 136 at 294-331, discussing how information disclosure under TRI drives performance improvements. Karkkainen discusses self-monitoring, peer monitoring, regulatory monitoring, community monitoring and market monitoring effects. In particular, Karkkainen discusses the interrelated, mutually reinforcing pressures that these strategies exert for continuous improvement. *Ibid.* at 328-331. And compare also, Tietenberg, *supra* footnote 136, at 591-592 discussing information effects in the product market, capital market, labor market, judicial system, and the legislature.

¹⁴⁰ "There are two problems with informational strategies. First, providing information may be expensive, sometimes costing more than it is worth. Second, the provision of information is sometimes ineffectual, or even counterproductive." Sunstein, *supra* footnote 137 at 626.

¹⁴¹ See Percival, *supra* footnote 29, at 518. "Discoveries of asbestos often produced panicked reactions from parents and school authorities that actually may have exacerbated the risks to children."

¹⁴² Both cases highlight the difficulty of allowing the public to make "risk assessments" directly based on incomplete or uncertain scientific or data disclosures. ¹⁴³

In designing information regulatory schemes and systems, it becomes necessary to understand how information interacts with private sector decision-making ¹⁴⁴ and public sector response. Systems need to be designed to provide not just data disclosure but the institutional mechanisms to manage the data, turn it into useful information, and provide effective decision making support. ¹⁴⁵ The interaction of data release and private sector

¹⁴² See Eliot Marshall, "A is for Apple, Alar, and ... Alarmist?" 254 Science 20-22 (1991). (risks after the controversy found to be less than half those estimated by EPA earlier) and Timur Kuran and Cass R. Sunstein, "Availability Cascades and Risk Regulation," 51 Stanford L. Rev. 683, 698-701 (1999) (EPA found risk to be 25 times less than NRDC had earlier publicized). But cf. David Rall and Philip J. Landrigan, "Of Apples and Alar," Washington Post, Jan. 13, 1998, at A14 (claiming that "the Alar episode was based on solid science").

¹⁴³ To some extent, these difficulties result from both the imperfect availability of information (supply side) and from the difficulties in consuming information (demand side, see footnote 144 infra).

With regard to supply, public information flows are to some extent controlled by "information entrepreneurs", including activists and the media, who attempt to engender information cascades to further their own particular agenda. (We do not mean to imply that these actors are not justified in their concerns, only that their particular focus comes to dominate the information flow.) "An [information] cascade is a self-reinforcing process of collective belief formation by which an expressed perception triggers a chain reaction that gives the perception increasing plausibility through its rising availability in public discourse." Kuran and Sunstein, supra footnote 142 at 684.

Because media focus can result in such cascades, relatively minor risks can be overblown causing both unnecessary concern and a misallocation of resources to resolve the issue. The result is often a high level of social anxiety, the expenditure of significant resources, and the imposition of costly regulation in situations where other risks, of greater magnitude, are ignored. Compare for example, Alar and tobacco. See generally, Kuran and Sunstein, *ibid.* 683-768. And see "Chapter 4: This Month's Risk," in Cass R. Sunstein, Risk and Reason: Safety, Law, and the Environment, 78-98, Cambridge: Cambridge University Press (2002).

¹⁴⁴ *Ibid.* at 264. That is, how information is used or consumed. "Studies of risk communication have emphasized that information becomes relevant to people through their specific background assumptions, knowledge, and systems of value. Effective information disclosure requires knowledge of the beliefs on which citizens are likely to draw. If these background frameworks are incomplete or error-filled, factually accurate information may well be ignored or misunderstood. More information might even make people less informed."

"If information is not provided in a clear and usable form, it may actually make people less knowledgeable than they were before, producing overreactions, or underreactions, based on an ability [sic] to understand what the information actually means." Sunstein, supra footnote 137, at 628.

¹⁴⁵ These requirements should include significant investment in public education on environmental issues. As noted in our Conclusion, *infra*, we call for increased focus of federal resources on enhancing environmentally-relevant information flows; this call would include direct investment in environmental education – both in the form of programs for general public awareness and specific environmental curriculum programs for schools. See, for example, Taipale, footnote 167 *infra*. And,

behavior needs further examination, however, as a general rule, we propose that open access and more disclosure should lead to improved environmental decision making.¹⁴⁶

Informational approaches to environmental regulation require more sophisticated understanding of environmental problems and their consequences than those required by command-and-control.¹⁴⁷ Regulators will have to consider the informational effects of disclosure and better understand public and firm decision making processes in order to adopt new regulatory structures that can appropriately affect private sector behavior.¹⁴⁸

[G]iven the world's increasing technological sophistication and the close interaction between technological progress and environmental concerns, there is a need to develop a technologically and environmentally literate citizenry.

Braden R. Allenby, et al. "Overview and Perspectives" in Deanna J. Richards, et al., Information Systems and the Environment, at 1-12, 11, Washington, DC: National Academy Press (2001).

¹⁴⁶ See Tietenberg, supra footnote 136, at 599, concluding that "The evidence in general suggests that disclosure strategies can ultimately motivate polluters to reduce emissions even in the absence of more traditional regulatory controls. This is an important result because disclosure regulations are normally justified only in terms of the moral principle that victims have the right to know the risks they face. This analysis suggests that disclosure strategies may have an efficiency role to play as well."

See also Karkkainen, supra footnote 136 at 328-331 and Percival, supra footnote 29, at 516-538 and see, for example, Rechtschaffen, "How to Reduce Lead Exposure with One Simple Statute: The Experience of Proposition 65," 29 Env. L. Rep. 10581 (1999) excerpted in Percival at 526-530.

As previously noted throughout, it is the thesis of this article that developments in information technology can improve environmental information flows that can not only enable certain new mechanisms but can enhance existing strategies by lowering transaction costs, and identifying and monitoring previously hidden externalities. See footnote 19 supra.

¹⁴⁷ See, for example, Kuran and Sunstein, supra footnote 142, at 685-701, discussing the impact of "information cascades" resulting from public disclosure of information relating to perceived dangers and suggesting certain mechanisms to mitigate harmful outcomes, including new governmental structures designed to give agencies better insulation against mass demands for regulatory change and better accessibility to scientific databases in order to reduce mass dependence on "popular (mis)perceptions". And see "More Effective Communication of Risk Information" in Sunstein, supra footnote 143, at 264-266.

¹⁴⁸ See Al Alm, "Science, Social Science, and the New Paradigm," 26 Envtl. Sci. Tech. 1123 (1992) available online at <http://pubs.acs.org/emeta/AcsLogin?url=%2FUADB%2Farcxppview%2Fcgi-bin%2Farchive.cgi%2Festhag%2F1992%2F26%2Fi06%2Fpdf%2Fes50002a014.pdf&mode=login> (such information disclosure strategies require "a basic understanding of how decisions are made in the private sector, what stimuli would change private sector behavior, and how public sector activities could make a difference."). See also Granger Morgan, Baruch Fischhoff, Ann Bostrom, Lester Lave and Cynthia J. Atman, "Communicating Risks to the Public," 26 Envtl. Sci. Tech. 2048 (1992). And see generally Roger E. Kasperson and Pieter Jan M. Stallen, Communicating Risks to the Public: International Perspectives (Technology, Risk, and Society), Boston: Kluwer Academic Publishers (1991).

In sum, economic incentive mechanisms may be superior to command-and-control regulations in many environmental situations because they can achieve any given level of abatement for the lowest overall social cost and with great flexibility.¹⁴⁹ Such systems are by nature economically efficient in allocating scarce resources.¹⁵⁰ In addition, by providing continuous positive pressure on decision making these mechanisms can affect institutional behaviors more broadly and with greater effect than mandated command-and-control strategies applying behavior thresholds through uniform standards.¹⁵¹

¹⁴⁹ The choice of what level of abatement and of who should bear the costs remains a political and/or ethical one. See generally Mercurio, *supra* footnote 1, at 43 (formulating a social welfare function), and Coase, *supra* footnote 103, at 154 ("welfare economics must ultimately dissolve into a study of aesthetics and morals," quoted in footnote 107 *supra*). See also footnote 150 *infra*.

