Duke Law Journal

VOLUME 45 MARCH 1996 NUMBER 5

COMPLEXITY THEORY AS A PARADIGM FOR THE DYNAMICAL LAW-AND-SOCIETY SYSTEM: A WAKE-UP CALL FOR LEGAL REDUCTIONISM AND THE MODERN ADMINISTRATIVE STATE

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Imagine driving in a world with no traffic controls—no speed limits, no traffic lights, no stop signs, and no rights to prevent or punish reckless driving. Now imagine driving in a world brimming with a plethora of traffic controls—lights at every corner, every street a one-way, speed zones changing by the block, causes of action available to challenge the slightest of driving inetiquettes. In which world would you rather drive? In the lawless world—the world of total driver freedom—would you not yearn for some degree of socially imposed management of the exercise of free will, so that navigating each intersection would not require negotiations with other motorists? In the world of omnipresent controls—the world of total social suppression of free will—would you not long for the discretion to move about with some self-judgment and freedom? Where is the point, balanced between too much and too little control of free will, at which individual freedom, third-party rights, and social regulation are mutually optimized so as to produce a world of happy drivers moving in an efficient, adaptive flow of traffic? And which measures are the best to adopt in striking that balance? These are questions for the scientific theory of nonlinear dynamical system behavior, and they are the subject of this Article.

INTRODUCTION

It might be stating the obvious to say that law acts as a context for society. Humans, at both individual and collective levels, respond and adapt to the legal systems they devise and to changes in the laws that emanate from legal institutions. Since the time of the Code of Hammurabi, humans in every organized society have devoted a great deal of energy to coping with (and not always by obeying) laws.

It might also be stating the obvious, at least if said to legal historians, to observe that society acts as a context for law. The legal system of any society is seldom static. Laws and legal institutions change in response to changing social mores and ethics, technological advancements, and other evolutions in and affecting human society.

What is far from obvious, however, is how law and society, each a context for the other, interact. If society evolves in response to changes in law, and vice versa, then law and society must co-exist in an evolving system. Each needs the other to define itself. Yet, most commentary on "law and society" has been

devoted to explaining how one element of that system reacts to the other—how law reacts to society, or how society reacts to law. For example, one legal commentator has explained that

> [t]he controversy between those who believe that law should essentially follow, not lead, and that it should do so slowly, in response to clearly formulated social sentiment—and those who believe that the law should be a determined agent in the creation of new norms, is one of the recurrent themes of the history of legal thought.[1]

As I demonstrate in this Article, however, the manner in which the two subcomponents of the system made up of law and society interact cannot be fully understood through such disaggregation. One "side" does not "lead" the other, and any attempt to understand how to have one do so to the other, or to predict the outcome of such efforts is doomed from the start.

To evolutionary scientists, the answer to the question "Which came first, the chicken or the egg?" is that they happened together.[2] So, too, with law and society. They happened together and continue to happen together. How we go about explaining and working within that process is the subject of this Article.

To explore this topic, I borrow from theories unfolding at the forefront of science to formulate a theory of law that grounds our understanding in the *complexity* of the law-and-society system's behavior. In so doing, I demonstrate the fallacies and shortcomings of the positivist-bred,[3] reductionist[4] thesis that has defined the

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1. W. FRIEDMAN, LAW IN A CHANGING SOCIETY 3 (1959). Similarly, sociologists have attempted to describe "the variation of law across social space . . . to predict and explain this variation, and so to contribute to a scientific theory of law." DONALD BLACK, THE BEHAVIOR OF LAW, at ix (1976).

2. More accurately, a non-chicken hen laid the first egg from which a chicken hatched. The chicken got its character as a chicken at conception, but we did not know it was a chicken until it hatched out of the egg; the egg got its character as a chicken egg when it was laid, but we did not know it was a chicken egg until it hatched the chicken. The time of hatching thus is the earliest time when we could have discovered the character of either the chicken or the egg—the chicken and the egg happened together. The concept is best summed up by the old adage that to a chicken, an egg is the way to make another chicken, but to an egg, a chicken is just a way to make another egg. *Cf.* JACK COHEN & IAN STEWART, THE COLLAPSE OF CHAOS 56–96 (1994) (discussing the organization of biological development).

3. By positivist, I mean the "doctrine that we can have no knowledge other than that provided directly by our senses." PETER COVENEY & ROGER HIGHFIELD, THE ARROW OF TIME 364 (1990). Positivism is the philosophical variant of empiricism developed by August Comte, who advocated that all scientific study, including the study of humani-

debate in American legal theory and that has come to dominate the approach of American legislation, administration, and jurisprudence. This may sound ironic—to use scientific theories to disprove legal theories whose very point has been to explicate law through techniques of the classical scientific method. But like classical science, the major schools of American legal theory have been so mired in reductionist thought that they have failed to see the system behaviors that throughout time have denied legal theorists the Holy Grail of a predictive model of law. And it is precisely the failure of American legal theory to produce a predictive model, and legal institutions' fear of what that means, that has promoted the rise of an administrative state built on layer upon layer of reductionist premises. The point of this Article, therefore, is not to esponse a theory that will allow absolute prediction of law's impact on society, or vice versa, as either goal is no longer scientifically rational. Rather, the exercise is intended to allow a greater appreciation of the forces at play in the interaction of law and society, and which, ultimately, doom any reductionist, prediction-oriented theory of law and legal administration.

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ty, must be based on objective study of observable phenomena. *See* AUGUSTE COMTE, THE POSITIVE PHILOSOPHY (R.W. Rieber ed., AMS Press 1974) (Harriet Martineau trans., 1855). The use of positivist theory to formulate legal theory is a dominant theme of legal theoreticians grouped (by others) under the heading of legal formalism, and has been a major focus of American legal theory schools derived from and reacting to legal formalism—i.e., by their generally accepted monikers, legal realism, law and economics, and Critical Legal Studies (CLS). *See infra* text accompanying notes 120–155. These labels for the different schools of American legal theory unfairly simplify their respective theses and impose artificially sharp divisions between their theoretical paradigms. I confess to using them principally to advance the discussion, and also because everyone else does. *See* NEIL DUXBURY, PATTERNS OF AMERICAN JURISPRUDENCE 1 (1995) ("[T]hose who concern themselves with American jurisprudence in particular recognize the necessity of thinking and writing in shorthand.").

4. By reductionist, I mean the "doctrine according to which complex phenomena can be explained in terms of something simpler." PETER COVENEY & ROGER HIGHFIELD, FRONTIERS OF COMPLEXITY 432 (1995). Reductionism leads to the belief that an observable, complex phenomenon can be studied and fully understood by first reducing it to the simplest, indivisible subcomponents in operation during the phenomenon, then studying each of those subcomponents, and then reassembling them to gain a full understanding of the rules of operation of the whole phenomenon. That form of reductionism has predominated as an organizing principle for classical scientific inquiry, *see* COHEN & STEWART, *supra* note 2, at 33–34, as well as being a force in the philosophy of ethics. *See* DEREK PARFIT, REASONS AND PERSONS 210–14 (1984). As I posit herein, reductionism also has been a theme common to modern legal theories of legal formalism, legal realism, law and economics, and CLS, as well as the so-called post-modern autopoietic law theory.

To accomplish this goal, I engage in a bit of a fiction, namely that the law-and-society system is capable of being completely described using scientific method. Of course, a "pure" legal positivist—if there is one—may object to my characterization of that premise as a fiction, but my response would be that one can't get just one's toes wet. In other words, if we are asked by legal positivists to accept, for purposes of analysis, that the law-and-society system is capable of being fully described through scientific method, then we should demand that their legal theory not ignore significant components of the full body of scientific knowledge. Taking that plunge means dealing with the implications of the developing scientific theories used to explain the qualities of chaos, emergence, and catastrophe—each of which poses problems for the reductionist approach of classical science, and which, therefore, presents similar theoretical obstacles not only to legal positivists, but also generally to any theory of law relying on reductionist premises.

