BEYOND TORT: COMPENSATING VICTIMS OF ENVIRONMENTAL TOXIC INJURY

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ABSTRACT

Environmental toxic tort cases often pose difficult problems of proof. A substance's toxicity may be unknown or uncertain. A combination of factors may cause a plaintiff's injury, and the injury may arise many years after a plaintiff's exposure to a toxic substance. On the one hand, some plaintiffs, particularly those with "signature" illnesses or whose illnesses occur as a cluster of cases, may be able to gather sufficient evidence to support a tort action. On the other hand, it is likely that many environmental injury victims simply fail to recognize their illnesses as tortious injuries and never receive compensation. Cancer and various respiratory ailments, for instance, can result from exposure to commonly found and commonly released pollutants. Because of the difficulty of identifying potential defendants and proving causation, such cases simply fall outside of the tort system. This leaves social costs externalized and victims uncompensated.

In response to this problem, this Article proposes a risk-based administrative system of liability and compensation for exposure to environmental pollutants. At the time pollutants are released, major pollution emitters would pay levies. The levies would be based on the

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amount of pollutants discharged, the likely exposure of persons to those pollutants, the risk of harm from that exposure, and the expected costs of that harm to the victims. Individuals would receive compensation according to the health risk borne by each person as a result of their exposure to the pollution. This compensation-for-risk approach avoids troublesome case-by-case determinations of specific causation. This approach also provides compensation prior to illness, which may facilitate preventive measures. Although the scientific information necessary to support such a system is not yet available, advances in toxicogenomics, biomonitoring, and environmental monitoring will permit implementation of such a system in the not-too-distant future.

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INTRODUCTION

A 2004 study estimated that fine particle pollution released by United States power plants causes nearly 24,000 deaths, 38,200 nonfatal heart attacks, and hundreds of thousands of asthma, cardiac, and respiratory problems each year.[1] In all likelihood, the companies that operate these plants will be required to compensate few, if any, of the victims. Power plants are not the only source of toxic chemical emissions. Daily, hundreds of chemical substances enter our bodies through the air we breathe, the water we drink, the food we eat, and the things we touch. Although some of these substances are benign, others are harmful, and the vast majority have unknown and uncertain effects on human health and the environment.[2]

The difficulties of proving causation in such cases confound environmental tort plaintiffs. Assuming that victims are even aware that they have been injured, victims must overcome gaps in knowledge regarding causation, risk, and harm to obtain compensation for their injuries. The characteristics of environmental toxic injuries[3] complicate efficient liability determinations. These injuries tend to involve a large number of persons exposed to significant, albeit low, probability risks. A long latency period between exposure and illness and multiple alternate

1. CONRAD G. SCHNEIDER, CLEAN AIR TASK FORCE, DIRTY AIR, DIRTY POWER: MORTALITY AND HEATH DAMAGE DUE TO AIR POLLUTION FROM POWER PLANTS 4 (2004). *See also* ABT ASSOCS. INC., POWER PLANT EMISSIONS: PARTICULATE MATTER-RELATED HEALTH DAMAGES AND THE BENEFITS OF ALTERNATIVE EMISSION REDUCTION SCENARIOS (2004) (detailing the findings of the underlying study). Another study attributed 30,100 deaths per year to power plant emissions. *See* Eric Pianin, *Study Ties Pollution, Risk of Lung Cancer; Effects Similar to Secondhand Smoke*, WASH. POST, Mar. 6, 2002, at A1.

2. *See* ROBERT L. GLICKSMAN ET AL., ENVIRONMENTAL PROTECTION: LAW AND POLICY 642 (4th ed. 2003) (stating that over nine million chemicals appear in the registry of the American Chemical Society and that the registry expands at a rate of around 10,000 new entries per week); RICHARD B. PHILP, ECOSYSTEMS AND HUMAN HEALTH: TOXICOLOGY AND ENVIRONMENTAL HAZARDS 45 (2d ed. 2001) (estimating that, of 60,000–70,000 industrial and commercial chemicals currently used in North America, only 3500 have been studied sufficiently to conduct a risk assessment regarding human health); ENVTL. DEFENSE FUND, TOXIC IGNORANCE 7 (1997) (estimating that basic toxicity testing results cannot be found in the public record for nearly seventy-five percent of the top-volume chemicals in commercial use); Carl F. Cranor & David A. Eastmond, *Scientific Ignorance and Reliable Patterns of Evidence in Toxic Tort Causation: Is There a Need for Liability Reform?*, LAW & CONTEMP. PROBS., Autumn 2001, at 5, 11 (estimating that 100,000 substances or their derivatives are used in commerce, most of which have not been well assessed for health effects).

3. In this Article, "environmental toxic injuries" refers to harms caused by substances in the general environment, as opposed to harms caused by use of a particular product. *Cf.* Troyen A. Brennan, *Environmental Torts*, 46 VAND. L. REV. 1, 2 (1993) (distinguishing personal injuries caused by toxic substances in the environment from traditional trespass, nuisance, and product liability claims).

causes of illness exacerbate this causation problem.[4] These difficulties, combined with the costs of litigation, result in the systematic undercompensation of environmental tort victims and the systematic underdeterrence of polluters.[5]

One promise of the digital age, however, is a dramatically enhanced ability to track environmental pollution at reasonable cost.[6] In the near future, it may be possible to track a pollutant from its point of release into the environment to the receptor that ultimately absorbs it.[7] The technologies that could enable such a system include minuscule wireless sensors that can monitor microenvironments and sophisticated computer models that track the movement of pollutants.[8] In addition, developments in toxicogenomics, the study of the effects of exposure to a toxic substance on genes,[9] will augment our ability to analyze the effects of chemical substances on human health. These technological advances may revolutionize the protection of human health and the environment by elucidating otherwise unknown causal relationships between pollutants and human illness. As a result, society may be able to compensate environmental tort victims appropriately and internalize presently overlooked externalities. Such technological advances will lower barriers to cost internalization—whether by tort, administrative, or contractual means.[10]

Imagine, for example, a situation in which members of a community can estimate their expected exposure to pollutants emitted by a new factory, as well as the incremental risk of environmental illness. Armed with this information, community members may be able to negotiate compensation for their increased risk of injury as a condition of the factory's operation.[11] Such contractual exchanges offer the potential to internalize upfront the costs to the community, but they are suitable for

4. *See infra* Section I.A. *See also* Daniel C. Esty, *Environmental Protection in the Information Age*, 79 N.Y.U. L. REV. 115, 131 (2004) ("People affected by pollution often do not know what potential environmental injuries they face, where particular harms are coming from, how much those harms affect them, what value to place on the injuries or effects they suffer, nor whether they have a right to be free of the harm."); W. Kip Viscusi, *Foreword* to CUTTING GREEN TAPE: TOXIC POLLUTANTS, ENVIRONMENTAL REGULATION AND THE LAW, at x–xiii (Richard L. Stroup & Roger E. Meiners eds., 2000) [hereinafter CUTTING GREEN TAPE].

5. *See infra* Section I.B.

6. *See* Esty, *supra* note 4, at 118–19.

7. *See infra* Section II.C.

8. *See infra* Section II.C.2.

9. *See infra* Section II.C.1.b.

10. *See* Esty, *supra* note 4, at 176–77.

11. *See id.* at 180.

only a handful of environmental exposure situations. Transaction costs are likely to be high, with each individual's expected harm likely to be small. Individuals will have only a limited desire to expend resources to negotiate compensation agreements with all polluters that may affect them.[12]

Like contractual approaches, tort approaches would offer only limited relief to the environmentally injured in our hypothetical scenario. Given the ex post nature of tort liability, victims will still face the risk that a polluter will become insolvent. Moreover, notwithstanding an enhanced capability to track pollution, many potential plaintiffs will face insurmountable obstacles in proving causation. Where multiple risk factors for environmental illness are present, science will often be unable to demonstrate that exposure to a particular defendant's pollutants was the "but for" cause of the illness.[13] Even plaintiffs armed with detailed information about the source of the pollutants to which they were exposed may be unable to meet their burdens of establishing causation due to evidentiary requirements and scientific limitations.[14] In addition, the costs of litigating against all possible defendants and the respective burdens on the judicial system make the prospect of tort compensation unattractive, if not unworkable.

This Article proposes a risk-based administrative system of liability and compensation for exposure to environmental pollutants as an alternative and a complement to the tort system. Under this proposal, major sources of pollution would pay levies ex ante. These levies would be based on the amount of pollutants released, the likely exposure of persons to those pollutants, the risk of harm from that exposure, and the expected costs of that harm to the victims. Compensation would be based on the health risk borne by each individual as a result of that individual's exposure.

This proposal differs fundamentally from earlier proposals for administrative compensation in that it uses a risk-based approach to capitalize on technological advances in gathering health and environmental information. These advances will promote an understanding of the causal

12. *See* DON N. DEWEES, DAVID DUFF & MICHAEL TREBILCOCK, EXPLORING THE DOMAIN OF ACCIDENT LAW: TAKING THE FACTS SERIOUSLY 266 (1996) (observing that negotiations will not take place in most cases of pollution emissions because of the presence of multiple victims, multiple sources, and great uncertainty); Esty, *supra* note 4, at 180–81; Louis Kaplow & Steven Shavell, *Property Rules Versus Liability Rules: An Economic Analysis*, 109 HARV. L. REV. 713, 749 (1996) (noting reasons why "[b]argaining appears to have relatively little importance in the context of industrial pollution," including collective action difficulties).

13. *See infra* Sections I.A.2, V.A.

14. *See id*.

relationships between toxic exposure and harm, and provide increasingly accurate estimates of the extent and the cost of environmental harms. Based on these advances, polluters can be forced to internalize the costs of toxic risks and to provide upfront compensation to victims. This ex ante approach facilitates preventative and mitigating measures while avoiding difficult case-by-case determinations of specific causation. Although this proposed system is not yet feasible as a comprehensive approach, technological advances in our ability to track, measure, and "price" environmental toxic harms will make this system an increasingly attractive complement to existing legal doctrines.

Part I of this Article describes the problems of proof presently faced by environmental tort plaintiffs. This discussion focuses on the difficulties of proving causation and the overall inadequacy of the tort system in addressing environmental toxic injuries. Part II presents the policy rationale for a new administrative system. This discussion first compares the current regulatory, tort, and administrative approaches to the problem. This part then discusses various technological advances that make an administrative system both possible and attractive. Part III reviews earlier administrative proposals for addressing environmental toxic injury and delineates the proposed risk-based system. Part IV explores the practical feasibility of this proposal by examining previously implemented administrative schemes and by illustrating how this proposal builds upon them. These previous schemes include a rudimentary pollution-compensation scheme adopted in Japan in the 1970s, New Zealand's no-fault compensation system for accidental injury, and the workers' compensation system in the United States. Part V considers possible objections to the proposal, including whether merely modifying the tort system might be preferable. In Part VI, this Article concludes that an administrative system is better suited than the tort system to capitalize on the advances of the digital age in order to achieve deterrence and compensation goals.

I. THE PROBLEM WITH TORT

The judicial system has struggled to address mass toxic torts in a fair, efficient, and inexpensive manner, as, for example, the Agent Orange and asbestos cases demonstrate.[15] Judicial management is complicated by the

15. *See* Robert L. Rabin, *Some Thoughts on the Efficacy of a Mass Toxics Administrative Compensation Scheme*, 52 MD. L. REV. 951, 952–54 (1993) [hereinafter Rabin, *Some Thoughts*]. The traditional tort process is not well-suited to handle scientific determinations of causation involving latent and sometimes intangible harms. Such difficulties are only compounded when cases arise *en*

large number of cases that arise and the individual factual variations among them. Yet even these examples understate the problem. Agent Orange and asbestos plaintiffs are generally able to point to a particular exposure to an identifiable substance as the possible cause of their illnesses. In contrast, persons injured by environmental pollution often have difficulty identifying a causal agent to link their injuries to an identifiable defendant.

A. CHARACTERISTICS OF ENVIRONMENTAL TORTS

The paradigmatic traditional tort case involves a single identifiable plaintiff, a single identifiable defendant, and a readily determinable cause of the tortious event.[16] For example, a pedestrian struck by a car can identify the driver of the car and the driver's negligence as the cause of the pedestrian's resulting injuries. Although the parties may dispute the driver's negligence or the harm suffered by the plaintiff, the judicial process is well equipped to determine such issues. Our judicial system is similarly able to handle classic strict liability claims, such as a dynamite explosion, a sudden flood from a reservoir, or even a catastrophic Bhopal-type accident.[17] In such cases, cause and effect are readily identifiable.[18] An environmental tort plaintiff, however, often faces far more formidable problems of proof. As an initial matter, courts generally apply a negligence standard rather than a strict liability standard to ordinary economic activities.[19] Only where a polluter is engaged in abnormally dangerous activities do courts apply a strict liability standard.[20] Furthermore, environmental tort plaintiffs must overcome the high hurdles of causation and latency of harm.[21]

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masse. *See* Robert L. Rabin, *Continuing Tensions in the Resolution of Mass Toxic Harm Cases: A Comment*, 80 CORNELL L. REV. 1037, 1038–39 (1995) [hereinafter Rabin, *Continuing Tensions*].

16. *Cf.* Glen O. Robinson, *Probabilistic Causation and Compensation for Tortious Risk*, 14 J. LEGAL STUD. 779, 780 (1985) ("One of the illusions fostered by traditional tort doctrine is that events have determinate causes that can be identified by careful investigation.").

17. *See* Peter Huber, *Environmental Hazards and Liability Law*, *in* LIABILITY: PERSPECTIVES AND POLICY 128, 129–30 (Robert E. Litan & Clifford Winston eds., 1988) (discussing *Rylands v. Fletcher*, L.R. 3 H.L. 330 (1868), in which the defendant was held strictly liable for flooding caused by its artificial reservoir).

18. *Id.* at 130.

19. *See, e.g.*, Indiana Harbor Belt R.R. v. Am. Cyanamid Co., 916 F.2d 1174 (7th Cir. 1990) (rejecting the application of strict liability to the transportation of acrylonitrile, a flammable and toxic chemical, through heavily populated areas).

20. *See, e.g.*, Luthringer v. Moore, 190 P.2d 1 (1948) (holding an exterminator strictly liable for the injury caused by fumigating a building with cyanide gas); RESTATEMENT (SECOND) OF TORTS § 519 (1977).

21. *See* Esty, *supra* note 4, at 132 (contending that "[m]odern day pollution control problems are rarely of the simple 'A causes harm to B' type that the property-versus-liability-rules debate explores").

1. Latency of Harm

Latency of harm complicates proving causation with any environmental disease that takes time to develop. For example, consider an individual who is diagnosed with cancer many years after an exposure to carcinogenic pollutants released from an industrial facility. Over the course of a lifetime, this individual has been exposed to numerous carcinogens through various pathways, including air, water, and food supply. In contrast to the paradigmatic tort plaintiff described above, this plaintiff's injury is latent, appearing some time after exposure.[22] The length of the latency period may vary among individuals. Thus, even when a population is exposed simultaneously to a pollutant, incidences of disease occur over a period of time that can span several decades.[23]

This latency and lack of simultaneity make evidence more difficult to gather. For example, victims may not have been aware of their first exposure to a toxic substance. Therefore, years later, they will likely be unable to prove the fact, timing, or extent of exposure.[24] Exposure often occurs at low levels over extended periods of time. The passage of time not only complicates proof, but also increases the risk that a defendant will no longer be financially viable, assuming that the defendant can even be identified.[25] Compounding plaintiffs' difficulties, statutes of limitations may bar suit, although some jurisdictions have rules tolling the statutory period until the time when the injury is discovered.[26]

2. Causation

An even greater barrier faced by plaintiffs is causation.[27] Toxic tort plaintiffs typically must establish two types of causation. First, a plaintiff must prove general causation—that a substance is capable of causing the

Historically, liability law dealt with diffuse hazards through nuisance doctrine, which required proof of serious, continuing, and unreasonable disturbance. *See* Huber, *supra* note 17, at 129.

22. *See* Viscusi, *supra* note 4, at x.

23. *See* David Rosenberg, *The Causal Connection in Mass Exposure Cases: A "Public Law" Vision of the Tort System*, 97 HARV. L. REV. 849, 919 (1984).

24. *See* Donald N. Dewees, *Insurance, Information, and Toxic Risk*, *in* CUTTING GREEN TAPE, *supra* note 4, at 187, 188–89; Jeffrey Trauberman, *Statutory Reform of "Toxic Torts": Relieving Legal, Scientific, and Economic Burdens on the Chemical Victim*, 7 HARV. ENVTL. L. REV. 177, 185 (1983) (noting that at-risk individuals may be unaware of exposure in the absence of acute health effects).

25. *See* Rosenberg, *supra* note 23, at 919–20.

26. DEWEES ET AL., *supra* note 12, at 274–75; Note, *Latent Harms and Risk-Based Damages*, 111 HARV. L. REV. 1505, 1508 (1998).

27. *See* DEWEES ET AL., *supra* note 12, at 273 ("The difficulty of proving causation is a crippling barrier to traditional tort lawsuits for the vast majority of pollution problems experienced in North America.").

injury at issue. Second, a plaintiff must prove specific causation—that exposure to the substance in fact caused that plaintiff's injury.[28] The scientific uncertainty that surrounds causation can make these burdens insurmountable.[29]

A few diseases, such as asbestosis, are so-called "signature diseases"—diseases that are extremely rare in the general population, but far more prevalent in persons exposed to a particular substance.[30] These illnesses can be traced to exposure to a specific substance. Illnesses involving environmental toxic exposure, however, often can result from multiple causes.[31] For example, an individual instance of lung cancer might be attributed to exposure to tobacco smoke, exposure to pollutants from a nearby factory, or exposure to pollutants from traffic on a local highway.[32] Separating the roles of the potential causal agents, which may interact in complex ways, is often problematic, if not impossible.[33] Unlike our automobile accident example, there is usually no obvious evidence that a particular agent caused the plaintiff's harm in environmental tort cases.[34]

a. General Causation

Much of the difficulty with environmental tort litigation is due to an insufficient scientific understanding of general causation. Essentially, the question is whether a certain chemical has the ability to cause a particular illness and, if so, to what extent. Reliable information regarding carcinogenic and other health effects is available for relatively few

28. *See* Daniel A. Farber, *Toxic Causation*, 71 MINN. L. REV. 1219, 1227–28 (1987).

29. *See* E. Donald Elliott, *The Future of Toxic Torts: Of Chemophobia, Risk as a Compensable Injury and Hybrid Compensation Systems*, 25 HOUS. L. REV. 781, 786 (1988).

30. *See* Farber, *supra* note 28, at 1251–53. Because acutely dangerous environmental contaminants are often directly regulated, such diseases are relatively uncommon. *See* Peter S. Menell, *The Limitations of Legal Institutions for Addressing Environmental Risks*, 5 J. ECON. PERSP., Summer 1991, at 93, 102.

31. *See* Rosenberg, *supra* note 23, at 856–57.

32. *See* Menell, *supra* note 30, at 94 (noting that many forms of cancer associated with pollution are also associated with other factors). *Cf.* Bruce N. Ames, *Six Common Errors Relating to Environmental Pollution*, 7 REG. TOXICOLOGY & PHARMACOLOGY 379, 382 (1987) (estimating that over fifty percent of all tested chemicals cause cancer if encountered in high doses).

33. *See* DEWEES ET AL., *supra* note 12, at 274; Shelly Brinker, Comment, *Opening the Door to the Indeterminate Plaintiff: An Analysis of the Causation Barriers Facing Environmental Toxic Tort Plaintiffs*, 46 UCLA L. REV. 1289, 1298–99 (1999) (noting that the intermingling of substances can make it virtually impossible for a plaintiff to identify a particular substance as a cause of injury).

34. *See* Menell, *supra* note 30, at 99; Jack B. Weinstein, *Preliminary Reflections on the Law's Reaction to Disasters*, 11 COLUM. J. ENVTL. L. 1, 10 n.24 (1986); Steve Gold, Note, *Causation in Toxic Torts: Burdens of Proof, Standards of Persuasion, and Statistical Evidence*, 96 YALE L.J. 376, 379–80 (1986).

substances. For many substances, health effects are unknown.[35] Molecular assays and animal bioassays provide some information on mutagenicity or carcinogenicity.[36] Scientists, however, caution that this information cannot always be extrapolated in a reliable manner to estimate human cancer risks.[37]

Courts tend to view epidemiological studies, which apply statistical techniques to explain variations in disease rates of human populations, as the most persuasive and acceptable type of general causation evidence in toxic tort cases.[38] Yet the very use of such studies creates difficulties. Epidemiological studies establish associations between alleged causes and effects by comparing either the incidence of disease across exposed and unexposed populations or exposure levels across sick and healthy

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35. *See supra* note 2. *See also* Dewees, *supra* note 24, at 195 (noting a 1990 EPA report, which stated that only ten percent of two hundred known atmospheric pollutants had been tested for mutagenicity or carcinogenicity). As one scholar has noted:

> There are thousands of regulated substances that rarely, if ever, could be the subject of a successful tort action. The available evidence is sufficient to support a finding that they probably cause nontrivial injuries of some types, but it is insufficient to support a finding that they probably caused any particular injury.

Richard J. Pierce, Jr., *Causation in Government Regulation and Toxic Torts*, 76 WASH. U. L.Q. 1307, 1308 (1998). There is even disagreement regarding the risk posed by low-level exposure to asbestos, which has been the subject of numerous epidemiological studies. Dewees, *supra* note 24, at 196.

36. Given ethical constraints on human health experiments, scientists primarily rely on indirect methods to test for toxicity or carcinogenicity, such as using molecular assays, animal bioassays, and epidemiological studies. *See* Menell, *supra* note 30, at 95. The Ames test, for instance, crudely screens substances for carcinogenicity based on the number of mutations occurring in bacteria exposed to each substance. *See* JEFFREY W. VINCOLI, LEWIS' DICTIONARY OF OCCUPATIONAL AND ENVIRONMENTAL SAFETY AND HEALTH 53–54 (2000).

37. *See* Dewees, *supra* note 24, at 194–95, 197. *See also* Ames, *supra* note 32, at 380; Heidi Li Feldman, *Science and Uncertainty in Mass Exposure Litigation*, 74 TEX. L. REV. 1, 24 (1995) (noting that because animal studies generally involve extremely high doses of a substance to estimate toxic effects, researchers must first extrapolate from high-dose effects to low-dose effects in animals and then estimate low-dose effects in humans). *Cf.* Gen. Elec. Co. v. Joiner, 522 U.S. 136, 144–47 (1997) (holding that the district court did not abuse its discretion in excluding a study in which infant mice were injected with massive doses of polychlorinated biphenyls ("PCBs") as the basis for an expert opinion that PCBs caused the plaintiff's lung cancer).

38. *E.g.*, *In re* "Agent Orange" Prod. Liab. Litig., 611 F. Supp. 1223, 1239 (E.D.N.Y. 1985) ("In a mass tort case such as Agent Orange, epidemiologic studies on causation assume a role of critical importance."). *See also* Jean Macchiaroli Eggen, *Toxic Torts and Causation: The Challenge of* Daubert *After the First Decade*, 17 NAT. RESOURCES & ENV'T 213, 214–15 (2003); Melanie B. Leslie, *Liability for Increased Risk of Harm: A Lawyer's Response to Professor Shafer*, 22 CARDOZO L. REV. 1835, 1840–41, 1840 n.25 (2001) (discussing cases in which summary judgment was granted to defendants because no reliable epidemiological studies had been performed). Courts are more reluctant to consider other types of scientific evidence, such as differential diagnosis. *See infra* note 47. This reluctance has been criticized as grounded in a misunderstanding of the nature of scientific inquiry. *See, e.g.*, Cranor & Eastmond, *supra* note 2, at 34–41 (arguing that various kinds and patterns of evidence support a consensus that certain substances probably cause cancer in humans).

populations.[39] Based on these comparisons, epidemiological studies estimate the "excess risk" created by a toxic agent compared to the "background risk" created by all other factors.[40] There are, however, significant limitations to epidemiological analysis. Such studies may be unable to detect small increases in risk; these studies can lack sufficient follow-up times to discover diseases with long latency periods, and they may fail to account for as-of-yet unknown factors that affect disease rates.[41] Detailed epidemiological data is available only for relatively few toxic substances. Furthermore, where such data is available, there may be uncertainty regarding the magnitude of the risk involved.[42]

b. Specific Causation

Specific causation is also frequently uncertain with environmental toxic injuries. Epidemiological studies may establish that a substance can cause the type of harm suffered by a plaintiff, satisfying general causation. But a plaintiff must still demonstrate that the particular harm was in fact the result of exposure to a given substance. Epidemiological studies, however, can only attribute a proportion of the incidence of disease in a population to any particular source. They are not designed to prove specific causation.[43] Specific causation requires a plaintiff to prove by a preponderance of the evidence that the defendant caused that particular plaintiff's harm. Many courts interpret the preponderance standard to require a relative risk ratio of 2.0 or greater[44]—for example, a defendant's conduct more than doubled the plaintiff's risk of injury.[45] This doubled-risk requirement, however,

39. *See* Gold, *supra* note 34, at 380.

40. *See* Rosenberg, *supra* note 23, at 857.

41. Feldman, *supra* note 37, at 25. *See also* Farber, *supra* note 28, at 1254–56 (noting that epidemiological studies are difficult to conduct if a substance may cause very small increases to existing widespread risks).

42. *See* Viscusi, *supra* note 4, at xiii.

43. *See* FED. JUDICIAL CTR., REFERENCE MANUAL ON SCIENTIFIC EVIDENCE 337 (2d ed. 2000) ("[E]mploying the results of group-based studies of risk to make a causal determination for an individual plaintiff is beyond the limits of epidemiology."); Rosenberg, *supra* note 23, at 856–57; Douglas L. Weed, *Causation: An Epidemiologic Perspective (In Five Parts)*, 12 J.L. & POL'Y 43, 44 (2003) ("What epidemiologists do *not* do is study disease causation in order to assign responsibility for harm caused to individuals; *specific causation* is not a traditional problem for epidemiologists.").

44. Relative risk, a commonly used approach for expressing the association between an agent and a disease, is the ratio of the incidence rate of disease in exposed individuals to the incidence rate in unexposed individuals. *See* FED. JUDICIAL CTR., *supra* note 43, at 348–49.

45. *E.g.*, Allison v. McGhan Med. Corp., 184 F.3d 1300, 1315 n.16 (11th Cir. 1999); Daubert v. Merrell Dow Pharm., Inc., 43 F.3d 1311, 1321 (9th Cir. 1995); DeLuca v. Merrell Dow Pharm., Inc., 911 F.2d 941, 958–59 (3d Cir. 1990); *In re* Breast Implant Litig., 11 F. Supp. 2d 1217, 1225–26 (D. Colo. 1998); Hall v. Baxter Healthcare Corp., 947 F. Supp. 1387, 1404 (D. Or. 1996). *See also* Gary E. Marchant, *Genomics and Toxic Substances: Part II—Genetic Susceptibility to Environmental Agents*, 33 ENVTL. L. REP. 10,641, 10,647 (2003) (noting that many courts require proof that a defendant's

conflates two distinct burdens: the plaintiff's substantive burden of proof and the standard of persuasion applicable to that burden.[46] Thus, if an epidemiological study indicates that exposure to a particular substance increases the incidence of a disease among those exposed by only forty percent, then a court will probably find that the plaintiff has failed to meet the burden of proving specific causation unless more direct evidence is offered.[47]

Indeed, some courts demand particularistic proof of a causal connection—probabilistic proof is insufficient on its own.[48] In such cases,

actions doubled the background risk, despite the fact that relatively few toxic substances cause a doubling of risk for commonly occurring health effects); Frederica P. Perera, *Environment and Cancer: Who Are Susceptible?*, 278 SCIENCE 1068, 1072 (1997) ("In epidemiology, it has been difficult to detect relative risks of 1.5 or even 2.0."). *But see, e.g.*, Woolf v. Consol. NDE, Inc., 796 A.2d 906, 908, 912 n.1 (N.J. Super. Ct. App. Div. 2001) (rejecting the contention that the materiality of exposure should be judged by comparing estimated increased rates to overall cancer rates, with respect to the issue of whether workplace radiation substantially contributed to development of cancer).

46. Gold, *supra* note 34, at 380–86. For instance, epidemiological evidence may demonstrate that a substance causes a thirty-percent increase in cancer rates, with the scientific community being ninety-nine percent certain of this causal relationship. Relying on this evidence, a hypothetical plaintiff would never be able to recover under the doubled-risk requirement because the majority of cancer cases were not caused by the substance. Unless traditional tort requirements are relaxed (for example, through the adoption of proportional liability, *see infra* Section V.B.2), the defendant would never be held accountable for a thirty-percent increase in cancer rates. Even plaintiffs who were able to identify the cause of their injuries would remain uncompensated. *See id*. *Cf*. Mark Geistfeld, *Scientific Uncertainty and Causation in Tort Law*, 54 VAND. L. REV. 1011, 1033–36 (2001) (criticizing the requirement that epidemiological proof must show a doubling of risk, noting that it is inconsistent with tort norms that traditionally redress less drastic risk exposure); Joseph H. King, Jr., *Causation, Valuation, and Chance in Personal Injury Torts Involving Preexisting Conditions and Future Consequences*, 90 YALE L.J. 1353 (1981) (arguing that loss of a chance should be compensable even if the chance is less than even).

47. Plaintiffs sometimes introduce expert testimony based on differential diagnosis to establish specific causation—a physician rules out other possible causes of the injury based on the case history and clinical evidence. Courts are divided on the acceptability of this approach. *See* Gary E. Marchant, *Genomics and Toxic Substances: Part I—Toxicogenomics*, 33 ENVTL. L. REP. 10,071, 10,077–78 & nn.76–77 (2003). One commentator has proposed the combined use of differential diagnosis and epidemiological studies. This combination could ameliorate judicial reservations about the probative value of studies alone, if those studies indicated relative risk ratios between 1.0 and 2.0. *See* Alani Golanski, *General Causation at a Crossroads in Toxic Tort Cases*, 108 PENN ST. L. REV. 479, 502–04 (2003).