For a detailed analysis and the presentation of a unified framework of the structural institutional forces (based on a metaphor of a political market) controlling the choice of policy instruments, see Keohane, *supra* footnote 34:

At least in theory, market-based instruments minimize the aggregate cost of achieving a given level of environmental protection and provide dynamic incentive for the adoption and diffusion of cheaper and better control technologies. Despite these advantages, market-based instruments have been used far less frequently than command-and-control standards.

Ibid. at 314. Keohane, et al., postulate a theory based on the equilibrium of aggregate demand and supply for certain regulatory instruments and their effects. *Ibid.* 323-325. As noted previously, *supra* footnote 127, we believe that adoption of new technologically enabled approaches to environmental policy will bring new participants and new interests into the environmental policy arena, thus, potentially upsetting this equilibrium and thereby providing new opportunities for the adoption of additional new regulatory mechanisms. This political interest disruption is in addition to the disruption that widespread distribution of environmental data and tools will have on certain existing information asymmetries that have historically justified or preferred command-and-control outcomes. For a general discussion of disruptive technologies and change, see Peter F. Drucker, *Post-Capitalist Society*, New York: Harper Business (reprint ed. 1994).

¹⁵⁰ Interestingly, economic incentive mechanisms also may be more equitable, or at least more democratic in adoption and implementation. Cass Sunstein argues that regulatory strategies based on economic incentive mechanisms focus the polity on the appropriate political question – how much environmental protection at what cost – and eliminate some of the opportunity for interest-group maneuvering and the resultant legislative and regulatory capture problems inherent in the traditional command-and-control approach. Sunstein, *supra* footnote 143 at 272-273 and see Bruce Ackerman and Richard B. Stewart, "Reforming Environmental Law: The Democratic Case for Market Incentives," 13 *Columbia J. Env. L.* 171 (1988). As noted in footnote 34 *supra*, the fundamental environmental policy issue is where (in what forum) and how (by which mechanism) this political question is answered.

¹⁵¹ This is a significant point. Command-and-control is particularly effective at identifying and dealing with easily recognized or egregious problems, and at implementing compliance and enforcement of site specific point source or 'end-of-pipe' standards. However, to accomplish broader environmental improvements (including to remake "the technologies of production", see Commoner, *supra* footnote 34), mechanisms that can extend environmental values into everyday private economic decision-making are necessary. Resources for enforcing command-and-control regimes are limited, thus, to get actors to go beyond the standards, or to reach actors not subject to particular enforcement focus, the mechanisms themselves must affect private decision-making generally. Therefore, strategies that provide economic incentives or disclose externalities to market forces generally will have wider effect.

However, in order for incentive-based systems to be adopted and to function properly they are dependant on low transaction costs and freely flowing information.¹⁵² In cases of high transaction costs and restricted information flows, economic incentive regimes may serve to further distributional inequities and prevent economic efficiencies by sub-optimally allocating resources to second or third best outcomes. Additionally, distributional issues of regime adoption need to be taken into account when designing and implementing such systems in order to meet constituent expectations and achieve acceptance by affected stakeholders.

For a variation of this point, see "Enterprise – Background Document to EEE Directive Proposal" available at http://europa.eu.int/comm/enterprise/electr_equipment/eee/background.htm, discussing "integrating the environmental dimension into enterprise policy".

¹⁵² See Rose, *supra* footnote 14, at 167.



IV. INFORMATION TECHNOLOGY AS AGENT OF CHANGE

Advances in information and communication technologies are rapidly changing the amount of data that can be collected, stored, analyzed and distributed, and the speed and efficiency at which these tasks can be accomplished, while at the same time significantly lowering the cost of doing so. These developments provide the opportunity to transform environmental analysis and policy.¹⁵³

Adoption of new regulatory schemes, particularly economic incentive-based mechanisms, is dependent on lowering the costs of adopting and managing such regimes.¹⁵⁴ In addition, any market-based mechanism requires freely flowing, sufficient and timely information in order to

¹⁵³ Developments in information technology are transforming environmental analysis:

Cheaper and faster computers are opening the way to ever more sophisticated models and simulations. Developments in computer graphics and information processing are changing the way researchers visualize their results, while networking technologies such as the internet [sic] make it easier to share those results with others.

Mike Sharp, "The 21st Century Analyst: Developments in Data Analysis and Visualization," 4 *J. Envtl. Monit.* 33N (2002).

Improvements in environmental data analysis in turn provide opportunities for new policy options:

Today, solutions to environmental challenges are aided by an arsenal of information and knowledge systems that were unavailable for most of the last 30 years when environmental management was predicated on "command-and-control" mechanisms such as remediation of specific sites or compliance with, and enforcement of, end-of pipe emissions requirements and standards. As knowledge about the causes of environmental ills has grown, so too has the number of options on how to handle them and the development of collaborations or partnerships aimed at harnessing the growing incentive-based approaches to environmental protection.

Allenby, *supra* footnote 145, at 1.

For a general discussion of environmental information systems, including data capture, storage, analysis and metadata management, see Oliver Guenther, *Environmental Information Systems*, New York: Springer Verlag (1998).

¹⁵⁴ See footnotes 118-119 *supra* and see generally the discussion accompanying footnotes 114-127. And cf. Latin, *supra* footnote 83, arguing that high "information collection and evaluation costs", among other things, may make adoption of economic incentive or other 'fine-tuning' mechanisms to price externalities less efficient than adopting uniform standards under a command-and-control regime. Following Professor Latin's argument, lower costs should enable adoption of such mechanisms.

function smoothly, efficiently and effectively.¹⁵⁵ For mechanisms employing tradable regulatory property or consumption rights, those rights must be defined, allocated and tracked.¹⁵⁶ To insure market integrity, participants must be monitored for compliance.¹⁵⁷ For EPR strategies in which lifecycle responsibility is assigned to product manufacturers, such products must be tracked and production, reuse and disposal monitored.¹⁵⁸ For information disclosure strategies to succeed, information must be managed and appropriately distributed.¹⁵⁹ In all cases, for regulators to develop effective incentive-based regulatory regimes and for such mechanisms to work to harness private decision-making, they must be able to better predict, identify, monitor and assess environmental hazards and improvements.¹⁶⁰

Additionally, in order to adopt any new regulatory structure, political and distributional realities must be addressed and satisfied.¹⁶¹ New political coalitions and constituencies need to be formed and managed.

Current developments in information and communication technologies can support the adoption, implementation, and management of such schemes by improving methods for monitoring,

¹⁵⁵ "[O]ne of the basic assumptions of a purely competitive, perfectly functioning market is that all [participants] have perfect information over all facets of all market transactions. However, if the requirement of perfect information is not met, then conditions arise that can ... prevent the market from obtaining a Pareto optimal outcome." Mercurio, *supra* footnote 1, at 15.

¹⁵⁶ See footnote 14 *supra* (citing and quoting Rose).

¹⁵⁷ *Ibid.*

¹⁵⁸ Even without EPR schemes, information technology can be used to track products and provide needed information for end-of-cycle disposal. See, for example, Steven Saar and Valerie Thomas, "Towards Trash That Thinks," 6 *J. of Industrial Ecology* 133 (2002) discussing 'smart' product tags for environmental management. End-of-cycle and waste stream information availability can facilitate development of secondary markets. See footnote 185 *infra* and accompanying text.

¹⁵⁹ See footnotes 144-148 and accompanying text.

¹⁶⁰ See "Flying Blind," in "A Survey of the Global Environment," *The Economist*, July 6, 2002, at 3-16, 5-6. And see generally Bruce Tonn and Robert Turner, "Environmental Decision Making and Information Technology: Issues Assessment," National Center for Environmental Decision Making Research, Oak Ridge National Laboratory (May 1999) (report presents a summary of the "Information Technology and Environment Workshop" held at Harvard University, October 1-3, 1999) available online at <http://www.ncedr.org/pdf/99-01.pdf>.

analyzing and distributing information, and by lowering adoption, transaction and management costs. In addition, these technologies provide opportunities to develop new coalitions to overcome entrenched political and economic resistance to regulatory structure change.

MONITORING

Identifying, measuring and monitoring environmental impacts accurately and efficiently is fundamental to the adoption of any strategies that seek to more accurately and efficiently price environmental externalities.¹⁶² Further, the ability to measure, monitor and report on performance is a requirement for adopting economic incentive mechanisms, particularly those based on tradable permits or regulatory property rights¹⁶³ or information disclosure.¹⁶⁴

Mobile input devices are already changing the way professional researchers capture field data and provide opportunities for development of new data sets.¹⁶⁵ New low-cost monitoring

¹⁶¹ See Merrill, *supra* footnote 77, at 297-298. And, see generally Keohane, *supra* footnote 34 (discussing the 'political market' governing environmental policy and regulation). And, see footnote 242 *infra*.