Part I of this Article begins the exercise by establishing the playing field of the law-and-society system and the lexicon of the scientific theorems that can be used by analogy to describe phenomena of that system. The discussion demonstrates that the interaction of law and society can be modeled using the characteristics of dissipative, nonlinear dynamical systems;[5] that is, when conceived as a unified system, the interaction of law and society evolves in an unfolding nonreversible manner that is not based on components with directly proportional relationships capable of being graphed as a straight line. Rather, the current condition of any one component in the system depends in a nonlinear fashion on the immediately preceding condition of all the other components. As do all such dynamical systems, the analogical law-and-society system model has a multi-dimensional playing field, or "space," within which the system dynamics occur; it is governed by a nonfinite set of rules prescribing the system's trajectory, and that trajectory is hurtling among basins of influence defined by the system's "attractors."

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5. Dynamical systems is a "[g]eneral term for systems whose properties change with time. Dynamical systems can be divided into two kinds, conservative and dissipative. In the former the time evolution is reversible, in the latter it is irreversible." COVENEY & HIGHFIELD, *supra* note 3, at 361. Nonlinearity means the system components' relationships are nonproportional (e.g., as x increases, y increases at a varying rate). *Id.* at 184. All references herein to dynamical systems are to the dissipative, nonlinear type.

The discussion in Part I further maintains that an important set of attractors for the law side of the law-and-society system is freedoms, rights, and regulations. These qualities define how the law-and-society system uses laws to cope with the complicating factor of human free will, a factor that I show contributes significantly to the dynamics of the law-and-society system and is therefore essential for the system's sustainability. Freedoms, rights, and regulations present very different, often inconsistent approaches for managing human free will. The particular "blend" of these approaches a law-and-society system uses for that purpose will largely define the character and dynamics of the system. Examples from enviroumental law are used to illustrate that underlying feature of the law-and-society system's dynamics. Environmental law, as much as any component of the law-and-society system, has witnessed a flux and struggle in the system's movement between freedoms, rights, and regulations as to which has been and will be the dominant attractor.[6] Describing a law-and-society system through analogy to the lexicon of dynamical systems theory allows us to understand better how the system chooses from these various instruments for implementing socio-legal structures.

Part II of the Article takes what is learned from that exercise and explores how we should establish the goals of the law-and-society system. In scientific applications, dynamical systems theory has described several sources of "surprise" that can make prediction of a system's outcomes difficult, if not impossible. Known as chaos, emergence, and catastrophe,[7] it is the ability of a particular

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6. As Professor William H. Rodgers, Jr. states:

> The catchword for the study of environmental law is complexity . . . . Environmental law arises in a world of many parties where issues are linked together in mysterious ways, and each "definitive" resolution is but the prelude to future bargaining, compromise, and defection. The field presents an ongoing kaleidoscope of tussling organizations, interests, jurisdictions, and states where strategies, goals and outcomes are subject to constant redefinition.

WILLIAM H. RODGERS, JR., ENVIRONMENTAL LAW § 1.2, at 24–25 (1994). This complicated, evolving quality of environmental law, plus environmental law's intricate connection to changing social perceptions, make it a prime candidate for nonlinear dynamical systems theory. To the extent environmental law is in this respect more "unstable" than other fields of law, lessons dynamical systems theory teaches us about environmental law provide all the more value to the general thesis of how we go about promoting sustainability of the law-and-society system.

7. The field of dynamical systems theory, and particularly the study of chaos, emergence, and catastrophe, is extremely technical, *see, e.g.*, STUART A. KAUFFMAN, THE ORIGINS OF ORDER (1993), and this Article does not purport even to begin to explore the elaborate mathematical theorems used to portray dynamical system behavior and

system to survive and adapt to these surprise generators that dictates the system's long-term sustainability. Catastrophe occurs when a system suffers a discontinuity that radically shifts the location and trajectory of the system. Chaos occurs when the deterministic rules of the system produce seemingly random system behavior. Emergence is characterized by changes in the system's trajectory as a result of the self-organized patterns of interaction between the system's components. The lesson for the law-and-society system is that the rules of any nonlinear dynamical system (including laws in the law-and-society system model), even when followed deterministically by the components of the system (society and its members in the law-and-society system model), are capable of producing these unexpected behaviors that move the system off of its expected trajectory in unpredictable ways.[8]

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phenomena. On the other hand, humans live in and are constantly confronted by dynamical systems, such as weather and the economy, and hence many observations drawn from dynamical systems, though abstractly counterintuitive, somehow make sense when described in real world contexts. There is, in other words, an observational side to complexity theory, just as there is a visual and organic style of mathematics. *See* Ian Stewart, *Portraits of Chaos*, *in* EXPLORING CHAOS: A GUIDE TO THE NEW SCIENCE OF DISORDER 44, 45 (Nina Hall ed., 1991). It is for that reason that theorists in social sciences have attempted to import the scientific findings of dynamical systems theory to their fields as a way of explaining observed effects that previously had not been capable of cogent theoretical description. This Article is very much about experimenting with that observational form of application of dynamical systems theory, in this case through application to an analogical model of law and society as a unified dynamical system. For comprehensive discussions of dynamical systems theory for the technically disinclined, including reading lists of works exploring both the technical and the observational sides of dynamical systems theory applied in a variety of fields, see COHEN & STEWART, *supra* note 2; JOHN L. CASTI, COMPLEXIFICATION (1994); COVENEY & HIGHFIELD, *supra* note 3; STUART A. KAUFFMAN, AT HOME IN THE UNIVERSE (1995); COVENEY & HIGHFIELD, *supra* note 4; JAMES GLEICK, CHAOS (1987). I recommend reading these works in the order cited.

8. There is a small but emerging body of commentary exploring the value of dynamical systems theory in legal theory. Several authors have provided cogent descriptions of nonlinear dynamical analysis in broad theoretical applications to law. *See* Thomas E. Geu, *The Tao of Jurisprudence: Chaos, Brain Science, Synchronicity, and the Law*, 61 TENN. L. REV. 933 (1994) (discussing the potential significance of chaos and emergence to legal theory); Andrew W. Hayes, *An Introduction to Chaos and the Law*, 60 UMKC L. REV. 751 (1992) (general discussion of chaos theory and its application to judicial decisionmaking); Robert E. Scott, *Chaos Theory and the Justice Paradox*, 35 WM. & MARY L. REV. 329 (1993) (applying chaos theory to the legal dilemma between "present justice" and "future justice"). Several other works discuss nonlinear dynamical analysis, albeit sometimes very briefly, in specific legal settings. *See* Lawrence A. Cunningham, *Capital Market Theory, Mandatory Disclosure, and Price Discovery*, 51 WASH. & LEE L. REV. 843 (1994) (application of chaos theory to capital market regulation); Lawrence A. Cunningham, *From Random Walks to Chaotic Crashes: The Linear Geneology of the*

The goal of the law side of the law-and-society system, therefore, is to promote sustainability of the system—the quality that allows a dynamical system to survive the surprise generators of chaos, emergence, and catastrophe is maximized. Dynamical systems theory teaches us that promoting system sustainability often involves principles that are counterintuitive. Trying to understand how dynamical systems evolve into that position of maximum sustainability is the focus of a branch of dynamical systems theory known as complexity theory.[9] The message of complexity theory is that there is a "sweet spot" in the spectrum of different system structure possibilities that provides the optimal blend of stability, simplicity, and adaptability needed to sustain the system.