48. *See* Rosenberg, *supra* note 23, at 857. *Compare* Smith v. Rapid Transit, Inc., 58 N.E.2d 754, 754–55 (Mass. 1945) (directing a verdict for the defendant, a bus company, after the plaintiff produced almost no particularized evidence that the defendant's bus probably caused the accident, despite the fact that mathematical probabilities suggested otherwise), *with* United States v. Veysey, 334 F.3d 600, 604–06 (7th Cir. 2003) (discussing *Smith* and the evidentiary value of probabilistic evidence). The refusal to accept probabilistic evidence as sufficient to establish causation reflects a simplistic approach to causation more consistent with eighteenth century Newtonian science than with modern scientific inquiry. *See* Troyen A. Brennan, *Causal Chains and Statistical Links: The Role of Scientific Uncertainty in Hazardous-Substance Litigation*, 73 CORNELL L. REV. 469, 491–93 (1988); *infra* Section I.A.2.c.

it is insufficient even to prove that exposure to a substance more than doubled a plaintiff's risk of injury.[49] In addition, if a particular disease-causing substance was generated by more than one source, a plaintiff may also have to demonstrate which of multiple potential defendants produced the substance responsible for the injury.[50] But if a plaintiff is able to identify two or more tortfeasors who collectively released sufficient pollutants to cause the harm, courts may be willing to attach liability to each one. Courts may treat each as a causal agent under a "substantial factor" test, under a theory of joint and several liability, or under a theory of market share liability.[51]

Resolution of all of these issues requires costly expert testimony. Here, environmental tort plaintiffs face another hurdle—the fairly rigorous standard for expert testimony mandated by *Daubert v. Merrell Dow Pharmaceuticals*.[52] In *Daubert*, the Supreme Court interpreted the Federal Rules of Evidence to require that the trial judge serve as a gatekeeper for scientific testimony. The Court identified several factors for trial courts to consider in determining the admissibility of scientific testimony.[53] The *Daubert* standard has proven to be too strict for many toxic tort plaintiffs to meet—courts often find the proposed experts' testimony to be too unreliable to be admissible in light of scientific uncertainty and incomplete scientific knowledge.[54]

49. *See* Rosenberg, *supra* note 23, at 858 ("Because long latency periods and the mysteries of disease etiology necessitate exclusive reliance on statistical evidence, the strong version of the preponderance rule requires the dismissal of all mass exposure claims.").

50. *See* Feldman, *supra* note 37, at 38–39. *See generally* Andrew B. Nace, Note, *Market Share Liability: A Current Assessment of a Decade-Old Doctrine*, 44 VAND. L. REV. 395 (1991) (reexamining market share liability).

51. *See* DAN B. DOBBS, THE LAW OF TORTS 415 & n.6, 424–25, 430–32 (2000).

52. Daubert v. Merrell Dow Pharm., Inc., 509 U.S. 579 (1993). *Daubert* was itself a toxic tort case. On remand from the Supreme Court, the Ninth Circuit held that the plaintiffs' scientific evidence, which consisted of a reanalysis of epidemiological evidence, lab studies on animal tissues, and chemical structure analysis, was insufficiently reliable to be admitted under the Federal Rules of Evidence. *See* Daubert v. Merrell Dow Pharm, Inc., 43 F.3d 1311 (9th Cir. 1995).

53. *See Daubert*, 509 U.S. at 589–95.

54. *See, e.g.*, Mitchell v. Gencorp Inc., 165 F.3d 778, 782–83 (10th Cir. 1999); Schudel v. Gen. Elec. Co., 120 F.3d 991, 997 (9th Cir. 1997). *See also* Lynn L. Bergeson, Lisa M. Campbell & Richard P. Bozof, *Toxicogenomics*, ENVTL. F., Nov.–Dec. 2002, at 28, 35 (noting that the judicial trend requires studies involving humans to establish causation in toxic tort actions, specifically requiring that epidemiological studies demonstrate at least a doubling of risk); Cranor & Eastmond, *supra* note 2, at 6 (contending that "the way in which some courts have implemented evidentiary reform has, in all likelihood, precluded some litigants with reliable, but not ideal, scientific evidence from a jury trial"); Joseph Sanders & Julie Machal-Fulks, *The Admissibility of Differential Diagnosis Testimony to Prove Causation in Toxic Tort Cases: The Interplay of Adjective and Substantive Law*, LAW & CONTEMP. PROBS., Autumn 2001, at 107, 137 (concluding that differential diagnosis testimony is viewed more skeptically today than was the case prior to *Daubert*). *See generally* MOLLY TREADWAY JOHNSON,

c. Scientific Causation Versus Legal Causation

Ultimately, the judicial struggle with causation reflects the inherent tension between traditional causal analysis and modern science's probabilistic understanding of causation.[55] The traditional view characterizes causation in terms of collisions following the laws of Newtonian physics where discrete, identifiable actors injure a readily identified victim.[56] This view of causation emphasizes individual responsibility and corrective justice, but does so by looking backwards at specific prior events. In contrast, scientific causation is forward looking—it studies the past in order to predict future events. Scientific causation depends on analyzing likelihood and collective effects to generate probabilistic evidence.[57] Traditional causation and modern scientific causation come into conflict in environmental toxic tort cases—a conflict that is likely to be exacerbated as technology advances.

B. TORT OBJECTIVES UNDERMINED

The difficulties of overcoming latency and proving causation undermine the tort system's ability to meet its principal objectives. The tort system is said to have three primary objectives: (1) compensation, (2)

CAROL KRAFKA & JOE S. CECIL, FED. JUDICIAL CTR., EXPERT TESTIMONY IN FEDERAL CIVIL TRIALS: A PRELIMINARY ANALYSIS (2000) (reporting survey results indicating that, as a result of *Daubert*, federal judges are more likely to exclude expert testimony in civil trials).

55. *See* Brennan, *supra* note 48, at 490 (explaining that the scientific association between a toxic substance and an injury relies on probabilistic evidence in the form of epidemiological studies and statistical associations); Marcia R. Gelpe & A. Dan Tarlock, *The Uses of Scientific Information in Environmental Decisionmaking*, 48 S. CAL. L. REV. 371, 374 (1974) ("[T]here is a basic tension between legal concepts of cause and the conditions for valid scientific predictive inferences which has become increasingly important as regulators turn to scientists . . . for the basic information on which regulations and other sanctions aimed at minimizing potential risks of adverse environmental impact are based.").

56. *See* Brennan, *supra* note 48, at 483–91.

57. *See id.* at 489, 521; Gelpe & Tarlock, *supra* note 55, at 386–87; Edward J. Imwinkelried, *Evidence Law Visits Jurassic Park: The Far-Reaching Implications of the* Daubert *Court's Recognition of the Uncertainty of the Scientific Enterprise*, 81 IOWA L. REV. 55, 62 (1995) ("Science often cannot make a truly definitive pronouncement. Therefore, scientists must be content with probabilistic statements based on an imperfect, incomplete state of knowledge.") (internal footnotes omitted)). Brennan suggests that courts might be "instructed" to adopt probabilistic reasoning, but she concludes that "given the importance of the moral concept of individual responsibility in tort law, we can expect courts to accommodate only so much probabilistic reasoning." Brennan, *supra* note 48, at 491. *See also* Gelpe & Tarlock, *supra* note 55, at 388 ("[T]he law cannot afford the tentativeness science permits in the process of hypothesis verification, for the law is interested in simple rather than complex relationships.").

deterrence, and (3) corrective justice.[58] Compensation is provided to plaintiffs who can demonstrate that they were harmed by the activities of others. Here, the tort system essentially serves as social insurance by spreading the costs of accidents to risk creators and their consumers.[59] Deterrence is achieved through the threat of financial liability—economically rational actors are forced to take into account the impacts of their activities on others. Proponents of efficient deterrence argue that liability rules should be designed to induce efficient levels of activity and care.[60] Proponents of corrective justice contend that those responsible for violating other persons' autonomy should restore those persons to their preinjury status.[61] In environmental toxic tort cases, the tort system fails to serve any of these objectives well.[62]

1. Undercompensation

Given the difficulties discussed above, environmental tort plaintiffs often face very limited prospects for obtaining compensation. In contrast to highly publicized toxic tort cases such as those involving Love Canal[63] or

58. *See* GUIDO CALABRESI, THE COSTS OF ACCIDENTS: A LEGAL AND ECONOMIC ANALYSIS 24–33 (1970) (describing the principal goals of accident law as justice and the reduction of accident costs, the latter of which includes subgoals of deterring accidents, reducing administrative costs, and reducing societal costs, typically through compensation); DEWEES ET AL., *supra* note 12, at 5–9 (identifying these three objectives as the major normative perspectives of tort law); STEPHEN D. SUGARMAN, DOING AWAY WITH PERSONAL INJURY LAW 3–72 (1989) (criticizing tort law's common justifications of deterrence, compensation, and corrective justice). Furthermore, as one scholar has noted:

> First, [tort law] seeks to allocate resources to those who have been injured by unduly risky conduct or products. Second, it aims to deter excessively risky conduct . . . . Third, it tries to expressively yoke victims of overly risky activity with their injurers by requiring injurers to compensate those they have harmed.

Feldman, *supra* note 37, at 34. There are, of course, disagreements over the exact characterizations and the relative importance of each objective.

59. *See* DEWEES ET AL., *supra* note 12, at 6–7.

60. *See id.* at 5.

61. Jules L. Coleman, *Tort Law and the Demands of Corrective Justice*, 67 IND. L.J. 349, 357 (1992) ("Corrective justice demands that wrongful (or unjust) gains and losses be rectified, eliminated, or annulled."); Ernest J. Weinrib, *Toward a Moral Theory of Negligence Law*, 2 LAW & PHIL. 37, 38 (1983) (explaining that corrective justice "considers the position of the parties anterior to the transaction as equal, and it restores this antecedent equality by transferring resources from defendant to plaintiff").

62. *See, e.g.*, MICHAEL J. MOORE & W. KIP VISCUSI, PRODUCT LIABILITY ENTERING THE TWENTY-FIRST CENTURY 38 (2001) ("Clearly, mass toxic torts as currently manifested in the litigation process are not meeting the stated objectives of the tort system. Determination of the appropriate compensation level is difficult, particularly when the cause of illness is uncertain.").

63. *See, e.g.*, Donald G. Gifford, *Public Nuisance as a Mass Products Liability Tort*, 71 U. CIN. L. REV. 741, 810–43 (2003) (describing legal theories applied in certain Love Canal litigation); A. Theodore Steegmann, Jr., *History of Love Canal and SUNY at Buffalo's Response: History, the University Role, and Health Research*, 8 BUFF. ENVTL. L.J. 173 (2001).

the Woburn, Massachusetts case described in *A Civil Action*[64] (in which a cluster of leukemia cases was allegedly caused by drinking water contamination), most instances of environmental injury involve widely dispersed and commonly released pollutants such as sulfur dioxide or fine particulate matter. Victims tend to suffer cancer, heart disease, respiratory illness, and other maladies[65] not readily traced to potential defendants.[66] Although the exact number of uncompensated deaths and illnesses is uncertain, studies indicate this number is substantial.[67]

For instance, in 2002, one study concluded that the inhabitants of heavily polluted metropolitan areas in the United States face a twelve-percent higher risk of lung cancer than inhabitants of the least polluted areas.[68] This increase is attributed to long-term exposure to fine particulate air pollution from coal-fired power plants, factories, and diesel trucks.[69] Another study, also completed in 2002, estimated that sulfur dioxide and nitrogen oxide emissions from eight electric utility systems in the midwestern United States and the southern United States cause 5900 premature deaths from lung cancer and other respiratory illnesses, 4300 cases of chronic bronchitis, and 140,000 asthma attacks per year.[70] The Environmental Protection Agency ("EPA") estimates that exposure to toxic

64. JONATHAN HARR, A CIVIL ACTION (1996).

65. *See* AM. LAW INST., 1 ENTERPRISE RESPONSIBILITY FOR PERSONAL INJURY 308–09 (1991) (noting that environmental injuries include not only cancer, but also dermatological, gastrointestinal, coronary, respiratory, musculoskeletal, and neurological illnesses).

66. *See id.* at 321–23 (noting that groundwater pollution cases are difficult to win, but that cases involving airborne or waterborne toxic substances are even harder to win because toxic substances and injuries are widely dispersed); Huber, *supra* note 17, at 150 ("Those who favor broader liability are probably correct in their general claim that the total environmental liability payments currently made by all industrial defendants are lower than the total external environmental costs their activities generate, since most low-level releases still go unnoticed.").

67. The American Law Institute reported in 1991 that, even assuming the "most conservative estimates" of 10,000 environmentally related cancer deaths per year, there had been comparatively little litigation alleging personal injury as a result of exposure to these hazardous substances. *See* AM. LAW INST., 2 ENTERPRISE RESPONSIBILITY FOR PERSONAL INJURY 355–56 (1991).

68. Pianin, *supra* note 1.

69. *See* C. Arden Pope III et al., *Lung Cancer, Cardiopulmonary Mortality, and Long-term Exposure to Fine Particulate Air Pollution*, 287 JAMA 1132, 1137 (2002) (finding that the number of lung cancer deaths increased approximately eight percent, and that overall deaths increased approximately four percent, for every ten-microgram-per-cubic-meter increase in fine particulate matter emitted); Pianin, *supra* note 1 (discussing the results of that study). Other studies have estimated that long-term respiratory exposure to fine particles causes 60,000 deaths per year in the United States. *See* Jocelyn Kaiser, *Evidence Mounts that Tiny Particles Can Kill*, 289 SCIENCE, July 7, 2000, at 22–23. Worldwide, exposure to air pollution has been estimated to cause annually 62,000 lung cancer deaths and 712,000 other deaths from noncancer cardiac and respiratory diseases. A.J. Cohen, *Air Pollution and Lung Cancer: What More Do We Need to Know?*, 58 THORAX 1010, 1010–11 (2003).

70. *See* ABT ASSOCS. INC., PARTICULATE-RELATED HEALTH IMPACTS OF EIGHT ELECTRIC UTILITY SYSTEMS, ES-1 to -3 (2002).

air pollutants generates a lifetime cancer risk exceeding ten in one million for all United States residents.[71] For more than twenty million Americans, that risk may exceed one hundred in one million.[72] In fact, a 1998 study attributed some 30,000 cancer-related deaths each year in the United States to chemical exposure.[73] The trend of increasing exposure to chemicals suggests that these numbers are only likely to rise in the future.[74] Ultimately, few of the victims of these injuries are compensated because of the numerous pollutants involved, the multiple sources for each pollutant, and the uncertainty of the causal relationships between exposures and injuries.

Like all tort plaintiffs, those few environmental tort victims who can demonstrate liability receive only partial compensation once attorneys' fees are paid. According to a recent estimate, of each dollar spent in insured tort cases, twenty-two cents compensates for economic loss, twenty-four cents compensates for noneconomic loss, and the remaining fifty-four cents goes to attorneys and administrative costs.[75] These figures are consistent with previous studies that have found that tort plaintiffs recover less than half of the total amount expended by defendants and their insurers.[76] The

71. U.S. EPA, TECHNOLOGY TRANSFER NETWORK AIR TOXICS ASSESSMENT, SUMMARY OF RESULTS (1996), http://www.epa.gov/ttn/atw/nata/risksum.html.

72. *Id.* Nevertheless, many instances of cancer are caused by risks within personal control such as smoking and diet. *See* Bruce N. Ames & Lois Swirsky Gold, *The Causes and Prevention of Cancer: Gaining Perspectives on the Management of Risk*, *in* RISKS, COSTS, AND LIVES SAVED 9–18 (Robert W. Hahn ed., 1996). Estimates tend to hold environmental pollution responsible for a relatively small fraction of overall cancer rates in the United States, although the number of such cancer cases per year is estimated to be in the thousands. *See* David L. Eaton, *Scientific Judgment and Toxic Torts—A Primer in Toxicology for Judges and Lawyers*, 12 J.L. & POL'Y 5, 28 (2003).

73. *See* David Pimentel et al., *Ecology of Increasing Disease: Population Growth and Environmental Degradation*, 48 BIOSCIENCE 817, 818 (1998). Worldwide, an estimated forty percent of deaths can be attributed to environmental factors, including chemical pollutants and tobacco. *Id.* In addition, approximately three percent of the 120,000 instances of developmental defects found annually are attributed to exposure to toxic chemicals and physical agents, including environmental factors. NAT'L RESEARCH COUNCIL, SCIENTIFIC FRONTIERS IN DEVELOPMENTAL TOXICOLOGY AND RISK ASSESSMENT 1 (2000).

74. *See* Pimentel et al., *supra* note 73, at 818.

75. TILLINGHAST-TOWERS PERRIN, U.S. TORT COSTS: 2003 UPDATE 17 (2003).

76. *See* DEWEES ET AL., *supra* note 12, at 275–76 (reporting a 1985 Rand study estimating that plaintiffs retain forty-six percent of total expenditures as compensation in tort cases); STEVEN SHAVELL, ECONOMIC ANALYSIS OF ACCIDENT LAW 263 n.2 (1987) (identifying studies that found that administrative costs in tort liability cases approach or exceed the amounts received by victims); SUGARMAN, *supra* note 58, at 40 ("When payments for losses already covered by collateral sources and for pain and suffering are subtracted, one finds that only about 10–15 percent of the costs of the tort system go to compensating victims for out-of-pocket medical expenses, lost income, and the like."); Menell, *supra* note 30, at 100 (reporting that plaintiffs received, on average, only thirty-nine percent of the total paid in asbestos litigation). *Cf.* Jeffrey O'Connell & James F. Neale, *HMOs, Cost Containment, and Early Offers: New Malpractice Threats and a Proposed Reform*, 14 J. CONTEMP. HEALTH L. &

difficulties of proving causation make it likely that the share of proceeds going toward compensation is even lower in environmental toxic injury cases.[77]

The chance of a plaintiff's successful recovery is further eroded by the legal remoteness of damages, the difficulty of valuing subjective losses, and the difficulty of accounting for the increased risk of latent harms.[78] Damages are often paid years after a victim has been injured; thus, the recovery may be of little use to the victim. Often, only the victim's survivors receive the benefit of any recovery. Furthermore, the tort system's general lack of oversight and coordination adds to the inequities—dissimilar awards are common for similarly situated victims.[79] Finally, if a defendant becomes insolvent, remaining plaintiffs will be unable to secure compensation.[80]

Undercompensation thus appears to be the norm. One might argue, however, that an individual plaintiff who does manage to demonstrate liability is overcompensated. Courts award full compensation whenever the "more probable than not" standard is met, despite a significant probability that there were other causal factors involved. Therefore, a plaintiff may be overcompensated to the extent that damages are recovered for these other factors.[81] Overcompensation may also occur in a case in which a court has

POL'Y 287, 298 (1998) (estimating that between sixty cents and seventy-two cents of every dollar in medical malpractice cases is spent on administrative costs).

77. *See* DEWEES ET AL., *supra* note 12, at 276 (noting that asbestos plaintiffs recovered only thirty-seven percent of the total expenditure by defendants and their insurers, but suggesting that the percentage may be even lower in environmental litigation where less is known about harmful effects of environmental toxic substances).

78. *Id.* at 293–94. Exposed but as-of-yet unimpaired individuals have an elevated risk of future disease, but recovery is generally unavailable in the absence of physical injury. A few jurisdictions do allow plaintiffs facing such elevated risks to recover expenses for the costs of medical monitoring. Richard A. Nagareda, *Autonomy, Peace, and Put Options in the Mass Tort Class Action*, 115 HARV. L. REV. 747, 763–64 (2002) (citing Metro-North Commuter R.R. v. Buckley, 521 U.S. 424 (1997)). *See also* AM. LAW. INST., *supra* note 67, at 375–79 (recommending medical monitoring damages for the purpose of epidemiological investigation); Amy B. Blumenberg, Note, *Medical Monitoring Funds: The Periodic Payment of Future Medical Surveillance Expenses in Toxic Exposure Litigation*, 43 HASTINGS L.J. 661, 679–82 (1992) (discussing the growing number of courts that recognize claims for postexposure, presymptom medical monitoring).

79. *See* SUGARMAN, *supra* note 58, at 38 (criticizing the arbitrariness of tort compensation).

80. *See* Jerry L. Mashaw, *A Comment on Causation, Law Reform, and Guerrilla Warfare*, 73 GEO. L. J. 1393, 1395 (1985). For example, in asbestos litigation, at least fifty-six companies have filed for bankruptcy, leaving remaining plaintiffs either to seek other defendants or to go without compensation. *See generally* Francis E. McGovern, *The Tragedy of the Asbestos Commons*, 88 VA. L. REV. 1721 (2002) (discussing the failure of asbestos manufacturers and victims to cooperate in settling claims).

81. *See* Tamsen Douglass Love, Note, *Deterring Irresponsible Use and Disposal of Toxic Substances: The Case for Legislative Recognition of Increased Risk Causes of Action*, 49 VAND. L.

misunderstood scientific evidence and granted compensation despite inadequate proof of causation.[82] Nonetheless, the overall problems of proof suggest that victims of environmental pollution are being dramatically undercompensated as a group.[83] As the American Law Institute remarked: "[T]he large gap between potential and actual [environmental] tort claims . . . is at least as serious a social and legal problem as is the surplus of claims that is popularly supposed to afflict other areas of personal injury."[84]

2. Underdeterrence

Like compensation, deterrence is a basic objective of the tort system that fails in environmental toxic injury cases.[85] In theory, a tort system could be designed to achieve efficient deterrence by internalizing all of the social costs of each tortfeasor's activities.[86] Environmental toxic torts

REV. 789, 810 (1996). *See also* Gerald W. Boston, *Toxic Apportionment: A Causation and Risk Contribution Model*, 25 ENVTL. L. 549, 648 (1995) (predicting overdeterrence in a joint and several liability regime if firms "predict disproportionate and excessive liabilities because of their wealth and their ability to anticipate the presence of insolvent or immune firms").

82. *See* AM. LAW. INST., *supra* note 67, at 356–57; Elliott, *supra* note 29, at 787 (stating that a plaintiff may prevail in some cases only because a jury has nullified the overly harsh formal requirements of tort law).

83. *See* AM. LAW. INST., *supra* note 65, at 319–21 (concluding that courts are not overcompensating environmental injury victims, given the relatively low total damages awarded in such cases compared to the large number of likely victims).

84. AM. LAW. INST., *supra* note 67, at 356.

85. *See* Trauberman, *supra* note 24, at 187 n.48 (citing numerous commentators who have concluded that the legal system fails to efficiently transfer the costs of toxic substance pollution). Donald Dewees has not found any data that precisely estimated the degree of underdeterrence in environmental tort litigation. But Dewees noted the relatively limited amount of such litigation compared to the annual estimate of over 10,000 environmentally-caused cases of cancer. Dewees concluded that barriers to lawsuits must result in systematic underdeterrence. DEWEES ET AL., *supra* note 12, at 277, 296–97 (observing that less than fifty million dollars was paid for personal injuries in cases involving toxic waste sites between 1983 and 1986). *See also* Brennan, *supra* note 3, at 6–7 (using similar evidence to conclude that "environmental tort suits currently send a weak deterrent signal").

86. The discussion here assumes a perspective in which the negative health effects of pollution are treated as externalities generated by polluters' activities. *See* A.C. PIGOU, THE ECONOMICS OF WELFARE 185–86 (4th ed. 1932); BRUCE YANDLE, COMMON SENSE AND COMMON LAW FOR THE ENVIRONMENT: CREATING WEALTH IN HUMMINGBIRD ECONOMIES 38–39 (1997). The natural extension of this perspective, the "polluter pays principle," requires that the costs of these externalities be internalized to polluters to achieve efficiency and fairness. *See* MICHAEL FAURE & GÖRAN SKOGH, THE ECONOMIC ANALYSIS OF ENVIRONMENTAL POLICY AND LAW 26–27 (2003); PIGOU, *supra*, at 192–93. As Ronald Coase argued, however, pollution problems can also be conceptualized as conflicts among property rights in which, if transactions costs are assumed to be zero, socially efficient results may be reached through bargaining between polluters and those exposed to pollution. R.H. Coase, *The Problem of Social Cost*, 3 J.L. & ECON. 1 (1960). Nevertheless, the Coasean approach is of marginal applicability if transaction costs are high, which is likely to be the case where each pollution source

involve one party's unilateral imposition of risk onto others. Usually, victims are unaware of the risk and unable to take steps to protect themselves.[87] Economic models indicate that in such situations, strict liability rules can be used to induce socially optimal behavior. In other words, efficient activity levels and efficient caretaking can be promoted.[88]

For efficient deterrence, an actor's expected liability must equal the total expected social costs of the activity. Thus, actors must have accurate information regarding their expected future tort liability.[89] With respect to environmental toxic injuries, underdeterrence is virtually guaranteed. Assessing future liability is clouded by ignorance of the dangers, by the scope of exposure, and by the low probability that defendants will be held responsible for those dangers.[90] Most air and water pollution impose small costs on a large number of people. They are thus unlikely to warrant the costs of litigation for any individual victim.[91] In addition, potential defendants are likely to discount the long-term negative effects of present

imposes low-level but significant risks on large numbers of exposed individuals. *See id.* at 18 (noting that governmental administrative regulation may be more efficient than market transactions in the case of "smoke nuisance, [where] a large number of people are involved and in which therefore the costs of handling the problem through the market or the firm may be high").

87. *See* AM. LAW. INST., *supra* note 67, at 367–68 (stating that in contrast to product liability, "virtually all the victims of environmental risk are 'strangers' to the enterprise that creates the risk and can do little if anything to protect themselves"); Jennifer H. Arlen, *Compensation Systems and Efficient Deterrence*, 52 MD. L. REV. 1093, 1095 (1993) ("Injuries to community residents caused by a producer's hazardous waste or other environmental pollutant is a classic example of a unilateral risk accident between strangers.").

88. *See* SHAVELL, *supra* note 76, at 23. *See also* CALABRESI, *supra* note 58, at 70–71; RICHARD A. EPSTEIN, MODERN PRODUCTS LIABILITY LAW 27 (1980) (arguing that, regardless of fault, it is fair for a party who has benefited from an activity to bear the risk of loss); A. MITCHELL POLINSKY, AN INTRODUCTION TO LAW AND ECONOMICS 92–93 (1983); RICHARD A. POSNER, ECONOMIC ANALYSIS OF LAW 178 (4th ed. 1992) (acknowledging the appropriateness of imposing strict liability on conduct such as ultrahazardous activities in which only the injurers, as opposed to victims, are able to reduce risk); Trauberman, *supra* note 24, at 208–10 (arguing that Calabresi's view—that costs should be allocated to the cheapest cost avoider to minimize transaction costs—suggests that enterprises dealing with toxic substances should be liable because they can best determine whether the social costs of the activity exceed the potential benefits). The socially optimal level of care is the level of care that minimizes the total social cost of accidents—a level that minimizes both the cost of risk-reduction measures and the cost of those accidents that do occur. SHAVELL, *supra* note 76, at 7.

89. *See* SUGARMAN, *supra* note 58, at 6–7.

90. *See* Steven Shavell, *A Model of the Optimal Use of Liability and Safety Regulation*, 15 RAND J. ECON. 271, 271 & n.2 (1984) (noting that "liability does not create sufficient incentives to take appropriate care because of the possibility that parties would not be able to pay fully for harm done or would not be sued for it," particularly with respect to environmental and health-related risks).

91. *See* DEWEES ET AL., *supra* note 12, at 275.

decisions because plaintiffs' injuries will not arise until far into the future.[92] When injuries do arise, plaintiffs will face numerous problems of proving causation.[93] Corporations generally amortize such future costs by incorporating a discount rate into their calculations of future cash flow.[94] If an injury does not occur until twenty or thirty years after exposure, the discounted value of the injury is likely to approach zero.[95]

Moreover, organizations may be deterred only to the extent that decisionmakers in the organization bear responsibility for their decisions.[96] This is unlikely to happen where injuries are latent. Internal corporate structures may not provide the proper incentives to corporate decisionmakers, who may not be with the corporation decades later when liability is imposed.[97] Liability insurance, where available,[98] further reduces corporate decisionmakers' incentives to consider the full cost of negative externalities.[99] This is especially so if insurance premiums fail to reflect the risks associated with a particular insured's activities.[100]

Not surprisingly, the limited empirical data available suggests that common law tort litigation has had little deterrent effect on polluter behavior. The exceptions are instances where a harm can be readily linked to a large and isolated pollution source.[101] In theory, if a plaintiff has sufficient data to show that one of several defendants caused the plaintiff's

92. *See* Mashaw, *supra* note 80, at 1394 (arguing that current tort law "may have no deterrent effect in practice" because of the long latency periods between exposure, injury, and any determination of liability).

93. *See* SUGARMAN, *supra* note 58, at 9 (arguing that discounting the threat of liability is rational because some bona fide victims are averse to litigation, some have other sources of compensation, some have small individual losses, and some are unaware of the identity of their injurers).

94. *Cf*. Daniel A. Farber, *From Here to Eternity: Environmental Law and Future Generations*, 2003 U. ILL. L. REV. 289, 295–97 (discussing the effect of varying discount rates over time).

95. *See id.*

96. *See* Menell, *supra* note 30, at 102.

97. *See id*.; Robinson, *supra* note 16, at 784–85 (noting that managerial incentives in modern corporations skew decisionmaking toward short-term gains); Love, *supra* note 81, at 803. *See generally* Timothy F. Malloy, *Regulating by Incentives: Myths, Models, and Micromarkets*, 80 TEX. L. REV. 531 (2002) (criticizing the assumption made by regulators that business organizations are monolithic entities that act rationally).