¹⁶² See generally "Flying Blind," *supra* footnote 159. And, see Freeman, *supra* footnote 19, "A surprising number of environmental problems are caused, at least in part, by inappropriate prices for some of the goods and services that people buy and by barriers to the effective functioning of markets."

¹⁶³ See footnote 14 *supra*.

¹⁶⁴ See text accompanying footnotes 136-148 *supra*. And see Glenna Ford, "Using Information Technology to Measure, Monitor and Report on Environmental Performance," issues paper, available online at <http://www.environmental-center.com/articles/article38/article38.htm> (discussing the need for sophisticated environmental management systems for businesses subject to environmental reporting):

Businesses around the world are coming under increasing pressure to reduce or eliminate the environmental impacts of their operations. In order to accomplish these goals, they need to implement effective environmental management systems (EMS) to measure, monitor and report on the environmental aspects relating to their activities, products and services.

Ibid.

¹⁶⁵ Sharpe, *supra* footnote 153, at 35N:

Using a personal digital assistant (PDA), researchers can now capture field data electronically, and generate live reports on the sampling process. Leading commercial systems, such as Earthsoft's ... environmental database, are now available in mobile versions. [citation omitted] Combining a database, a GIS [geographic information systems] application and a global positioning system (GPS), these devices provide powerful solutions for managing data in the field. Such mobile solutions open the way to cradle-to-grave electronic handling and management

devices, connected to wide-area networks such as the Internet, can make identifying, measuring and monitoring of both discharges and ambient conditions cheaper and more widely available.¹⁶⁶ In addition to attaching such devices directly at point sources, new methods of gathering large data sets can be devised. An example might be enlisting every high school in the United States to input local environmental data or connect remote sensing devices as part of a single, nationwide, environmental curriculum project.¹⁶⁷

Low cost monitoring devices, widely distributed to local communities and connected to the Internet, could provide statistically significant primary ambient data inputs across entire geographic regions as well as within local sectors.¹⁶⁸ Additionally, such broadly based inputs can significantly improve the ability to develop sophisticated computer models to track and predict environmental effects. By encouraging large numbers of local participants, data sets and model accuracies could be improved by orders of magnitude.

¹⁶⁶ See, for example, the U.S. EPA Project EMPACT: Environmental Monitoring for Public Access and Community Tracking (more information at <http://www.epa.gov/empact/>), which provided grants to local communities to develop environmental monitoring and information sharing at the local level.

For another example, see the Iwate Environment Network (IEN), a Japanese project using the Internet for environmental monitoring and education. IEN is a joint project of the Iwate Prefecture Government, the Institute of Advanced Studies of the United Nations University, and Nippon Telegraph and Telephone linking real-time environmental monitoring sensors for air (NO₂, CO₂ and suspended particulates) and water quality to Internet accessible databases. Information available online at <http://www.ias.unu.edu/research/iwate.cfm>

¹⁶⁷ See K. A. Taipale, "Proposal: A Nation of Environmental Scientists: Creating a National Environmental Curriculum," (unpublished proposal, on file with the author) (1995) (calling for the distribution of low cost air monitoring devices to schools across the country).

Compare the Cherry Blossom Project of the Iwate Environment Network, *supra* footnote 166, in which Japanese primary and middle school students collected, recorded and submitted via the Internet locally collected data regarding cherry blossoming across two Japanese prefectures.

¹⁶⁸ With respect to local use of such information, see EPA EMPACT project, *supra* footnote 166:

EMPACT has met its goal of helping communities bring people up-to-date local environmental information they can understand and use in making daily decisions about protecting their health and environment.

Ibid. at <http://www.epa.gov/empact/>. Further, remote, automated monitoring significantly lowers transaction and enforcement costs enabling application of more sophisticated regulatory tools.

Remote sensing using conventional aerial or satellite imagery is already in widespread use. The EPA uses remote sensing to locate and investigate hazardous waste sites,¹⁶⁹ plan oil spill response,¹⁷⁰ delineate wetlands,¹⁷¹ assess chemical exposures¹⁷² and directly support CERCLA¹⁷³ and RCRA.¹⁷⁴ EPA has also funded programs to develop remote sensing technologies for automobile emissions,¹⁷⁵ real-time remote sensing of urban air quality,¹⁷⁶ and submerged aquatic vegetation,¹⁷⁷ among others. More generally, global tracking of atmospheric pollution and natural resource consumption using satellite data is also a reality.¹⁷⁸ Making such data directly available over wide area networks provides new opportunities for novel regulatory mechanisms, particularly market-based mechanisms, dependant on real-time accurate data to function.

¹⁶⁹ EPA, "Using Aerial Photographs for Locating and Investigating Hazardous Waste Sites, available online at <http://www.epa.gov/nerlesd1/land-sci/epic/pdf/fs-hazard.pdf>.

¹⁷⁰ EPA, "Aerial Photography for Oil Spill Response Planning and Prevention," available online at <http://www.epa.gov/nerlesd1/land-sci/epic/pdf/fs-oilspill.pdf>.

¹⁷¹ EPA, "Wetlands Delineation for Environmental Assessment," available online at <http://www.epa.gov/nerlesd1/land-sci/epic/pdf/fs-wetlands.pdf>.

¹⁷² EPA, "Aerial Photography to Support Chemical Exposure Assessments," available online at <http://www.epa.gov/nerlesd1/land-sci/epic/pdf/fs-ce.pdf>.

¹⁷³ EPA, "Using Historic Photographs and Maps to Document Waste Disposal Site Activities," available online at <http://www.epa.gov/nerlesd1/land-sci/epic/pdf/fs-historic.pdf>.

¹⁷⁴ EPA, "Remote Sensing in Support for RCRA," available online at <http://www.epa.gov/nerlesd1/land-sci/epic/pdf/fs-rcra.pdf>.

¹⁷⁵ EPA, "Remote Sensing of Automobile Emissions," available at http://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/1704.

¹⁷⁶ EPA, "Development of Real Time Remote Sensing Network to Monitor Small Fluctuations in Urban Air Quality," available online at http://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/2150.

¹⁷⁷ Summary of AVIRIS Analysis Chesapeake Bay project, available online at <http://geo.arc.nasa.gov/sge/johnson/epa/chesbay.html>.

¹⁷⁸ See Sharon Hatch Hodge, "Satellite Data and Environmental Law," 14 *Pace Envtl. L. Rev.* 691, 701-704 (1997) ("Applications to Date"). For a discussion of the challenges involved in using such remote sensing and digital information as evidence in environmental decisions vulnerable to legal challenge, see Kenneth J. Markowitz, "Legal Challenges and Market Rewards to the Use and Acceptance of Remote Sensing and Digital Information as Evidence," 12 *Duke Envtl. L. & Pol'y F.* 219 (2002).

Advances in monitoring technology are also being applied in many areas of environmental resource management, including wildlife management. For example, wireless remote sensing devices and networks are being used to track, monitor and manage endangered species and other wildlife resources.¹⁷⁹ Aerial forward-looking infrared surveying has been used for animal population surveys for more than a decade.¹⁸⁰ Further development of these technologies and others (for example, GPS tracking of individual animals) has the potential to support the increased use of incentive-based mechanisms, including the use of property and contract right mechanisms, to manage wildlife conservation.