How to begin translating those dynamical systems principles into doctrines for the analogical model of the law-and-society system is the subject of Part III of this Article.[10] Just as science

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Efficient Capital Market Hypothesis, 62 GEO. WASH. L. REV. 546 (1994) (application of chaos theory to capital market regulation); Michael J. Gerhardt, *The Role of Precedent in Constitutional Decisionmaking and Theory*, 60 GEO. WASH. L. REV. 68, 94–98 (1991) (explaining Supreme Court constitutional jurisprudence using, among other mediums, a brief foray into chaos theory); Glenn H. Reynolds, *Is Democracy like Sex?*, 48 VAND. L. REV. 1635 (1995) (using complexity theory, particularly its evolutionary biology applications, to explore representative government structures); Glenn H. Reynolds, *Chaos and the Court*, 91 COLUM. L. REV. 110 (1991) (explaining Supreme Court constitutional jurisprudence using chaos theory); William H. Rodgers, Jr. *Where Environmental Law and Biology Meet: Of Pandas' Thumbs, Statutory Sleepers, and Effective Law*, 65 U. COLO. L. REV. 25 (1993) (using chaos theory surfacing in evolutionary biology commentary as a metaphor for evolution of environmental law). This Article expands the discussion to include the full message of what scientists refer to as complexity theory. *See infra* note 9.

9. Although the familiar label for dynamical systems theory is *chaos* theory, in fact what is known as *complexity* theory more fully captures the whole picture of dynamical systems behavior that the scientific research has revealed. *See, e.g.*, CASTI, *supra* note 7, at 260–78. *See generally infra* text accompanying notes 102–09. Dynamical systems theory is developing, and there is not complete agreement in the scientific literature as to its lexicon or meaning. Although scientists always knew that dynamical systems existed and, since before Newton, had endeavored to explain them, it was not until the introduction of the high-speed computer in the 1950s that they could extensively analyze their behavior. Since then, dynamical systems theory has been developing as fast as advancements in computers allow, and complexity theory represents its most advanced model. For a history of early dynamical systems theory, see COVENEY & HIGHFIELD, *supra* note 3; STEVEN H. STROGATZ, NONLINEAR DYNAMICS AND CHAOS 2–5 (1994).

10. Some legal commentators—primarily German "post-modern" legal theorists—have examined the dynamical nature of the law-and-society system's behavior under the label of autopoietic (self-productive) legal evolution. *See, e.g.*, GUNTHER TEUBNER, LAW AS AN AUTOPOIETIC SYSTEM (Zenon Bankowski ed., Anne Bankowska & Ruth Adler, trans., 1993); AUTOPOIETIC LAW: A NEW APPROACH TO LAW AND SOCIETY (Gunther Teubner ed., 1988); Arthur J. Jacobson, *The Other Path of the Law*, 103 YALE L.J. 2213 (1994);

has begun to apply dynamical systems theory to uncover new meanings in fields such as ecology[11] and evolution,[12] so too have social scientists begun exploring the application of dynamical systems theory to questions in such fields as anthropology[13] and economics.[14] These applications are controversial because they involve transporting principles learned initially from computer-generated mathematical models to real-world contexts such as ocean ecosystems and human economies.[15] More to the point, dynamical

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Niklas Luhman, *Law as a Social System*, 83 NW. U. L. REV. 136 (1989); Arthur J. Jacobson, *Autopoietic Law: The New Science of Niklas Luhman*, 87 MICH. L. REV. 1647 (1989) [hereinafter *Autopoietic Law*]. Because there are some parallels to complexity theory, the autopoiesis paradigm—indeed, the entire body of knowledge in evolutionary science—is useful for exploring the mechanisms of the emergence behavior in dynamical systems, and when applied to the law-and-society system model helps to illustrate the qualities of the common law that I argue should make it our legal approach of first resort. *See infra* text accompanying notes 186–193. Thus far, however, the literature on autopoiesis as a legal paradigm has not fully connected with complexity theory. *See, e.g.*, Jacobson, *Autopoietic Law, supra*, at 1658 n.33 (acknowledging that "autopoiesis undoubtedly belongs to the science of chaos," but declining to go further in bonding the two). Moreover, there are significant differences between how the autopoietic law school of legal theory has embraced autopoietic behavior as an organizing principle and the role autopoiesis plays in complexity theory, suggesting that if the two paradigms ever do connect, adherents of the autopoietic law theory will need to reconsider the way things work. *See infra* text accompanying notes 143–153.

11. *See, e.g.*, ANDREW GOUDIE, THE NATURE OF THE ENVIRONMENT ix (3d ed. 1993); COHEN & STEWART, *supra* note 2, at 309–95.

12. *See, e.g.*, COHEN & STEWART, *supra* note 2, at 94–133. For an insightful discussion of how some of the new concepts in evolutionary and ecological biology may affect environmental law, albeit with no particular focus on either the dynamical systems analysis leading to those new scientific understandings or whether they have any analogical value to law, see Jonathan B. Wiener, *Law and the New Ecology: Evolution, Categories, and Consequences*, 22 ECOLOGY L.Q. 325 (1995) (reviewing JONATHAN WEINER, THE BEAK OF THE FINCH: A STORY EVOLUTION IN OUR TIME (1994)); *see also* Fred P. Bosselman & A. Dan Tarlock, *The Influence of Ecological Science on American Law: An Introduction*, 69 CHI.-KENT L. REV. 847 (1994); A. Dan Tarlock, *The Nonequilibrium Paradigm in Ecology and the Partial Unraveling of Environmental Law*, 27 LOY. L.A. L. REV 1121 (1994) (describing the implications of a paradigm shift in ecology on environmental law).

13. *See, e.g.*, THE COLLAPSE OF ANCIENT STATES AND SOCIETIES (Norman Yoffee & George L. Cowgill eds., 1988)

14. *See, e.g.*, W. Brian Arthur, *Positive Feedbacks in the Economy*, SCIENTIFIC AMERICAN, February 1990, at 92, 94–99; Donald N. McCloskey, *The Gulliver Effect*, SCIENTIFIC AMERICAN, Sept. 1995, at 44. For an excellent overview of how dynamical systems theory has influenced economics since Arthur's early exploration of the subject, see Geu, *supra* note 8, at 975–82. Even psychotherapy has imported nonlinear science to improve its methodology. *See* John Horgan, *Complexifying Freud*, SCIENTIFIC AMERICAN, Sept. 1995, at 28.

15. *See, e.g.*, VLADIMIR I. ARNOLD, CATASTROPHE THEORY (2d ed. 1986) (critiquing application of catastrophe theory to social sciences); ALEXANDER ROSENBERG, ECONOM-

systems theory challenges the foundations of classical physical and social sciences by exposing the fallacies of the reductionist premises that have dominated those fields. Similarly, American legal theory has struggled for a century over whether and how to apply scientific method to legal analysis,[16] and strong currents of the reductionist approach of classical science have been ingrained in American legal theory and legal institutions as a result. But just as the descriptions of chaos, emergence, and catastrophe have begun to draw boundary lines on the usefulness of reductionist thought in the physical sciences, so also is there a limit to how far reductionism can carry legal theory and law. Indeed, perhaps more so in law than in any other field of humanities does a culture of reductionism doom the system, for only in the law-and-society system do the system components get to write the rules and decide whether to obey them. When those rules—society's laws—are written, studied, and evaluated from a predominantly reductionist perspective, we inevitably are befuddled when the dynamical system surprises produced by chaos, emergence, and catastrophe occur. Fighting those phenomena with more reductionist approaches leads us only further into the abyss.

Reductionist influence in American legal theory and institutions thus has led the law side of our law-and-society system

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ICS—MATHEMATICAL POLITICS OR SCIENCE OF DIMINISHING RETURNS (1992) (critiquing the use of science to explain economics).