98. Although most general liability insurance policies contain pollution exclusions, courts are divided on whether these exclusions apply to environmental toxic injury claims. *See* John N. Ellison, Richard P. Lewis & Nicholas M. Insua, *Recent Developments in the Law Regarding the "Absolute" and "Total" Pollution Exclusions, the "Sudden and Accidental" Pollution Exclusion and Treatment of the "Occurrence" Definition* (ALI-ABA Continuing Legal Education Course of Study) (June 16, 2005), *available at* SK095 ALI-ABA 1 (Westlaw).

99. SUGARMAN, *supra* note 58, at 12–13; Menell, *supra* note 30, at 102.

100. *See* Richard J. Pierce, Jr., *Encouraging Safety: The Limits of Tort Law and Government Regulation*, 33 VAND. L. REV. 1281, 1298–1300 (1980).

101. *See* DEWEES ET AL., *supra* note 12, at 288–90.

harm—for example, if a plaintiff's disease was caused by one of several nearby factories—joint and several liability could result in overdeterring deep-pocketed defendants.[102] For most sources of common pollutants, however, victims simply cannot show causation, and polluters, who face almost no risk of liability, are undeterred.

3. Corrective Justice

The third objective of the tort system is to provide corrective justice, which has been defined as "the defendant's obligation to compensate for harm that she has caused wrongfully or in violation of the plaintiff's rights."[103] With environmental toxic injuries, the tort system fails to provide corrective justice to victims for many of the same reasons that it fails to achieve compensation and deterrence. Here again, the causation inquiry is critical. Many commentators consider causation central to corrective justice because it establishes the essential nexus between the parties by identifying the specific victim of the injurer's acts.[104] Yet the obstacles to proving causation in environmental toxic tort cases often prevent any such nexus from being established.

II. THE CASE FOR REPLACING TORT WITH ADMINISTRATIVE COMPENSATION

Having examined the tort system's failure to address environmental toxic injuries in Part I, we must consider which new legal solutions might offer a better approach.

A. INSTITUTIONAL OPTIONS

Legal institutions can be described as information processing systems. Each system differs in how it processes information and in how strict a

102. *Cf.* Boston, *supra* note 81, at 589–90 (proposing apportionment of liability as a solution).

103. Kenneth W. Simons, *Corrective Justice and Liability for Risk-Creation: A Comment*, 38 UCLA L. REV. 113, 125–26 (1990).

104. *See, e.g.*, Weinrib, *supra* note 61, at 38 ("The requirement of factual causation establishes the indispensable nexus between the parties by relating their rights to a transaction in which one has directly impinged upon the other."). *Cf.* George P. Fletcher, *Fairness and Utility in Tort Theory*, 85 HARV. L. REV. 537, 542 (1972) (contending that tort liability rests on injuries to a victim caused by a tortfeasor's imposition of nonreciprocal risks); Christopher H. Schroeder, *Corrective Justice and Liability for Increasing Risks*, 37 UCLA L. REV. 439, 465–66 (1990) (arguing that corrective justice merely requires demonstrating that the defendant caused an increased risk of harm, rather than demonstrating the causing of actual harm).

standard of causation it requires.[105] For example, legislation sets ambient air quality standards based on only minimal information linking the problem (harm to public health and the environment) to its source (pollution).[106] In contrast, tort litigation requires very specific information causally linking a particular plaintiff's injuries to the conduct of a particular defendant.[107] Administrative compensation systems occupy an intermediate position in this spectrum. Such systems require moderate amounts of information because they address classes of activities or injuries without necessarily matching particular injuries to particular actions.[108]

Legal institutions also vary in terms of whether they function ex ante or ex post. Safety regulations and corrective taxes are ex ante mechanisms that apply before, and independent of, the occurrence of an injury. In contrast, tort liability and most monetary penalties are triggered ex post by the occurrence of the harm.[109] Administrative systems may function in either manner. Ex ante approaches tend to be advantageous in situations where linking harms to injurers is difficult or where injurers may escape responsibility because of financial insolvency.[110] These are the very problems that characterize environmental toxic injuries. Ex post approaches, however, generally involve lower administrative costs since the costs are borne only if harm occurs.[111] Ex post approaches can be advantageous where the injurer has better information about risks than the government may have. In such cases, the injurer is in a better position to decide how to reduce risks.[112] This informational advantage, however, does not exist with respect to many health-related and environmental risks. In these cases, injurers have little incentive to generate or obtain such risk-related information.[113] For these risks, ex ante government regulation may be more appropriate.[114]

105. E. Donald Elliott, *Goal Analysis Versus Institutional Analysis of Toxic Compensation Systems*, 73 GEO. L.J. 1357, 1373 (1985).

106. *Id.* at 1373–74.

107. *Id.*

108. *Id.* at 1374. *See also* Gelpe & Tarlock, *supra* note 55, at 375 (noting that a finding by "a legislature or administrative agency that a circumscribed activity may cause adverse social impacts need not be made with the same degree of specificity as a court's finding that a defendant committed a criminal act, or as a plaintiff's proof of cause-in-fact in a civil action.").

109. SHAVELL, *supra* note 76, at 278.

110. *Id.* at 279–82.

111. *Id.* at 282.

112. *Id.* at 281.

113. *See infra* Section V.D.1.

114. SHAVELL, *supra* note 76, at 281–82.

Information disclosure requirements complement these more traditional forms of regulation by promoting informed decisionmaking that reduces toxic chemical exposure.[115] Two examples of such statutes are the Emergency Planning and Community Right-to-Know Act ("EPCRA")[116] and California's Proposition 65.[117] EPCRA requires companies to submit data regarding the amounts of toxic chemicals released annually. The EPA then compiles the data in a publicly available database, the Toxics Release Inventory.[118] Proposition 65 requires businesses to provide a "clear and reasonable" warning prior to exposing any individual to a listed carcinogen or toxicant.[119] By employing public pressure and facilitating bargaining, such information disclosure programs encourage the reduction of pollution to levels below those mandated by other forms of regulation.[120] But on their own, disclosure programs neither internalize costs nor provide compensation. Unfortunately, the information disclosed can sometimes be uninformative, irrelevant, confusing, or overwhelming.[121]

The United States has addressed the problem of pollution-based injury with two divergent institutional mechanisms: tort liability and command-and-control regulation. At one end, if sufficient causal information exists to attribute individual liability, the tort system regulates ex post the release of substances that result in injury. At the other end, command-and-control regulation prohibits ex ante the release of certain substances that are known or believed to be injurious. Command-and-control regulation may also restrict pollution levels for other substances to thresholds intended to protect human health and the environment.[122]

For example, under the Clean Air Act,[123] the EPA has promulgated national ambient air quality standards for six "criteria" pollutants.[124] These

115. *See* Esty, *supra* note 4, at 126; Clifford Rechtschaffen, *The Warning Game: Evaluating Warnings Under California's Proposition 65*, 23 ECOLOGY L.Q. 303, 313–18 (1996).

116. Emergency Planning and Community Right-to-Know Act of 1986, 42 U.S.C. §§ 11001–11050 (2000).

117. CAL. HEALTH & SAFETY CODE § 25,249.6 (West 2005) (codifying California's Proposition 65 warning requirement).

118. *See* 42 U.S.C. § 11023 (2000) (codifying the Toxics Release Inventory reporting requirements).

119. CAL. HEALTH & SAFETY CODE § 25,249.6.

120. Mark A. Cohen, *Information as a Policy Instrument in Protecting the Environment: What Have We Learned?*, 31 ENVTL. L. REP. 10,425, 10,427 (2001).

121. *See* Rechtschaffen, *supra* note 115, at 333–37.

122. In addition to health-based standards, regulations may employ either technology-based standards or a balancing approach. *See* ROBERT V. PERCIVAL ET AL., ENVIRONMENTAL REGULATION: LAW, SCIENCE, AND POLICY 126 (4th ed. 2003).

123. Clean Air Act, 42 U.S.C. §§ 7401–7671q (2000).

standards are intended "to protect the public health" with "an adequate margin of safety" and to protect the public welfare from "any known or anticipated adverse effects."[125] Similarly, under the Safe Drinking Water Act,[126] the EPA has established "maximum contaminant level goals" based solely on what is necessary to prevent adverse health effects, allowing "an adequate margin of safety."[127]

Underlying such statutory goals is the "threshold hypothesis," which states that human health can be protected as long as exposure levels remain below certain thresholds.[128] For many years, scientists widely accepted the hypothesis as an accurate characterization of noncarcinogenic toxic risks.[129] Thus, scientists developed the concept of the "no observed-effect level" ("NOEL")—the level of exposure at which no adverse effects were observed in studies.[130] An "acceptable daily intake" is calculated by dividing the NOEL by a safety factor of 100.[131] For carcinogenic risks, however, the EPA has found no credible way to demonstrate a NOEL. For the purposes of regulation, the EPA has instead merely designated certain levels of risk from exposure to carcinogens as "acceptable."[132]

Toxicological and epidemiological research, however, increasingly suggests that many substances cause significant but low level risks at very low concentrations. This may be true even for noncarcinogenic substances.[133] In some instances, stricter regulation or outright prohibition

124. The criteria pollutants are carbon monoxide, nitrogen dioxide, sulfur oxides, ozone, lead, and particulate matter. *See* 40 C.F.R. pt. 50 (2005).

125. 42 U.S.C. § 7409(b)(2) (2000). *See also id.* § 7412(f)(2)(A) (2000) (requiring the regulation of hazardous air pollutants with "ample margin of safety"). From a utilitarian perspective, procedures designed to overestimate risk are justified because safety concerns are more important than economic considerations. *See* Mark Geistfeld, *Reconciling Cost-Benefit Analysis with the Principle that Safety Matters More than Money*, 76 N.Y.U. L. REV. 114, 118 (2001).

126. Safe Drinking Water Act of 1974, 42 U.S.C. §§ 300f–300j-25 (2000).

127. 42 U.S.C. § 300g-1(b)(4)(A) (2000).

128. *See* NAT'L RESEARCH COUNCIL, SCIENCE AND JUDGMENT IN RISK ASSESSMENT 29 (1994).

129. *See id.* at 29–30.

130. *See id.* at 30.

131. *Id.*

132. Historically, 1×10^{-6} (one in one million) has represented the de minimis level of acceptable risk. But in some cases the EPA has moved to an acceptable risk range of between 1×10^{-6} and 1×10^{-4} (between one in one million and one in ten thousand). Adam Babich, *Too Much Science in Environmental Law*, 28 COLUM. J. ENVTL. L. 119, 152–53 (2003).

133. *See* Cary Coglianese & Gary E. Marchant, *Shifting Sands: The Limits of Science in Setting Risk Standards*, 152 U. PA. L. REV. 1255, 1286 (2004); Elliott, *supra* note 105, at 1372 (noting that for some cancer victims, the problem of proving causation is created by multiple sources of low-level risk rather than scientific uncertainty); Gary Koop & Lise Tole, *Measuring the Health Effects of Air Pollution: To What Extent Can We Really Say that People Are Dying from Bad Air?*, 47 J. ENVTL. ECON. & MGMT. 30, 32 (2004) (noting that studies suggest that there is no safe level of exposure to

may be appropriate.[134] But the complete elimination of risk will often be socially undesirable, if not impossible.[135] The use of pesticides, medicines, and other chemical substances involves substantial benefits, as well as risks. Ultimately, command-and-control regulation reflects policy choices made after a consideration of the costs and benefits. The weakness of such regulations, however, is that they generally do not internalize health costs, but allow them to fall where they may.[136] An administrative compensation system could fill this gap by forcing pollution sources to internalize the social costs of pollution without banning the pollution absolutely.

B. ADVANTAGES OF AN ADMINISTRATIVE SYSTEM

In theory, the tort system could serve deterrence, compensation, and corrective justice goals even in the context of environmental injury. As seen in Part I, however, the present tort system underdeters environmental toxic injury and undercompensates victims. Even if better injury and causation data existed, the system would still be ill-suited to handle

particulate matter); Marchant, *supra* note 45, at 10,656 (discussing the difficulty of setting threshold levels of exposure, below which no adverse health effects are presumed, given the growing indications that population subgroups vary in their sensitivity to pollutants); Joseph W. Thornton, Michael McCally & Jane Houlihan, *Biomonitoring of Industrial Pollutants: Health and Policy Implications of the Chemical Body Burden*, 117 PUB. HEALTH REP. 315, 318–19 (2002) (calling for the reevaluation of the axiom that chemicals have thresholds below which they cause no adverse effects, given the findings in developmental toxicology and the existence of high background levels of chemical exposure).

134. *See* Brennan, *supra* note 3, at 40–42 (arguing against the use of economic incentives to regulate toxic pollutants because such pollution infringes on the freedom of exposed individuals).

135. *See* Babich, *supra* note 132, at 147 ("We impose risks on each other simply by going through the motions of daily life."); Coglianese & Marchant, *supra* note 133, at 1328 (noting that the consistent application of a principle of minimizing risks "would effectively call for the elimination of all economic activities"); Marchant, *supra* note 45, at 10,656 (suggesting that a zero emission standard "'for almost any of the major air pollutants would virtually halt industrialization'") (quoting William K. Reilly, *Forward* to ROBERT D. FRIEDMAN, SENSITIVE POPULATIONS AND ENVIRONMENTAL STANDARDS, at vii–viii (1981)); *id.* at 10,658 ("The unfortunate reality is that we probably cannot afford to provide full protection to the most susceptible genotypes in the population, and indeed such protection may not even be possible."); Cass R. Sunstein, *Your Money or Your Life*, NEW REPUBLIC, Mar. 15, 2004, at 27, 30 (book review) ("Risks are often found on all sides of [a] social situation, and risk reduction itself produces risk."). *See also* Samuel J. Rascoff & Richard L. Revesz, *The Biases of Risk Tradeoff Analysis: Towards Parity in Environmental and Health-and-Safety Regulation*, 69 U. CHI. L. REV. 1763, 1763 (2002) (acknowledging that "[r]egulations undertaken to minimize or eliminate certain health risks often have the perverse effect of promoting other risks," but arguing that risk-tradeoff analysis should consider ancillary benefits in addition to the negative secondary effects of risk regulation).

136. *See* Brennan, *supra* note 3, at 35–37 (noting that present environmental regulatory regimes fail to guarantee that discrete communities are not exposed to dangerous levels of hazardous substances).

environmental toxic injuries.[137] Ultimately, litigation is too costly and unwieldy to address diffuse environmental risks and the resulting injuries.

From an institutional analysis perspective, administrative systems have certain characteristics that make them a superior alternative for addressing the environmental toxic injury problem.[138] Administrative systems typically employ specialized or expert decisionmakers who can conduct their own studies and consider a broad range of information.[139] Administrative systems can also provide more continuous oversight and distribute compensation more fairly among a class of victims.[140] In addition, administrative systems are, in theory, more politically accountable than the judicial system.[141] This is not to suggest that setting compensation should be politicized; rather, the scientific uncertainty inherent in environmental toxic injuries necessitates making policy decisions.[142] In an

137. *See* DEWEES ET AL., *supra* note 12, at 290 (describing the tort system as "inherently inappropriate for dealing with widespread pollution problems"); *infra* Section V.A. *Cf.* RICHARD H. GASKINS, ENVIRONMENTAL ACCIDENTS: PERSONAL INJURY AND PUBLIC RESPONSIBILITY 53 (1989) ("The judicial crisis over toxic tort litigation reveals a widening gap between our incipient environmental knowledge and the individualist mode of public response. Events governing the onset of serious disease may never be definable below the level of probabilistic evidence, even as that evidence is steadily accumulated to include further natural and social agents.").

138. As one scholar has noted:

> [D]ifficulties in the details of administration should not obscure the conclusion that such a compensation system would be preferable to the current tort system's handling of latent-disease injuries, which fails to accomplish Calabresi's three goals of reducing accident costs through primary accident cost avoidance, distributing losses, and controlling administrative costs.

Donald G. Gifford, *The Peculiar Challenges Posed by Latent Diseases Resulting from Mass Products*, 64 MD. L. REV. 613, 619–20 (2005). *See generally* Elliott, *supra* note 105, at 1369–76 (arguing that legal institutions should be matched to the nature of the particular toxic problem being addressed).

139. Elliott, *supra* note 105, at 1366–68; Menell, *supra* note 30, at 97–99.

140. *See* Menell, *supra* note 30, at 98; Pierce, *supra* note 100, at 1310 (noting an administrative agency's advantage as a centralized decisionmaker in gathering data and making calculations).

141. *See, e.g.*, Chevron, U.S.A., Inc. v. Natural Res. Def. Council, Inc., 467 U.S. 837, 865–66 (1984) (noting that agencies, as part of the executive branch, may appropriately make policy choices, in contrast to federal judges, who are not politically accountable); Richard A. Nagareda, *In the Aftermath of the Mass Tort Class Action*, 85 GEO. L.J. 295, 313, 323–29 (1996) (noting that an administrative state provides a greater opportunity for the public scrutiny of decisionmaking than a tort system does). *But see* Kevin R. Johnson, *Los Olvidados: Images of the Immigrant, Political Power of Noncitizens, and Immigration Law and Enforcement*, 1993 B.Y.U. L. REV. 1139, 1205–07 (noting that "administrative agencies theoretically are politically accountable," but that accountability can be distorted by particularly vocal constituencies).

142. *Cf.* Holly Doremus, *The Purposes, Effects, and Future of the Endangered Species Act's Best Available Science Mandate*, 34 ENVTL. L. 397, 437–38 (2004) (arguing in the context of the Endangered Species Act that, given the limits of science, agencies should acknowledge that many science-based decisions are policy decisions and that political choices must be made in the face of scientific uncertainty); Rena I. Steinzor, *Pragmatic Regulation in Dangerous Times*, 20 YALE J. ON REG. 407, 422 (2003) (reviewing SIDNEY A. SHAPIRO & ROBERT L. GLICKSMAN, RISK REGULATION AT RISK: RESTORING A PRAGMATIC APPROACH (2003)) ("Because the body politic has consciously

administrative system, that inescapably political judgment is subject to indirect democratic control.

Administrative systems also offer flexibility in the processes used to manage cases. For example, agencies can employ ex post adversarial processes to decide cases on an individual basis. Or agencies can assign costs and benefits ex ante to groups of similarly situated parties based on risk assessments. Individualized, quasi-judicial proceedings offer the advantage of precisely tailored outcomes, which may be beneficial when dealing with intangible losses such as pain and suffering.[143] But greater efficiency may be gained by using a standardized schedule of damages to make determinations without any adversarial proceeding.[144]

These characteristics should enable a well-designed administrative compensation system to achieve deterrence and redress more effectively than the current tort system does. Attaining a desired level of deterrence is simpler through an administrative system than through a decentralized tort system. If sufficient scientific data were available, the system could be calibrated through taxation or a similar mechanism to hold risk-creators responsible for the harm they cause.[145] Such taxes force a polluter to consider ex ante the likely costs of an activity when deciding whether to adopt precautionary measures. Moreover, a polluter will consider these costs when deciding whether to engage in the activity at all.[146] Indeed, by taking a broader and more systematic perspective, agencies can consider

rejected the tort law approach of paying people after-the-fact in favor of a policy of prevention, in a world of bounded rationality, scientific uncertainties must be weighed along with all of the other elements considered valid in a 'messy' real world.").

143. *See* Kenneth S. Abraham, *Individual Action and Collective Responsibility: The Dilemma of Mass Tort Reform*, 73 VA. L. REV. 845, 894–95 (1987) (suggesting that, to limit costs, an administrative system would have to deny compensation for intangible losses and avoid disputes that require individualized factfinding proceedings). *Cf.* Rabin, *Continuing Tensions*, *supra* note 15, at 1038 (contending that "tort law has always dealt uneasily with assessments of intangible harm").

144. *Cf.* CALABRESI, *supra* note 58, at 209 (noting that the decision about whether a fixed schedule or a particularized inquiry should be employed depends on whether the increased accuracy of a more particularized approach warrants the expense).

145. *See* Kaplow & Shavell, *supra* note 12, at 751 (explaining that the total quantity of pollution will be approximately efficient under a cost-benefit analysis if a pollution tax is set at a level equal to the expected harm). A.C. Pigou argued that a corrective tax can remedy a market imperfection if the tax reflects the true costs caused by the activity. *See* PIGOU, *supra* note 86, at 192–93. A Pigouvian tax, as opposed to Coasean bargaining, is an especially suitable means for internalizing costs where a large number of people are affected by a polluter's conduct but the effects vary. *See* YANDLE, *supra* note 86, at 57.

146. *See* Kaplow & Shavell, *supra* note 12, at 752 (noting that the use of pollution taxes alleviates the problem of judgment-proof defendants, whereas the imposition of ex post liability does not).

the cumulative social costs of pollution and take social tradeoffs into account.[147]

Administrative agencies are likely better suited than courts to determine the optimal level of deterrence because agencies possess the in-house expertise to evaluate the complex and conflicting scientific evidence in environmental tort cases.[148] In contrast, judges and juries tend to be generalists, who lack the scientific competence to critically assess expert testimony.[149] Courts can appoint experts and special masters to assist on technical issues,[150] but such assistance cannot substitute for the full-time expertise available in an administrative system.[151] Unlike courts, administrative agencies can conduct independent studies, devote their full attention to assessing health and environmental risks, and otherwise take advantage of the economies of scale involved in developing expert knowledge.[152]

An administrative system is also likely to be more effective in achieving compensation goals than is a tort system. Appropriate compensation is more likely when scientific determinations are made by

147. *See* Peter Huber, *Safety and the Second Best: The Hazards of Public Risk Management in the Courts*, 85 COLUM. L. REV. 277, 324, 329 (1985) (arguing that agencies are better equipped to make public risk choices, whereas, when assessing liability, courts tend to overlook a product's contribution to decreasing risk); Menell, *supra* note 30, at 101 (noting that determining the proper incentives for those that create environmental risks is "extremely complicated" because many risky activities actually decrease other risks in society). *Cf.* Huber, *supra*, at 297 (arguing that overall risk levels have decreased as natural toxic substances are replaced by artificial ones that are less potent, produced in smaller quantities, or more easily controlled); Thornton et al., *supra* note 133, at 320 (arguing that current regulation based on "acceptable" levels of local contamination inappropriately focuses on single substances and single facilities, ignoring the build-up of bioaccumulative substances from multiple sources). *But cf.* Abram Chayes, *The Role of the Judge in Public Law Litigation*, 89 HARV. L. REV. 1281, 1307–09 (1976) (noting the role of judges in determining issues of public law, and identifying the advantages they bring to adjudications, including their experience in reflective and policy-oriented analysis).

148. *See, e.g.*, Margaret G. Farrell, *The Function and Legitimacy of Special Masters: Administrative Agencies for the Courts*, 2 WIDENER L. SYMP. J. 235, 237 (1997) (acknowledging that tasks such as imposing the social costs of industrial production on consumers require "flexibility, expertise, informality, investigative authority, administrative capacity, and time, which are qualities usually associated with administrative agencies").

149. *See* Menell, *supra* note 30, at 100.

150. *See* Rosenberg, *supra* note 23, at 925–27. *See generally* Farrell, *supra* note 148 (defending the use of special masters in mass toxic tort litigation).

151. *See* Edward K. Cheng, *Changing Scientific Evidence*, 88 MINN. L. REV. 315, 336 (2003).

152. *See* Menell, *supra* note 30, at 101 (noting that administrative regulation features specialized decisionmakers, centralized research facilities, continual oversight of regulatory problems, and a broad array of regulatory tools); Rosenberg, *supra* note 23, at 928; Steven Shavell, *Liability for Harm Versus Regulation of Safety*, 13 J. LEGAL STUD. 357, 369 (1984) ("[I]n dealing with many health-related and environmental risks, a regulatory agency may have better access to, or a superior ability to evaluate, relevant medical, epidemiological, and ecological knowledge.").

experts rather than judges or layperson juries. Moreover, administrative systems can deliver compensation more cost-effectively than can the tort system, where transaction costs often dwarf compensation paid to injured claimants.[153] In administrative systems such as workers' compensation or social security, transaction costs are significantly lower than in tort litigation.[154] Even greater cost efficiency can be achieved by an administrative system that handles claims on a collective basis without complex, individualized determinations of causation and liability.[155] Transaction costs have substantially discouraged tort claims for environmental injuries, which are often widely dispersed but likely to result in only modest rewards.[156]

The goal of corrective justice generally receives less attention in an administrative system than in a tort system where individualized adjudications focus on the causal link between the defendant and the plaintiff.[157] But if an administrative system provided ex ante compensation to persons who would otherwise receive nothing in tort (such as future victims who do not yet display symptoms of an illness), that system would provide some marginal benefit of corrective justice.[158] Furthermore, if ex

153. *See supra* notes 75–77 and accompanying text.

154. For a discussion of transaction costs for workers' compensation programs, see *infra* notes 399–02 and accompanying text. *See also* CONG. BUDGET OFFICE, THE ECONOMICS OF U.S. TORT LIABILITY: A PRIMER 21 (2003) (concluding that "given the large percentage differences between the tort liability system and no-fault compensation systems . . . the tort system costs more than does an available alternative method of compensating victims," with respect to transaction costs); Mashaw, *supra* note 80, at 1394 (contrasting social security disability benefits, for which administrative costs are less than one percent of benefits, with asbestos tort litigation, for which transaction costs are more than half of the amount of compensation paid); Menell, *supra* note 30, at 100–01 (contrasting tort transaction costs, which consume sixty-one percent of the total paid, with transaction costs under other compensation systems, such as twenty percent of the total paid for first-party insurance premiums, and thirty-eight percent paid from workers' compensation revenues).

155. As one scholar has commented:

> The high transaction costs of the tort system are inherent in the system itself. . . . Compensation is dependent on issues of causation and fault, which require investigation and are frequently contested. The assessment of damages, tailored to each case, invites additional controversy. In sum, the system is geared to individualized processing and does not favor economies of scale.

John G. Fleming, *Is There a Future for Tort?*, 44 LA. L. REV. 1193, 1207–08 (1984).

156. Shavell, *supra* note 152, at 363, 370.

157. *See supra* notes 55–57 and accompanying text.

158. Christopher Schroeder has argued that a system that imposes liability based on risk of harm rather than on actual harm would be *more* consistent with corrective justice principles than the current tort system is. That is because the moral quality of a defendant's behavior would be judged according to the information available to the defendant at the moment of decision. Schroeder, *supra* note 104, at 451–68. This understanding of corrective justice might also support compensation based on risk of harm, rather than on actual harm. *See* Simons, *supra* note 103, at 128–29. *See also* Esty, *supra* note 4, at 150–53 (arguing that as transaction and information costs fall, the ability of environmental regulatory institutions to promote corrective justice increases).

ante compensation helps those who eventually suffer injury to be made whole (for instance, by enabling those exposed to risk to purchase insurance), then such a system would be consistent with corrective justice.[159]

Adopting an administrative system without individualized adjudications and their corrective justice benefits would be to recognize that the low-level risks characteristic of environmental toxic exposure are not readily amenable to traditional corrective justice approaches.[160] These low-level risks translate into probabilistic causation evidence, which fits far more readily into an administrative system than into the tort system's corrective justice paradigm.[161]

Admittedly, the tort system does possess some advantages over ex ante administrative regulation. First, public agencies may require greater oversight, as they are more vulnerable than the judiciary to capture by regulated parties—an agency may become more responsive to particular special interests than it is to the legislative or executive branch.[162] Second, the tort system has the advantage of hindsight. Ex ante regulation requires information at the outset—risks of injury and the costs and benefits of particular standards must be known beforehand.[163] In contrast, the tort system focuses on a specific claim that arises after an injury occurs. Given the scope of uncertainty regarding the effects of exposure to many chemical substances, any administrative or regulatory ex ante scheme is likely to be considerably incomplete in the foreseeable future. The tort system will continue to act as a critical safety net even as environmental information gaps are narrowed.[164]

159. Christopher H. Schroeder, *Corrective Justice, Liability for Risks, and Tort Law*, 38 UCLA L. REV. 143, 159–60 (1990).

160. *See* Schroeder, *supra* note 104, at 475–77 (contending that a liability-for-risk approach is suitable for latent toxic torts).

161. *See* Brennan, *supra* note 48, at 522–23; *supra* Section I.A.2.c.

162. *See* CHARLES FRIED & DAVID ROSENBERG, MAKING TORT LAW: WHAT SHOULD BE DONE AND WHO SHOULD DO IT 42 (2003). For sources discussing agency capture, see David B. Spence & Frank Cross, *A Public Choice Case for the Administrative State*, 89 GEO. L.J. 97, 105 n.37 (2000).

163. *Cf.* Jon D. Hanson & Kyle D. Logue, *The Costs of Cigarettes: The Economic Case for Ex Post Incentive-Based Regulation*, 107 YALE L.J. 1163, 1268–71 (1998) (arguing, in the context of liability for smokers' injuries, that ex post incentive-based regulation requires less information on the part of the regulator than ex ante incentive-based regulation does).

164. *See* Esty, *supra* note 4, at 182 (noting that in the future, "[i]mproved information will not mean perfect information"); Nagareda, *supra* note 141, at 315–16 (articulating a view that the tort system functions as a safety net so that private individuals can challenge past shortcomings in regulatory programs in a manner independent of the government).

C. TECHNOLOGICAL ADVANCES MAKING AN ADMINISTRATIVE SYSTEM POSSIBLE

The theoretical advantages of an administrative compensation system are irrelevant if the information necessary to support such a system is unavailable. This section surveys recent technological advances in potentially relevant fields. This survey demonstrates that scientific groundwork is now being laid that may eventually enable the implementation of an ex ante risk-based administrative system of liability.