Additional remote monitoring technologies are available or being developed that have great potential to further improve environmental data availability and monitoring. The military has developed sophisticated new surveillance technologies for tracking and monitoring enemy combatants and activities all of which can be applied to managing environmental solutions.¹⁸¹ For example, remote, pilot-less drones using ultra-sensitive sensors could be used to surveil fishing fleets to enforce quotas, or patrol remote wilderness areas to monitor wildlife or resource extraction activity. The ability to monitor remote performance lowers the transaction and enforcement costs for using consumption rights-based mechanisms.¹⁸² Sophisticated new radars and sensing devices can also be used to uncover new pollution sources.¹⁸³

¹⁷⁹ Remote sensing network technologies are a significant improvement over traditional invasive methods for monitoring habitats in which human disturbance may distort results or disturb or destroy observed species by introducing stress or causing a shift to unsuitable habitat. See Alan Mainwaring, et al., "Wireless Sensor Networks for Habitat Monitoring," *WSNA '02* Atlanta, GA (September 28, 2002) (ACM 1-58113-589-0/02/0009) describing the design and operation of a wireless habitat monitoring network on Great Duck Island in Maine. See also Alberto Cerpa, et al. "Habitat Monitoring: Application Driver for Wireless Communications Technology," 2001 Proceedings of the ACM SIG-COMM Workshop on Data Communications in Latin America, San Jose, Costa Rica (April 2001) describing habitat monitoring itself as an application driving wireless sensing network technology development.

¹⁸⁰ See, for example, Bureau of Land Management, Request for Proposal, *Commerce Business Daily* (May 14, 1996) PSA#1594, "seeking a qualified contractor to conduct an infrared population survey scan of wild burros and mule deer within an approximately 200,000 acre habitat along the western side of the lower Colorado River basin." Available online at [http://www.fbodaily.com/cbd/archive/1996/05\(May\)/14-May-1996/Tsol011.htm](http://www.fbodaily.com/cbd/archive/1996/05(May)/14-May-1996/Tsol011.htm)

¹⁸¹ For example, laser and ultrasonic sensors, and millimeter radar, mounted on remote pilot-less vehicles and aircraft.

¹⁸² Consumption rights mechanisms are discussed in the text accompanying footnotes 128-135 *supra*. Obviously, such technologies also improve the enforcement ability of traditional command-and-control

Life-cycle product tracking and smart labeling have the potential to greatly enhance efficacy and efficiency of recycling programs,¹⁸⁴ and can contribute to the development of secondary markets in goods – both creating new market opportunities and decreasing the demand for new goods.¹⁸⁵ Further, a better understanding (that is, wider availability of information concerning) waste stream composition can lead to the development of new recycling, recovery or other secondary use markets.¹⁸⁶

Advances in information technologies for identifying, measuring and monitoring environmental conditions and changes accurately and efficiently are lowering the adoption and transaction costs associated with the implementation of decentralized, economic incentive-based mechanisms for reducing environmental externalities, thus, enabling their consideration as appropriate environmental policy tools.¹⁸⁷

regulations as well. But see footnote 183 infra discussing Fourth Amendment concerns regarding the use of remote sensing for law enforcement purposes. Additionally, better tracking of performance enables greater reliance on private property based mechanisms enforced through traditional tort law.

¹⁸³ Use of new, more sophisticated remote sensing technologies for environmental law enforcement may raise Fourth Amendment issues. See NASA Office of the Inspector General, "Remote Sensing and the Fourth Amendment: A New Law Enforcement Tool?" (February 22, 2001), available online at <http://www.hq.nasa.gov/office/oig/hq/remoted4.html>, discussing Dow Chemical v. United States, 476 U.S. 227 (1986), in which the Supreme Court upheld (5-4) aerial surveillance by the EPA of an industrial complex without a search warrant; and comparing United States v. Myers, 46 F. 3rd 668 (7th Cir. 1995) in which a warrantless thermal scan of a residence was upheld with United States v. Kyllo, 140 F. 3rd 1249 (9th Cir. 1998) in which a warrantless thermal scan of a residence was found to be an unreasonable search in violation of the Fourth Amendment). Subsequently, the Supreme Court has upheld the 9th Circuit's Kyllo ruling that a warrantless thermal scan of a private residence violates the Fourth Amendment, Kyllo v. United States, 533 U.S. 27 (2001), distinguishing Dow Chemical as applying a lower standard to an industrial complex, "which does not share the Fourth Amendment sanctity of the home," 533 U.S. at 37. And see Krysten C. Kelly, "Note: Warrantless Satellite Surveillance" Will Our 4th Amendment Privacy Rights Be Lost in Space?" 13 J. Marshall J. Comp. & Info L. 729 (1995).

¹⁸⁴ Saar and Thomas, *supra* footnote 157.

¹⁸⁵ See Valarie Thomas, "Demand and Dematerialization Impacts of Second-hand Markets," Princeton Environmental Institute, Working Paper (April 29, 2003) (on file with the author) finding that lower transaction costs for exchange are key to developing second-hand markets. "Development of Internet-based markets has put downward pressure on transaction costs." *Ibid.* at 7. "It is plausible that as transaction costs are reduced ... through continued development of information technologies, second-hand markets will grow." *Ibid.* at 8.

¹⁸⁶ *Ibid.*

¹⁸⁷ Decentralized, distributed environmental information networks undermine the "economies of scale" rationale for centralized command-and-control regulation that is based on the perceived need (because of

ANALYZING

Advances in data analysis, including complex environmental modeling,¹⁸⁸ advanced visualization techniques,¹⁸⁹ and sophisticated data-mining technologies¹⁹⁰ can provide the tools for managing and understanding the increasingly large, complex, multivariate datasets that are being generated

high cost and lack of local expertise) to develop and control environmental data centrally through hierarchical processes and therefore implement and enforce environmental standards through central command. Decentralized, market-based mechanisms, including property-based models, requires that information be considered time- and place-specific (and available to local decision-makers) rather than general and concentrated in the hand of experts. See Anderson, *supra* footnote 12, at 5.

Also, to the extent that monitoring technology can better identify sources and effects and make those widely known, it also has the potential to militate against the "race-to-the-bottom" (where states compete to attract industry by lowering environmental standards) and the "spillover" (where environmental effects are shifted to other states) rationales for federal (over state or local) regulation (by exposing such effects to political process control). Cf. generally, Stewart, *supra* footnote 22, discussing "The Rationales for Centralization," at 184-191.

¹⁸⁸ For a general discussion of environmental modeling, that is, the use of computer simulations to represent complex real-world environmental states, see "Introduction" in B. Halling-Sorenson, S. N. Nelson, and Sven E. Jorgenson, eds. Handbook of Environmental and Ecological Modeling, Boca Raton: Lewis Publishers (1995). See also Michael L. Deaton and James J. Winebrake, Dynamic Modeling of Environmental Systems, New York: Springer Verlag (1999).

For an example of an environmental modeling project intended to develop "a technology foundation to support community-based environmental decision-making and risk assessment," see Description of FY 1997 EPA Project, available online at <http://www.ccic.gov/pubs/imp97/120.html>.

¹⁸⁹ For a general description of "visualization" see the EPA's Scientific Visualization Web site available online at http://www.epa.gov/vislab/svc/overview/what_is_vis.html citing ACM SIGGRAPH 21 Computer Graphics (November 1987) No. 6:

Visualization is a method of computing. It transforms the symbolic into the geometric, enabling researchers to *observe* their simulations and computations. Visualization offers a method for seeing the unseen. It enriches the process of scientific discovery and fosters profound and unexpected insights. In many fields it is already revolutionizing the way scientists do science.

Also, see generally William S. Cleveland, Visualizing Data, Summit, NJ: Hobart Press (1993). While modeling or simulations involves computational representations of real-world processes, visualization is a tool for interpreting result – whether from models, laboratory analysis or field observation. Sharpe, *supra* footnote 153, at 33N Box 1.