16. For an overview of the use of classical Newtonian scientific method in American legal theory, see Nancy Levit, *Listening to Tribal Legends: An Essay on Law and the Scientific Method*, 58 FORDHAM L. REV. 263, 274–95 (1989). For the first step beyond classical scientific theory, providing an exploration of how twentieth-century post-Newtonian physics might serve as a metaphorical background for new legal theories, see Laurence H. Tribe, *The Curvature of Constitutional Space: What Lawyers Can Learn from Modern Physics*, 103 HARV. L. REV. 1 (1993). Professor Tribe's "modern physics" is relativity theory and quantum mechanics, however, and thus he has not described his vision of how to incorporate the newer scientific concepts of chaos, emergence, and catastrophe. Nevertheless, his overarching conclusion provides the same starting point for my analysis of American legal theory and institutions that post-Newtonian theory provided for today's science theorists:

> A parallel conception [to post-Newtonian physics] in the legal universe would hold that, just as space cannot extricate itself from the unfolding story of physical reality, so also the law cannot extract itself from social structures; it cannot "step back," establish an "Archimedean" reference point of detached neutrality, and selectively reach in, as though from the outside, to make fine-tuned adjustments to highly particularized conflicts. Each legal decision restructures the law itself, as well as the social setting in which law operates . . . .

Id. at 7–8. Complexity theory provides the foundation from science for the next post-Newtonian step in the process of figuring out how that restructuring takes place.

straight into the conceptual fallacies that have plagued science for centuries, causing us to focus on attempting to achieve absolute system predictability by adopting an increasingly complicated architecture of rules and organizations. Excessive doses of hyperdetailed regulation and ingrained reliance on top-heavy administrative structures have buried the more fundamental legal structures—the first principles—so deep that we no longer can explain, much less predict, how the law-and-society system will respond to a new socio-legal challenge. Flexible organizing principles of the sort found in the common law have been supplanted by a culture of regulatory micromanagement in legislation, administration, and jurisprudence, leaving society poorly equipped to survive the dynamical system surprise phenomena. The recondite analysis found in the Federal Register is our reality; the simple justice meted out in Judge Wapner's Peoples' Court is our television show satire.

Even recent calls to reform the complexity (used in the traditional sense of complicatedness) of the legal system, such as Richard Epstein's *Simple Rules for a Complex World*,[17] usually fall into the reductionist trap and thus largely miss the point. Replacing what are perceived to be "complex" legal rules with "simple" ones to run the law-and-society system model does not necessarily produce a more adaptive law-and-society system. Dynamical systems theory shows that the surprise phenomena produced by chaos, emergence, and catastrophe can occur in systems following simple, deterministic rules of motion. Legal reform therefore misses the mark when it is aimed principally at simplifying *laws*; rather, the full message of complexity theory is that it is more important to aim legal reform efforts toward the factors in the law-and-society *system* that threaten dynamical system sustainability. Legal reform in the former sense may occasionally promote legal reform in the latter sense, but only coincidentally.

Indeed, in order to illustrate how radically different American legal institutions would function from their present structure were we to apply complexity theory to its fullest in legal reform, Part IV of this Article carries the exercise in analogy to its logical conclusion by offering several broadly principled, anti-reductionist reforms designed to more effectively manage chaos, emergence, and catastrophe in the modern American law-and-society system.

17. RICHARD EPSTEIN, SIMPLE RULES FOR A COMPLEX WORLD (1995), discussed *infra* text accompanying notes 171–181.

Reductionist approaches to legal administration have produced a system that, in the lexicon of nonlinear dynamical systems theory, is sitting predominantly on the nonadaptive, static regulations attractor in a futile effort to increase the predictability of the law-and-society system. This has been accomplished at the expense of freedoms and rights, which are more adaptive in nature than are regulations. Reversing this reductionist influence on our legal institutions would require a complete overhaul of our approach to legislation, administration, and jurisprudence—producing a system that de-emphasizes the regulations attractor by de-emphasizing the place of codified rules within the system, and which, consequently, is more consistent with basic constitutional precepts than is the tangled bowl of regulatory spaghetti in which we find ourselves today. The three steps that I posit will be important in making that reversal are (1) the return of common law to its rightful place as our first choice law-based method of establishing and managing the balance between freedoms and rights; (2) the aggressive enforcement of the nondelegation doctrine so as to require Congress to spell out what it wants and means; and (3) the reversal of doctrines requiring legislative and administrative deference to administrative decisions.

Implementing the legal reforms proposed herein will only make it harder for legal theorists to divine the rules of system prediction, but that is the whole point of dynamical systems theory—you can't ever reach absolute system predictability for a nonlinear dynamical system. This reality may disappoint legal positivists the most, as they are the most deeply entrenched in reductionist premises. But what appears initially to be the legal positivists' nightmare—scientific proof that there is no absolutely predictive theory of the law-and-society system—is actually their salvation, for they need not fret any longer about their failure to produce such a theory. After all, it is not their fault; with complexity theory at their side, they can blame it on chaos, emergence, and catastrophe.

I. DESCRIBING THE INTERACTION OF LAW AND SOCIETY AS A NONLINEAR DYNAMICAL SYSTEM—FREEDOMS, RIGHTS, AND REGULATIONS AS "ATTRACTORS" IN THE LAW-AND-SOCIETY SYSTEM MODEL

Ask people to discuss local traffic patterns and they are likely to use terms describing interaction between traffic regulations and drivers' behavior. A particular traffic signal, for example, may have been installed to alleviate rush hour traffic jams. On the other hand, sometimes the blame for rush hour traffic jams is laid on a poorly conceived traffic signal. It is clear that traffic regulations and drivers' behavior interact.

Interaction between system components is an inherent quality of all systems.[18] Dynamical systems theory provides a lexicon for describing system interaction, so that we may translate observations of system behavior into models of reality. That lexicon can easily be used through analogy[19] to describe a model for the interaction of law and society.

A. *A Primer on Dynamical Systems and Their Attractors*

The traffic metaphor provides an able medium for describing in very simplified terms the basic language of dynamical systems theory.[20] Consider a driver, Betty, who is leaving her house to visit her friend, John. Each dynamical system has an n-dimensional *playing space*, known technically as a manifold or phase space, which contains all the possible system states.[21] In Betty's traffic

18. *See* CASTI, *supra* note 7, at 10. Casti observes that "the subjective everyday notion of complexity is really more a property of the *interaction* between two systems than it is an intrinsic aspect of a system taken in isolation." *Id.*

19. As Geu points out, at least one legal commentator has suggested direct applicability of dynamical systems theory to the law-and-society system, whereas he prefers to leave it as a metaphorical relationship. *See* Geu, *supra* note 8, at 935 n.3. I am not convinced the relationship is one of direct applicability or simple metaphor, and thus I choose to describe it as analogical.

20. The abbreviated dynamical systems theory lexicon that follows in the text is taken mainly from Casti's work on complexity theory. CASTI, *supra* note 7, at 26–27.