1. General Causation

Scientists are now developing increasingly sophisticated techniques for studying biomarkers (indicators of chemical substance, events or conditions in the human body). They are also making advances in toxicogenomics and in other technological fields described below. By capitalizing on these advances, scientists will soon be able to more rapidly screen chemical substances for toxicity and to more effectively study the causal relationships between exposure and illness.[165]

Assessing causation begins with analyzing one's exposure to environmental chemicals. Historically, scientists have estimated exposure by collecting information on the attributes of exposure (such as magnitude, duration, frequency, and timing) through questionnaires, interviews, and centralized monitoring.[166] The inexactness of these methods introduces substantial uncertainty into the resulting estimates of exposure.[167] Direct measurement of an individual's environment, such as with a portable monitor, can provide a more accurate record of chemical contact. Such methods are costlier, however, and fail to measure actual chemical uptake, a weakness these methods share with the less direct methods of estimating exposure.[168]

a. Biomonitoring

Biomonitoring techniques allow for far more accurate assessments of exposure because scientists can look for biomarkers directly in the human

165. *See generally* Jamie A. Grodsky, *Genetics and Environmental Law: Redefining Public Health*, 93 CAL. L. REV. 171, 179–98 (2005) (summarizing the changing landscape in the science underlying pollution control).

166. Ken Sexton, Larry L. Needham & James L. Pirkle, *Human Biomonitoring of Environmental Chemicals: Measuring Chemicals in Human Tissues Is the 'Gold Standard' for Assessing People's Exposure to Pollution*, 92 AM. SCIENTIST, Jan.–Feb. 2004, at 38, 38.

167. *Id.*

168. *Id.*

body.[169] Molecular biomarkers can be used to assess a range of critical information, from discovering a person's susceptibility to disease from chemical exposure, to detecting exposure, and finally to recognizing the effects of that exposure.[170] Technologies for measuring biomarkers include chemical biomonitoring analyses, toxicogenomics, and potentially, future nanotechnology in which analytical materials and devices will be sized to a microscopic scale (one to one hundred nanometers).[171]

Chemical biomonitoring assesses exposure by measuring the levels of chemicals or their metabolites[172] in human blood, urine, saliva, or tissue.[173] Such substances can now be detected from relatively small samples, even at extremely low levels, such as parts per billion, parts per trillion, or even parts per quadrillion.[174] Historically, biomonitoring has been used in occupational environments (such as welding and metal recycling facilities) to test workers for exposure to heavy metals and other toxic substances.[175] More recently, the Centers for Disease Control ("CDC") conducted biomonitoring for a range of chemical substances in the U.S. population. The CDC reported its exposure data for 148 chemicals in 2005.[176] Over 250 compounds are now testable by biomonitoring, including metals,

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169. SAMUEL H. WILSON & WILLIAM A. SUK, BIOMARKERS OF ENVIRONMENTALLY ASSOCIATED DISEASE 6 (2002); Sexton et al., *supra* note 166, at 39.

170. WILSON & SUK, *supra* note 169, at 6. There are three basic types of biomarkers. "Biomarkers of effect" measure bodily changes that quantitatively or qualitatively predict health dangers that result from toxic exposure. Gary E. Marchant, *Genetic Susceptibility and Biomarkers in Toxic Injury Litigation*, 41 JURIMETRICS J. 67, 72 (2000). They are especially useful to identify symptomatic or presymptomatic persons who have been adversely affected by a toxic exposure. *Id.* "Biomarkers of exposure" measure an individual's exposure to a particular agent. *Id.* at 73–74. Measuring the concentration of a substance within the body (the internal dose) provides a more accurate and useful estimate of exposure than measuring the concentration of the substance in the exposure vehicle, such as ambient air. *Id*. "Biomarkers of susceptibility" reveal an individual's altered susceptibility to an environmental exposure, often as a result of a genetic disposition. *Id.* at 70.

171. WILSON & SUK, *supra* note 169, at 11.

172. A metabolite is the chemical alteration of the original compound by the body's tissues. CTRS. FOR DISEASE CONTROL AND PREVENTION, THIRD NATIONAL REPORT ON HUMAN EXPOSURE TO ENVIRONMENTAL CHEMICALS 1 (2005) [hereinafter CDC], *available at* http://www.cdc.gov/exposurereport/.

173. Richard Jackson et al., *Will Biomonitoring Change How We Regulate Toxic Chemicals?*, 30 J.L. MED. & ETHICS 177, 178 (2002).

174. Sexton et al., *supra* note 166, at 40. *See also* Christopher Wanjek, *Get a Load of the Mono-2-Ethylhexyl-Phthalate in that Guy*, WASH. POST, Feb. 3, 2004, at F1 (contrasting the ability of present technology to detect complicated trace pollutants in the body at harm threshold levels, with the limited capabilities of the past, when most pollutants were present at levels too low to be measured by the techniques of the day).

175. Ken Sexton & P. Barry Ryan, *Assessment of Human Exposure to Air Pollution: Methods, Measurements, and Models*, *in* AIR POLLUTION, THE AUTOMOBILE, AND PUBLIC HEALTH 225 (Ann Y. Watson, Richard R. Bates & Donald Kennedy eds., 1988).

176. *See generally* CDC, *supra* note 172 (reporting the chemical exposure data).

dioxins, furans, polychlorinated biphenyls ("PCBs"), pesticides, volatile organic compounds ("VOCs"), phthalates, phytoestrogens, and environmental tobacco smoke.[177]

By measuring the actual concentrations of toxicants in an individual, as opposed to estimating exposures based on ambient levels found in the environment, biomonitoring increases the accuracy and reliability of health risk assessments.[178] For instance, the biomonitoring of deoxyribonucleic acid ("DNA") adducts (complexes that form when a chemical binds to a biological molecule)[179] measures the molecular dose of a toxic substance by examining the extent to which the substance or its metabolic products have bonded with DNA molecules.[180] Biomonitoring data can also be used to ascertain a baseline or reference range for exposure, establishing the concentration of a particular substance normally present in the general population.[181] Ultimately, biomonitoring may justify a greater reliance on the controlled studies of the effects of chemical substances on laboratory animals. By measuring actual chemical levels in tissue, scientists who conduct biomonitoring can account for interspecies differences in metabolism and excretion rates.[182]

b. Toxicogenomics

The emerging field of toxicogenomics relies on a particular type of biomarker—genetic biomarkers. These genetic markers are used to analyze the causal relationships between toxic exposure and disease. Toxicogenomics studies the relationship between the structure and activity of the genome and the adverse biological effects of chemical substances.[183] The central principle underlying toxicogenomics is that exposure to a toxic

177. Sexton et al., *supra* note 166, at 44–45.

178. *See* Jackson et al., *supra* note 173, at 179–81 (describing the use of biomonitoring data to determine toxicity levels of lead and cotinine, thereby resulting in policy changes to protect the public health); Thornton et al., *supra* note 133, at 319 (describing the use of chemical body-burden data, derived from biomonitoring, to establish that childhood exposure to dioxins and PCBs is associated with reduced cognitive ability, shortened attention span, and other deficiencies). *See generally* Sexton et al., *supra* note 166, at 38–39, 41 (noting that measuring the amount of a compound that crosses into the body is far more valuable in estimating risks than measuring the degree of external physical contact).

179. *See* PHILP, *supra* note 2, at 30.

180. *See* Christiana P. Callahan, Note, *Molecular Epidemiology: Future Proof of Toxic Tort Causation*, 8 ENVTL. LAW. 147, 153 (2001).

181. *See* CDC, *supra* note 172, at 1–3; Jackson, *supra* note 173, at 182; Thornton, *supra* note 133, at 318.

182. Boston, *supra* note 81, at 609 ("[O]ne of the principal reasons why different animal species experience varying effects from the same dose of a chemical is because they possess differing absorption, distribution, excretion, and metabolic processes."). *Cf.* Thornton et al., *supra* note 133, at 319 (noting causal links between diseases in species along a food chain).

183. Marchant, *supra* note 47, at 10,071.

substance changes the manner and extent to which genes produce either proteins or their biochemical precursors.[184] These changes in gene expression, which can be detected through the use of DNA microarrays (also called DNA chips), may be either the cause or consequence of a toxic response.[185] Detecting changes in gene expression offers a unique, early, and more sensitive indicator of a toxic response than does detecting the toxicological endpoint itself (for example, than detecting a tumor).[186] Researchers predict that they will soon be able to use DNA chips to quickly and cheaply predict the toxicological natures and mechanisms of previously untested chemicals.[187] Regulators have expressed optimism about the use of this DNA chip data to protect the public health.[188]

Toxicogenomics will further the understanding of general causation in at least three ways. First, toxicogenomics can screen substances for potential toxicity more quickly, cheaply, and accurately than can animal testing.[189] Second, for substances already known to be toxic, toxicogenomics will enable a more qualitative and quantitative assessment of the risks posed by exposure.[190] Third, toxicogenomics can help to identify persons who have been impacted by environmental factors.[191]

Nevertheless, a causal relationship between exposure and disease is not sufficiently established by either the use of biomonitoring to identify a

184. *See id.*

185. *Id.* at 10,072. A DNA microarray is a set of different single-stranded genetic sequences fixed to a glass slide or membrane. *Id.*

186. *Id.* A toxicological endpoint, such as a tumor, may be caused by several different mechanisms, but the gene expression profile produced by a specific chemical is likely to be unique. *Id.* at 10,073.

187. *Id.* at 10,073–74. In contrast to the widely used Ames test, DNA assays screen directly for changes in expression in human genes, thus avoiding the need to extrapolate results between species. DNA assays also produce gene expression data, which are useful in understanding the mechanisms of toxicity. *See id.* at 10,073.

188. *See* Kris Freeman, *Toxicogenomics Data: The Road to Acceptance*, 112 ENVTL. HEALTH PERSP. A678, A680 (2004) (quoting EPA officials regarding the potential use of microarrays to either help prioritize chemicals for testing or to help monitor the environment for toxic substances).

189. *See* Bergeson et al., *supra* note 54, at 31. For example, the EPA is developing microbial water quality indicators that use genomics to assess the safety of a given source of water for human consumption or contact. *See* Paul Gilman, *A Powerful Tool with Great Promise for Risk Assessments*, ENVTL. F., Nov.–Dec. 2002, at 30, 30.

190. *See* Bergeson et al., *supra* note 54, at 31. Toxicogenomic data can improve risk assessment in a number of ways: by better quantifying human exposure, by shedding light on the mechanism of a particular substance's toxicity, by providing dose-response information through detection of low-dose effects, and by determining the relevance of animal studies to human risk through comparisons of changes in gene expression. *See* Marchant, *supra* note 47, at 10,080–82.

191. *See* Paul A. Locke, *EPA Is Right to Be Cautious; Utility Is Limited by Many Factors*, ENVTL. F., Nov.–Dec. 2002, at 32, 32.

particular toxic substance in the body or the use of toxicogenomics to identify a change in gene expression.[192] Additional scientific research is required to determine the level of exposure likely to cause harm. For some environmental chemicals, such as lead, studies already provide an understanding of the risks associated with different chemical levels in the blood.[193] For other substances, however, further research is necessary.[194] Although increasingly sophisticated biomonitoring techniques and toxicogenomics possess tremendous promise, our knowledge is currently incomplete—we must study how changes in gene expression relate to disease.[195]

c. Other Advances

Other advances will also contribute to an improved understanding of general causation. For instance, nanotechnology could be used to develop biosensors for detecting and analyzing biomarkers in blood or saliva.[196] Also, geographical information systems technology ("GIS") will increase the ability of epidemiologists to study the relationships between exposure and disease. Using GIS, researchers can quickly and inexpensively integrate large quantities of geographic and nongeographic data to test hypotheses for the causes of disease.[197]

2. Specific Causation

Proof of specific causation in toxic tort cases typically requires both proof that a pathway of exposure exists from the pollution source to the injured person and proof that the exposure caused a particular effect.[198] An administrative compensation system, however, generally demands less

192. *See* CDC, *supra* note 172, at 4; Jackson et al., *supra* note 173, at 178; Locke, *supra* note 191, at 32.

193. *See* CDC, *supra* note 172, at 4. Similarly, exposure to aflatoxins (toxic compounds produced by fungi that contaminate stored food supplies such as animal feed and peanuts) has been connected to levels of aflatoxin-DNA adduct, which, in turn, has been associated with an increased risk of liver cancer. WILSON & SUK, *supra* note 169, at 10.

194. Although other promising biomarkers are based on the detection of DNA or protein adducts, only a few have been developed as successfully as the aflatoxin biomarker. *Id.*

195. *See* Locke, *supra* note 191, at 32.

196. *See* WILSON & SUK, *supra* note 169, at 11.

197. *See generally* Marilyn F. Vine, Darrah Degnan & Carol Hanchette, *Geographic Information Systems: Their Use in Environmental Epidemiologic Research*, 105 ENVTL. HEALTH PERSP. 598 (1997) (discussing advances in and use of GIS technology). For example, one study combined emissions data, dispersion models, and GIS to estimate long-term individual exposure to air pollution as part of an epidemiological study of lung cancer. *See generally* Tom Bellander et al., *Using Geographic Information Systems to Assess Individual Historical Exposure to Air Pollution from Traffic and House Heating in Stockholm*, 109 ENVTL. HEALTH PERSP. 633 (2001) (discussing the study).

198. *See supra* note 28 and accompanying text.

specific evidence than the tort system does. An administrative system could even rely on projected rather than measured exposure to show specific causation. Nevertheless, even estimates of exposure require a reasonable understanding of both the pathways of exposure and the effects of exposure. Today, that understanding can be refined by a variety of methods and technologies—including portable personal monitors, biomarkers, data extrapolation from monitoring networks, mathematical models, or any combination of the above.[199]

a. Measuring, Monitoring, and Attributing Exposure

Individual exposure to pollutants may be estimated directly, through personal monitoring or biomonitoring, or indirectly, by combining data on pollutant concentrations at fixed locations with data on personal activity patterns.[200] To measure exposure directly, researchers can use lightweight and portable personal monitors that can measure exposure to common pollutants such as carbon monoxide, nitrogen oxides, ozone, benzene, formaldehyde, and particulates.[201] But measurement costs using individualized monitors tend to be relatively high.[202]

Indirect methods of estimating exposure are usually less expensive. Perhaps the simplest method is categorical classification. With this method, researchers use data on residence, occupation, and the like to develop crude estimates of exposure.[203] Such estimates, however, are generally considered inadequate for epidemiological purposes.[204] For more precise estimates, researchers must use other techniques and devices to perform monitoring and modeling.

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199. *See* Ole Hertel et al., *Human Exposure to Outdoor Air Pollution*, 73 PURE & APPLIED CHEMISTRY 933, 952 (2001).

200. *See* Demetrios J. Moschandreas et al., *Chapter Three: Methodology of Exposure Modeling*, 49 CHEMOSPHERE 923, 926 (2002).

201. *See* Hertel et al., *supra* note 199, at 940–41; Moschandreas et al., *supra* note 200, at 939–40; Sexton & Ryan, *supra* note 175, at 211–12 (1988). At a California school where high levels of naturally occurring asbestos have been found, the EPA is considering a study to estimate exposure levels in which personal monitors would be worn by one hundred students. Chris Bowman, *Asbestos Testing May Get Personal*, SACRAMENTO BEE, Mar. 21, 2004, at A1.

202. *See* Sexton & Ryan, *supra* note 175, at 212–13 (discussing the practical difficulties involved in carrying out personal monitoring studies); Steen Solvang Jensen, A Geographic Approach to Modelling Human Exposure to Traffic Air Pollution Using GIS 14 (1999) (Ph.D. thesis, University of Roskilde, Denmark), http://www.dmu.dk/1_Viden/2_Publikationer/3_ovrige/rapporter/phd_SSJ.pdf (noting that personal monitoring is generally limited to studies involving small numbers of subjects).

203. *See* Hertel et al., *supra* note 199, at 934.

204. *See id.* at 952; Jensen, *supra* note 202, at 14. Individual exposure to pollutants varies dramatically, in part because of the different amounts of time people spend in various locations performing different activities. *See* Sexton & Ryan, *supra* note 175, at 208.

i. Environmental Monitoring

The EPA's Ambient Air Monitoring Program, for instance, collects air samples through a network of approximately 4000 monitoring stations distributed nationwide.[205] Samples collected by the network are typically analyzed for the six criteria pollutants designated by the EPA, but the network can be adapted to monitor for other pollutants, as well.[206] The government or private parties often monitor a broader range of contaminants at individual sites to address local public health concerns. For example, an oil refinery in Rodeo, California, installed a real-time fence-line air-monitoring system after community concerns were raised over the release of toxic emissions.[207] The system operates twenty-four hours a day and can detect thirty-eight different chemicals.[208] In other studies, researchers have installed similar remote sensors along streets and highway ramps to measure air emissions from passing cars.[209]

Advances in wireless sensor technology will soon enable pollution monitoring with even greater resolution. Engineers are working on tiny, remotely accessible, wireless "smart dust" sensors that can be located where data transmission and power lines are unavailable.[210] These sensors are essentially microchips that convert environmental analog data into digital information.[211] In contrast to most sensors used in today's

205. *See* U.S. EPA, The Ambient Air Monitoring Program, http://www.epa.gov/oar/oaqps/qa/monprog.html (last visited Sept. 23, 2005). Uncertainty tends to surround individual exposure estimates that are based on measurements from fixed-site monitors because of large local variations in pollution concentrations. Hertel et al., *supra* note 199, at 936.

206. In 2003, the EPA began to retrofit many of these monitors in order to detect pathogens such as anthrax, smallpox, and other biological agents. *See Terror Fight Opens New Front on the Microscopic Level*, ENGINEERING NEWS-REC., Feb. 3, 2003, at 17.

207. *See* J.N. Pawloski & D.G. Iverson, *Use Optical Remote Sensing Techniques to Monitor Facility Releases*, HYDROCARBON PROCESSING, Sept. 1998, at 125, 125.

208. *Id.* The system is composed of "open-path remote sensing" devices utilizing Fourier transform infrared spectroscopy and both ultraviolet and laser monitors. These systems can detect a substance without being in direct contact with that substance. In each system, a monitor identifies and quantifies the presence of a chemical by analyzing the amount and wavelength of the energy absorbed when a light beam of a known wavelength passes through the air. *Id.* at 126–27. Analysis of the raw data can reveal the presence of three hundred additional chemicals. U.S. EPA, Featured Stories: Tosco Refinery: Monitoring How the Fenceline Monitors Work, http://www.epa.gov/region09/features/tosco/monitoring.html (last visited Sept. 23, 2005).

209. *See* OFFICE OF TRANSP. & AIR QUALITY, U.S. EPA, GUIDANCE ON USE OF REMOTE SENSING FOR EVALUATION OF I/M PROGRAM PERFORMANCE 12 (2002); Daniel B. Klein, *Fencing the Airshed: Using Remote Sensing to Police Auto Emissions*, *in* THE HALF-LIFE OF POLICY RATIONALES 86, 93 (Fred E. Foldvary & Daniel B. Klein eds, 2003).

210. *See* Gregory T. Huang, *Casting the Wireless Sensor Net*, TECH. REV., July 2003, at 50, 51 (discussing wireless sensor technology); *Desirable Dust*, ECONOMIST, Feb. 2, 2002, at 10 (discussing "smart dust" technology).

211. *See Desirable Dust*, *supra* note 210, at 10.

automobiles and factories, these sensors communicate with each other via radio waves, share computations, and output information in a directly usable form.[212] These devices are already being tested for such diverse uses as monitoring microclimates, tracking pests in vineyards, monitoring the nesting habits of sea birds, measuring the effects of seismic waves on buildings, and tracking radiation and hazardous chemicals in shipping containers.[213] Although widespread application of this technology is not yet possible, barriers, such as high power consumption, price, and lack of standardization, are being addressed and are being overcome.[214] Furthermore, wireless sensor technology could eventually be combined with advances in nanotechnology to conduct environmental monitoring and gas detection.[215]

ii. Environmental Modeling

Environmental monitoring is complemented by environmental modeling, which can predict conditions across varying terrains rather than just at the monitoring sites.[216] Using such predictions, scientists can assess ex ante the impact of new emissions sources and estimate the individual exposures that will result from these new emissions. Exposure models require data on a source's emission rate, meteorological conditions, and the

212. *See* Huang, *supra* note 210, at 51.

213. *See* William J. Broad, *A Web of Sensors, Taking Earth's Pulse*, N.Y. TIMES, May 10, 2005, at F1, *available at* 2005 WLNR 7325648; David Essex, *Who Knew Dust Could Be So Smart?*, GOV'T COMPUTER NEWS, Dec. 15, 2003, at 33; Huang, *supra* note 210, at 52.

214. *See Desirable Dust*, *supra* note 210, at 10 (noting that "the novelty is not that these sensors exist at all, but that they have suddenly become cheap enough to be used in ordinary everyday products"); Essex, *supra* note 213, at 33 (quoting researchers regarding the availability of the networking software and standards needed to make the technology work); Huang, *supra* note 210, at 52 (comparing the present state of wireless sensor-web technology to the Internet in the 1970s); Pat Phibbs, *Volatile Organic Compounds Detected by Nanoengineered Air Pollution Device*, 35 ENV'T REP., at 1816–17 (Aug. 27, 2004) (reporting that a nanoengineered device that can detect VOCs is nearly ready for commercialization and that scientists are working on a variety of sensors, including those that can detect metals in drinking water or other media); Chris Taylor, *What Dust Can Tell You*, TIME, Jan. 12, 2004, at 58, 58 ("[A]nalysts say the mote market could be worth $50 billion in 10 years' time and the price, currently $50 a mote, could easily come down to less than 10 [cents] each in the same period.").

215. *See, e.g.*, Jose Ramirez, *Leap in Sniffing: Nanotubes Can Name That Gas*, N.Y. TIMES, July 22, 2003, at F2, *available at* 2003 WLNR 5656125 (reporting on the use of nanotube technology to build small, low-powered sensors to instantaneously detect the presence of gases).

216. *See* Jan Beyea & Maureen Hatch, *Geographic Exposure Modeling: A Valuable Extension of Geographic Information Systems for Use in Environmental Epidemiology*, 107 ENVTL. HEALTH PERSP. 181, 181 (Supp. 1999) ("Geographic modeling strives to create the equivalent of a hypothetical ideal monitoring system that would have measured the concentration of pollutants at all locations and times in the medium and domain under study."); Moschandreas et al., *supra* note 200, at 943 (noting that "[m]easurement is the preferred means to obtain data," but that modeling can quickly and inexpensively provide more comprehensive data).

emitted chemical's transportation, diffusion, and transformation mechanisms.[217] Pollution transport models, such as those for air pollution dispersion, generally cannot establish the exact pollutant concentrations at specific times or locations. However, these models may be sufficiently precise and reliable to support an administrative scheme. Such models provide reasonably reliable estimates of maximum and average pollutant concentrations over longer periods.[218]

EPA researchers have developed various pollution exposure models, including the Assessment System for Population Exposure Nationwide ("ASPEN"). ASPEN characterizes the magnitude, extent, and significance of outdoor airborne concentrations for 148 hazardous airborne pollutants in each United States census tract.[219] With respect to outdoor concentrations of VOCs, a study found ASPEN's modeled estimates to be reasonably accurate when compared with actual exposures measured by personal monitors.[220] The study did find, however, that the ASPEN model underestimated concentrations of VOCs that have significant indoor sources.[221] To account for individual movements and exposures to varying

217. *See* Moschandreas et al., *supra* note 200, at 927.

218. *See* ROD BARRATT, ATMOSPHERIC DISPERSION MODELING 99–100, 113 (2001) (noting that error rates in the highest estimated concentrations typically range from ten to forty percent and that estimated concentrations at specific times or sites are poorly correlated with actually observed concentrations). *See also* P.A. Davis et al., *BIOMOVS II: An International Test of the Performance of Environmental Transfer Models*, 42 J. ENVTL. RADIOACTIVITY 117, 127 (1999) (in evaluating environmental assessment models for released radioactivity, discovering confidence intervals on predictions and finding the difference between predictions and observations to be generally less than a factor of ten); Puttanna S. Honaganahalli & James N. Seiber, *Measured and Predicted Airshed Concentrations of Methyl Bromide in an Agricultural Valley and Applications to Exposure Assessment*, 34 ATMOSPHERIC ENV'T 3511 (2000) (stating that the application of two air dispersion models was "moderately successful" in predicting dispersion of emissions from multiple agricultural sources and suggesting that the prediction would be improved with refined source estimates and better meteorological data); Matthew Lorber, Alan Eschenroeder & Randall Robinson, *Testing the USA EPA's ISCST-Version 3 Model on Dioxins: A Comparison of Predicted and Observed Air and Soil Concentrations*, 34 ATMOSPHERIC ENV'T 3995 (2000) (assessing the ability of air quality dispersion models to predict air and soil concentrations of dioxins and furans that result from municipal waste incinerator emissions and finding the predicted and measured values to be generally within a factor of ten of each other). *Cf.* James A. Westbrook, *Air Dispersion Models: Tools to Assess Impacts from Pollution Sources*, 13 NAT. RESOURCES & ENV'T 546 (1999) (noting that regulatory air dispersion models tend to err on the side of caution and suggesting that advances in modeling should result in greater certainty, which would enable relaxing the assumptions underlying conservative models).

219. *See generally* Tracey J. Woodruff et al., *Public Health Implications of 1990 Air Toxics Concentrations Across the United States*, 106 ENVTL. HEALTH PERSP. 245, 245–46 (1998) (discussing the ASPEN monitoring program).

220. Devon C. Payne-Sturges et al., *Personal Exposure Meets Risk Assessment: A Comparison of Measured and Modeled Exposures and Risks in an Urban Community*, 112 ENVTL. HEALTH PERSP. 589, 595 (2004).

221. *Id.* at 596.

environments, the EPA is developing other models. Those models estimate apparent concentrations of inhalation exposures based on census data, human activity patterns, indoor and outdoor concentration relationships, and other data.[222]

Another pollution exposure model, the Operational Street Pollution Model ("OSPM"), estimates exposure to street pollution in urban areas.[223] Researchers have used this microenvironmental model to estimate the pollution exposure of workers like bus drivers and letter carriers. The OSPM incorporates data on traffic, street configuration, and bus schedules with information contributed from diaries.[224] The OSPM predictions have proved accurate when compared with actual measurements from personal monitors.[225] A childhood cancer study also used the same model; utilizing street addresses and other information, the study estimated the exposure of children to nitrogen dioxide and benzene.[226]

Researchers can incorporate GIS into modeling programs to account for buildings, street configurations, and other geographic features. This provides more accurate and refined estimates of exposure.[227] Such modeling programs can include multiple sources of pollutants and can reconstruct past exposures.[228] For example, the OSPM has been integrated with GIS technology to create an exposure model that predicts past, present, and future exposures to selected single-source ambient-air pollutants from traffic—benzene, carbon monoxide, nitrogen dioxide, and ozone.[229] This model achieves both a high spatial and temporal resolution.[230] The integrated model uses GIS technology to provide the required input parameters for the OSPM—digital maps with geocoded buildings and addresses, traffic and population data, and meteorological

222. *See* U.S. EPA, Technology Transfer Network, National Air Toxics Assessment: Further Technical Details About HAPEM4, http://www.epa.gov/ttn/atw/nata/modelexp.html (last visited Sept. 24, 2005).

223. *See* Hertel et al., *supra* note 198, at 944.

224. *Id.* at 944–45.

225. *See id. See also* Jensen, *supra* note 202, at 139 ("Validation studies of the OSPM model shows [sic] that it predicts ambient levels and the temporal variation very well.").

226. *See* Hertel et al., *supra* note 199, at 945. This model's accuracy was validated by comparing predicted and observed concentrations of pollutants at 200 different addresses. *Id.*

227. *See id.* at 947; Beyea & Hatch, *supra* note 216, at 181.

228. Beyea & Hatch, *supra* note 216, at 188.

229. *See* Jensen, *supra* note 202, at 7.

230. *See id*. Other sources of pollution, such as industrial sources, can be incorporated into the model. *Id.* at 36–37.

parameters are all included.[231] From this data, the OSPM generates hourly human exposure estimates at address-specific locations.[232]

Finally, Global Position System ("GPS") transmitters can provide data on the patterns of an individual's activities over time, enabling the development of models to estimate personal exposure.[233] Additionally, GPS transmitters are less burdensome on study participants than personal exposure monitors or personal activity logs.[234]

iii. Attributing Exposure

The use of these improved environmental monitoring and modeling techniques is not limited to estimating past, present, or future exposure to emissions. These techniques could also be used to attribute exposure to a particular source. For example, litigants in Superfund cases[235] already use contaminant transport models.[236] These models determine and allocate liability for past contamination by estimating the origin and timing of contaminant releases.[237] There are other environmental forensic techniques that identify the source of contaminants from among several potential sources. For example, chemical fingerprinting, weathering pattern analysis, chemical biomarker analysis, isotopic analysis, and other developing techniques can help trace releases of petroleum hydrocarbons, chlorinated solvents, and other chemicals to their sources.[238]

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231. *See id.* at 7.

232. *See id.* at 7, 37. Although the OSPM describes exposure at specific locations, it could serve as the basis for a personal exposure model that accounts for an individual's movements through different locations. *See id.* at 116–17.

233. *See id.* at 16, 117. GPS tracking devices could also be used to estimate emissions by mobile sources of pollution. *See, e.g.*, Robert Salladay, *DMV Chief Backs Tax by Mile*, L.A. TIMES, Nov. 16, 2004, at B1 (reporting that GPS tracking devices in cars are being tested for their potential use in calculating a tax that would be based on distance traveled).

234. *See* Jensen, *supra* note 202, at 117.

235. *See infra* note 258.

236. *See, e.g.*, New Mexico v. Gen. Elec. Co., 335 F. Supp. 2d 1266, 1281–85 (D. N.M. 2004); City of Wichita v. Trustees of the APCO Oil Corp. Liquidating Trust, 306 F. Supp. 2d 1040, 1080 (D. Kan. 2003).

237. *See* Robert D. Morrison, *Application of Forensic Techniques for Age Dating and Source Identification in Environmental Litigation*, 1 J. ENVTL. FORENSICS 131, 141–45 (2000) [hereinafter Morrison, *Forensic Techniques*]; Robert D. Morrison, *The Evolution of Environmental Forensics in the United States*, 2 ENVTL. FORENSICS 177, 177 (2001).