¹⁹⁰ See Amit Roy, "Data Mining for Environmental Management," DS* (dsstar) The Online Executive Journal for Data-Intensive Decision Support, Vol. 3 No. 3 (January 19, 1999) available online at <http://www.hpcwire.com/dsstar/99/0119/100521.html>. Data-mining has been formally defined as "the non-trivial extraction of implicit, previously unknown, and potentially useful information from data." William J. Frawley, Gregory Piatetsky-Shapiro and Christopher J. Matheus, "Knowledge Discovery in Databases: An Overview," AI Magazine, at 213-228 (Fall 1992). See also Usama Fayyad, Gregory Piatetsky-Shapiro, Padhraic Smyth and Ramasamy Uthurusamy (eds.), Advances in Knowledge Discovery and Data Mining, Cambridge: MIT Press, at 6 (1996) and see generally Usama Fayyad, Gregory Piatetsky-Shapiro and Padhraic Smyth, "From Data Mining to Knowledge Discovery in Databases," 17 AI Magazine 37 (Fall 1996).

through advances in monitoring and measuring technology.¹⁹¹ Adoption of these technologies allows for earlier and more precise identification of environmental problems and their solutions. A better understanding of environmental cause-and-effect enables the adoption of strategies that recognize differences among sources and potential solutions, and can better match characteristics of particular policy instruments to specific problems.¹⁹²

Computer modeling or simulation of the environmental effects of adopting a particular policy or mechanism, of investing in a particular production method or land development, or of introducing chemicals or biological agents into the natural environment, can provide public and private decision-makers more choice and better options at lower cost and with greater efficiencies.¹⁹³

¹⁹¹ The development of advanced modeling, visualization and data-mining techniques is a direct result of the growth in data volumes. Traditional database analysis relies on individual database analysts, familiar with the particular data and database structure, submitting specific queries. This manual probing of a data set is slow, expensive and highly subjective, particularly as data sets grow. (Databases are increasing in size in two ways: (1) the number of records or objects in the database and (2) the number of fields or attributes to an object.) As databases grow manual data analysis becomes impractical. Thus, the need to scale up human analytic capabilities through computational automation is driven by a commercial imperative. Given the complexity and large size of environmental data sets these techniques are particularly applicable to environmental data analysis.

¹⁹² For example, see footnote 100 supra ("the preference for a particular system [tax or tradable permit] should vary depending on the estimated clean-up costs," citing Breyer, supra footnote 5, at 273, and "the optimal choice between tradable permits and emissions taxes is dependant on case specific factors," citing Keohane, supra footnote 34, at 315-316). And, see generally, "Chapter VI: The Choice in Regulatory Tools," in Revesz, supra footnote 22, at 148-180.

¹⁹³ For example, many environmental problems are characterized by large information asymmetries where identifying specific individual contribution to the problem is either technically difficult or too costly for traditional approaches. Water pollution due to agricultural run-off is one such problem. Advances in information modeling provide opportunities to regulate (or 'price') environmental harms by using model estimates of environmental impacts.

See Eirik Romstad, "Point Source Pollution Contracts – Emissions Based Regulation Through Models," Discussion Paper #D-01/2002, 2002 World Congress of Environmental and Resource Economists, Monterey, CA (June 23, 2002) available online at <http://www.nlh.no/ios/Publikasjoner/d2002/d2002-01.html>, for a discussion of "model based environmental performance instruments" as a viable alternative to traditional "input regulation" as a resource allocation mechanism.

See also, "Analytic Support for Cost Effective Pollution Control," in Pollution Prevention and Abatement Handbook, Washington, DC: World Bank Group (1998) available online at [http://wbinfo018.worldbank.org/essd/essd.nsf/GlobalView/PPAH/\\$File/14_cost.pdf](http://wbinfo018.worldbank.org/essd/essd.nsf/GlobalView/PPAH/$File/14_cost.pdf) ("Analytical tools have been developed by the World Bank Group to estimate rapidly the extent and impacts of pollution in a given situation and to support decisions on pollution management. These tools help decision-makers overcome the frequent lack of data concerning emissions from different sources, their impact on ambient quality, and mitigation alternatives.")

For an example of a complex regional modeling project using both simulation and visualization to provide greater understanding of environmental effects, see the PRISM: Puget Sound Regional Synthesis Model (and Virtual Puget Sound) project of the University of Washington:

Modeling ecosystems can provide important decision support for resource management¹⁹⁴ (including lowering the information costs associated with market-based solutions based on Coasian bargaining¹⁹⁵) and provide the basis for more sophisticated environmental asset valuation¹⁹⁶ for either traditional benefit-cost analysis or for market-based trading or offset mechanisms.¹⁹⁷

Analysis of abatement or remediation strategies can provide better clean-up at lower cost and can enable equitable initial allocations of tradable permits or consumption rights, as well as economically efficient choice of mechanism when incentive-based strategies are designed, adopted or employed.¹⁹⁸ Sophisticated computer-based production design can reduce the use of hazardous and toxic materials in production processes and products, and can provide new opportunities to build in lower recycling costs during manufacture, thus enabling life-cycle financial responsibility to be imposed without creating undue burdens or costs.¹⁹⁹ These

With PRISM, investigators can construct new scenarios about regional growth and resource use scenarios that will assist decision-makers in planning for the future and in meeting the management challenges of today.

About PRISM, available online at <http://www.prism.washington.edu/about.html>.

¹⁹⁴ See generally Virginia H. Dale, ed., *Ecological Modeling for Resource Management*, New York: Springer Verlag (2003) and Bruce Hannon and Matthias Ruth, *Modeling Dynamic Biological Systems*, New York: Springer Verlag (1997).

¹⁹⁵ See discussion of Coasian mechanisms in text accompanying footnotes 103-113 supra. In general, the impediments to Coasian bargaining that intelligent data analysis can help address are high transaction and contracting costs in acquiring information, difficulties in valuing environmental harms and benefits, and finding causation in cases of diffuse or multiple sources.

¹⁹⁶ See the ecosystem valuation references in footnote 5 supra.

¹⁹⁷ Including, for example, for the development and management of complex indices for trading ecosystem development rights or other multivariate derivatives, see footnote 226 infra.

¹⁹⁸ For example, see footnote 100 supra, discussing the outcome effects of the choice between Pigouvian and pseudo-Coasian mechanisms based on knowing the estimated clean-up cost. And, see generally, "Chapter VI: The Choice in Regulatory Tools," in Revesz, supra footnote 22, at 148-180.

¹⁹⁹ Lifecycle responsibility strategies (such as EPR) are discussed above in the text accompanying footnotes 93-94 and 102. Life cycle design or analysis ("LCA") (also called "green design" or "design for environment – DFE") accounts for environmental externalities of the manufacture, use and ultimate disposal or reuse of a product introduced into commerce at the time of initial design. See generally Bert Bras, "Incorporating Environmental Issues in Product Design and Realization," 20 *Industry and Environment*, Special Issue on Product Design and the Environment, United Nations Environment Programme/Industry and Environment (UNEP/IE) (1997) available online at <http://www.srl.gatech.edu/education/ME4171/UNEP-IE-paper.pdf>.

advances in knowledge management can help reduce environmental impacts of production at the product design, product life and disposal, as well as the new product development stages,²⁰⁰ thus enabling more sophisticated and nuanced pricing of externalities through economic incentive (or other regulatory) mechanisms.

Advances in 3D visualization and statistical modeling allow for more accurate prediction of the effects of modulating environmental inputs and outputs through regulatory or market mechanisms by making large, complex databases more understandable.²⁰¹ Geographic information systems ("GIS") allow complex data to be overlaid on maps or photographs making complex environmental effects readily apparent to policy makers or market participants without requiring advanced scientific or other expert knowledge on their part. Regulatory efforts can then be directed at areas where they can achieve greatest positive effect and results can be readily assessed.

Sophisticated data mining techniques that find previously unrecognized patterns in large data sets can identify new environmental threats before harmful results become otherwise apparent and can establish causation in ambiguous situations.²⁰² When applied to sufficiently robust data

See also, William McDonough and Michael Braungart, Cradle to Cradle: Remaking the Way We Make Things, New York: North Point Press (2002) and Hawken, supra footnote 12.

For an overview of the LCA process and an example of how information technology can facilitate such analysis, see Katherine L. Yuracko and Bruce E. Tonn, "Using Information Technology To Push The Boundaries Of Life Cycle Analysis For D&D Decision-Making," Report prepared by the Oak Ridge National Laboratory, managed by Lockheed Martin Energy Research Corp. for the U.S. Department of Energy under contract number DE-AC05-96OR22464, available online at <http://corbu.aq.upm.es/~cbedoya/webacv/informes/boundari.pdf>.

See also, Kosuke Ishii, "Modular Design for Recyclability," in Richards, supra footnote 145, at 105 (describing a "methodology that helps design engineers plan for potential uses of a product after it is retired").

²⁰⁰ See Paul R. Kleindorfer and Eli M. Snir, "Environmental Information in Supply-chain Design and Coordination," in Richards, supra footnote 145, at 115.

²⁰¹ See generally EPA Scientific Visualization Center, information available online at <http://www.epa.gov/vislab/>.