21. Phase space is "[a]n abstract space in which a single point completely defines the instantaneous state of a dynamical system. . . . The dimension of the space depends on the number of variables needed to define the system." COVENEY & HIGHFIELD, *supra* note 3, at 364. Hence, phase space is not simply the four-dimension space-time space that we observe in the physical world, but rather an *n*-dimensional playing field, with *n* being all the relevant variables of system operation, within which the instantaneous state of the

world, her playing space is the local roadway network. Each system also must have a set of *rules of motion*, known technically as vector fields, which tell the system components where and how to go next from wherever they are now. For Betty, her rules are the traffic regulations that exist on the route she takes between her and John's houses. The path that a system takes—Betty's route to John's house—is the system *trajectory*,[22] and the system starting point—Betty's house in our traffic world—is the system's *initial state*.[23] Finally, and most important of all, the final condition of the system's trajectory—John's house for Betty—is the system's *attractor*.[24]

A system's behavior is defined by the number and character of its attractors, and a system may have a multitude of attractors. Once we know the system's playing space, initial state, and rules of motion, the system is off and running. The important questions, however, are where is it going and what path does it take? The attractor defines the region of the playing space that "attracts" the trajectory of the system as time passes. In Betty's case, the attractor was defined by a fixed point—John's house—that we would observe by following Betty's rather methodical trajectory. In the Indianapolis 500, by contrast, the attractor appears by observation of the drivers' trajectories to be an orbit repeating endlessly around a fixed path. And in a high-speed car chase, the trajectory is a tangled mess with no apparent final condition in sight.

Indeed, in dynamical systems theory parlance there are three types of attractors of relevance to this discussion: *fixed point*, *limit*

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system is a single point representing the concurrently instantaneous values of all the variables of the system. *See* Stewart, *supra* note 7, at 46–47.

22. Thus, "[a]s the system evolves in time it maps out a trajectory in the phase space." COVENEY & HIGHFIELD, *supra* note 3, at 364.

23. The initial state, also known as the initial condition, consists of "[t]he quantities (such as position and velocity) which must be specified at an initial moment in time in order to predict subsequent behavior." *Id.* at 362.

24. Thus, the attractor is "[a] way to describe the long-term behavior of a dissipative system in phase space." *Id.* at 360. The term attractor is somewhat misleading, as it implies the presence of a force of attraction or a goal-oriented state, whereas the term is intended to mean simply that the rules of motion of the system produce a certain behavior that the attractor describes. *See* COHEN & STEWART, *supra* note 2, at 206–07. The distinction is aptly described through the example of a lake draining a watershed. As rain falls within the watershed, rules of chemistry, gravity, and physics operate on the water. The result of the water's behavior is the lake—the attractor—but the lake did not itself exert an attractive force upon the water. *See* KAUFFMAN, AT HOME IN THE UNIVERSE, *supra* note 7, at 78.

cycle, and *strange*.[25] Each type of attractor corresponds to a type of dynamical system behavior pattern.[26] Find the attractors and you will understand the system as much as current science allows, for while any point in the playing space can define the system's behavior for the very short term, in the long term "the only possible behaviors are the attractors themselves."[27] Thus, for example, a fixed point attractor is exemplified by Betty's trip to John's house. When she arrived there, the trip was over. A fixed point attractor defines system behavior known as *stable steady states*—not very interesting. Somewhat more dynamical, by contrast, is the limit cycle attractor, which describes systems with trajectories that are repeating in cyclic fashion, such as a clock, or the Indianapolis 500. Limit cycle attractors correspond to system behavior characterized as *stable periodic cycles*—also not very interesting.

Strange attractors, which produce the behavior of what are known as *chaotic* systems, hold more interest for scientists not only because of their intriguing nature, but also because they appear more frequently in the real world than do the classical fixed point and limit cycle attractors.[28] Betty stopped moving once she landed at John's house, and the Indy cars go round and round on the same course. In strange attractor systems, by contrast, once the system state is on the attractor it assumes an open pattern trajectory that never intersects itself and never links up so as to repeat itself. A tangled fish line or a bowl of spaghetti provide good mental images.[29] While the system is on a particular orbit around a strange attractor, moreover, it is highly sensitive to small perturbations so that if "nudged" ever so slightly off the orbit path just a little bit, the system responds over time with an arbitrarily large trajectory shift. Strange attractor systems thus "amplify tiny differences hidden far along the decimal tail, well below any error threshold you may care to set."[30] Classic examples of strange

25. The description of the types of attractors and their behaviors that follows in the text also is derived largely from Casti's explanation. *See* CASTI, *supra* note 7, at 28–35; *see also* COHEN & STEWART, *supra* note 2, at 190–93, 436–441; GLEICK, *supra* note 7, at 121–53.

26. *See* CASTI, *supra* note 7, at 28–29; COHEN & STEWART, *supra* note 2, at 205.

27. GLEICK, *supra* note 7, at 138.

28. *See* CASTI, *supra* note 7, at 37.

29. *See* CASTI, *supra* note 7, at 29; GLEICK, *supra* note 7, at 140.

30. COHEN & STEWART, *supra* note 2, at 191.

attractors in natural systems include the weather and predator-prey food webs.[31] Given their strange attractor characteristics—open trajectories and high sensitivity to change—it is very difficult for us to predict the behavior of such systems and divine their rules of motion.[32] That is the challenge posed by strange attractors in dynamical systems.

The discussion thus far has grossly simplified the nature of dynamical systems for purposes of spelling out the basic lexicon to be used in drawing rough analogies to the law-and-society system. In reality, few systems can be described as simply as Betty's drive to John's house—indeed, even her trip, in its fullest dynamical dimensions, involved a myriad of subsystems and attractors, such as Betty's proclivity to stop at the Baskin Robbins on 10th Street. Given a particular blend of attractors in a system, a system trajectory may traverse a variety of behaviors. A system might be dominated by fixed point, limit cycle, or strange attractors, but it is not necessarily the case that the only behavior experienced everywhere in a dynamical system's space will be one or the other of stable steady, stable periodic, or chaotic behavior.

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31. *See* CASTI, *supra* note 7, at 93–98, 187–91; COHEN & STEWART, *supra* note 2, at 184–93; COVENEY & HIGHFIELD, *supra* note 3, at 37, 243–49. The so-called "butterfly effect" is the most familiar example of a strange attractor system in operation in nature—in this case concerning weather. The computational weather models developed by Ed Lorenz in the 1960s demonstrated that following the strictly deterministic rules of weather formation, a butterfly flapping its wings in China could produce a snowstorm in Alaska. In other words, the rules operate so as to "allow minuscule changes at one location to percolate through the system so as to bring about major effects somewhere else." CASTI, *supra* note 7, at 89–90.

32. A useful mental image that illustrates the difficulty of predicting the behavior of strange attractors is provided by the story of German theoretical chemist Otto Rossler, who observed a saltwater taffy-pulling machine in operation. The story, as told by Casti, is that Rossler observed that the contraption stretched and folded a batch of raisin taffy according to the same mechanical procedure over and over again, but that the raisins in the taffy appeared to change relative positions with no *apparent* order. He contemplated the question of what would be the long-term fate of two raisins initially placed close together, surmising that over time they might separate in position quite dramatically. Indeed, although we know that the machine applies the same procedure *ad infinitum* to the taffy, it would be very difficult to predict where the raisins will be in relation to each other, say, one month into the process. Moreover, if we were to produce a plot graph tracing the paths of the raisins' motions over that month, it would be very difficult for anyone unfamiliar with the machine to explain the rules of motion that produced the paths. *See* CASTI, *supra* note 7, at 91–92. For those who would like to duplicate Rossler's observations at home but do not own a taffy-pulling machine, drop some raisins in a bread-making machine when the kneading step begins.