238. *See* Morrison, *Forensic Techniques*, *supra* note 237, at 132–41; Zhendi Wang & Merv Fingas, *Fate and Identification of Spilled Oils and Petroleum Products in the Environment by GC-MS and GC-FID*, 25 ENERGY SOURCES 491 (2003) (discussing technology that allows oil spills to be traced back to the polluter). Chemical fingerprinting of petroleum hydrocarbons involves the analysis of unique patterns of individual chemicals present in petroleum products. *See* Morrison, *Forensic Techniques*, *supra* note 237, at 136. Other techniques similarly rely on the presence of unique molecules or characteristics. *See id*. at 139–41.

b. Identifying Effects of Exposure

Proving specific causation not only requires proving an exposure pathway, but it also requires tracing the harmful result to that pathway.[239] Whether based on environmental monitoring or modeling, predicting levels of toxicants in individuals requires simplifying assumptions about personal habits, lifestyles, genetic factors, and the like.[240] But a more accurate picture of an individual's intake and absorption levels can be achieved by monitoring an individual's actual contaminant levels.

Such monitoring will be increasingly feasible thanks to advances in biomonitoring and toxicogenomics. Ultimately, toxicogenomic assays may permit researchers not only to detect exposure to specific chemicals,[241] but also to quantify an individual's level and duration of exposure.[242] These analyses could satisfy specific causation if the exposure was to a substance that was produced only by the defendant. Causation would then be established if the exposure resulted in either a unique gene expression pattern in the victim or a chemical-specific genetic mutation comparable to a fingerprint.[243] Toxicogenomics has not yet resolved certain key issues, such as determining how representative a particular gene expression pattern may be or establishing the time period in which gene expression changes follow toxic exposure. But the potential is there.[244]

III. A PROPOSAL FOR A NEW, RISK-BASED ADMINISTRATIVE APPROACH

Part I detailed the inadequacies of the traditional tort system. Part II demonstrated that scientific advances may make it possible to design a

239. *See supra* Section I.A.2.b.

240. *See* Jackson et al., *supra* note 173, at 178–79.

241. *See* Marchant, *supra* note 47, at 10,074.

242. *See id.*; Bergeson et al., *supra* note 54, at 35–36. Such information not only may help to establish specific causation, but also may facilitate increased health monitoring, preventive treatments, and protective measures designed to avoid further exposures. Bergeson et al., *supra* note 54, at 33.

243. *See* Bergeson et al., *supra* note 54, at 36; Marchant, *supra* note 47, at 10,073 & n.29, 10,078. (describing a growing body of evidence that specific chemicals or classes of chemicals with similar toxicological properties produce a characteristic gene expression profile, called a "fingerprint").

244. *See* Marchant, *supra* note 47, at 10,074–75. The specific issues that would need to be addressed include: (1) the quantitative relationship between the level of exposure and the magnitude of gene expression changes, (2) whether interindividual differences in susceptibility affect gene expression patterns, and (3) whether short-term gene expression changes reflect long-term risk. *Id. See* Jon R. Pierce & Terrence Sexton, *Toxicogenomics: Toward the Future of Toxic Tort Causation*, 5 N.C. J.L. & TECH. 33, 57 (2003) (concluding that toxicogenomics will allow future litigants to trace discrete gene pathways from exposure to injury, but advising judges to deem such evidence inadmissible until more research is available).

complementary administrative system in the future. This part explores what such a system would look like.

A. EARLIER ADMINISTRATIVE PROPOSALS

The inadequacies of the tort system have previously prompted a limited number of proposals for handling environmental tort claims administratively.[245] These proposals aimed to reduce the barriers to victims that prevent recovery. But these proposals offered only limited prospects for better addressing compensation, deterrence, and fairness goals. The flaw in these proposals, as in the tort system, is that they rely on costly and time-consuming individualized adjudications.

1. Environmental Law Institute Proposal

One of the earliest of these proposals,[246] found in a model toxic tort statute drafted by the Environmental Law Institute ("ELI") in 1983, sought to compensate toxic tort victims who were unable to identify a financially viable defendant.[247] Under this proposal, a fund would be generated from three sources: a tax on petroleum and chemical production, an annual hazard fee that roughly reflected the risk-generating characteristics of the substances produced, and public revenues.[248] A person injured from exposure to a hazardous substance could either (1) proceed in tort and seek

245. *See, e.g.*, Clifford Fisher, *The Role of Causation in Science as Law and Proposed Changes in the Current Common Law Toxic Tort System*, 9 BUFF. ENVTL. L.J. 35 (2001); Rabin, *Some Thoughts*, *supra* note 15; Trauberman, *supra* note 24.

246. Another early proposal involved creating an administrative board that would undertake the tasks of claims adjustment, adjudication of technical and scientific issues, and regulation of toxic substances. Stephen M. Soble, *A Proposal for the Administrative Compensation of Victims of Toxic Substance Pollution: A Model Act*, 14 HARV. J. ON LEGIS. 683, 730 (1977). The board's primary function would be to certify claimants as victims of toxic-substance injuries if they made sufficient showings of causation, and to order the responsible pollution source to compensate those victims. *Id.* at 732. With respect to causation, the victim would have to demonstrate that the alleged polluter generated a toxic substance, that an exposure pathway from the polluter to the victim existed, and that the pollution "resulted in the etiology of the injury or disease claimed." *Id.* at 796–97. Such a showing would then shift the burden of proof to the emitter, who would then have to disprove causation. *Id.* at 797. Because this proposal resembles the ELI and Rabin proposals described in the main text, *infra* Sections III.A.1, III.A.2, it is not discussed further. Each of these proposals treats causation similarly and would require individualized causation inquiries, although the Soble proposal would require the most detailed inquiry.

247. *See* Trauberman, *supra* note 24, at 179–83. A study group created by the 1980 Superfund statute made a proposal similar to the ELI proposal. *See* Rabin, *Some Thoughts*, *supra* note 15, at 960. The study group proposal was limited in scope to the compensation of harm arising from exposure to hazardous waste. It would have been funded by taxes on both the production of chemicals and the disposal of hazardous waste. *See id.* at 960–61.

248. Trauberman, *supra* note 24, at 241–42, 272–78.

full damages, or (2) file a claim against the fund.[249] The fund, however, would compensate only for pecuniary losses, not for pain and suffering.[250] The fund would thus serve only as an alternative source of compensation.

Claimants against the fund would only have to demonstrate that they suffered from a covered disease and that their toxic exposure was a substantial factor in causing that disease.[251] No showing of fault would be required.[252] Claimants would then have the benefit of a rebuttable presumption of causation. They would be compensated unless the fund could show that the exposure was not a substantial causal factor.[253] The fund would have subrogation rights and could seek to recover against the party who caused the injury.[254] Claimants could not subsequently initiate tort actions unless they first reimbursed the fund for both the benefits received and administrative costs.[255]

The ELI proposal was intended to be an "interim solution" to supplement the tort system.[256] Although the proposed system would have made proving causation somewhat easier, causation disputes would have still been inevitable. Causation disputes would have still existed when the fund sought to overcome the presumption of causation or when the fund brought subrogation proceedings against polluters. Furthermore, the proposal's funding mechanism represented only a half-hearted effort at achieving deterrence. As the proposal's authors acknowledged, the funding mechanism represented a "compromise"[257]—then-available scientific techniques and data were inadequate to support a more refined system. Ultimately, deterrence would not be efficiently achieved by a model that removed tortfeasors from direct responsibility for the harms they caused. Political support for such a system would likely be thin.[258]

249. *Id.* at 216.

250. *Id.* at 237–38, 263, 265–68.

251. *Id.* at 263. Designating a substance as "hazardous" would have the effect of establishing a prima facie causal relationship between exposure to the substance and the disease. *Id.* at 235 & n.358.

252. *Id.* at 247.

253. *Id.* at 263–64.

254. *Id.* at 246.

255. *Id.* at 245.

256. *See id.* at 249.

257. *See id.* at 243.

258. The proposed funding mechanism was modeled on the funding scheme of the federal Superfund. At its inception, the Superfund relied primarily on taxes on petroleum and chemical feedstocks. *See id.* at 242. This tax expired in 1995 and has not been reauthorized. The money available in the Superfund has since dwindled. General tax funds have been used to finance cleanups, but the number of Superfund cleanups has declined. *See* Eric Pianin, *Superfund Faces Struggle for Room in the Budget*, WASH. POST, Sept. 14, 2003, at A9. Similarly, as described below, the initial industry support for a Japanese administrative compensation scheme gradually gave way to complaints that industry

2. Rabin's Proposal

In 1993, Robert Rabin made a proposal designed to harness the potential of the tort system to identify toxic health hazards that would be compensable under an administrative system.[259] Rabin adopted the ELI's plan to fund a compensation system in part through a fee that roughly reflected the risk-generating character of contributing industries.[260] In addition, Rabin's proposal created a designated list of toxic substances that would serve as the basis for determining liability in mass toxic claims.[261] First, injured individuals would make a binding choice whether to proceed administratively or in tort.[262] If they chose the administrative option, claimants would then be required to make an individualized showing that they had been exposed to one of the listed substances.[263] Claimants would be compensated only for pecuniary losses related to particular, listed harms.[264] Rabin also proposed a "switching" mechanism that transferred cases from the judicial system to the administrative system. If sufficiently numerous tort claims involved a particular unlisted substance, a special judicial panel could order those claims to be "switched" into the administrative system.[265] This mechanism would thus capitalize on new information about toxic risks developed in litigation.[266]

Like the ELI model, Rabin's proposal retained the tort system as an alternative form of relief. Rabin's unwillingness to part with the tort system may be attributable in part to his skepticism that science would be able to

members were being forced to bear unfair burdens. *See infra* Section IV.A. Both of these experiences illustrate the political difficulty of maintaining an industry-wide tax to support a liability scheme. *See also* Rabin, *Some Thoughts*, *supra* note 15, at 977 ("Fairness considerations serve as an alternative rationale for creating as close a linkage as possible between risk-producing activities and financial responsibility for the consequences.").

259. *See* Rabin, *Some Thoughts*, *supra* note 15, at 965. Rabin also considered other models in designing his proposed scheme, including the compensation and limited liability scheme for nuclear accidents under the Price-Anderson Act, as well as the National Childhood Vaccine Injury Act of 1986. *Id.* at 955–60.

260. *Id.* at 977. Rabin suggested, however, that there may be little practical difference between a flat tax and a risk-sensitive schedule of charges because of the unforeseeability of the risks and the disinclination of management to consider long-term consequences. Nevertheless, he recognized that corrective justice concerns could justify risk-specific charges. *Id. But see* Arlen, *supra* note 87, at 1099 (contending that "[e]xperience rating is more important than Rabin suggests" because proper deterrence requires that "each injurer bears more directly the costs of the risks she actually creates").

261. Rabin, *Some Thoughts*, *supra* note 15, at 967–69.

262. *Id.* at 976.

263. *Id.* at 967–70.

264. *Id.* at 968–70, 972, 976.

265. *Id.* at 968–69.

266. *See id.*

provide sufficiently reliable risk information to support an administrative compensation system.[267] In addition, for Rabin's model, the tort system would serve as a "fail-safe" option for the most severely disabled, who might be undercompensated by an administrative system.[268] Also, the tort system would guarantee that ceilings on compensation in an administrative system would not be set too low.[269] The tort option might, however, appeal more to those plaintiffs who had the strongest cases for recovery—the same cases that could be handled the most efficiently by an administrative system.[270] As a general rule, allowing such individuals to opt out of an administrative system would tend to undermine the system's economies of scale.[271]

3. Fisher's Proposal

In 2001, Clifford Fisher made another administrative proposal, described as an "Environmental Compensation program" patterned after the workers' compensation system.[272] The proposal would require industry to buy pollution compensation insurance. Victims would receive compensation if they demonstrated "injuries of a type that some credible scientific evidence suggests may be causally related to exposure to a toxic substance."[273] Any time after exposure, victims could file claims to recover either for exposure to risk or for actual physical injury.[274] But if there was uncertainty as to whether exposure caused a victim's disease, compensation would be discounted.[275] Claims would be handled by the insurance industry, although an independent panel of medical experts would weigh the evidence and make compensation decisions on a case-by-case basis.[276] Fisher contended that his proposal "would eliminate the problems of toxic tort causation" and result in lower transaction costs.[277]

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267. *See id.* at 979 (noting that most toxic-listing mechanisms, such as California's Proposition 65, *see supra* text accompanying note 117, do not purport to establish a foundation for individual claims of personal harm).

268. *Id.* at 976.

269. *Id.* at 975–76.

270. Arlen, *supra* note 87, at 1096.

271. As Rabin noted, one key advantage of an administrative approach over the tort system is its ability to process a high volume of claims. *See* Rabin, *Some Thoughts*, *supra* note 15, at 965.

272. *See* Fisher, *supra* note 245 (outlining the proposed scheme).

273. *Id.* at 142.

274. *See id.* at 149.

275. *See id.* at 149–50.

276. *See id.* at 143, 147–48.

277. *Id.* at 161.

Despite that contention, Fisher's proposal creates a number of concerns. First, under the proposal, a victim would simply submit a claim for compensation "to the insurance industry."[278] But if victims are unable to correctly identify the specific pollution source that caused their injuries, insurers would be unable to adjust premiums to account for risk. Second, a claimant's burden of proof would be so minimal that the proposal would encourage poorly supported claims. Lowering the burden of proof pressures risk-creators to generate information on risk, but it also shifts the biases of the compensation system toward overdeterrence and overcompensation.[279] Third, the cost and efficiency benefits of the proposal would be relatively modest—the proposal would simply replace individualized judicial determinations with individualized administrative ones. Indeed, because claims could be premised on exposure to risk, the number of individualized claims would likely overwhelm the proposed panel of experts.

B. THE NEW PROPOSAL

Earlier administrative proposals that address environmental toxic injury have failed to capitalize on the ability of administrative systems to process a large volume of cases. Also, prior proposals have not accounted for current or future scientific advances. What kind of an administrative system might then be appropriate, given these advances and considering society's goals of compensation, deterrence, and fairness? A proposed system should take advantage of the refined and individualized assessments of risk that will be possible through increasingly sophisticated monitoring, toxicogenomics, modeling, and biomonitoring techniques. To advance deterrence and compensation goals, assessments of risk should be as accurate as possible, in quantifying risks and in identifying risk generators and persons exposed to risk. Nevertheless, as previously noted, administrative systems have relatively modest informational requirements compared to the tort system.[280] Thus, administrative systems can address situations of limited knowledge more adequately.

The administrative system proposed here would internalize health-related pollution costs through a risk-based liability and compensation system. The federal government would assess individualized levies on pollution sources, taking advantage of an economy of scale unavailable to

278. *Id.* at 143.
279. *See infra* Section V.B.3.
280. *See supra* notes 105–08 and accompanying text.

the states alone.[281] The government would then use the revenues collected through the levies to make redistributions to persons exposed to pollution. The proposed system would coexist with current environmental standards, which would continue to provide a basic level of protection for human health and the environment. Because such a system would nevertheless represent a drastic departure from the present tort system, this Article offers a proposal that is more conceptual than detailed in nature. A finalized system would need to be refined in light of experience and technological developments.

1. Levies on Pollution Sources

In order to provide appropriate deterrence incentives, this proposal would have the federal government collect from pollution sources levies that reflect the human health costs of the pollution. The amount of each levy would depend on the amount of pollutants released by a polluter, as well as the likely exposure of persons to the pollutants, the risk of harm due to such exposure,[282] and the expected costs to the victims of such harm.[283] This proposal would require significant pollution sources to make these payments if chemicals are released above designated threshold levels. The

281. *See* Daniel C. Esty, *Revitalizing Environmental Federalism*, 95 MICH. L. REV. 570, 614–15 (1996). For example, data collection, analysis, and risk assessment are highly technical activities that involve significant economies of scale. *Id*.

282. A risk-based liability system, as opposed to a harm-based liability system, mitigates the problem of "moral luck" by treating individuals with identical culpability the same. *See* Ehud Guttel & Alon Harel, *Probability Matching and the Law: A New Behavioral Challenge to Law and Economics* 28 (2004) (Am. Law & Econ. Ass'n, Working Paper No. 39), *available at* http://www.law.bepress.com/alea/14th/art39/.

283. The process of quantifying these costs likely will involve some controversy. For further discussion of this topic, which is beyond the scope of this Article, see generally FRANK ACKERMAN & LISA HEINZERLING, PRICELESS: ON KNOWING THE PRICE OF EVERYTHING AND THE VALUE OF NOTHING (2004) (examining how economists price intangible values, such as human life); RISKS, COSTS, AND LIVES SAVED: GETTING BETTER RESULTS FROM REGULATION (Robert W. Hahn ed., 1996) (compiling the views of economists and scientists on the measurement, analysis, and regulation of risk); Richard L. Revesz, *Environmental Regulation, Cost-benefit Analysis, and the Discounting of Human Lives*, 99 COLUM. L. REV. 941 (1999) (examining the differences inherent in discounting the risks of latent harm versus instantaneous death); Cass R. Sunstein, *Lives, Life-years, and Willingness to Pay*, 104 COLUM. L. REV. 205 (2004) (discussing how to monetize the shortening of one's life); Sunstein, *Your Money or Your Life*, *supra* note 135 (reviewing ACKERMAN & HEINZERLING, *supra*).

284. If numerous pollution sources feature very diffuse effects, it may be simpler and more cost-efficient to achieve deterrence and compensation through general taxes. Spending could also be focused on preventive care.

proposal would collect the levies through an environmental permitting process or tax system.[284]

In return for making payments into the system, a pollution source would be shielded from potential tort liability to the extent that its payments covered known or accounted-for risks. Thus, the administrative system would not replace the tort system altogether; rather, it would function alongside the tort system. The scope of the administrative system would extend to substances for which sufficiently reliable information exists regarding health risks. Substances whose health effects are unknown or inadequately understood, however, would remain outside the administrative system and could be the subject of tort litigation if adverse effects are discovered in the future.[285]

For example, if an oil refinery's sulfur dioxide emissions were expected to cause fifty additional cases of lung disease and ten additional deaths per year, the refinery would make a payment to the administrative system reflecting the costs of those injuries. In return, the refinery would be released from potential tort liability for lung disease arising from exposure to the sulfur dioxide. The refinery would remain subject to potential tort liability, however, to the extent that it releases other harmful pollutants not covered by the system. In addition, the refinery would remain liable for unexpected types of harm caused by the sulfur dioxide emissions. As explained below, the administrative system would distribute the funds collected to exposed individuals in the community.

2. Distributions to Exposed Persons

Preferably, the administrative system would employ a compensation-for-risk approach, in which each individual would have a personal account within the system. In order to shield pollution sources from tort liability for risks covered by the system, individuals would not be allowed to opt out of the system to pursue tort claims. Each individual's account would receive payments based on that individual's estimated exposure, above a minimal threshold, to pollution from sources contributing to the system. Air modeling or sampling could be used to estimate exposure in different microenvironments. Using reasonable modeling of exposure pathways, these estimates could be based on an individual's residence and place of

285. Tort liability reinforces administrative regulation in two ways. First, it serves as a safety net if agencies lack jurisdiction or resources to address certain risks. Second, it provides a decisionmaking authority that is at least partially independent from political pressures. *See* FRIED & ROSENBERG, *supra* note 162, at 79–80.

work. Biomonitoring and other sampling methods could provide more accurate estimates of exposure, but would raise greater privacy and cost concerns. Because the purpose of the accounts would be to compensate individuals for their exposure and the resulting increased risk of injury, the proposal would limit use of account funds to insurance, medical expenses, preventative care, or similar types of expenditures.

Alternatively, the system could distribute revenues based on actual physical injury as opposed to mere exposure. This option would direct resources to persons with the greatest need, but would also entangle the system in questions of specific causation. Namely, payments made by a pollution source into the system would be sufficient to compensate only for the increased disease incidence caused by that source. It would not be sufficient to compensate for the base rate disease incidence. To be financially sound, the system would have to distinguish between cases caused by exposure to pollution sources that had contributed into the system, for which payments would be made, and all other cases.[286] Drawing these distinctions would require the administrative system to wrestle with the same difficult specific causation issues that challenge the tort system.

In contrast to compensation for injury, compensation for increased risk avoids difficult specific causation issues.[287] Because exposure to risk of harm would trigger compensation payments, there would be no need to determine whether an injury later occurred or why. Such issues give rise to many, if not most, of the costs and procedural problems that accompany mass tort litigation.[288] These issues are especially problematic in environmental toxic injury cases.

Moreover, by providing compensation in advance of any injury, the compensation-for-risk approach enables individuals to pay for medical monitoring or preventative care. Such measures can reduce an individual's overall risk while ameliorating the psychic anxiety of anticipated future

286. Under this arrangement, political pressure might tend to broaden eligibility for compensation to cover all cases, as happened with the federal black lung program. *See infra* Section IV.D.

287. *Cf.* Leslie, *supra* note 38, at 1848 (noting in the toxic tort context that if plaintiffs no longer have to prove specific causation, *Daubert* hearings will involve fewer experts and will entail lower costs). But to the extent that a compensation-for-risk system avoids specific causation determinations, the primary goal of corrective justice—establishing the causal connection between tortfeasors and victims—is not addressed. *Cf.* Geistfeld, *supra* note 46, at 1024 (noting that tort norms based on corrective justice make causation an essential predicate of liability).

288. *See* FRIED & ROSENBERG, *supra* note 162, at 96–97 ("The effort to tailor judgments to the specific legal and factual features of an individual claim . . . to determine 'specific causation' is enormously expensive."); Abraham, *supra* note 143, at 887.

injury. Admittedly, compensation-for-risk payments would not provide full compensation for individuals whose exposure later resulted in actual injuries to their health.[289] The exception would be the rare case where compensation is paid for an exposure that bears a one hundred percent risk that actual injury will result. Individuals could, however, address this compensation gap by using compensation proceeds to pay for insurance.[290] An administrative system should accommodate such expenditures by allowing individuals to use funds to purchase insurance to cover medical expenses, loss of income, or disability.[291]

Restricting individuals' use of compensation proceeds to insurance, medical expenses, and preventative care would educate and remind the public of the purpose of the compensation payments. The restriction would promote corrective justice by ensuring that compensation actually addresses the harm caused by the polluter. It would also allay one potential overcompensation concern—some may presume that if a person does not suffer physical injury, there is no "harm" and thus there should be no compensation. Although this overcompensation argument makes the debatable assumption that the burden of potential injury is not a real harm,[292] restricting the use of proceeds to purposes that alleviate health risks will prevent compensation from becoming a windfall.

3. The Informational Foundation

The informational needs of the proposed administrative system would be significant. At least two existing databases may help to identify pollutants to be covered by the system and help to establish research priorities: (1) the Agency for Toxic Substances and Disease Registry

289. Robinson, *supra* note 16, at 786–87 (explaining that, in the absence of insurance, a victim's ex ante recovery for risk of harm is insufficient to cover actual losses).

290. *See* Note, *supra* note 26, at 1517 (noting that awards of risk-based damages do not undercompensate plaintiffs who later develop diseases if the plaintiffs are able to purchase insurance with discounted damage proceeds).

291. *See* Andrew R. Klein, *A Model for Enhanced Risk Recovery in Tort*, 56 WASH. & LEE L. REV. 1173, 1188 & n.77 (1999) (noting that several commentators have proposed compensating for enhanced risk by allowing exposed persons to recover insurance premiums designed to cover the risk of future disease). Compensation-for-risk payments would cover only the portion of insurance premiums that represent the incremental risk due to exposure. Individuals would have to supplement the compensation-for-risk distribution with their own funds. *See* Robinson, *supra* note 16, at 787 (noting that recovery for risk provides immediate compensation, but that a person exposed to risk must either bear or insure against any residual loss). An alternative would be to require polluters to purchase insurance policies to cover diseases that exposed individuals are at risk of developing. *See* Note, *supra* note 26, at 1520. Such an approach, however, would require either that cases caused by background risk be distinguished or that polluters also bear the cost of such cases.

292. *See* Robinson, *supra* note 16, at 786.

("ATSDR"), which gathers toxicological information;[293] and (2) the EPA's Integrated Risk Information System ("IRIS") database.[294]

ATSDR has produced "toxicological profiles" for arsenic, lead, mercury, and over 270 other hazardous substances.[295] The EPA and ATSDR prioritize the hazardous substances to be profiled based on the frequency of occurrence at toxic waste sites, toxicity, and potential for human exposure.[296] Each peer-reviewed profile reviews research on the substance's toxicologic properties and characterizes information on toxicity and adverse health effects. Each profile includes: (1) an identification of major sources of release to the environment, based on data from the Toxics Release Inventory;[297] (2) the potential for human exposure through various routes; and (3) the potential health effects, including estimated levels of exposure at which carcinogenic and noncarcinogenic health effects may occur.[298] For each profiled substance, ATSDR also determines whether adequate information on health effects is available. If such information is not available, ATSDR, in cooperation with the National Toxicology Program, initiates research to determine those health effects.[299]

The EPA's less-detailed IRIS database summarizes the EPA's consensus position on the potential adverse effects of over 500 chemicals.[300] For each chemical, the database lists estimated oral and inhalation unit risks of carcinogenic effects—the risk of cancer for exposure to a given concentration of pollutant.[301] The database also lists

293. Pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act ("CERCLA"), ATSDR, in conjunction with the EPA, maintains a list of hazardous substances most commonly found at facilities on the CERCLA National Priorities List. ATSDR prepares toxicological profiles for each substance on the list and ascertains significant human exposure levels with associated health effects. *See* 42 U.S.C. § 9604(i) (2000). One commentator has suggested that ATSDR's informational databases could serve as a basis for apportioning liability for harm among defendants who generate different toxic substances. *See* Boston, *supra* note 81, at 622, 632–33.

294. U.S. EPA, What is IRIS?, http://www.epa.gov/iris/intro.htm (last visited Sept. 24, 2005).

295. *See* Agency for Toxic Substances & Disease Registry, Toxicological Profile Information Sheet, http://www.atsdr.cdc.gov/toxpro2. html (last visited Sept. 24, 2005).

296. Boston, *supra* note 81, at 632.

297. *See supra* text accompanying note 118.

298. *See, e.g.*, Agency for Toxic Substances & Disease Registry, Toxicological Profile for Lead, http://www.atsdr.cdc.gov/toxprofiles/tp13.html (last visited Sept. 24, 2005); Agency for Toxic Substances & Disease Registry, Toxicological Profile for Vinyl Chloride—Draft for Public Comment, http://www.atsdr.cdc.gov/toxprofiles/tp20.html (last visited Sept. 23, 2005).

299. *See* 42 U.S.C. § 9604(i)(5) (2000) (requiring research if health effects are unknown).

300. *See* U.S. EPA, IRIS Substance List, http://www.epa.gov/iris/subst/index.html (last visited Sept. 24, 2005) (listing each substance tracked). *See also* PHILP, *supra* note 2, at 67; U.S. EPA, *supra* note 294 (outlining the project's objectives).

301. *See* U.S. EPA, *supra* note 294. The EPA describes IRIS as "a tool that provides hazard identification and dose-response assessment information." *Id*. When combined with specific exposure

estimated oral reference doses and inhalation reference concentrations for chronic noncarcinogenic health effects—the levels of chemical exposure that are likely to be without appreciable risk.[302]

A scientific panel could assess toxicity information from these databases and other sources to determine which substances should be included in the administrative system. The panel could also act on petitions by parties who submit data on toxic risks associated with unlisted substances.[303] Thus, the panel would apply its expertise both in making listing decisions and in assessing the risk data used to determine the contributions and payments required by the system. A separate panel with economic and ethical expertise could address the determination of the appropriate payment levels.

C. COMPARISON WITH EARLIER PROPOSALS

The risk-based proposal presented in this Article differs from the earlier administrative proposals in several important respects. First, compensation would be based on exposure to risk rather than on physical injury. The greatest advantage of risk-based compensation is that it makes questions of specific causation irrelevant. Although the ELI and Rabin proposals attempt to sidestep the issue of specific causation by creating a presumption of liability,[304] that issue nevertheless persists because the presumptions are rebuttable. Although the Fisher proposal allows victims to file claims any time after exposure, it too retains an individualized causation inquiry, albeit a cursory one. Additionally, a risk-based proposal has the advantage of automatically aggregating compensation funds from multiple pollution sources. This facilitates the purchase of preventative care or insurance.[305]

Second, the risk-based proposal more precisely tailors the levies on pollution sources to match the risks generated.[306] Both the ELI and Rabin

information, IRIS "can be used for characterization of the public health risks of a given chemical in a given situation." *Id*. The EPA cautions, however, that "IRIS values cannot be validly used to accurately predict the incidence of human disease or the type of effects that chemical exposures have on humans." *See* U.S. EPA, IRIS Limitations, http://www.epa.gov/iris/limits.htm (last visited Sept. 24, 2005).

302. *See* U.S. EPA, *supra* note 294.

303. *Cf.* Rabin, *Some Thoughts*, *supra* note 15, at 968 (proposing the creation of a similar panel of scientists).

304. *See id.* at 967.

305. *See supra* Section III.B.2.

306. *See* Arlen, *supra* note 87, at 1098 ("For deterrence purposes, the cost of an injurer's risky activity is best measured as the cost of the *risk* she imposes on each affected person, not the cost of any resulting injuries.").

proposals would have been partially funded by industry-based hazard fees, with only a limited effort made to incorporate risk generation into their financing schemes. Although these earlier proposals would be simpler to implement, their funding would not rest on scientifically generated risk assessment data. The Fisher proposal relies on insurance carriers to account for risks by adjusting premiums, but, as noted above, such adjustments can be made only if claimants trace their injuries directly to pollution sources.