²⁰² Traditional information retrieval from a database returns arrays consisting of data from individual fields of records (or entire records) from the database in response to a defined or specified database query. The

sets, these technologies also become predictive so problems or dangers can be identified before they occur.²⁰³ Again, these advances provide opportunities to more closely match policy instruments to particular problems and desired outcomes. In particular, by highlighting previously hidden externalities (identifying formerly unrecognized patterns and relationships) these technologies are especially suited to supporting self-adjusting market mechanisms and dynamic regulatory approaches.²⁰⁴

Advances in intelligent processing combined with better measuring and monitoring technologies can provide the kind of information availability required for the design and adoption of increasingly complex and nuanced environmental policies that use economic incentive and market mechanisms to more effectively and precisely price environmental externalities in order to achieve greater overall efficiency in allocating environmental costs, benefits and harms.

DISTRIBUTING

Networked communication systems can make information widely available at low cost. A single web server can make a large data set available to millions of simultaneous users for almost the

results of the traditional database query are explicit in the database, that is, the answer returned to a query is itself a data item (or an array of many items) in the database.

Data-mining techniques, however, extract knowledge from the database that is implicit – knowledge that "typically [does] not exist a priori" is revealed. See Thomasz Imillienski and Heikka Mannila, "A Database Perspective of Knowledge Discovery," *Communications of the ACM*, Vol. 39 No. 11, at 60 (November 1996). Data-mining generally identifies patterns or relationships among data items or records that were not previously identified but that are revealed in the data itself. See generally, K. A. Taipale, "Data-mining and Domestic Security," *Colum. Sci. & Tech. L. Rev.* at [in publication for Fall 2003 issue].

Uniting data-mining techniques with visualization techniques is at the forefront of current explorations in knowledge discovery techniques, see generally Usama Fayyad, et al., *Information Visualization in Data Mining and Knowledge Discovery*, San Francisco: Morgan Kaufman (2001).

²⁰³ See Fayyad, "From Date-mining to Knowledge Discovery in Databases," supra footnote 189, at 39.

²⁰⁴ Dynamic decision making to manage complex, dynamic systems requires constant updating through continuous input of information and analysis. See Kai N. Lee, *Compass and Gyroscope: Integrating Science and Politics for the Environment*, Washington, DC: Island Press (1994, 1993), and George Frampton, "Ecosystem Management in the Clinton Administration," 7 *Duke Env'tl. L. & Pol'y F.* 39, 45 (1996) (noting that 'adaptive management' requires that plans be continuously revised and adjusted as conditions change).

same cost as for a single scientist accessing the same data from a single workstation. Once digital data is available and on the network there is no marginal cost involved in making it available to another person. This characteristic of networked information has great potential to militate against asymmetries in information availability (for example, where the polluter has the information) and in information distribution and use (for example, where economic power traditionally conferred advantage in access to and use of information). Information symmetry helps overcome representational disparities and makes Coasian-bargaining together with court enforcement of property or contract rights more feasible as an alternative environmental policy prescription.²⁰⁵

Centralized command strategies in environmental policy are often rationalized over state or local (or private market) regulation by the existence of such representational disparity, or by economies of scale, and to avoid spillover effects (burden-shifting between localities) and the 'race-to-the-bottom' (competition among localities to attract industry by lowering local environmental standards).²⁰⁶ Widespread distribution of and access to environmental information can ameliorate these concerns. In addition to mitigating information asymmetries and eliminating economies of scale (at least with respect to information disparities and the need for generalized information controlled by experts²⁰⁷), general information availability and transparency exposes spillover and 'race-to-the-bottom' effects to general political and market control and correction, thus, making good environmental policy a competitive advantage.²⁰⁸

Economic incentive mechanisms depend on free flowing market information to function, thus, they are dynamic systems requiring adaptive regulatory structures and management in order to succeed.

²⁰⁵ See footnote 110-111 supra and accompanying text (discussing the failure of Coasian-bargaining due to distributional asymmetries).

²⁰⁶ See Stewart, supra footnote 22, discussing "The Rationales for Centralization," at 184-191.

²⁰⁷ See footnote 187 supra.

²⁰⁸ To a large extent, information disclosure acts on administrative and legislative bodies much like information disclosure acts on private firms. See generally footnotes 136-148 (and NEPA in 137) and the accompanying text. See also Keohane, supra footnote 34, discussing existing environmental regulation functioning within a 'political market'. If environmental externalities are exposed, "competition [among localities] may lead to improvements in environmental quality." See Jonathan R. Macey and Henry N. Butler, "Federalism and the Environment," in Meiners and Morris, supra footnote 7, at 158-181, 174 (in particular, see "Jurisdictional Competition: The Myth of the Race to the Bottom," at 173-175.)

For distributed information to be useful for policy guidance or market determinations, however, there is an overriding need to insure that environmental information is of high quality, accurate and easily accessible for a variety of uses. This requires intelligent tools for access. Improved client-side browsers with specialized analytic tools are being developed for a variety of purposes.²⁰⁹ These tools can be widely distributed by making them available over the Internet, thus enabling an entire nation of "environmental scientists".²¹⁰ Every student, school, community group and local government agency can be networked and integrated into a single, distributed environmental information system that can collect, analyze and re-distribute relevant environmental data and information in real-time to local decision makers and other affected parties. Regulated industries can benefit as well -- real-time information feedback allows for dynamic resource allocation and activity modulation to meet ambient conditions. Further, information sharing within firms²¹¹ and among firms is greatly enhanced²¹² allowing for environmental goals to be met at lower cost, with more flexibility and with less intrusion than under monolithic command regimes.

The availability of technologies to increase information accessibility is itself increasing demand by the public and by industry for access to information collected by government agencies.²¹³ At a

²⁰⁹ For example, the Environmental Data Exchange Network, a collaborative project among the U.S. Environmental Protection Agency, the U.S. Department of Defense, the U.S. Department of Energy, and the National Institute of Standards and Technology, seeks to provide a dynamic information system for accessing environmental data stored in diverse distributed databases using intelligent software agents to provide uniform access to environmental data through standard Internet browsers. See Allenby, *supra* footnote 145, at 9, and Greg Pitts and Jerry Fowler, "InfoSleuth: An Emerging Technology for Sharing Distributed Environmental Information," in Richards, *supra* footnote 145, at 159-172.

²¹⁰ See Taipale, *supra* footnote 167.

²¹¹ See generally Part II, "Information Systems Within the Firm," in Richards, *supra* footnote 145, at 59-150.

²¹² See generally Part III, "Opportunities for Collaboration and New Technologies," in Richards, *supra* footnote 145, at 151-210.

²¹³ See Patrick D. Eagan, et al., "Public Access to Environmental Information," in Richards, *supra* footnote 145, at 173-184, 176-177 ("the public [is] demanding that compliance and permit data be made available in electronic formats and be accessible on the World Wide Web" and "industry is interested in both product assessment and supply-chain environmental compliance performance.").

minimum, existing environmental information should immediately be made available over the Internet, including the public distribution of permits, applications, environmental impact statements, compliance and other related information.²¹⁴

Widespread availability of and easy access to environmental data sets and tools²¹⁵ will create a market for the development of other information management tools and related environmental technology innovations. Environmental information databases will themselves suggest other market opportunities to information technology and environmental technology innovators and entrepreneurs.²¹⁶

In addition, widespread information availability will assist in the enforcement of existing and future environmental laws (and private property rights). Private parties (including affected property owners), environmental organizations and enforcement agencies, will have direct access to the information needed to engage in decentralized enforcement through statutory or common law

²¹⁴ As noted earlier, this would have a significant effect on disparities in information access that distort current mechanisms and improve information flows necessary for market based mechanisms to function effectively to optimally allocate costs and benefits once targets have been set (and goals developed).

Information disclosure itself is an effective environmental regulatory policy that uses market forces to reduce undesirable behavior. See footnote 146 supra. For example, as noted in Eagan, supra footnote 210, at 177, "The reduction in emissions from industrial sources attributed to the [Toxics Release Inventory] program has demonstrated the value of having a variety of environmental data compiled in one report and made widely available. ... [S]ince the inception of [the TRI program] reported releases of pollution into the community have declined by 46 percent." (Citing D. Kearns, "Toxics Release Inventory Community Right to Know." Press Release, Washington, DC: U.S. Environmental Protection Agency (May 20, 1997)).