Indeed, the importance of defining the three types of attractors in dynamical systems theory has been the discovery that certain blends of attractors produce a dominant system behavior quite unlike the stable steady, stable periodic, or chaotic. Scientific models have shown that systems possessing a narrowly defined blend of fixed point, limit cycle, and strange attractors, and that sit "at the edge" of falling into dominant chaotic behavior tend to exhibit tremendous ability to adapt.[33] These systems exist in the region known as the complex, which is characterized by a system behavior state known as *complexity*—not to be confused with complicatedness—and which is the subject of the complexity theory branch of dynamical systems theory. If we want a sustainable law-and-society system, it is that region in which we want the law-and-society system to reside. To know how to get there, however, we first must understand the law-and-society system's attractors and the dynamical system forces that alter or emphasize them.[34]

B. *Attractors in the Law-and-Society System Model*

Although the maxim "history repeats itself" may suggest that the law-and-society system is a stable periodic cycle and some societies do appear sufficiently static even to qualify as stable steady states, mere lay observation of societies and their laws confirms that they interact in a way that defies prediction; they move, rapidly or slowly, through unpredictable tidal shifts of socio-legal structure. The Founders probably would not have predicted the existence of today's Environmental Protection Agency (EPA), or even thought it possible, and yet all the *rules* of the American law-and-society system have been followed (arguably) to get EPA to this point. Moreover, if, at certain crucial turning points, the system's trajectory had been slightly perturbed, the system trajectory may have traversed a different path through phase space and perhaps there would be no EPA today. For example, if the Supreme Court had taken years ago a different view of the nondelegation doctrine, sharply limiting Congress's authority to

33. M. MITCHELL WALDROP, COMPLEXITY: THE EMERGING SCIENCE AT THE EDGE OF ORDER AND CHAOS 293 (1992).

34. For those readers who have to skip ahead to the end of the story, see *infra* text accompanying notes 97–113 for a description of how complexity theory synthesizes the major themes of dynamical systems theory and the application thereof to the law-and-society system.

assign legislative decisionmaking power to administrative agencies instead of giving Congress *carte blanche* discretion to do so, EPA would not be what it is today.[35] EPA is but a microexample of how what we observe as the basic behavior of law-and-society system components can be described through analogy to the lexicon of dynamical systems theory.

The interaction of law, society, and the real world environment in which that system is embedded can be described through analogy to a nonlinear dynamical system. The playing space is the full socio-legal dimension—that is, anything that has to do with the interaction of law and society as broadly as we wish to define those two domains. The rules of motion are laws themselves, on the law side, and social mores and ethics, on the society side. The initial state, at its most distant, was when society first emerged, but for purposes of this study, it is whenever we want to begin examining the effect of a new rule of motion on the system. The trajectory is the rate and direction of the historical socio-legal evolution of the total system in phase space.

To be sure, the fit between the interaction of law and society and the analogical model provided so far by dynamical systems theory is not perfect. Two significant complicating factors are present—humans and the coevolving real world. Humans pose a complication for the model in the form of free will.[36] When a mathematician programs a dynamical system into a computer model, the components obey the rules as given. Humans are not that accommodating, and attempting to "program" or "model" their exercise of discretion requires more of dynamical systems theory than science may ever have to offer. The ability of humans to exercise free will (i.e., to rewrite or disobey the rules) and thereby alter the attractors of the dynamical law-and-society system model

35. For a more detailed discussion of the importance and impact of Congress's practice of delegating legislative authority to administrative agencies, see *infra* text accompanying notes 160–164, 171–177.

36. One commentator explains the complications free will poses to formulation of predictive models of natural systems, including human social systems, with "the paradox of someone (the *predictor*) who uses the determinism of physical laws to foresee the future, and then uses free will to contradict the predictions." DAVID RUELLE, CHANCE AND CHAOS 32–33 (1991). The paradox is resolved only when we comprehend that no predictor has the ability to do the job so well that the paradox arises. *Id.* at 33. One can also present free will as the manifestation of the fact that each human is a dynamical system consisting of at least some strange attractors, and thus behaves in unpredictable ways.

eliminates any possibility of producing a stationary model. Then there is the real world, the law-and-society system's coevolving environment, which presents happenstance—unanticipated events external to the law-and-society system model, such as death and natural disasters, which can disrupt the system if the system cannot adapt to them. While these complications limit the fit of dynamical systems theory to the interaction of law and society, their presence does not suggest that the analogy is inapposite. Indeed, an important field of research within dynamical systems theory has been determining whether and how systems survive such external complications through evolution.[37] Hence, so long as we accept that the exercise is one of analogy, there is much to be gained by exploring the application of dynamical systems theory to the law-and-society system model.

In fact, perhaps the most useful way of exploring the law-and-society system model is to use the complicating factor of free will as the parameter for defining the system's law attractors. In other words, when confronted by the potential for exercise of free will by the system components, how does the law side of the law-and-society system behave? Using environmental law as the representative of the larger system, we find insights for the answer to that question laid out, although without using the dynamical systems theory lexicon, by the Supreme Court in *Lucas v. South Carolina Coastal Council*.[38] The Court came closer in *Lucas* than in any other case—still not very close—to explaining the scope of the Fifth Amendment's prohibition against governmental taking of private property without just compensation.[39] The Court's earlier

37. Complexity theory owes its origins in large part to the study of how physical systems respond to external sources of disturbances, such as turbulence factors in fluid flows, an area of research that has advanced significantly with the benefit of a greater understanding of chaos behavior. *See* Tom Mullin, *Turbulent Times for Fluids*, *in* EXPLORING CHAOS: A GUIDE TO THE NEW SCIENCE OF DISORDER 59 (Nina Hall ed., 1991). Perhaps the most exciting front of current complexity theory research is the exploration of the forces and mechanics of evolution and coevolution in physical, biological, and human systems. *See, e.g.*, KAUFFMAN, AT HOME IN THE UNIVERSE, *supra* note 7, at 149–271. This research illustrates why the schemata that system components develop for responding to external threats and disturbances—for example, the flight pattern of prey when confronted by predator—play an important role in the evolutionary fitness of that component. *See* MURRAY GELL-MANN, THE QUARK AND THE JAGUAR: ADVENTURES IN THE SIMPLE AND THE COMPLEX 235–60 (1994).

38. 112 S. Ct. 2886 (1992).

39. "[N]or shall private property be taken for public use, without just compensation." U.S. CONST. amend. V.

jurisprudence had established the "regulatory takings" doctrine—that is, "if [governmental] regulation goes too far it will be recognized as a taking."[40] Although its jurisprudence developed little in the way of guidelines for applying that principle, the Court's cases evolved toward the general doctrine that land use regulation constitutes a taking when it "does not substantially advance legitimate state interests or denies an owner economically viable use of his land."[41]

Lucas involved the second branch of that doctrine: the circumstance when regulation denies a property owner all economically viable use of the property. In such cases, explained the Court, the government "may resist compensation only if the logically antecedent inquiry into the nature of the owner's estate shows that the proscribed use interests were not part of his title to begin with."[42] The conundrum faced under that test is how to define what uses the property owner had available to it as part of the title prior to introduction of the regulation in issue, so that the effect of the regulation can be measured. For that inquiry, the Court prescribed the following analysis:

> We believe . . . confiscatory regulations, *i.e.*, regulations that prohibit all economically beneficial use of land . . . cannot be newly legislated or decreed (without compensation), but must inhere in the title itself, in the restrictions that background principles of the State's law of property and nuisance already place upon land ownership. A law or decree with such an effect must, in other words, do no more than duplicate the result that could have been achieved in the courts—by adjacent landowners (or other uniquely affected persons) under the State's law of private nuisance, or by the State under its complementary power to abate nuisances that affect the public generally, or otherwise.[43]

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40. Pennsylvania Coal Co. v. Mahon, 260 U.S. 393, 415 (1922). For an extremely comprehensive history of the regulatory takings doctrine and the legal commentary thereon, see William Michael Treanor, *The Original Understanding of the Takings Clause and the Political Process*, 95 COLUM. L. REV. 782 (1995).

41. Agins v. City of Tiburon, 447 U.S. 255, 260 (1980) (citations omitted).

42. *Lucas*, 112 S. Ct. at 2899.