The risk-based proposal, like the ELI and Rabin proposals, envisions a continuing role for the tort system. The risk-based proposal, however, makes a greater commitment to the administrative system by eliminating all potential tort liability for risks covered by the system. The exclusivity of coverage under either the tort or administrative systems guards against overdeterrence and overcompensation while enhancing the political viability of the proposal.[307] Although any proposal will face opposition from the business community to the extent that it requires compensation for costs that are not currently internalized, the levies contemplated by the ELI and Rabin proposals would likely encounter strong opposition because paying the levies would not protect against tort liability. While the risk-based proposal lacks the Rabin proposal's mechanism for switching claims from the tort system to the administrative system, it nevertheless leaves room for the tort system to play a role. The tort system could be used to identify substances that should be incorporated into the administrative system, perhaps through a petitioning process.

IV. FEASIBILITY OF THE PROPOSAL: LESSONS FROM OTHER ADMINISTRATIVE SYSTEMS

The proposed system is theoretically attractive and scientifically plausible. The question remains whether it is practically feasible. This part addresses feasibility by discussing domestic and foreign precedents for replacing substantial portions of the tort system with an administrative compensation system. In particular, this part examines the lessons to be gleaned from those precedents. Perhaps the most germane proposal comes from Japan, where the government adopted an administrative compensation system for pollution-related illnesses in the 1970s.[308] In the same decade,

307. *Cf.* Charles D. Kolstad, Thomas S. Ulen & Gary V. Johnson, *Ex Post Liability for Harm vs. Ex Ante Safety Regulation: Substitutes or Complements?*, 80 AM. ECON. REV. 888, 889 (1990) (arguing that ex ante regulatory standards should be set at a socially optimal level of safety only where ex post liability cannot be imposed, but if ex ante and ex post policies are used jointly, then ex ante standards should be set at a socially suboptimal level).

308. *See infra* Section IV.A.1.

New Zealand partially replaced tort claims by instituting a no-fault administrative compensation system for accident-related personal injuries.[309] In the early twentieth century, individual states in this country began to replace tort and contract actions arising from workplace injuries with workers' compensation systems.[310] On a more limited scale, the Federal Government adopted the Black Lung Program, which compensated retired coal miners for respiratory disease.[311] Although all of these systems have encountered difficulties and undergone reforms, they demonstrate the potential advantages of administrative systems and suggest issues to consider when designing an administrative compensation scheme.

A. POLLUTION COMPENSATION IN JAPAN

Japan adopted a compensation program to address the precise problems identified in this Article—the failure of the tort system to internalize the costs of pollution and its failure to provide adequate compensation to environmental tort victims. Although its scope has narrowed, the Japanese program continues to operate today.

1. Description

Japan's adoption of this administrative system was prompted by two factors: the serious industrial pollution that accompanied the country's rapid economic growth starting in the 1950s, and the related rising incidence of pollution-related diseases near certain industrial facilities.[312] Dissatisfied with mediation as a means to resolve pollution-related conflicts, victims turned to the courts and filed negligence claims.[313] Despite difficult proof requirements and the absence of discovery mechanisms, victims won several important decisions in which industrial polluters were held liable.[314] These decisions expanded environmental civil liability through four doctrinal innovations: (1) interpreting negligence to

309. *See infra* Section IV.B.1.

310. *See infra* Section IV.C.1.

311. *See infra* Section IV.D.1.

312. *See* JULIAN GRESSER, KOICHIRO FUJIKURA & AKIO MORISHIMA, ENVIRONMENTAL LAW IN JAPAN 29–30 (1981).

313. *See id.* at 37; A. Morishima, *Environmental Liability in Japan*, *in* MODERN TRENDS IN TORT LAW: DUTCH AND JAPANESE LAW COMPARED 183, 184 (Ewoud Hondius ed., 1999).

314. *See* Morishima, *supra* note 313, at 184–87. The first three of these cases consisted of two actions against large chemical companies for mercury poisoning and one action against a mining company alleging that cadmium discharge had caused a painful bone syndrome called Itai-itai ("Ouch, ouch"). A fourth suit named six defendants—a petroleum refinery, a power plant, and four chemical plants—and alleged that their discharge of sulfur oxides jointly caused the plaintiffs' injuries. *Id*.

essentially impose strict liability, (2) allowing causation to be proved by epidemiological evidence, (3) applying a form of joint and several liability, and (4) calculating damages through a "comprehensive method" that provided for standardized damage calculations based on degree of injury.[315] This last innovation eliminated the need to estimate victims' incomes, which resulted in courts being able to handle a larger volume of cases.[316]

Despite these innovations, environmental tort litigation in Japan remained inefficient and inadequate for those plaintiffs who could not prove causation.[317] Nevertheless, such innovations pressured industry to pursue alternatives to tort, thus laying the foundation for the 1973 Pollution-Related Health Damage Compensation Law.[318] This law established an administrative compensation program, financed primarily through taxes on industry based on sulfur oxide emissions.[319] This program provided disability benefits, reimbursement for medical expenses, and compensation for lost earnings.[320]

The Compensation Law provided compensation to a *certified* victim of a *designated* disease who lived in a *designated* area.[321] A polluted area could be designated as either Class I or Class II.[322] Class I areas contained extreme air pollution and a substantial number of victims of respiratory disease.[323] Four respiratory diseases—emphysema, chronic bronchitis, asthma, and asthmatic bronchitis—were defined as *designated* diseases in Class I areas.[324] Although these diseases could be caused by multiple sources, victims were not required to demonstrate that pollution was a "but for" cause in order to receive compensation.[325] Class II areas were those where a causal relationship between a disease and pollution was deemed to be clearly established.[326] The legislature identified three signature diseases

315. *See id.* at 185–87.

316. *See id.* at 187.

317. *See id.* at 190–91.

318. Kōgai Kenkō Higai Hoshō Hō [Pollution-Related Health Damage Compensation Law], Law No. 111 of 1973.

319. *See* GRESSER ET AL., *supra* note 312, at 288–300.

320. *See id.* at 288–90.

321. Morishima, *supra* note 313, at 191.

322. *Id.*

323. As of March 1988, when the designation of new Class I areas was cancelled, there were fifty Class I areas. *Id.*

324. *Id.* at 192.

325. *See* GRESSER ET AL., *supra* note 312, at 293.

326. Morishima, *supra* note 313, at 191–92.

as *designated* diseases in Class II areas—Minimata disease, Itai-itai disease, and chronic arsenic poisoning.[327]

Victims could be certified if they suffered from a designated disease and had lived in a designated area for a certain period of time.[328] Certified patients were assigned one of four ranks according to severity of injury;[329] each rank corresponded to a particular coverage rate. The Compensation Law provided compensation for disability, medical care, funeral expenses, and payments to survivors.[330] It did not cover property damage or pain and suffering.[331]

Ostensibly, the Compensation Law was intended to mitigate pollution through a "polluter-pays principle."[332] In Class II areas, responsible companies compensated patients directly, with national and local governments bearing some of the rehabilitation and administrative costs.[333] In Class I areas, however, numerous stationary and mobile pollution sources made allocating costs more complicated. The Compensation Law provided that in Class I areas, a graduated levy on sulfur oxide emissions paid for eighty percent of compensation costs.[334] A tonnage tax on

327. GRESSER ET AL., *supra* note 312, at 292; Morishima, *supra* note 313, at 192. In theory, the government could designate additional diseases for coverage within the system when sufficient data was compiled. GRESSER ET AL., *supra* note 312, at 293. But it made no such designations after 1974. Alice Stewart, *Japan's 1987 Amendment to the 1973 Pollution-Related Health Damage Compensation Law: Tort Reform and Administrative Compensation in Comparative Perspective*, 29 HARV. INT'L L.J. 475, 483 (1988).

328. SHIGETO TSURU, THE POLITICAL ECONOMY OF THE ENVIRONMENT: THE CASE OF JAPAN 146–47 (1999). The number of years of residence required for certification was one year for bronchial asthma and asthmatic bronchitis, two years for chronic bronchitis, and three years for pulmonary emphysema. *Id.* at 147. As of 1986, 1959 patients had been certified in Class II areas, compared to over 100,000 in Class I areas. Helmut Weidner, *An Administrative Compensation System for Pollution-Related Health Damages*, *in* ENVIRONMENTAL POLICY IN JAPAN 139, 147 tbl.3.2.3 (Shigeto Tsuru & Helmut Weidner eds., 1989).

329. Morishima, *supra* note 313, at 192.

330. GRESSER ET AL., *supra* note 312, at 293–95.

331. *Id*. at 294–95.

332. *See* TSURU, *supra* note 328, at 146. A 1972 report explained the polluter pays principle as follows:

> The principle to be used for allocating costs of pollution prevention and control measures to encourage rational use of scarce environmental resources and to avoid distortions in international trade and investment is the so-called "Polluter-Pays Principle." This Principle means that the polluter should bear the expenses of carrying out the above mentioned measures decided by public authorities to ensure that the environment is in an acceptable state.

Org. for Econ. Dev. & Cooperation, Recommendation of the Council on Guiding Principles Concerning International Economic Aspects of Environmental Policies (1972), http://webdomino1.oecd.org/horizontal%5Coecdacts.nsf/Display/ 7D5EFAB92ACDB4D7C1257087007E8BA2?OpenDocument.

333. GRESSER ET AL., *supra* note 312, at 300.

334. *See id*. at 298–300. Sulfur oxide emissions were chosen for the following reasons: (1) the evidence indicated that sulfur dioxide was a principal cause of illnesses, (2) the government had the

automobiles paid for the remaining twenty percent.[335] Of those costs allocated to emitters of sulfur oxides, ninety percent would be paid by facilities located in Class I areas based on their emissions during the previous year. The remainder would be paid by facilities outside Class I areas.[336]

From an economic perspective, the design of the Class I levy was far from ideal. Using sulfur oxide emissions as a basis for the levy was driven primarily by the desire to establish a convenient way to finance compensation payments. The desire to internalize pollution costs accurately was less important.[337] The scheme ignored nitrogen oxides, carbon monoxide, and particulates, even though they were also believed to contribute to the designated respiratory diseases.[338] Moreover, the government made no attempt to internalize costs accurately, even with respect to sulfur oxide emissions. Instead, levies on present sulfur oxide polluters paid for the costs of harms from past emissions.[339]

In an attempt to make the system fairer, the government subsequently raised levy rates in areas with higher concentrations of claimants.[340] As sulfur oxide emissions declined, however, the government had to increase per-ton levies across the board to ensure sufficient funds for compensation.[341] Increased levies in the face of declining sulfur oxide emissions generated pressure from the business community to cancel the Class I area designations.[342] At the same time, there was growing recognition of the importance of nitrogen oxide pollution as a cause of disease.[343] Rather than incorporating nitrogen oxide emissions as a basis for levy collection, however, the government cancelled all Class I area designations in 1988, which prevented more patients from being

most data on sulfur dioxide and best understood the problem of controlling it, and (3) sulfur oxide emissions could be easily calculated and monitored. *Id.* at 298.

335. *Id.* at 300.

336. Morishima, *supra* note 313, at 192. The rationale for charging a reduced levy to firms outside designated areas was that their emissions also contributed to health problems through long-range transport. *See* Weidner, *supra* note 328, at 149.

337. *See* Weidner, *supra* note 328, at 148 (noting that the use of a sulfur oxide levy allowed speedy implementation of the compensation scheme). Indeed, administrators downplayed the regulatory aspects of the levy because charges based on exact emissions were considered to be impractical and politically infeasible. GRESSER ET AL., *supra* note 312, at 298.

338. *See* GRESSER ET AL., *supra* note 312, at 298.

339. *See id.* at 299.

340. Weidner, *supra* note 328, at 150.

341. *See* GRESSER ET AL., *supra* note 312, at 311.

342. *See* TSURU, *supra* note 328, at 148–49.

343. *See id.* at 149; Stewart, *supra* note 327, at 484–85.

certified.[344] The government indicated that it would instead promote comprehensive research and remedial measures to protect human health and the environment.[345]

2. Lessons from Japan

Compared to the present proposal, Japan's pollution compensation system was limited in scope—it was designed to respond to a small number of pollution problems in specific geographic areas.[346] Furthermore, contextual nuances must be weighed when drawing lessons from Japan's experience. Compared to the United States' legal system, Japan's legal system has traditionally been more receptive to the independent administrative resolution of disputes, which is preferred to judicial intervention.[347]

Nevertheless, Japan's experience is instructive in several ways. First, thoughtful and equitable design is critical. Using levies on sources of *present* pollution to fund the compensation payments to victims of *past* pollution ultimately undermined the Class I system. For this reason, emitters reasonably contended that it was unfair to hold them financially responsible for illnesses caused by other polluters.[348] From the perspective of industry, causation standards were so relaxed that the system became a no-fault compensation scheme that had little deterrent effect.[349]

The Class I system's rough-justice approach might have survived these criticisms were it not for the drastic decline in sulfur oxide emissions. This decline underscored how greatly the system had departed from the polluter-pays principle. By arguing that the system discouraged further emissions reductions, industry succeeded both in challenging sulfur oxide emissions as a basis for levies and in eliminating the Class I levy itself.[350]

The decline in sulfur oxide emissions also highlighted how incomplete the knowledge base for the system was. The intent of the law had been to ensure the rapid support for victims of environmental pollution; the scientific basis was a secondary concern.[351] Sulfur oxide emissions could be readily measured, and thus offered a convenient basis for computing

344. TSURU, *supra* note 328, at 149–50.
345. *See* Stewart, *supra* note 327, at 486–87; Weidner, *supra* note 328, at 161.
346. *See* DEWEES ET AL., *supra* note 12, at 330.
347. Stewart, *supra* note 327, at 487 n.74.
348. *See* GRESSER ET AL., *supra* note 312, at 311.
349. *See* Stewart, *supra* note 327, at 497.
350. *See* GRESSER ET AL., *supra* note 312, at 311.
351. *See* Weidner, *supra* note 328, at 154.

levies.[352] Industry, government, and victims all had an interest in having the Compensation Law enacted. Industry was willing to accept uncertainty and policy compromises as long as its financial burden was low.[353] Once costs escalated, however, industry complained that it was paying more than its fair share and demanded a more economically rational basis for the pollution levies.[354]

Japan's experience with Class I areas carries several implications for the system proposed in this Article. Stakeholders in the system must view it as equitable. The polluter-pays principle may be an appropriate guiding criterion, but the system must assess specific levies and distribute payments equitably.[355] Furthermore, the system must have adequate monitoring mechanisms to guard against evasion. At a minimum, the system must be based on reliable mechanisms of revenue collection. In addition, the proposed system must be grounded in well-developed and defensible scientific knowledge. The fact that Japan's Class II designations fared better politically than its Class I designations[356] can be attributed to two factors: the greater certainty of the data regarding causation in Class II areas, and the more plausible link between responsible parties and compensated victims.[357]

One should not interpret Japan's scaling back of Class I compensation as a repudiation of the concept of an administrative compensation system.[358] The compensation scheme was left untouched in Class II areas. Even with respect to Class I areas, public sentiment actually favored

352. GRESSER ET AL., *supra* note 312, at 316.

353. *Id.* at 311.

354. *Id.*

355. Assessing liability in proportion to the probability of each company's contribution to actual injury will likely still encounter industry opposition. But a fair and accurate determination of probabilities will weaken the basis for such opposition. *See, e.g.*, Stewart, *supra* note 327, at 497–98 (noting that Japanese companies' consistent opposition to the Class I compensation system suggests that they would have fought for specific causal showings).

356. This is not to overlook grievances by Class II victims, who complained that the criteria for disease certification were unreasonably restrictive. *See* GRESSER ET AL., *supra* note 312, at 308. One commentator has suggested that the certification board's close scrutiny of Class II claimants' medical tests and history of exposure essentially required such claimants to demonstrate individual causation. *See* Stewart, *supra* note 327, at 481 & n.37.

357. Industry also had less of an incentive to seek repeal of the Class II designations as far fewer persons were certified in Class II areas. *See* GRESSER ET AL., *supra* note 312, at 304–05; *supra* note 328.

358. One commentator has suggested that an appropriate compensation scheme would combine Class I and Class II features. Compensation would be awarded when exposure to an alleged toxic substance was established and alternate sources of injury were ruled out. A showing of a statistically demonstrated increased risk of environmental health injury would be required. Stewart, *supra* note 327, at 498.

incorporating nitrogen oxide emissions into the calculation of levies rather than eliminating the system completely. Ultimately, Japan's experience demonstrates that a viable administrative compensation scheme must be fair and supported by sufficient data.

B. ACCIDENT COMPENSATION IN NEW ZEALAND

1. Description

Like Japan, New Zealand adopted an administrative compensation system in the 1970s. Unlike Japan, this system addressed accidents rather than pollution-related injury. The 1972 Accident Compensation Act ("the Act") replaced common law tort claims for accidental personal injury with a no-fault compensation system.[359] The enactment largely followed the recommendations of the Woodhouse Report.[360] The Woodhouse Report noted the lottery-like nature of personal injury awards, the inadequacy of compensation under the existing workers' compensation system, and the limited availability of social security benefits.[361] The report recommended replacing this "fragmented and capricious response" to personal injury with a comprehensive no-fault compensation plan that would offer the prospect of more complete injury coverage with lower administrative costs.[362]

Central to the Act was what the Woodhouse Report called the principle of "community responsibility."[363] Community responsibility refers to society's responsibility to compensate the "random but statistically necessary victims" of everyday activity in modern society.[364] Consistent with that principle, the Act emphasized the compensation of accident victims rather than the deterrence of individual causes of injury.[365]

The Act bars tort claims for death or personal injury caused by accidents. In its place, it mandates a no-fault system of compensation

359. *See* GASKINS, *supra* note 137, at 326–30.

360. N.Z. Royal Comm'n of Comp. for Personal Injury, Compensation for Personal Injury in New Zealand: Report of the Royal Commission of Inquiry (1967) [hereinafter Woodhouse Report].

361. *See* GASKINS, *supra* note 137, at 327–28.

362. *See id.*; Brian Easton, *The Historical Context of the Woodhouse Commission*, 2 VICTORIA U. WELLINGTON L. REV. 207, 210–11 (2003) (noting that the Woodhouse Report estimated that under the adoption of a comprehensive administrative scheme, administrative costs would drop from forty-two percent of the amount paid out in claims to eleven percent).

363. *See* GASKINS, *supra* note 137, at 328.

364. Woodhouse Report, *supra* note 361, at 40. Accidents were "'statistically necessary'" in that they were an inevitable by-product of economic activity and social progress. GASKINS, *supra* note 137, at 336–37.

365. *See id.* at 340–42.

administered by the state-run Accident Compensation Corporation ("ACC").[366] The Act generally excludes coverage for injury caused by disease.[367] This exclusion was the result of a political decision to concentrate first on the problems that accompany accident liability and workers' compensation—waste, delay, and adversarial conflict.[368] Pragmatic concerns, including a shortage of reliable data and the difficulty of forecasting costs, convinced the drafters to leave coverage for diseases to future legislation.[369]

The payable benefits include full medical costs, partial earnings-related compensation, permanent disability benefits, funeral costs, and other expenses.[370] The benefit structure is intended to enable an injured person to be absent from work without financial hardship, while also providing some financial incentive to return to work.[371]

The Act set up three separate compensation funds, each intended to be self-supporting: (1) the Earner's Compensation Fund, (2) the Motor Vehicle Compensation Fund, and (3) the Supplementary Compensation Fund.[372] The Earner's Compensation Fund was supported by levies on employers and on self-employed persons. Levy rates were based on the past accident-cost experience of the industrial group into which each employer fell.[373] The Motor Vehicle Compensation Fund was supported by levies on motor vehicle owners. Levies were based on the size, weight, and type of vehicle, with an additional levy on licensed drivers.[374] General taxation financed the Supplementary Compensation Fund, which covered injured persons outside the Earner's or Motor Vehicle schemes.[375] Although the statute authorized experience rating in the form of bonuses

366. *See* James A. Henderson, Jr., *The New Zealand Accident Compensation Reform*, 48 U. CHI. L. REV. 781, 782–85 (1981) (book review).

367. TERENCE G. ISON, ACCIDENT COMPENSATION: A COMMENTARY ON THE NEW ZEALAND SCHEME 18–19 (1980).

368. *See id.* at 20.

369. *Id.* at 20–21. *See also* Woodhouse Report, *supra* note 361, at 26 ("[T]he proposals now put forward for injury leave the way entirely open for sickness to follow whenever the relevant decision is taken.").

370. ISON, *supra* note 367, at 15.

371. *Id.* at 40.

372. D.R. Harris, *Accident Compensation in New Zealand: A Comprehensive Insurance System*, 37 MOD. L. REV. 361, 366 (1974).

373. *See* Richard S. Miller, *An Analysis and Critique of the 1992 Changes to New Zealand's Accident Compensation Scheme*, 52 MD. L. REV. 1070, 1078 (1993).

374. Harris, *supra* note 372, at 367.

375. *See id.* at 367–68.

and penalties for individual employers or penalties for poor drivers, such authority was never exercised under the original Act.[376]

As a result of pressure from employers opposed to increased levies, the system underwent significant modification in 1992 with the passage of the Accident Rehabilitation and Compensation Act ("the 1992 Act").[377] The 1992 Act reflected a philosophical shift from community responsibility to individual responsibility. The previous scheme of comprehensive, social insurance was replaced by an individual accident insurance scheme. Accordingly, the Act reduced the scope of coverage and benefits.[378] Despite contentions that the most disabled members of society should have priority,[379] the system continues to categorically exclude disease from coverage.[380]

The 1992 revisions also changed the funding mechanisms for the scheme. In response to complaints about unfairness and the failure to adjust individual levies for risk, the 1992 Act explicitly mandated experience rating for work injuries.[381] The 1992 Act also removed the obligation that employers buy nonwork-injury insurance for their employees and instead required that employees buy such insurance themselves.[382] Notwithstanding these changes, this compensation scheme has permanently supplanted the tort system for accidents in New Zealand. The scheme has survived relatively intact after three decades of analysis and revisions. As one commentator stated, "[A] return to tort seems unthinkable."[383]

2. Lessons from New Zealand

One might assert that New Zealand's experience with the Accident Compensation Act has limited applicability to the system proposed by this Article. The Act only provided coverage for accidents and deliberately

376. Miller, *supra* note 373, at 1078–79.

377. *See* Margaret Vennell, *Brief Country Reports: New Zealand*, 15 U. HAW. L. REV. 568, 568–70 (1993).

378. *See* Miller, *supra* note 373, at 1071–73; John Miller, *Trends in Personal Injury Litigation: The 1990s*, 34 VICTORIA U. WELLINGTON L. REV. 407, 408 (2003).

379. *See, e.g.*, ISON, *supra* note 367, at 21–22; Henderson, *supra* note 366, at 792–93.

380. *See* ISON, *supra* note 367, at 21; Ruth Dyson, *Summary*, 34 VICTORIA U. WELLINGTON L. REV. 465, 467 (2003).

381. *See* Miller, *supra* note 373, at 1081, 1086.

382. *Id.* at 1079.

383. Stephen Todd, *Privatization of Accident Compensation: Policy and Politics in New Zealand*, 39 WASHBURN L.J. 404, 495 (2000). *See also* Alan Clayton, *Some Reflections on the Woodhouse and ACC Legacy*, 34 VICTORIA U. WELLINGTON L. REV. 449, 458 (2003) (concluding that the scheme "has survived institutional infancy and adolescence and now provides a more mature exemplar . . . of a rational approach to personal injury compensation in the common law world").

excluded coverage for illness, including environmental illness.[384] The Act made a limited attempt to link the premiums paid by those deemed responsible to the risks they caused. Lastly, the Act was implemented in a relatively homogeneous culture with a strong commitment to social welfare.[385] Nevertheless, the New Zealand experience sheds light on replacing a tort system with an administrative compensation scheme and demonstrates the potential thereby to reduce administrative costs.

From the outset, critics attacked New Zealand's system as providing inadequate incentives for deterrence.[386] Like Japan, New Zealand focused primarily on compensation. But the flat-rate levy on privately owned automobiles and the industry-based levy on employers represented only a crude reflection of risk.[387] Until the 1992 revisions, system administrators failed to tailor such levies through differential assessments.[388] A more balanced approach attuned to compensation and deterrence goals would have addressed complaints of inequity and created incentives for deterrence. Indeed, the New Zealand experience underscores the importance of gathering data to accurately estimate the risks on which the levies are based. The perception that employers were being unfairly taxed for injuries occurring outside the employment context helped to fuel a backlash against the system. In turn, this led to the 1992 modifications.

A more fundamental shortcoming of the Act is its exclusion of disease, particularly environmental illness. Environmental illness would seem to be a prime candidate for inclusion in a compensation scheme premised on community responsibility given the disparate causes of these illnesses, the consequent difficulty of proving individual causation, and the universal vulnerability to disease-causing hazards in the environment.[389]

Like the Act, the administrative scheme proposed here is partial; it would only cover diseases caused by environmental exposure. Distinguishing between environmental injuries and accidental injuries is appropriate because the tort system is relatively adequate to address the latter. Furthermore, it may appear unfair from a compensation perspective

384. GASKINS, *supra* note 137, at 327–30.

385. *See id.*, at 326 (noting New Zealand's history of social innovation and commitment to social welfare); Richard Gaskins, *The Fate of "No-Fault" in America*, 34 VICTORIA U. WELLINGTON L. REV. 213, 215 (2003).

386. *E.g.*, Miller, *supra* note 373, at 1086–87. *Cf.* Bryce Wilkinson, *New Zealand's Failed Experiment with State Monopoly Accident Insurance*, 2 GREEN BAG 2D 45, 52 (1998) (criticizing the lack of data available to assess the Act's success at deterring accidents).

387. *See* Henderson, *supra* note 366, at 796.

388. *See* Miller, *supra* note 373, at 1086–87.

389. *See* GASKINS, *supra* note 137, at 337–39.

to distinguish between environmental injuries, for which compensation would be available, and hereditary diseases, for which no compensation would be available. The need to deter polluters, however, justifies a system that addresses the specific problem of environmental injury alone.

Finally, it is encouraging to find that the costs of administering New Zealand's accident compensation system have proven manageable.[390] Only about ten percent of the ACC's funds are expended for administrative purposes.[391] This percentage represents a significant cost benefit when contrasted with the estimated forty percent overhead cost associated with the common law and workers' compensation systems that preceded the Act.[392]

C. WORKERS' COMPENSATION IN THE UNITED STATES

Although the United States has never adopted an administrative system like Japan's,[393] the American workers' compensation system does offer a relevant point of comparison. A comprehensive assessment of workers' compensation is beyond the scope of this Article, but the brief examination below offers insight into the feasibility of an analogous administrative system for environmental toxic injury.

1. Background

The workers' compensation system was established in the United States in the early twentieth century in order to address the growing problem of employees injured on the job, who were often without

390. *See* Walter Gellhorn, *Medical Malpractice Litigation (U.S.)—Medical Mishap Compensation (N.Z.)*, 73 CORNELL L. REV. 170, 193 n.67 (1988). Although critics initially predicted that the transaction costs under the administrative system would be high, the savings have been described as "substantial" when compared to the tort system. *Id*.

391. *See id*. *See also* N.Z. House of Representatives, Annual Report of the Accident Compensation Corporation for the Year Ended 30 June 2003 108–09 (2003) (listing an accounting for the ACC's 2002–2003 fiscal year); Gellhorn, *supra* note 390, at 193 n.67 (noting that from 1983 to 1987, between eighty-nine cents and ninety-three cents of every dollar paid out actually went to injured persons); Sir Geoffrey Palmer, *"The Nineteen-Seventies": Summary for Presentation to the Accident Compensation Symposium*, 34 VICTORIA U. WELLINGTON L. REV. 239, 240 (2003) ("In recent years it has cost about 7 cents . . . to deliver a dollar in benefits."); Vennell, *supra* note 377, at 569 (claiming that ninety-four cents of every levied dollar paid out has been for compensation).

392. *See* Palmer, *supra* note 391, at 240.

393. The recent settlement agreement between the tobacco industry and the states, however, does provide an example of an ex ante approach. Under the agreement, the tobacco industry agreed to make payments to the states out of future revenues in return for protection against liability for past and future Medicaid costs. *See* Eric A. Posner, *Tobacco Regulation or Litigation?*, 70 U. CHI. L. REV. 1141, 1145 (2003). Thus, the settlement primarily spread the costs to future consumers of cigarettes rather than extracting a lump-sum damages payment from the industry. *See id.*

compensation for medical costs and lost wages.[394] Although injured employees could attempt to bring tort or contract claims against their employers, litigation was onerous and expensive.[395] Furthermore, employers often defeated workers' claims through such defenses as assumption of the risk, contributory negligence, and the fellow-servant rule.[396] Against this backdrop, the workers' compensation system was expected to benefit both employers and workers by replacing uncertain remedies with certain ones. Both sides benefited by avoiding the expenses and risks of tort litigation as injury disputes were channeled through a presumably cheaper administrative system.[397] The system was designed to provide compensation to the injured in a nonadversarial manner, without regard to fault. Employers received immunity from suit in return for paying premiums to support the system.[398]

In 2001, workers' compensation programs in the United States covered nearly 127 million workers, cost employers $63.9 billion, and paid out $49.4 billion in benefits.[399] The difference between benefits and employer payments is explained by expenses such as administrative and loss-adjustment costs, taxes, and contributions for special funds.[400] Administrative costs thus account for less than a quarter of total system costs, a figure that contrasts favorably with the share consumed by transaction costs in the tort system.[401] These figures suggest the potential cost savings of adopting a compensation system that avoids individual disputes over causation. An administrative system that provides

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394. *See* JAY E. GRENIG, WORKERS' COMPENSATION HANDBOOK 101–02 (1989).

395. *See id.*

396. *See* CARL A. AUERBACH ET AL., THE LEGAL PROCESS 401–02 (1961); GRENIG, *supra* note 394, at 101–02. The fellow-servant rule was a common law defense to an injured employee's claim based on the theory that the injury resulted from a negligent act or omission of a fellow employee. AUERBACH ET AL., *supra*, at 401–02. Between 1875 and 1910, many states abolished or modified the defenses of the fellow-servant rule and assumption of risk regarding some types of injuries. *Id.* at 404.