However, see Eagan, supra, at 178-182 discussing potential challenges relating to information disclosure, in particular, the need for accuracy and meaningfulness of data and interpretive guidance for specific uses of general or aggregate data. See also footnotes 136-148 supra and accompanying text (discussing potential problems with information disclosure strategies).

²¹⁵ Several examples of such tools are available through the EPA Web page at <http://www.epa.gov/epahome/whereyoulive.htm>, including particularly the "Window to My Environment" interface that provides interactive maps and tools to show local environmental conditions.

²¹⁶ But see Julie E. Cohen and William M. Martin, "Intellectual Property Rights in Data," in Richards, supra footnote 145, at 45-55, 46, "The current framework for legal protection of databases is ill-suited to promote progress in the field of industrial ecology and allied disciplines" ... "[b]ecause neither federal nor state intellectual property law provides satisfactory protection for databases." In order for new ancillary data markets to emerge in which private firms generate environmental data and analysis, incentives to generate environmentally relevant knowledge need to be addressed. See also, Amol Pachnanda, "Student Comment: Scientific Databases Should Be Protected Under a Sui Generis Regime," 51 *Buffalo L. Rev.* 219 (2003) for a general discussion of intellectual property protection for scientific databases.

mechanisms.²¹⁷ Improved data sets and analysis will make it easier to identify environmental problems, conclusively determine sources, and, where required, prove harm and causation.²¹⁸ These developments will also benefit producers and developers by differentiating environmentally responsible firms from those that are not. Exposing such differentiation to the general market makes effective environmental stewardship a competitive advantage for responsible firms (rather than a cost to be borne when externalities are generally hidden).²¹⁹

Because markets function best with well-informed participants, information availability can foster market-oriented solutions to environmental problems by exposing environmental externalities to market forces.²²⁰ The use of information disclosure strategies as regulatory mechanisms, including their economic and environmental effects, is discussed above in Part III.²²¹

²¹⁷ See footnote 22 *supra* regarding legal mechanisms for enforcement (including citizen suits, class actions and other representational plaintiff standing for statutory actions, and elimination of regulatory preemption for common law claims) necessary for decentralized mechanisms (particularly those based on private contract or property rights) to become viable alternatives to centralized command regulation.

²¹⁸ Strong enforcement of property rights is a requirement for market mechanisms to function efficiently. See Mercurio, *supra* footnote 1, at 15, discussing lack of rights enforcement as a cause of market failure. Also, see generally footnote 34 *supra*. Adoption of decentralized mechanisms for regulation (particularly relying on private property rights) or of market mechanisms for allocation of costs requires the availability of decentralized enforcement mechanisms (that is, the availability of statutory or common law mechanisms, to enforce standards or protect private property rights). See generally footnote 22 *supra*.

²¹⁹ See generally, Paul C. Killgoar, Jr. "Industrial Research and Development Collaborations: Increasing Environmental Knowledge for Competitive Advantage," in Richards, *supra* footnote 145, at 151-158, 156-157 (discussing the information requirements and the use of information technology to facilitate collaboration among the automobile manufacturers under the Cooperative Research and Development Act of 1984). And see Tietenberg, *supra* footnote 146, discussing the efficiency role of information disclosure.

²²⁰ See Stavins, *supra* footnote 91, at 53.

Advocates of "free market environmentalism," see footnote 12 *supra*, reject the market-failure model, see footnotes 4-5 *supra*, instead viewing the "problem of externalities as a failure to permit markets and create markets where they do not yet – or no longer – exist." Adler, *supra* footnote 12, at 667, quoting Fred L. Smith, Jr. "Conclusion: Environmental Policy at the Crossroads," in Michael Greve and Fred Smith, eds. Environmental Politics: Public Costs, Private Rewards 192 (1992).

Regardless of whether environmental externalities are characterized as a problem of 'market failure' or a problem of 'lack of markets', it is the fundamental premise of this article that improved information flows are necessary for effective 'pricing' of such externalities, whether the mechanism is the regulatory or political 'market' (see generally Keohane, footnote 34 *supra*), the court 'market' (see generally Posner, *supra* footnote 13), or the 'private or free market' (See Adler, *supra*). See also footnote 19 *supra*.

²²¹ See text accompanying footnotes 136-148 *supra*.

MANAGING MARKETS

Information technology significantly lowers the cost of adopting and administering new regulatory regimes and lowers transaction costs for participants, particularly for incentive-based systems relying on open information flows to function.²²²

Information technology has wide applicability in defining intangible property rights and providing a mechanism for tracking and trading such instruments. As with any trading system, the viability for resource trading lies in establishing a common metric. For diffuse, widespread pollution problems (particularly where there is no "hot spots" issue) this is fairly straightforward. Existing trading programs²²³ use a standard unit of pollution output such as residual-ton/year. So too, consumption rights programs to allocate use of fungible common goods such as water or fish can be easily defined and tracked.²²⁴ For these commodity-like instruments existing market institutions, such as the Chicago Board of Trade or other commodity trading organizations, may be sufficient once rights are clearly defined and allocated. More specialized markets to trade environmental instruments can also be developed following these models.²²⁵

For other systems, particularly where the environmental assets are not fungible, such as wetland mitigation, development offsets, or habitat trading, commodity market mechanisms may not work without devising new complex, multi-attribute indices of ecological value or calculating complex trading ratios in order to make these resources exchangeable.²²⁶

²²² See generally Part II *supra* for a discussion of the need to reduce transaction and contracting costs in order for economic incentive or property-based mechanisms to be adopted and function.

²²³ See footnotes 115-117 and accompanying text *supra*.

²²⁴ See footnote 134 and accompanying text.

²²⁵ The EPA supported the development of an industrial waste exchange at the Chicago Board of Trade. See U.S. EPA, "Review of Industrial Waste Exchanges," EPA-530-K-94-003 (September 1994) (cited in Thomas, *supra* footnote 185, at 7).

²²⁶ Stewart, *supra* footnote 11, at 125. See also Roger I.C. Hansell, et al., "A New Market Instrument for Sustainable Economic Environmental Development," 86 *Envtl. Monit. & Assess.* 203-209 (July/August 2003) (describing a tradable instrument for valuing ecosystem development rights).

However, even without developing such markets for direct trading, information sharing about these programs and the values established for non-interchangeable but like assets in different markets can provide local market guidance for any particular application or program. Such information availability or sharing would even help inform markets that in theory could never trade directly because they involve individually negotiated and contracted exchanges, such as conservation easement purchases. In addition, listing services for available easements or for organizations seeking easements would help develop more efficient markets by putting together more 'buyers' and 'sellers'.²²⁷

Information sharing among all these programs, even where direct trading of rights or assets is not possible, will lower implementation and management costs since duplicative development efforts can be eliminated and general transaction costs will be lowered through knowledge transfer. In addition, systems to increase awareness of opportunities even if direct trades are not possible will result in more overall market activity.²²⁸ In direct trading markets, information technology can lower the actual transaction costs incurred for individual participants by providing market-based commodity pricing and facilitating trades.

COALITION BUILDING AND GROUP ACTION

In addition to lowering adoption, administration and transaction costs for new mechanisms, information technology also has the potential to (i) significantly lower the cost of organizing and managing interest groups and (ii) bring powerful new allies into alignment with environmental goals.

²²⁷ See generally, Mercurio, *supra* footnote 1, at 5, describing requirements for a competitive market.

²²⁸ *Ibid.*

Networked information sharing and communication through email and web sites has substantially lowered the cost of organizing local and geographically dispersed interest groups.²²⁹ Bringing together individuals and groups whose per capita involvement with any particular problem was too small to overcome the organizational costs in the past is now possible.²³⁰ In addition, information sharing opens up new perspectives allowing previously unallied interests to recognize common goals. Once identified, networked communication technologies can mobilize these newly-allied forces to effect political and regulatory change.²³¹ These same potentials allow for aggregation of plaintiffs to pursue statutory or more traditional common law remedies.²³² For regulated industry, producers and developers, information sharing provides new opportunities for cost savings and better environmental management.²³³

Importantly, development of all of these new mechanisms also has the potential to bring new, powerful economic interests into the environmental coalition. Environmental issues will no longer just involve polluters or developers on the one hand and environmental groups on the other. To the extent that economic incentive and market-based mechanisms create new market opportunities a whole new set of entrepreneurial innovators will enter the market.²³⁴

In addition to technology innovators, established technology, telecommunication and financial institutions can all profit from the development of these markets as new demand for existing

²²⁹ See, for example, The Clean Water Network, an alliance of over 1,100 organizations that endorse the National Agenda for Clean Water. Information available online at <http://www.cwn.org/>.