43. *Id.* at 2900. *Lucas* has led to an avalanche of legal commentary to divine its meaning and posit broad or narrow applications to environmental regulation. For some of the more perceptive works in that regard, see Richard A. Epstein, Lucas v. South Carolina Coastal Council: *A Tangled Web of Expectations*, 45 STAN. L. REV. 1369 (1993); Douglas W. Kmiec, *At Last, the Supreme Court Solves the Takings Puzzle*, 19 HARV. J.L. & PUB. POL'Y 147 (1995); Glenn P. Sugameli, *Takings Issues in Light of* Lucas v. South

Lucas thus defines the three attractors among which laws in the law-and-society system travel with respect to the management of human free will in the context of private land use decisions: *freedoms*, represented by the property owner's Fifth Amendment protections against social interference in individual land use choices; *rights*, represented by the rights of nuisance recovery that adjacent property owners or the state may have against some uses of land; and *regulations*, represented by the direct governmental restriction of land uses. The Court pointed to no other factor to be used in defining the current position of takings law in the playing space of the law-and-society system. The fact that we perceive, even after *Lucas*, that the Court still has left us without a clear, bright-line rule for knowing when a regulation constitutes a regulatory taking is simply a reflection of the boundaries between the three attractors. There *is* a bright line—it's just that its description is infinitely complicated and impossible to reduce to a rule of general application for the present or future.

To be sure, *Lucas* represents one of many possible values that law in the law-and-society system could have taken to balance those three factors in a particular application. The result is that the *freedoms* to use property as one wishes are limited by the *rights* others have to recover in nuisance and the ability of the government to duplicate the effect of those rights through direct *regulations*. If one could "map" the locations of freedoms, rights, and regulations in the law-and-society system's playing space, the regulatory takings doctrine as a law value would be on the law-and-society system's trajectory somewhere between these three attractors.

Lucas represents the point in the law-and-society system's playing space where regulatory takings law has moved. All the cases prior to *Lucas* formulating and interpreting the regulatory takings doctrine can be thought of as points along a trajectory, bending and twisting around the freedoms, rights, and regulations attractors and leading (for now) to *Lucas*. The modern notion of regulatory takings did not even exist in the United States two centuries ago, mainly because the modern notion of land use regulation also did not.[44] In that world, freedom was the domi-

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Carolina Coastal Council: *A Decision Full of Sound and Fury Signifying Nothing*, 12 VA. ENVTL. L.J. 439 (1993).

44. It has been argued that the Takings Clause was included in the Constitution to

nant attractor. Nonconfiscatory restrictions on freedom to use property were few[45] and were overshadowed by the rights-based common law domain of nuisance. Nuisance law grew in weight over time as a land use control, particularly in its environmental pollution control branch, through development of principles such as ultrahazardous activity and nuisance per se.[46] During this period, the system trajectory was moving away from the freedoms attractor and predominantly toward the rights attractor represented by nuisance law. There still was no need for a regulatory takings doctrine in that world; indeed, the Court's jurisprudence was ignorant of, or at least resistant to, the very notion.[47] Fast forward to the 1980s, however, and an entirely different picture prevails. The Court's tacit restriction of the takings clause to physical invasions opened the door to regulatory approaches to land use control, and an immense infrastructure of land use regulations began to emerge by the early 1900s.[48] By the 1970s, nuisance law no longer was perceived as being able to address all the problems posed by pollution, and direct regulation began to fill the gap.[49] By the late

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require compensation for only *physical* occupation of private property by government, and that it was applied this way in state and federal cases through the nineteenth century even in the face of land use regulations. *See* Treanor, *supra* note 40, at 785–97. For the contrary view, see Roger Clegg, *Reclaiming the Text of the Takings Clause*, 46 S.C. L. REV. 531, 532–43 (1995). For a comprehensive history of land use regulation generally, beginning with "regulation" by armed bands in the Dark Ages, see Fred Bosselman, *Four Land Ethics: Order, Reform, Responsibility, Opportunity*, 24 ENVTL. L. 1439 (1994).

45. *See, e.g.*, Treanor, *supra* note 40, at 793–94.

46. The importance of nuisance law to environmental regulation should not be underestimated:

> To a surprising degree, the legal history of the environment has been written by nuisance law. There is no common law doctrine that approaches nuisance in comprehensiveness or detail as a regulator of land use and of technological abuse. Nuisance actions reach pollution of all physical media—air, water, land, groundwater—by a wide variety of means. Nuisance actions have challenged virtually every major industrial and municipal activity that today is the subject of comprehensive environmental regulation . . . .

RODGERS, *supra* note 6, § 2.1, at 112–13.

47. *See* Treanor, *supra* note 40, at 794–97; Clegg, *supra* note 44, at 563–71.

48. The Court's legitimization of zoning practices as consistent with due process and equal protection swung the door wide open to regulation of private property for the public good. *See, e.g.*, Hadacheck v. City of Los Angeles, 239 U.S. 394 (1915); Village of Euclid v. Amber Realty Co., 272 U.S. 365 (1926). *See generally* Clegg, *supra* note 44, at 570–72.

49. *See* ROBERT V. PERCIVAL ET AL., ENVIRONMENTAL REGULATION 72 (1992) ("[A]n appreciation of the inadequacies of the common law is crucial to understanding the rapid growth of public law and to evaluating its effectiveness in protecting the environment.").

1980s, the regulations attractor had become dominant in the system, by far superseding rights-based solutions as the principle land use control mechanism. Not coincidentally, a virtual frenzy of attention to the regulatory takings doctrine has prevailed ever since, culminating with the *Lucas* decision.

It may very well be that with *Lucas*, the 1990s will be known as the time when the system began curving away from the regulations attractor. Property rights bills, something unheard of in the 1980s, are passing in state legislatures and are given serious chances of passing in Congress.[50] These so-called property rights initiatives—somewhat of a misnomer since what they seek actually is land use *freedom*—may represent the beginning of a curving back towards the freedoms attractor. To be sure, property use freedoms will most likely never look as they did in the 1700s—the trajectory defined by a strange attractor never intersects with itself—but neither will property use regulations look as they did in the 1980s for very much longer. The system is moving; it is dynamical.

Although it risks appearing fashionable to say so, evidence of a curving away from the regulations attractor is everywhere in environmental law. Consider, for example, the recent emergence of the environmental justice movement, which essentially accuses the environmental regulation infrastructure of ignoring distributional justice across race and income lines.[51] Environmental justice pro-

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50. *See, e.g.*, H.R. 9, 104th Cong., 1st Sess. §§ 201–10 (1995) (passed House of Representatives Mar. 3, 1995) (requiring compensation of property owner if federal regulation restricting non-nuisance use of property reduces the value of a portion of the property in excess of 20% and other specified circumstances are satisfied); S. 605, 104th Cong., 1st Sess. (1995) (reported from committee) (similar to H.R. 9 except adopting a 33% devaluation threshold); TEX. GOV'T CODE ANN. § 2007 (West 1996) (requiring compensation of property owner if state regulation restricting non-nuisance use of property reduces the value of a portion of the property in excess of 25% and other specified circumstances are satisfied). *See generally* Nancie G. Marzulla, *State Private Property Rights Initiatives as a Response to "Environmental Takings,"* 46 S.C. L. REV. 613 (1995).