397. Joan T.A. Gabel, *Escalating Inefficiency in Workers' Compensation Systems: Is Federal Reform the Answer?*, 34 WAKE FOREST L. REV. 1083, 1089 (1999).

398. *See* GRENIG, *supra* note 394, at 102; JEFFREY V. NACKLEY, PRIMER ON WORKERS' COMPENSATION 7–8 (2d ed. 1989).

399. *See* CECIL THOMPSON WILLIAMS, VIRGINIA P. RENO & JOHN F. BURTON, JR., NAT'L ACAD. OF SOC. INS., WORKERS' COMPENSATION, BENEFITS, COVERAGE, AND COSTS, 2001 2 (2003).

400. *See id.* at 2–3.

401. *See supra* Section I.B.1 (noting that the transaction costs dwarf compensation paid in the tort system). *See also* Robert R. Potter & Joan T.A. Gabel, *The Emerging Bad Faith Cause of Action Takes on the Exclusive Remedy Doctrine*, 48 MERCER L. REV. 63, 79–80 (1996) (noting transaction cost advantages of workers' compensation over the tort system, particularly because workers' compensation has "less actual adjudication" and "is unfettered by expensive determinations of 'fault' or 'pain and suffering'").

compensation based on environmental toxic risk would likely offer similar cost advantages over the tort system.

Over the past two decades, employers have complained about the escalating costs of the workers' compensation system, while employees have complained of inadequate compensation.[402] Although costs stabilized in the mid-1990s,[403] with the number of claims following a downward trend, overall costs have risen dramatically in the last few years.[404] These increases may be due to rising medical costs, to attempts by insurers to compensate for having previously charged insufficient premiums, or to increased involvement of lawyers in the claims process.[405] Meanwhile, the decline in benefits has been blamed on the introduction of managed care and other cost controls.[406]

California's recent workers' compensation "crisis" illustrates many of these difficulties.[407] Historically, workers' compensation insurance rates in California were regulated under a minimum-rate law.[408] This law required insurers to charge premiums no lower than rates set by the state insurance commissioner.[409] Rates were based on analyses of data for premiums and losses, as well as on actuarial projections and were designed to include all benefit and administrative costs.[410] In 1993, however, California instituted an open-competition system in which insurers set their own rates, guided by state-developed, nonmandatory advisory rates.[411] A price war ensued—insurers attempted to increase market share at rates that eventually proved

402. *See, e.g.*, Martha T. McCluskey, *The Illusion of Efficiency in Workers' Compensation "Reform,"* 50 RUTGERS L. REV. 657, 683–703 (1998) (describing the workers' compensation "crisis" of rising costs and diminishing benefits).

403. *See* WILLIAMS ET AL., *supra* note 399, at 3 (noting that employer costs, relative to covered wages, declined from 1994 to 1998).

404. *See* Joseph B. Treaster, *Cost of Insurance for Work Injuries Soars Across U.S.*, N.Y. TIMES, June 23, 2003, at A1, *available at* 2003 WLNR 5234886 (noting that the average cost of workers' compensation insurance rose fifty percent in the previous three years nationwide, but it nearly doubled in California during the same period).

405. *Id.*

406. *See* WILLIAMS ET AL., *supra* note 399, at 39.

407. California's workers' compensation system has the highest costs, highest litigation rate, and highest medical expenses among all states. Yet California ranks in the bottom half of states in per capita benefits to workers. *See* Paul Herrera, *California Scrambles to Repair Broken Workers-Comp Insurance System*, PRESS-ENTERPRISE (Riverside, CA), Feb. 8, 2004, *available at* 2004 WLNR 12354775.

408. CAL. COMM'N ON HEALTH & SAFETY & WORKERS' COMP., STATE OF THE WORKERS' COMPENSATION INSURANCE INDUSTRY IN CALIFORNIA (2002), http://www.dir.ca.gov/chswc/StateInsuranceIndustry2002/Stateinsuranceindustry042002.html.

409. *Id.*

410. *Id.*

411. *Id.*

to be below cost.[412] Meanwhile, claim costs increased sharply due to the wide latitude given to doctors to treat claimants. Unlike most other states, California had no standard course of treatment or payout for specific injuries.[413] As a result, many carriers went out of business or abandoned the state, leaving the publicly owned state compensation-insurance fund to cover more than half of the state's employers.[414]

In 2003, California enacted legislation that restricted the number of medical visits per claimant and initiated a process to create a standardized system for treating injuries based on national medical standards.[415] In 2004, further legislation capped temporary disability payments, limited permanent disability payments to the percentage of injury incurred on the job, and incorporated an HMO-type system to provide medical care.[416]

2. Lessons from Workers' Compensation

To be sure, the historical context that led to the adoption of workers' compensation differs from that of the present proposal. Workers' compensation responded to an evident crisis, while environmental toxic injury has not been viewed as such. But as technological advances enhance our ability to recognize injury, an administrative compensation system could offer the same advantages over tort that workers' compensation does: remedy, avoidance of litigation risks and expenses, and more efficient processing of large numbers of claims.[417] Plaintiffs are already relying on evidence of common genetic variations, known as polymorphisms, to argue that they were particularly susceptible to a substance that defendants released.[418] These plaintiffs argue that they face a higher relative risk of

412. *See id.*

413. *See* Herrera, *supra* note 407. Prior to the legislation passed in 2003, California imposed no limits on the number of times a worker could see a doctor for an injury. Also, an injured employee's doctor was presumed correct in all treatment decisions. *See id.*; Roberto Ceniceros, *California's Comp Woes Illustrate Risk that Reforms Can Backfire*, BUS. INS., Oct. 20, 2003, at 10, *available at* 2003 WLNR 2223589.

414. *See* Marla Dickerson, *State Seeks 15% Cut in Costs of Workers' Comp*, L.A. TIMES, Nov. 7, 2003, at C1.

415. *See* Ceniceros, *supra* note 413; Herrera, *supra* note 407.

416. *See* Bill Ainsworth, *Work-Comp Reform Took 2 Governors 2 Long Years*, SAN DIEGO UNION-TRIB., Apr. 20, 2004, at C1, *available at* 2004 WLNR 12366189; Marc Lifsher & Don Lee, *Workers' Comp Bill Elicits Wary Optimism*, L.A. TIMES, Apr. 17, 2004, at A1.

417. *Cf.* Schroeder, *supra* note 104, at 474 (arguing that risk-averse individuals would prefer a system of risk-based liability, whereas risk-preferring individuals would prefer causation-based liability, and suggesting that the existence of insurance is evidence of risk aversion).

418. *See* Marchant, *supra* note 45, at 10,647.

exposure than the general population does.[419] Such cases hint at the potential litigation that may follow, as technological advances expand the class of potential plaintiffs. For instance, toxicogenomics may provide direct evidence of specific causation by revealing chemical-specific genetic markers of disease processes.[420] Furthermore, as gene expression assays are developed that provide reliable assessments of preclinical disease progression, exposed individuals who cannot demonstrate present injury may have stronger claims for medical monitoring.[421] As litigation risk increases, polluters may come to view administrative compensation as an attractive alternative to tort.

The present difficulties of the workers' compensation system in California nevertheless offer a cautionary lesson for the need to constrain costs in an administrative compensation system. In large part, efficiency advantages stem from the lack of individualized causation adjudications. California's workers' compensation system, however, sacrificed many of those advantages by allowing individualized courses of treatment based on subjective determinations. In turn, these led to frequent administrative disputes and litigation.[422] This suggests that the proposed environmental compensation system should strictly limit the ability of interested parties to challenge administrative risk determinations.

The problems resulting from the deregulation of California's system in the 1990s teach still another lesson. The government must play an active role in determining costs and providing actuarial information in order to reduce instability in the insurance market. Under this Article's proposal, the government would have to gather a tremendous amount of risk-related information in order to determine appropriate levy and compensation rates. This information should be made publicly available so that insurers can

419. *See id*. at 10,647 & nn.88–89 (citing Woolf v. Consol. NDE, Inc., 796 A.2d 906, 908, 912 n.1 (N.J. Super. Ct. App. Div. 2001) and Collins v. Hygenic Corp., 739 P.2d 1073, 1076–77 (Or. Ct. App. 1987)). A defendant might argue in response that a plaintiff's disease was caused by his or her genetic predisposition. *See, e.g.*, Howard v. Owens Corning, 85 Cal. Rptr. 2d 386, 395, 397 (Ct. App. 1999) (affirming a verdict in favor of the defendant asbestos manufacturer in light of evidence that respiratory illnesses are caused by factors other than asbestos, including genetic predisposition).

420. *See* Marchant, *supra* note 47, at 10,078. *See also* Bergeson et al., *supra* note 54, at 36 (predicting that courts may find toxicogenomic data to be sufficient to establish causation if it is combined with animal studies and nonepidemiological data).

421. *See* Marchant, *supra* note 47, at 10,079–80.

422. *See* STANFORD D. HERLICK, 1 CALIFORNIA WORKERS' COMPENSATION LAW § 1.19 (6th ed. 2000) (noting that the number of litigated cases filed with the California Workers' Compensation Appeals Board is steadily increasing). Against a backdrop of almost one million work-related injuries per year in California, over 100,000 petitions are filed to commence administrative proceedings and approximately 4000 reach the Appeals Board. *Id*.

consider it when setting premiums. The government must also use risk data to administer the system. Like Japan's experience with pollution compensation, the workers' compensation experience underscores the financial and political need to set levies on polluters at rates that reflect the social costs imposed by those sources.

Comparing the workers' compensation system with the proposal made here reveals a key difference, one that should help the proposed system avoid some difficulties associated with workers' compensation: under the proposal, individuals could use compensation proceeds to purchase insurance from the existing health insurance system. In contrast to workers' compensation, there would be no need for a separate insurance system with its own administrative apparatus and complex rules.

Finally, it should be remembered that despite the frequent criticisms of the workers' compensation system, there are no serious proposals to reverse course and return to tort. In short, there seems to be a solid consensus that workers' compensation has been more effective than the tort system at achieving deterrence and compensation goals.[423]

D. THE UNITED STATES' BLACK LUNG PROGRAM

Workers' compensation is not the only relevant domestic experience with administrative systems; the Federal Black Lung Program is also instructive. That program's history underscores the need for a well-defined mission and warns that expansionary pressures can undermine the financial viability of an administrative compensation scheme.

Congress established the Black Lung Program in 1969 to compensate an estimated 100,000 retired coal miners for certain respiratory diseases associated with exposure to coal dust.[424] The program was the federal government's first direct policy intervention in the field of workers' compensation, which had historically been the domain of the states.[425] Under the program, workers were presumed to be disabled if they had worked in a coal mine for at least ten years and had medical evidence of the

423. *See generally* Michael J. Moore & W. Kip Viscusi, *Promoting Safety Through Workers' Compensation: The Efficacy and Net Wage Costs of Injury Insurance*, 20 RAND J. ECON. 499, 499 (1989) (finding that the safety incentive of experience-rated premiums outweighs the moral hazard of less careful worker behavior, resulting in twenty-percent fewer fatalities than in the absence of workers' compensation).

424. Robert E. Litan, Peter Swire & Clifford Winston, *The U.S. Liability System: Background and Trends*, *in* LIABILITY: PERSPECTIVES AND POLICY, *supra* note 17, at 1, 14.

425. PETER S. BARTH, THE TRAGEDY OF BLACK LUNG: FEDERAL COMPENSATION FOR OCCUPATIONAL DISEASE 3, 275 (1987).

disease.[426] Beneficiaries received an annuity that was not tied to wages.[427] General revenues, and later a general tax on the coal industry, funded the program.[428] But this funding scheme failed to provide incentives for safer coal mining operations. During the 1970s, Congress repeatedly broadened the eligibility criteria. Congress added presumptions of eligibility and disability and drastically expanded the class of beneficiaries to include spouses and dependents.[429] These changes significantly increased the program's cost and triggered harsh criticism that led to the program's subsequent redesign.[430] Ultimately, the program's cost discouraged any efforts to have the federal government otherwise play a major role in workers' compensation.[431]

The controversy surrounding the program largely stems from disagreements concerning its mission.[432] Some conceived of it as a way to compensate injured workers. Others viewed it as a means of providing pensions to coal miners, regardless of injury. Still others saw the program as a vehicle for funneling federal money to economically depressed coal mining communities.[433] Because the Black Lung Program had broad, varying purposes that it could only partially fulfill, even its proponents were dissatisfied. Still, the program's failings should not be attributed to administrative compensation schemes in general. A properly designed system can be fiscally sound if the system remains faithful to its goals—internalizing costs, deterring polluters, and compensating victims.

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426. W. Kip Viscusi, *Liability for Occupational Accidents and Illnesses*, *in* LIABILITY: PERSPECTIVES AND POLICY, *supra* note 17, at 155, 180.

427. *Id.* at 180.

428. *Id.* at 180–81.

429. Litan et al., *supra* note 424, at 14 (noting that 542,000 miners, spouses, and dependents had received benefits under the program by 1981). *See also* GASKINS, *supra* note 137, at 270 (discussing the program's expansion); Allen R. Prunty & Mark E. Solomons, *The Federal Black Lung Program: Its Evolution and Current Issues*, 91 W. VA. L. REV. 665, 666 (1989) (estimating the program as having covered over one million claims at a cost of thirty billion dollars as of 1989).

430. *See* GASKINS, *supra* note 137, at 270–71; Brian C. Murchison, *Due Process, Black Lung, and the Shaping of Administrative Justice*, 54 ADMIN. L. REV. 1025, 1048 (2002) (noting that, by the mid-1990s, approval rates for claims had dropped to below ten percent); Peter H. Schuck, *Mass Torts: An Institutional Evolutionist Perspective*, 80 CORNELL L. REV. 941, 969 (1995).

431. *See* BARTH, *supra* note 425, at 284.

432. *Id.* at 278–79 (noting that disagreements over the program's vague purpose alienated supporters of a moderate program and confused the implementing agencies); Prunty & Solomons, *supra* note 429, at 667–68.

433. *See* Prunty & Solomons, *supra* note 429, at 668–69. One commentator described the program as "the epitome of political manipulation of the pork barrel process, under the guise of operating a workers' compensation scheme." BARTH, *supra* note 425, at 128.

V. POSSIBLE OBJECTIONS TO THE PROPOSAL

Parts II through IV of this Article constructed a case that an administrative compensation scheme is possible, feasible, and attractive. Nevertheless, creating an administrative compensation scheme to address environmental toxic injuries will not be technically or politically easy. A number of questions immediately come to mind: Will the tort system also reap the benefits of the technological advances discussed above? Could the tort system be modified to address the problems inherent in environmental toxic injury cases? Why consider the proposed system now, if science and technology are not yet able to support implementing it? How can the necessary information be gathered? How will any associated uncertainty be addressed? Will the proposal's informational needs threaten personal privacy? This part addresses these questions.

A. WHY NOT STICK WITH THE TORT SYSTEM?

Environmental toxic tort plaintiffs will likewise benefit from better evidence of general and specific causation.[434] For example, enhanced tracking technologies and improved environmental forensic techniques may establish the causal link between an exposure to a harmful substance and the particular source of that substance. These advances may establish that such exposures leave unique gene expression fingerprints on the victim.

Even if society had knowledge of every significant health effect of every major pollutant, the tort system would not fully compensate environmental tort plaintiffs. First, tort claims arise only when victims suffer harm. Therefore, problems associated with latency, such as insolvent defendants, faded memories, and lost or degraded evidence, will persist. Second, many potential tort plaintiffs will still face significant, even insurmountable, obstacles in proving specific causation. This is due to several factors: epidemiological limitations, difficulties handling probabilistic evidence, and requirements that both general and specific causation be proved by a preponderance of the evidence.

As noted earlier, epidemiological studies describe only the excess risk from exposure to a substance; they do not pinpoint the actual source of disease in an individual case.[435] Thus, where an environmental illness may

434. *See generally* Bergeson et al., *supra* note 54, at 35–36 (explaining how toxicogenomic data may facilitate establishing causation in toxic tort cases); Marchant, *supra* note 47, at 10,074–80 (describing the potential implications of toxicogenomics on toxic torts).

435. Rosenberg, *supra* note 23, at 857; *supra* Section I.A.2.b.

be caused by multiple sources, epidemiology cannot demonstrate that exposure to a particular defendant's pollutants was the "but for" cause of the illness.[436] For instance, a lung cancer victim may be unable to establish that the illness was caused by exposure to airborne carcinogens rather than smoking. Toxicogenomics offers the potential to identify chemical-specific genetic markers of disease processes.[437] Even with this data, however, specific causation issues will bar recovery if there are multiple potential sources of a disease-causing chemical. This would likely occur in a significant number of cases. Given that regulations ban or limit the use of the most noxious chemicals, many environmental toxic tort injuries will likely involve low-level, long-term exposures to chemicals generated by multiple sources.[438]

Furthermore, a greater scientific understanding of causal relationships will not necessarily resolve the difficulties of environmental tort plaintiffs. The probabilistic nature of scientific evidence will hamper recovering in tort.[439] Even if courts become more receptive to probabilistic evidence,[440] plaintiffs may be unable to prove causation by a preponderance of the evidence. For example, plaintiffs would be unable to meet their burden whenever the added tortious risk is less than the background cumulative risk attributable to all other factors.[441] Because most low-level exposures to toxic substances do not double the plaintiff's risk,[442] many environmental tort victims will continue to be uncompensated, regardless of whether scientific research unearths significant relationships between chemical exposure and harm.[443] The doubling of the risk threshold adopted by the tort system is not a necessary or particularly logical one.[444] Compensation,

436. *See* Brennan, *supra* note 48, at 499 (explaining that the probabilistic evidence provided by toxicology and epidemiology cannot produce mechanistic causal chains that link individual events to individual injuries); Rosenberg, *supra* note 23, at 869 ("The short answer to the demand for 'particularistic' evidence of causation in mass exposure cases is that no such evidence can be produced.").

437. Marchant, *supra* note 47, at 10,078.

438. *See supra* note 133 and accompanying text.

439. *See supra* Section I.A.2.c.

440. Courts increasingly have allowed litigants to rely on epidemiological or statistical proof in establishing causation. *See* Gold, *supra* note 34, at 377 & n.7.

441. *See* Rosenberg, *supra* note 23, at 857–58; *supra* notes 45–47 and accompanying text.

442. *See* Marchant, *supra* note 47, at 10,077.

443. *See* GASKINS, *supra* note 137, at 67 ("[E]pidemiology over the long term may simply compound our economic ignorance by continuing to discover significant but weak correlations across a growing range of activities. . . . We know just enough to suspect the existence of widespread social costs, but not enough to weave them securely into the market fabric.").

444. *See supra* note 46.

deterrence, and fairness goals all argue for a lower threshold, which the proposed administrative system endorses.

Finally, given the widespread exposure to chemical substances, the number of potential tort claims could overburden the courts. This would be particularly true if the tort system were to adopt a lowered compensable risk threshold. As more data on causation becomes available, more tort claims may become viable.[445] These cases will involve complex issues that can be resolved only through extended proceedings involving numerous expert witnesses.[446] As discussed in the next section, class actions and other modifications to the tort system would provide only limited relief.

B. WHY NOT MODIFY THE TORT SYSTEM?

Commentators have proposed variations of the basic tort action to address the difficulties that environmental toxic tort victims face. These proposals include imposing liability for risk of harm, imposing proportional liability, and certifying class actions. These proposals may improve on the current system, but they will nevertheless fall short in satisfying deterrence, compensation, and corrective justice goals.

1. Liability for Risk of Harm

Imposing tort liability on the creation of the risk of harm, rather than on the manifestation of harm, would address some of the latency problems associated with the traditional tort approach.[447] Risk-based liability would take advantage of evidence while it is still fresh.[448] In some instances, it

445. *See* Grodsky, *supra* note 165, at 267 (predicting, in light of new scientific possibilities, a rise in tort claims if the regulatory system does not account for newly identified health risks).

446. *See* Rosenberg, *supra* note 23, at 900.

447. *E.g.*, Klein, *supra* note 291, at 1194–96 (proposing that tort claims be allowed based on enhanced risk recovery, but only where toxic exposure has more than doubled the risk of harm); William M. Landes & Richard A. Posner, *Tort Law as a Regulatory Regime for Catastrophic Personal Injuries*, 13 J. LEGAL STUD. 417, 428–30 (1984) (suggesting that persons be compensated with expected damages when they are exposed to a harmful substance, but that the compensation be adjusted for the probability of suffering those damages); Robinson, *supra* note 16, at 781–83; Love, *supra* note 81, at 796 (arguing that recognizing a cause of action for the increased risk of illness from exposure to a toxic substance would overcome various barriers in traditional tort law). Courts have recognized premanifestation claims in the following contexts: invasion of mental well-being based on fear of disease, medical monitoring to detect the onset of a disease, and enhanced risk per se. *See* Klein, *supra* note 291, at 1175. Enhanced-risk plaintiffs, however, must generally demonstrate both the existence of some present injury due to the toxic exposure and the likelihood that they will develop the disease for which the exposure has increased their risk. *Id.* at 1179.

448. *Cf.* Robinson, *supra* note 16, at 783–84 (positing that the complexity of assigning causal responsibility is proportional to the elapsed time between the exposure and its causal determination).

would allow proactive steps to prevent or ameliorate the threatened injury. Furthermore, immediately confronting industry with the full social cost of its activities would promote more effective deterrence.[449]

The costs to construct and administer a tort system that addresses risk-based liability, however, may be even greater as a percentage of total costs than are the already high costs of the current tort system.[450] Risk-based claims likely would involve smaller damage awards than those based on harm, while administrative costs may not decrease in proportion. Exposed individuals who face relatively small increased risks and who do not currently manifest physical harm may not bother to file suit.[451] This would be especially true if the expected monetary and psychological costs of litigation exceed the likely modest recovery. To the extent that plaintiffs do make claims based on increased risk, the burdens on the judicial system would increase.[452]

2. Proportional Liability

Under a proportional liability scheme that used probabilistic causation evidence, plaintiffs would recover in proportion to the probability that they were harmed by the defendant.[453] Proportional liability could apply after

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Gene expression data is an example of fairly objective evidence of future risk. *See* Marchant, *supra* note 47, at 10,079.

449. *See* Robinson, *supra* note 16, at 784–85. *See also* Guido Calabresi, *Concerning Cause and the Law of Torts: An Essay for Harry Kalven, Jr.*, 43 U. CHI. L. REV. 69, 79 (1975) ("If specific deterrence were the only goal of tort law, collectively proscribed behavior would be penalized regardless of whether in a specific instance it was a *but for* cause of harm.").

450. *See* Robinson, *supra* note 16, at 796–97 (noting the high administrative costs of the tort system and suggesting that the ratio of administrative costs to compensation paid would not change in a risk-based tort compensation system).

451. *See* Farber, *supra* note 28, at 1256. In addition, settlements may be more difficult to achieve because of the disagreements over the exact magnitude of liability. *See* Brinker, *supra* note 33, at 1320.

452. *See* John C.P. Goldberg & Benjamin C. Zipursky, *Unrealized Torts*, 88 VA. L. REV. 1625, 1652–53 (2002); Klein, *supra* note 291, at 1194 (stating that proportional liability for increased risk "would allow millions of Americans to bring multiple enhanced risk tort actions").

453. Farber, *supra* note 28, at 1238. *See, e.g.*, AM. LAW INST., *supra* note 67, at 369–75 (describing the proposal for proportional recovery where between twenty percent and eighty percent of disease is attributable to particular exposure); Richard Delgado, *Beyond* Sindell*: Relaxation of Cause-in-Fact Rules for Indeterminate Plaintiffs*, 70 CAL. L. REV. 881, 899–902 (1982) (proposing a combination of proportionate recovery and burden shifting in "reverse *Sindell*" situations where a defendant has caused less than a fifty-percent increased incidence of harm); John Makdisi, *Proportional Liability: A Comprehensive Rule to Apportion Tort Damages Based on Probability*, 67 N.C. L. REV. 1063, 1063 (1989) (arguing for replacing causation with a probable causation-in-fact requirement in all tort cases and that damages be allocated in proportion to the probability of causation).

the harm has occurred, or it could be combined with risk-based liability to compensate for decreases in life expectancy.[454]

A tort system that incorporated proportional liability would be superior to the current tort system in achieving deterrence. In theory, polluters would have an incentive to act with optimal care. Polluters would be required to pay plaintiffs as a class for the full amount of injury caused by the chemicals that they released.[455] In practice, however, proportional liability, like risk-based liability, is likely to be plagued by high transaction costs. For environmental toxic injuries, where risks tend to be diffuse,[456] an action based on proportional liability often would not be worth the trouble.[457]

3. Shifting the Burden of Proving Causation

Another possible modification to the tort system would place the burden of disproving causation on defendants.[458] This approach would require a plaintiff to establish only: (1) an injury that might be attributed to exposure to a substance generated by the defendant, and (2) inadequate testing or warnings by the defendant.[459] At that point, the burden would shift to the defendant to prove either that the injury could not have been caused by exposure to the substance or that it was caused by exposure to another substance.[460] Such a scheme would create an incentive for industry to do more research on the health effects of its products and by-products.

This burden-shifting, however, might also shift the fundamental bias of the tort system. As one critic noted, "[E]xposure to *any* substance would be the basis for liability in a toxic tort case unless the firm that is

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454. *See* Farber, *supra* note 28, at 1238–39.

455. *Id.* at 1239; Rosenberg, *supra* note 23, at 866, 881.

456. *See* Shavell, *supra* note 152, at 363, 370.

457. One variant of the proportional liability scheme, known as the most likely victim approach, would pay full damages to the victims who can demonstrate the highest probability that their injuries were caused by the defendant. *See* Farber, *supra* note 28, at 1247–48. The advantage of this approach is that it can account for varying degrees of increased risk among those exposed. Thus, it maximizes the odds that the compensation paid by the defendant will go to those individuals whose injuries were actually caused by the defendant. *See id.*

458. Margaret Berger, for example, has advocated such an approach in the context of product liability cases. *See* Margaret A. Berger, *Eliminating General Causation: Notes Towards a New Theory of Justice and Toxic Torts*, 97 COLUM. L. REV. 2117 (1997). *See also* Delgado, *supra* note 453, at 899–902 (proposing that the burden of causation be reversed and that the defendant be required to prove noncausation in indeterminate plaintiff cases where the plaintiff shows that the defendant has caused a known number of injuries to a class).

459. *See* Berger, *supra* note 458, at 2143–44.

460. *See id.* at 2144–45.

responsible for the exposure could prove that it engaged in adequate premarket testing."[461] Unless there was a cap on damage awards,[462] overdeterrence might replace underdeterrence, and overcompensation might replace undercompensation.[463]

4. Class Actions

Perhaps the most viable tort alternative would be one that aggregated claims through class actions. Class actions can reduce judicial burdens, increase the efficiency of litigation, and offer a greater overall payoff to the injured.[464] In offering the benefits of cost-spreading and economies of scale, class treatment increases the optimal investment that parties and courts can spend to develop and analyze the merits of a case.[465]

But class actions have been sharply criticized. The criticisms include charges that some actions are frivolous, that some enrich attorneys rather than benefit plaintiffs, and that some result in unfair or improper settlements.[466] The incentive problems in class actions may be especially great in cases involving mass tort litigation, considering the multiplicity of parties and the potentially high financial stakes.[467]

461. Pierce, *supra* note 35, at 1317.

462. Possible options suggested by Berger for limiting damages include damage scheduling and the release of defendants from liability for pain and suffering. *See* Berger, *supra* note 458, at 2145.

463. For defendants who had met the standard of care for developing and disseminating information relevant to risk, Berger's proposal would relieve defendants of liability for injuries caused by exposure to their products. *See id.* at 2143, 2148.

464. *Cf.* John B. Oakley, *Introduction*: *Summing Up Procedural Justice: Exploring the Tension Between Collective Processes and Individual Rights in the Context of Settlement and Litigating Classes*, 30 U.C. DAVIS L. REV. 787, 788 (1997) (noting that class actions seek to address the Federal Rules of Civil Procedure's unresolved tension between individual rights and social efficiency).

465. Rosenberg, *supra* note 23, at 910–11; David Rosenberg, *Decoupling Deterrence and Compensation Functions in Mass Tort Class Actions for Future Loss*, 88 VA. L. REV. 1871, 1901–03 (2002).

466. *See, e.g.*, DEBORAH R. HENSLER ET AL., CLASS ACTION DILEMMAS: PURSUING PUBLIC GOALS FOR PRIVATE GAIN 3–7 (2000); John C. Coffee, Jr., *Understanding the Plaintiff's Attorney: The Implications of Economic Theory for Private Enforcement of Law Through Class and Derivative Actions*, 86 COLUM. L. REV. 669, 671–72 (1986) (noting that parties to class actions do not bear the full costs of litigation and that plaintiffs may sue primarily to extort recovery from defendants); Rabin, *Continuing Tensions*, *supra* note 15, at 1042–43 (noting the danger that class action settlements may result in the compromising of future claimants or other forms of discrimination against certain classes of stakeholders); Martin H. Redish, *Class Actions and the Democratic Difficulty: Rethinking the Intersection of Private Litigation and Public Goals*, 2003 U. CHI. LEGAL F. 71, 77–78 (arguing that "faux" class actions driven by "bounty hunter" attorneys eliminate compensatory aspects of substantive law without democratic process).

467. *See* HENSLER ET AL., *supra* note 466, at 6–7.