²³⁰ "Whenever a communication medium lowers the costs of solving collective action dilemmas, it becomes possible for more people to pool resources." Marc A. Smith, Microsoft research sociologist, quoted in Howard Reingold, Smart Mobs: Transforming Cultures and Communities in the Age of Instant Access at 31, Cambridge: Perseus Publishing (2002).

²³¹ See generally, Reingold, *supra* footnote 230, at 29-61, discussing "Technologies of Cooperation."

²³² For purposes of our analysis, we consider common law remedies a special case of incentive based mechanism allowing for decentralized enforcement of environmental policy based on a protection of private property and contract rights. See footnotes 12, 13, 20 and 34 *supra*.

²³³ See footnotes 212 and 213 *supra*.

²³⁴ New entrants have the potential to disrupt the "equilibrium support" for current environmental policy instruments as described in Keohane, *supra* footnote 34, at 322-326 and Figure 1 at 325, "An Equilibrium Framework for Examining the Political Market." And see Zywicki, *infra* footnote 245.

products and services develops to support these new mechanisms.²³⁵ Concerted efforts by environmentalist to ally themselves with these forces will help overcome distributional-based resistance to change likely to be encountered from symbiotic government bureaucracies, entrenched environmental interests and regulated industries and their stakeholders.²³⁶ Change-oriented policy makers and regulators also will be able to enlist these new interest groups against existing forces to better counterbalance entrenched interests and enact new policy initiatives based on decentralized mechanisms that rely on market-based pricing mechanisms based on open information flows. So too, regulated industry will have the opportunity to develop new alliances to pursue more efficient and less intrusive environmental solutions and to use environmental stewardship to competitive advantage.²³⁷

INFORMATION TECHNOLOGY AS AGENT OF CHANGE?

What do we mean by agent of change? Technology does not create markets or change human fates; rather, it alters the spectrum of potential within which people can act.²³⁸ Thus, information technology cannot solve environmental problems on its own. However, it is the thesis of this article that developments in information technology can lower the transaction and management costs of adopting new regulatory mechanisms as well as enhance the efficacy and efficiency of existing mechanisms by improving information flows, exposing externalities and allowing decentralized mechanisms to operate. Information technology has the potential to make more policy options (including relying more on private markets) and alternative regulatory instruments (including economic incentive-based mechanisms) available thereby providing opportunities to

²³⁵ Additionally, individuals with different skill sets and experience will be drawn to providing environmental solutions. "[M]arket-based instruments require market-trained thinkers, including people with MBAs, economists and others." Stavins, *supra* footnote 91, at 57.

²³⁶ See footnote 234 *supra* and 245 *infra*.

²³⁷ See footnote 219 *supra*.

²³⁸ Robert McClintock and K. A. Taipale, "Educating America for the 21st Century," New York: Institute for Learning Technologies, Columbia University, Circulation Draft v.2.1 (September 1994), at 2, available online at <http://www.taipale.com/ilt/ILTplan.html>.

achieve both environmental goals and further human and economic development more efficiently and effectively.

Further, new environmental policy approaches based in part on economic incentives and market pricing of externalities require dynamic decision-making and policy prescriptions that can adapt to new developments and incorporate innovations as they occur throughout complex systems.

Traditional command-and-control regimes tend to identify individual problems and adopt solutions for the long-term that may appear optimum at the moment but without mechanisms to reexamine or adapt to new circumstance as conditions or technologies change. Progressive environmental strategies, based on harnessing private decision-making and incorporating economic incentives and other decentralizing strategies, increasingly recognize the need for adaptive management of environmental policies,²³⁹ particularly as environmental policy tackles increasingly complex problems embedded in dynamic systems. These developments mirror developments and potentials arising from the use of information technology more generally throughout the economy and society.²⁴⁰ Decentralized and dynamic network enabled decision-making paradigms are being adopted throughout industry, academia, and government to better manage complex problems.²⁴¹ These general developments provide models and tools for environmental policy initiatives based on new mechanisms to improve internalization and efficient and equitable allocations of previously externalized environmental harms, costs and benefits.

This article has briefly examined how these emergent information technologies intersect with developments in environmental regulation. It is for environmentalists, free market advocates and economists, government policy-makers, regulators and reformers, technology innovators,

²³⁹ See, for example, J. B. Ruhl, "Sustainable Development: A Five-Dimensional Algorithm for Environmental Law," 18 *Stan. Envtl. L.J.* 31 (1999) (discussing "adaptive management versus prescriptive management," *ibid.* at 54-55). See also the references in footnote 204 *supra*.

²⁴⁰ See, generally, Michael Hammer and James Champy, *Reengineering the Corporation*, New York: HarperBusiness (1993) and Drucker, *supra* footnote 149.

²⁴¹ *Ibid.*

environmental entrepreneurs and industry, to seize these opportunities to make the best of the future by rethinking our approach to environmental policy and regulation free of historic technological constraints that produced information distortions that have helped shape and limit existing policy choices and required exclusive reliance on centralized command-and-control strategies to remedy perceived market failures. The historic preconditions that led to the dominance of centralized command-and-control strategies as the only acceptable mechanism to effectuate environmental policy have changed and new technologies open new possibilities. Networked information technologies enable distributed, decentralized strategies that harness private decision-making through private markets and economic incentives to be considered for managing environmental issues.²⁴²

²⁴² However, the difficulties of accomplishing technologically enabled change should not be underestimated:

Innovation makes enemies of all those who prospered under the old regime, and only lukewarm support is forthcoming from those who would prosper under the new.

Niccolo Machiavelli (1469-1527) in The Prince 17, London: W.W. Norton (1992), cited in Lawrence Lessig, The Future of Ideas 6, New York: Vintage (2002, 2001).

See also Keohane, *supra* footnote 34, outlining the disparities between normative theory and positive reality in choice of regulatory instrument in environmental policy within a framework of an equilibrium model based on the metaphor of a political market.

And see Todd J. Zywicki, "Industry and Environmental Lobbyists: Enemies or Allies?" in Meiners and Morris, *supra* footnote 7, at 185-210, 186, arguing that regulated "industry ... and environmental interest groups benefit from the current inefficient system of environmental regulation and share a commitment to preservation of the status quo."



V. CONCLUSION.

The existing system of environmental regulation is under stress.²⁴³ Command-and-control, which may have been sufficient to address point source pollution, is increasingly incapable of dealing with complex multi-dimensional environmental problems involving regional, national or global management of interrelated eco- and economic systems. New innovative approaches that seek to harness private decision-making and market forces to accomplish broad environmental goals need to be developed, adopted and administered. Developments in information and communication technologies provide new opportunities to implement change by reducing adoption, management and transaction costs of new regulatory structures, by loosening restrictions on information flows that distort pricing of environmental externalities, and by undermining the traditional rationales for centralized management of environmental protection.

Developing an effective regulatory approach to environmental problems in the twenty-first century will require developing and implementing mechanisms and adopting procedures that recognize both wealth-maximizing as well as distributional aspects of such change. Environmental concerns will need to be viewed as benefits to, not costs of, future economic and human development, and responsible environmental stewardship will need to be viewed as a competitive advantage for political states as well as private firms. In particular, mechanisms that internalize environmental costs into the normal course of everyday public and private decision-making and that take advantage of market-based efficiencies in allocation of such costs can achieve greater acceptance and provide for more positive environmental outcomes. Nevertheless, economic efficiency and free markets alone cannot guide environmental policy, particularly with respect to global, cross-generational concerns, and care must be taken to build in equitable, ecological and humane values. Widespread information availability and distribution is key to such success.

²⁴³ See generally, Part I supra.

As a near term policy goal, we would encourage centralized federal resources to be focused increasingly on enhancing information flows (by investing in and disseminating environmental information and scientific research as well as technologies for identifying, monitoring and understanding environmental problems) and to further lowering transaction costs for cooperative or private law resolution (by encouraging the creation of decentralized legal and regulatory mechanisms with an emphasis, where appropriate, on letting markets exist and set prices for environmental harms, benefits and abatements).