Environmental injury cases are not well-suited for class action status because such cases involve individuals with varying levels of exposure, severity, and timing, as well as disparate issues of comparative fault or assumption of risk.[468] Of course, the requirements of class action certification can be changed to address some of these concerns. For instance, David Rosenberg has proposed that all potential claims arising out of a particular incident be consolidated into a single class action.[469] Common questions would first be addressed to determine aggregate liability and damages.[470] To take full advantage of the economies of scale, participation would be mandatory. Actions would be predicated on claims of tortious risk, rather than on claims of actual harm.[471] Epidemiological data, statistical sampling, modeling, and extrapolation would be used to impose liability for expected aggregate harm, which would promote optimal deterrence.[472] Subsequent class litigation could then determine compensation to individual victims, with distributions made according to the relative severity of loss rather than the relative strength of legal claim.[473] Rosenberg contends that such a compensation scheme promotes optimal insurance despite sacrificing some corrective justice aims.[474]

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468. As the advisory committee's note to the 1966 Amendment to Federal Rule of Civil Procedure 23(b)(3) explains:

> A 'mass accident' resulting in injuries to numerous persons is ordinarily not appropriate for a class action because of the likelihood that significant questions, not only of damages but of liability and defenses of liability, would be present, affecting the individuals in different ways. In these circumstances an action conducted nominally as a class action would degenerate in practice into multiple lawsuits separately tried.

FED. R. CIV. P. 23(b)(3) advisory committee's note. *See also* DEWEES ET AL., *supra* note 12, at 275; Goldberg & Zipursky, *supra* note 452, at 1703 (noting that the courts of appeals and the Supreme Court have disfavored the use of Rule 23(b)(3) for mass tort class actions); Rosenberg, *supra* note 23, at 920 ("[W]hen disease claims arise over several decades, it will be impossible to convene a plaintiff class comprising all the disease victims."); D. Alan Rudlin & Christopher R. Graham, *Toxic Torts: A Primer*, 17 NAT. RESOURCES & ENV'T 210, 212 (2003) (noting that the modern trend is to deny class certification because individual issues predominate over the issues that are common to the class). *But see* AM. LAW INST., *supra* note 67, at 360 (suggesting that "[b]ecause evidence of causation [in environmental toxic injury cases] is likely to be group-based, procedure should be group-based as well").

469. *See* Rosenberg, *supra* note 465, at 1875–76.

470. *Id.* at 1875–77.

471. *See id.* at 1875, 1900–01. *Cf.* Glenn Shafer, *Causality and Responsibility*, 22 CARDOZO L. REV. 1811, 1833–34 (2001) (advocating that toxic tort claims be based on probabilistic increases in risk and that they be handled as class actions rather than as individual suits because of the impossibility of demonstrating probabilities as "certifiably causal").

472. Rosenberg, *supra* note 465, at 1876, 1893.

473. *See id.* at 1875. To address the distributional problems posed by mass tort bankruptcies—where future claimants tend to receive less compensation than existing claimants—Thomas Smith has proposed a "capital markets" approach. Under this approach, each successful tort claimant would receive shares in a trust fund instead of damages. *See* Thomas A. Smith, *A Capital Markets Approach to Mass Tort Bankruptcy*, 104 YALE L.J. 367, 397 (1994). Each share, which would be tradable, would

Rosenberg's proposal offers deterrence and efficiency benefits over individual tort litigation by avoiding questions of specific causation. Indeed, his proposal resembles the present proposal by predicating liability on risk in collective cases.[475] Rosenberg's proposal, however, is better suited for mass torts arising out of a single incident. In those cases, a claimant class has common issues that can be readily defined.[476] For diffuse environmental risks, however, the efficiency benefits are less apparent. There are fewer common issues, and disputes will arise regarding who belongs in the class. Also, low-level polluters will likely escape liability because of the transaction costs involved to litigate a class action claim.[477]

C. WHY NOW?

One might wonder whether it is premature to consider an administrative alternative to tort, given our limited understanding of toxicity and causation. Although current knowledge and technology are insufficient to permit immediate implementation, there are several reasons to seriously consider this risk-based proposal now.

First, enough information exists to begin implementing the scheme for a limited number of substances whose effects are well-documented and whose primary sources can be readily identified. A partial implementation pilot project would be a first step in addressing the undercompensation and underdeterrence that is endemic to toxic injuries. A pilot program would also provide valuable experience to aid designing a more comprehensive system. As discussed above, the EPA's IRIS database and ATSDR's

entitle the holder to a fraction of the trust fund at its dissolution date. Share price prior to dissolution would depend on the assessment of the capital markets of the total expected magnitude of liability. *See id.* at 398–99.

474. *See* Rosenberg, *supra* note 465, at 1876.

475. Rosenberg's proposal is essentially a hybrid between traditional tort litigation and an administrative compensation scheme. Mass tort class settlements, such as those arising out of asbestos and silicone breast implant litigation, often involve the creation of a private administrative system that pays compensation according to a preestablished grid. Nagareda, *supra* note 78, at 751.

476. *See* Brennan, *supra* note 3, at 46 (noting that the tort system operates most efficiently with environmental tort cases in which pollution is concentrated and originates from a small number of sources); Fisher, *supra* note 245, at 156 (discussing the Three Mile Island class action litigation).

477. *See* Brennan, *supra* note 48, at 522 & n.269 (contending that class action litigation is likely to be "an especially unwieldy method" of compiling a group of victims exposed to air or water pollution). Judging from past experience with mass tort litigation, disputes and delays are likely to characterize even class action claims. *See* Rabin, *Some Thoughts*, *supra* note 15, at 978–79. *See also* DEWEES ET AL., *supra* note 12, at 289 (contending that mandatory class action lawsuits may facilitate the efficient resolution of some lawsuits, but "seem[] unlikely to bring before the courts many cases that would not otherwise be brought").

toxicological profiles offer starting points for identifying substances to be covered.[478] These databases suggest the benefits of a centralized effort to collect, analyze, and disseminate scientific research on causation and toxicology.[479]

Second, an immediate consideration of the proposal would lay the technical groundwork and build institutional capacity for future implementation, even if the proposal is not implemented immediately. The information required by the proposal can be used to prioritize research in toxicogenomics and other fields.[480] Such prioritization is particularly necessary, given the disincentives for private toxicity testing.[481] For instance, initial efforts might focus on quantifying with greater precision the health risks attributable to widely distributed pollutants such as nitrogen oxides or sulfur dioxide.[482]

Third, and perhaps most important, serious discussion of the proposal now may help to lay the political foundation for implementation.[483] The proposal will require many pollution sources to internalize certain costs for the first time. Consideration of the proposal will enable sources to anticipate these costs and search for ways to minimize them through

478. *See supra* Section III.B.3.

479. *See* Brennan, *supra* note 48, at 524 & n.274.

480. This function could be performed through ATSDR, which currently reviews the adequacy of information on the health effects of each hazardous substance on its priority list and identifies future data needs. *See* 42 U.S.C. § 9604(i)(5) (2000).

481. *See* Wendy E. Wagner, *Congress, Science, and Environmental Policy*, 1999 U. ILL. L. REV. 181, 217 (arguing that the resolution of scientific uncertainties that plague environmental problems may require focused legal attention because the private sector is disinclined to gather this information voluntarily).

482. *See, e.g.*, AGENCY FOR TOXIC SUBSTANCES & DISEASE REGISTRY, TOXICOLOGICAL PROFILE FOR SULFUR DIOXIDE 97–99 (1998), http://www.atsdr.cdc.gov/toxprofiles/tp116.pdf (noting the lack of data regarding the inhalation risks of intermediate or chronic duration exposures to sulfur dioxide).

483. The proposed regulation of carbon dioxide emissions via emissions trading illustrates how a broad proposal may gain political acceptability over time. When it was first proposed, emissions trading did not receive a favorable response generally or as a solution to global warming. *See* John J. Fialka, *An Environment-Business Global-Warming Link*, WALL ST. J., Nov. 22, 2000, at A2. The mechanism nevertheless became the heart of the Kyoto Protocol—an international treaty for reducing carbon dioxide emissions that took effect in February of 2005. *See id.*; Mark Landler, *Mixed Feelings as Kyoto Pact Takes Effect*, N.Y. TIMES, Feb. 16, 2005, at C1, *available at* 2005 WLNR 2175085. The United States has declined to join the Kyoto Protocol, and serious questions remain regarding how much credit should be given for investing in projects that absorb carbon dioxide from the atmosphere. Some United States companies, however, are now participating in voluntary programs that reduce carbon dioxide emissions in anticipation of the eventual regulation of those emissions. Likewise, United States companies are now trading carbon dioxide credits. *See* Jeffrey Ball, *Knotty Question: If an Oak Eats CO2 in a Forest, Who Gets Emissions Credit?*, WALL ST. J., Dec. 10, 2003, at A1; Barnaby J. Feder, *Some Businesses Take Initiative to Voluntarily Reduce Emissions*, N.Y. TIMES, Dec. 1, 2003, at C9, *available at* 2003 WLNR 5644740; Landler, *supra*, at C1.

pollution controls or other measures. Furthermore, adoption of the proposal may be politically easier when interested parties face a veil of ignorance—because of scientific uncertainty, the relative burdens of the program within any industry are relatively undetermined. If the chemicals that polluters release are fairly benign, as industry sometimes asserts, then polluters should be willing to accept a system that internalizes health costs when health effects are better understood. On the other hand, if the chemicals turn out not to be benign, polluters may benefit from a system that could reduce their exposure to uncertain and potentially sizeable judgments.

In the meantime, the proposal can serve as a basis for criticizing and improving the current system by establishing a normative framework for regulation. At present, it is generally accepted that environmental tort victims have no recourse when their illnesses are due to "general" air pollution. The administrative compensation system proposed here underscores the tort system's inadequacy in dealing with injuries arising from exposure to commonly released substances.

D. WILL WE HAVE THE NECESSARY DATA?

As Part II stressed, the proposed system presumes the existence of significant quantities of data regarding exposure and associated health risks. This section explores whether sufficient incentives exist to generate this data and whether the resulting data will be of adequate quality.

1. Incentives

Risk-based liability proposals have been criticized for creating insufficient incentives to fund and perform scientific research on potentially toxic chemicals.[484] For obvious reasons, investment in environmental and health effects tends to lag behind investment in research that increases the value of private goods.[485] Indeed, rational-choice theory

484. *See, e.g.*, Leslie, *supra* note 38, at 1851. Melanie Leslie has expressed concern that research efforts would be stymied if even a slight increase in risk would trigger liability. *Id.* Such concerns can be ameliorated, however, by setting a minimum threshold for risk, below which there would be no liability.

485. *See* Carol M. Rose, *Scientific Innovation and Environmental Protection: Some Ethical Considerations*, 32 ENVTL. L. 755, 761–63, 763 n.33 (2002) (discussing examples of PCBs, dichloro-diphenyl-trichloroethane, and chlorofluorocarbons, all of which gained widespread use prior to research discovering their detrimental effects on human health and the environment). *See also* Golanski, *supra* note 47, at 500–01 ("Whereas levels of research about commercial products and their components may be directly sensitive to the manufacturer's particularized corporate interests, research into medical conditions and causal factors ordinarily flows from a different and more diffuse political dynamic that exists within the medical and scientific communities.").

predicts that if polluters are going to invest in research at all, they will dedicate resources to producing exculpatory evidence and concealing and contesting incriminating information.[486] Although tort liability theoretically creates incentives to learn about potential harms, the specter of liability is often too remote to motivate research.[487] Nevertheless, as society develops more information on the toxicity of common pollutants, the administrative system proposed here will become an increasingly attractive alternative to the tort system.

The prospect of avoiding future tort litigation creates some incentive to perform research. The attendant and unpredictable risks of substantial tort judgments also create an incentive for pollution injuries to be resolved within the proposed administrative system.[488] This would particularly be the case with substances for which there is growing evidence of toxicity that has not yet risen to the level of firm proof. In these cases, a polluter faces a significant but not readily predictable risk of potential tort liability. The risk of punitive damages exists as well, which might become excessive if imposed in multiple cases.[489] For polluters, an administrative compensation scheme could serve as a form of pollution liability insurance—a type of insurance that has otherwise become unavailable because of the uncertainty surrounding liability.[490] Admittedly, the fear of tort liability will not create a sufficient incentive for research in all cases in

486. *See* Wendy E. Wagner, *Commons Ignorance: The Failure of Environmental Law to Produce Needed Information on Health and the Environment*, 53 DUKE L.J. 1619, 1622, 1631–59 (2004).

487. *See* Cranor & Eastmond, *supra* note 2, at 46 ("The present causation element required of tort liability (together with substantial ignorance about toxic substances) creates a barrier to recovery in torts and 'creates incentives on the part of corporations not to know and not to disclose.'"); Rose, *supra* note 485, at 765 (noting that "manufacturers are unlikely to bother learning about . . . harmful side effects in any systematic way"); Shavell, *supra* note 152, at 360 (noting that the amount of research on chemical substances under the tort liability regime is likely to be suboptimal because the information yielded is a public good); Wagner, *supra* note 486, at 1637; Wendy E. Wagner, *Choosing Ignorance in the Manufacture of Toxic Products*, 82 CORNELL L. REV. 773, 792–94 (1997) (noting that the tort system offers manufacturers "practical immunity for remaining ignorant about the latent hazards of their products and byproducts").

488. *See* Brennan, *supra* note 48, at 476 (contending that inconsistent tort verdicts disrupt long-term corporate planning and reduce availability of insurance); Kaplow & Shavell, *supra* note 12, at 752 (advocating the use of pollution taxes rather than ex post liability and noting that the magnitude of taxes would be "lower, perhaps much lower, than the magnitude of possible liability").

489. *Cf.* Nagareda, *supra* note 78, at 757 (arguing that those class action plaintiffs who forgo seeking punitive damages provide a premium to defendants that protects against the risk of excessive punishment through duplicative punitive damages over time).

490. *See* Huber, *supra* note 17, at 146.

which it is warranted. Government intervention and funding would likely be necessary to set priorities and fill gaps in remaining research.[491]

The risks of liability for polluters are nonetheless quite real, as two examples suggest. First, the litigation brought by the states in the 1990s against the tobacco industry resulted in settlements worth an estimated $240 billion.[492] The underlying theories of legal liability included claims for reimbursement of tobacco-related health care costs, fraud, and conspiracy.[493] Even though many of these theories have been described as "implausible," the tobacco industry apparently concluded that its litigation risks were significant.[494] It would not require a considerable stretch of the imagination to apply analogous theories to pollution. Indeed, in the second example, eight states and New York City recently sued five utility companies under a public nuisance theory.[495] The plaintiffs sued to compel reductions in carbon dioxide emissions contributing to global warming.[496] Although the suit seeks no damages and has yet to be resolved,[497] it foreshadows the claims that polluters may someday face.[498]

2. Information Quality

Considerable costs will be involved in producing the research necessary to support the proposed system. Nevertheless, whatever data does become available will be associated with some uncertainty.[499] As the Supreme Court has stated, "Scientific conclusions are subject to perpetual

491. *Cf.* Wagner, *supra* note 486, at 1744 (arguing that "most basic research used for regulation . . . should be performed by disinterested government or federally funded academic scientists not influenced by sponsors or financial incentives" and proposing that polluters and others responsible for creating these research needs be taxed to pay for a portion of this research).

492. Hanoch Dagan & James J. White, *Governments, Citizens, and Injurious Industries*, 75 N.Y.U. L. REV. 354, 373 (2000).

493. *Id.* at 363.

494. *See* Posner, *supra* note 393, at 1143.

495. *See* Complaint, Connecticut v. Am. Elec. Power Co., No. 1:04-CV-05670 (S.D.N.Y. 2004).

496. *Id.*

497. The district court recently held the asserted claims to be nonjusticiable political questions. *See* Connecticut v. Am. Elec. Power Co., No. 04 Civ. 5669 (S.D.N.Y. Sept. 22, 2005). The plaintiffs have indicated they plan to appeal the ruling.

498. *See* Joan Lowy, *New Business Climate: Corporations Starting to See Need for Action on Global Warming*, THE RECORD, May 8, 2005, at O1 (noting the rising concern among energy companies regarding vulnerability to lawsuits seeking compensation for damage caused by climate change).

499. *See, e.g.*, Koop & Tole, *supra* note 133, at 30 (questioning the use of point estimates to calculate the health effects of air pollution and to establish air pollution standards, given the size of the standard deviations for pollution-mortality impacts when the uncertainty of the statistical models is considered).

revision."[500] Subsequent research may characterize risks more accurately or discover previously unknown impacts on health.[501] Although the compensation system would ideally reflect the full complexities of an exposure, the available data may not account for such factors as the synergistic effects from exposure to multiple substances, or the full range of individual sensitivities among members of the exposed population.[502]

These formidable information barriers are not insuperable. New scientific techniques will rapidly and economically yield much of the desired information.[503] Research into the effects of exposure to chemical substances is likely to be done anyway, at least for common pollutants. The adoption of a regulatory administrative system would simply channel that research. Nevertheless, any resulting data will inevitably be subject to some uncertainty.[504] Confidence intervals for probable effects may be sizable,[505] and statistical calculations will require reasonable assumptions.[506] This

500. Daubert v. Merrell Dow Pharm., Inc., 509 U.S. 579, 597 (1993). *See generally* Imwinkelried, *supra* note 57 (discussing the understanding of science expressed by the court in *Daubert*).

501. *See* Feldman, *supra* note 37, at 16 ("In science, revisability is always an option. As scientists acquire new data and change their collective judgments about which background assumptions to hold constant, they revise and replace even well-established scientific theories.").

502. *See, e.g.*, Abraham, *supra* note 143, at 889 (suggesting that the data necessary to support administrative compensation systems may not be sufficiently precise to estimate causal probabilities); Carl F. Cranor, *Eggshell Skulls and Loss of Hair from Fright: Some Moral and Legal Principles that Protect Susceptible Subpopulations*, 4 ENVTL. TOXICOLOGY & PHARMACOLOGY 239, 240 (1997) ("[T]here is considerable variation in individual responses to exposures to toxic substances due to genetics, the developmental stage a person is in, gender, race, age, ethnic background, disease status, lifestyle status or nutritional status."); Farber, *supra* note 28, at 1244 (noting that it is unrealistic to assume that an exposure creates a uniform increase in risk above the background rate). *Cf.* Babich, *supra* note 132, at 140–41 ("Because of information gaps, risk-assessment professionals tend to ignore potentially synergistic effects of multiple chemicals, unknown or poorly documented adverse effects from chemicals, and inadequately understood adverse effects from alternative exposure pathways."). Moreover, toxicogenetic research suggests that genetic polymorphisms result in varying susceptibility among individuals to environmental agents. Some polymorphisms may confer increased susceptibility to some toxicants yet confer decreased susceptibility to others. Marchant, *supra* note 45, at 10,643–46.

503. *See supra* Section II.C.

504. *See* Holly Doremus, *Listing Decisions Under the Endangered Species Act: Why Better Science Isn't Always Better Policy*, 75 WASH. U. L.Q. 1029, 1068 (1997) ("[A]ll data is to some degree equivocal. Observations of the natural world are an unavoidably messy business. Measurements are always subject to error, and random background variation, sometimes referred to as scatter or noise, often masks responses to experimental stimuli.").

505. A confidence interval is an estimated range of values, calculated from a sample, with a specified probability, to include an unknown population parameter. An arbitrary but commonly used confidence level is ninety-five percent, which means that there is a one-in-twenty chance that the interval does not contain the true value of the parameter. CHRISTOPHER CLAPHAM, THE CONCISE OXFORD DICTIONARY OF MATHEMATICS 47 (2d ed. 1996).

506. *See* Brennan, *supra* note 48, at 510–11. *Cf., e.g.*, Cass R. Sunstein, *The Arithmetic of Arsenic*, 90 GEO. L.J. 2255, 2258 (2002) (noting that the proposed standard for arsenic in drinking water could be projected to save between 5 and 112 lives and to provide monetized benefits ranging from $10

proposal, however, does not require perfect information or pinpoint precision in order to function. As Japan's experience suggests, in order to be scientifically and politically credible, a system merely requires information that can serve as a reasonable basis for assessing individual polluters and for making fair distributions to victims.[507]

What distinguishes the present situation from the Japanese experience is that technology and scientific knowledge have now advanced sufficiently to provide the necessary informational foundation for the proposed system. Advances in toxicogenomics and biomonitoring are enhancing the ability of epidemiological studies and like enterprises to detect and measure potential toxic effects. Today, researchers can monitor and model human exposure in microenvironments. In the future, researchers will be able to do so with even greater precision and detail, and at less cost. We no longer need to extrapolate monitoring data from wide areas and risk results that provide only rough estimates of exposure.[508]

Such rapid technological advances are occurring not only in the collection of data, but also in its analysis. Enhanced computing power will more readily allow scientists to identify causal relationships and to disentangle synergistic effects.[509] Technological advances will not eliminate the need for simplifying assumptions regarding baseline risks, exposures, and other variables. But those assumptions would not be unique to the regulatory realm. With enhanced analytic power, the assumptions used to support an administrative system can be more refined than those that have been routinely used to set safety requirements or to determine pollution control and cleanup standards.[510] Of course, judgment will still

million to $1.2 billion). The size of confidence intervals can be reduced by increasing the sample size in a study or by decreasing the degree of confidence demanded of the data. *See* Brennan, *supra* note 48, at 510–11.

507. *See generally* A. Dan Tarlock, *Who Owns Science?*, 10 PENN ST. ENVTL. L. REV. 135, 152 (2002) (arguing that environmental decisions should be reviewed by a "credible, peer-reviewed, consensus-based panel . . . within the scientific community" and contending that "a credible scientific foundation, rather than a higher but unattainable standard, is sufficient to promote the accountability necessary to integrate science into democratic decision-making processes"). For instance, one might reasonably assume that, in the absence of contrary evidence, the dose-response curve—the relationship between the exposure to a toxic substance and its effect on an individual—is linear. *See* Sunstein, *supra* note 506, at 2280, 2290–91 (noting the common assumption that genotoxic carcinogens exhibit linear dose-response curves).

508. Such extrapolations can result in crude estimates because of the high variability in pollution concentrations. *See* Hertel et al., *supra* note 199, at 952.

509. *See* Esty, *supra* note 4, at 158–59.

510. *See, e.g.*, Marchant, *supra* note 45, at 10,655 (noting that regulatory agencies such as the EPA have disregarded differences in genetic susceptibility because of the lack of usable data). This disregard exists despite statutory requirements to consider subpopulations with different susceptibilities

need to be exercised.[511] To reduce politicization of decisions, a panel composed of scientific experts would review scientific research and make determinations on proportionate causation and other technical matters.[512]

E. OTHER ISSUES

1. Behavioral Incentives

A scheme that compensates for pollution exposure could result in various moral hazards. For instance, making compensation available to exposed persons regardless of their behavior arguably reduces the incentive for individuals to take protective or risk-reducing measures.[513] But because environmental toxic injury generally involves the unilateral imposition of risk of injury on others,[514] the most effective risk-reducing measures are likely to be within the polluter's control. Indeed, the proposed scheme is unlikely to discourage a victim's risk-reducing behavior, as compensation is generally determined independently of changes in daily behavior, such as using an air purifier.

Changes in place of residence or employment will affect compensation paid under the system.[515] It is unlikely, however, that individuals—even risk-loving ones—will move closer to major pollution sources if compensation can be applied only toward insurance, medical

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to environmental exposures. But the problem of a lack of usable data may soon be resolved by a growing scientific understanding in that area. *Id.*

511. *Cf.* Holly Doremus, *Constitutive Law and Environmental Policy*, 22 STAN. ENVTL. L.J. 295, 331–32 (2003) (contending that environmental problems cannot be solved objectively because they are indeterminate in nature and involve conflicts over values); Doremus, *supra* note 504, at 1065 ("[S]imply characterizing a question as scientific does not guarantee an answer which is either objective or reliable."); Wendy E. Wagner, *Science in the Regulatory Process: The "Bad Science" Fiction: Reclaiming the Debate over the Role of Science in Public Health and Environmental Regulation*, LAW & CONTEMP. PROBS., Autumn 2003, at 63, 64–65 (noting that because "risk assessments combine scientific knowledge (for example, toxicity tests on animals) with science-policy judgments (for example, dose-response assumptions), . . . most decisions in public health and environmental regulation break down into a series of sub-decisions that alternate or zigzag between science and science-policy") (internal footnote omitted)).

512. Brennan presented a more detailed proposal for a similar federal hazardous substance science panel. Brennan's proposed panel would develop policies regarding hazardous substance injuries, review statistical and epidemiological evidence of injuries caused by hazardous substances, and establish guidelines for exposure to hazardous substances. *See* Brennan, *supra* note 48, at 525–28.

513. *See, e.g.*, DEWEES ET AL., *supra* note 12, at 267 (suggesting that victims who are fully compensated lack the incentive to mitigate damages or to engage in less sensitive activities).

514. *See supra* note 87 and accompanying text.

515. *Cf.* DEWEES ET AL., *supra* note 12, at 267 (noting that if victims are fully compensated, "there is theoretically nothing to deter sensitive victims from moving close to a source of pollution because they will be made whole for any losses that they suffer").

expenses, and the like. In addition, because compensation will be based on risk rather than actual injury, absolute differences in compensation may not be sufficient to prompt relocation to receive greater compensation. Such differences can nevertheless perform an important signaling function. Individuals who are particularly vulnerable or sensitive can use such information to relocate and thus reduce their exposure and health risks.[516]

For polluters, the system will magnify incentives to locate in sparsely populated areas, thereby reducing pollution costs. Ideally, society would internalize all pollution costs, including decreased agricultural productivity and damage to property, animals, and the environment.[517] Full cost internalization, however, is even less likely than the adoption of the present proposal. To protect against undesirable impacts on the environment, direct regulation will be necessary. Baseline pollution standards, zoning laws, anti-sprawl legislation, and similar measures will be required.

2. Privacy

Extensive monitoring of the environment and of individual health can raise serious concerns about privacy.[518] In designing a government administered compensation system, one should heed these concerns. To some extent, models can substitute for environmental monitoring. Such models, however, should be verified by comparing predictions with real world data. For example, rather than monitoring chemical levels in all individuals, researchers could conduct biomonitoring of a few volunteers to verify estimated levels of exposure and intake. Other simplifying assumptions may also be necessary to protect privacy. For example, although one could use GPS technology to track the specific location of individuals in order to estimate exposure, reasonable exposure estimates based on home and work addresses would be far less intrusive.

516. Toxicogenetics is increasingly able to provide individuals with information regarding their unique susceptibility to particular risks. *See* Marchant, *supra* note 45, at 10,663. Information may be disclosed by the administrative system, either directly through publishing the underlying data or indirectly through compensation payments. That information can also be used by communities and other stakeholders to put pressure on firms to better manage environmental risk. *See* Cohen, *supra* note 120, at 10,426.

517. *See* DEWEES ET AL., *supra* note 12, at 265–66.

518. *See, e.g.*, Wanjek, *supra* note 174, at F1 (noting the concern that biomonitoring data could be used for discriminatory purposes by insurance companies or employers); Lidia Wasowicz, *In Sensors Smaller May Be Smarter*, UNITED PRESS INT'L, July 14, 2003, http://www.upi.com/view.cfm?StoryID=20030714-112803-3242r (mentioning privacy and security concerns with respect to the use of "smart dust"). *See generally* A. Michael Froomkin, *The Death of Privacy?*, 52 STAN. L. REV. 1461 (2000) (discussing the legal implications of privacy-destroying technologies).

3. Autonomy

To some, the tort system represents an opportunity for victims to have their day in court. Under this rationale, the tort system facilitates individual autonomy. In contrast to an administrative system, the tort system might be thought to promote fairer outcomes because it adjudicates cases individually based on their specific facts.[519] In particular, the tort system adjusts damages to account for individualized circumstances of pain, suffering, and economic hardship.

The proposed administrative compensation system, like class action tort cases, compromises the benefits of individualized adjudications in order to gain efficiency.[520] With respect to environmental tort injuries, however, the benefits of tort are of little practical value—few individual cases are brought successfully in tort. For those few plaintiffs who do bring cases, most do not receive their day in court, let alone individualized justice in any meaningful sense. Cases tend to be settled rather than tried, and settlements tend to follow standardized valuation criteria that reflect average outcomes from similar cases.[521] The proposal does not provide victims with a literal day in court, but it does acknowledge the real risks and injuries borne by victims exposed to environmental pollutants.

VI. CONCLUSION

The tort system has largely overlooked the problem of environmental toxic injury, despite mounting evidence that exposure to common pollutants causes significant numbers of fatalities and serious illnesses. In the future, scientific research will continue to generate even more evidence of low-level but significant risks. The tort system, however, is unlikely to correct its failure to compensate injured environmental tort plaintiffs. It is unlikely that the tort system will one day help internalize the costs to human health of these environmental toxic injuries. The administrative

519. *See* David Rosenberg, *Class Actions for Mass Torts: Doing Individual Justice by Collective Means*, 62 IND. L.J. 561, 561 (1987) (describing a "private law adjudicatory ideal" in which norms are applied to "the specific, relevant circumstances of the particular parties in the given case"). *Cf.* Schuck, *supra* note 430, at 979 (describing the traditional, American distrust of governmental power, particularly in bureaucratic forms).

520. *See* Rosenberg, *supra* note 519, at 561–62. *Cf.* Schuck, *supra* note 430, at 979 n.173 (noting that courts that hear mass tort cases increasingly operate like administrative offices).

521. *See* FRIED & ROSENBERG, *supra* note 162, at 27 ("[G]iven the fact that 98 percent of triable cases settle, having a 'day in court' seems of interest only to academic lawyers."); Rosenberg, *supra* note 519, at 582 ("In contrast to the ideal of individual actions, the dominant feature of the tort system in practice is the bureaucratic justice of settlement.").

compensation system proposed in this Article is not a panacea for the problem, nor can it be implemented without overcoming practical and political challenges. Nevertheless, this proposed risk-based system offers a more effective approach. It can provide the proper signals for efficient deterrence. It can enable victims to respond to or mitigate risks. And it can promote corrective justice. To achieve these ends, this proposal capitalizes on technological advances and growing scientific knowledge. These advances present an important new opportunity. We should seize it.