51. One of the founders and leading advocates of the environmental justice movement describes its central thesis as being that "[c]ommunities consisting primarily of people of color continue to bear a disproportionate burden of this nation's air, water, and waste problems," and that such "[e]nvironmental racism exists within local zoning boards as well as the U.S. Environmental Protection Agency (EPA)." Robert D. Bullard, *The Threat of Environmental Racism*, NAT. RESOURCES & ENV'T, Winter 1993, at 23, 23. The topic of environmental justice in the last decade has exploded into legal commentary, *see, e.g.*, Symposium, *Urban Environmental Justice*, 21 FORDHAM URB. L.J. 425 (1994); Symposium, *Race, Class, and Environmental Justice*, 63 U. COLO. L. REV. 839 (1992), legal academic texts, *see, e.g.*, KENNETH A. MANASTER, ENVIRONMENTAL PROTECTION AND JUSTICE (1995), and governmental programs designed to identify and address instances of

ponents do not speak in terms of more regulations as the solution; rather, principally they seek rights-based outcomes.[52] Consider also efforts in the current Congress, which would have failed miserably just a few years ago, to inject greater cost-benefit sensitivity into the environmental regulation machine and thereby place a check on the reach of regulatory controls.[53] While the property rights, environmental justice, and cost-benefit analysis movements may not be pulling environmental law in the same direction, all are pulling environmental law away from the currently dominant regulations attractor. Environmental law today is not what it was twenty-five years ago and will not be the same twenty-five years hence.

As the environmental law experience demonstrates, any example of how the law-and-society system has used law to manage a particular manifestation of human free will can be expressed as a point on a trajectory that meanders among the attractors of freedoms, rights, and regulations. The location of that point dictates the relative mix of those three legal mechanisms that the law-and-society system uses to address the issue in question at the time in question. Freedom is a person's ability to act without restriction in accord with his own subjective free will in the absence of any countervailing right or regulation. A right is the ability, enforced by society, of one person to constrain another's freedom in the absence of direct governmental intervention. A regulation is society's direct intervention with respect to exercise of a freedom,

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environmental injustice. *See, e.g.*, Exec. Order No. 12,898, 3 C.F.R. 859 (1994), *reprinted in* 3 U.S.C. § 103 (1994) (directing executive agencies to develop strategy for identifying and addressing instances of environmental injustice); U.S. Environmental Protection Agency, Environmental Justice Strategy: Exec. Order 12,898, EPA/200-R-95-002 (1995) (report of the recently created EPA Office of Environmental Justice on implementation of Executive Order 12,898).

52. *See* Luke W. Cole, *Environmental Justice Litigation: Another Stone in David's Sling*, 21 FORDHAM URB. L. J. 523 (1994); Michael Fisher, *Environmental Racism Claims Brought Under Title VI of the Civil Rights Act*, 25 ENVTL. L. 285, 303–33 (1995); Allan Kanner, *Environmental Justice, Torts and Causation*, 34 WASHBURN L.J. 505 (1995); Gerald Torres, *Environmental Burdens and Democratic Justice*, 21 FORDHAM URB. L.J. 431 (1994). For a thorough bibliography of commentaries on the environmental justice issue, see Adam D. Schwartz, *The Law of Environmental Justice: A Research Pathfinder*, [1995] 25 Envtl. L. Rep. (Envtl. L. Inst.) 10,543 (July 1995).

53. *See, e.g.*, H.R. 9, 104th Cong., 1st Sess. §§ 401–440 (1995) (passed House of Representatives Mar. 3, 1995) (requiring federal agencies to compile a risk assessment, cost-benefit analysis, and peer review for major rules, defined as those likely to cost $25 million or more annually). *See generally infra* text accompanying notes 185–87.

regardless of the exercise of any one individual's rights. A map of the different outcomes that the law side of the law-and-society system has produced for managing human free will would identify points in the system playing space. Those points could be located by triangulating off of these three attractors.

Although *Lucas* provides a vehicle for making this point, it does so with an almost artificial neatness and division between the three attractors. The picture may often be much more sloppy than *Lucas* suggests, as the law-and-society system does not always provide such sharply defined choices as pure freedom versus tort cause of action versus direct government regulation. Some legal approaches resemble more of a hybrid between two or more of the three attractors, such as citizen suit provisions of environmental laws allowing private suit to challenge regulatory violations.[54] Still other approaches are weak versions of one of the attractors, such as tax policies intended to induce behavior indirectly rather than by directly imposing coercive constraints.[55]

Of course, that is what dynamical systems theory is all about—sorting through highly complicated, seemingly random system dynamics to find the governing influences. Hence, although it may not always manifest itself as neatly as it did in *Lucas*, law contributes to the resolution of issues of free will in a law-and-society system—contract disputes, gender discrimination, environmental pollution, or whatever else—through the balance of free-

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54. Many environmental laws, using virtually identical operative language, provide that

> any citizen may commence a civil action on his own behalf—(1) against any person (including (i) the United States, and (ii) any other governmental instrumentality or agency to the extent permitted by the eleventh amendment to the Constitution) who is alleged to be in violation of [the relevant statute, regulations, and orders], or (2) against the [relevant agency] where there is alleged a failure of [the agency] to perform any act or duty under this chapter which is not discretionary with [the agency].

33 U.S.C. § 1365(a) (1994) (Clean Water Act); *see also* 16 U.S.C. § 1540(g) (1994) (Endangered Species Act); 42 U.S.C. § 7604(a) (1988) (Clean Air Act); 42 U.S.C. § 6972(a) (1988) (Resource Conservation and Recovery Act).

55. For example, in response to criticism that the Endangered Species Act and other wildlife and habitat protection programs rely on unduly coercive regulatory approaches, many policy analysts, including several prominent conservation organizations, have begun advocating the use of tax incentive policies as a method of inducing private landowners to employ habitat conservation practices. *See, e.g.*, BUILDING ECONOMIC INCENTIVES INTO THE ENDANGERED SPECIES ACT (Wendy E. Hudson ed., 3d ed. 1994); *see also* S. 1365, 104th Cong., 1st Sess. (1995) (providing "federal tax incentives to owners of environmentally sensitive land to enter into conservation easements for the protection of endangered species habitat").

doms, rights, and regulations. Those are the law-and-society system's attractors for determining the mix of law-based mechanisms for managing the complications posed by human freedom of will.[56]

II. DESCRIBING THE GOALS OF THE LAW-AND-SOCIETY SYSTEM MODEL—SURVIVING THE SURPRISES PRODUCED BY CHAOS, EMERGENCE, AND CATASTROPHE

Although we may be able to conclude with some confidence that the proverbial train recently has left the regulation attractor station in environmental law, predicting where it is headed in terms of the shifting balance between the freedoms, rights, and regulations attractors will be more difficult. Besides the unpredictability posed by external happenstance, such exercises in prediction for any dynamical system are confounded by three phenomena of dynamical system behavior: chaos, emergence, and catastrophe.[57] The lexicon used to describe these "surprise" behaviors in dynamical systems also is useful for describing the challenges facing the law-and-society system model.

A. *A Primer on Chaos, Emergence, and Catastrophe*

Chaos, emergence, and catastrophe can be explained using the examples of snowflakes, snow, and avalanches.[58] All snowflakes

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56. Of course, freedoms, rights, and regulations can be viewed as the attractors within a larger attractor of law-based rules, which in turn is one attractor that defines whether the law-and-society system chooses legal or social mechanisms for imposing system rules. Nonlegal, socially defined rules of the law-and-society system, such as ethics and traditions, even brute force, may provide a competing attractor. Hence, another important area of inquiry with regard to management of free will in the law-and-society system would be describing the balance between the law-based and society-based attractors. That scope of inquiry is closer to Kauffman's second level of complexity theory—the coevolution of system components—and it is a topic I hope that I and others will be able to explore in the future. *See* KAUFFMAN, AT HOME IN THE UNIVERSE, *supra* note 7, at 208, 215–21.

57. For excellent historical expositions on the early stages of scientific exploration of chaos, emergence, and catastrophe, particularly through the formation and continuing efforts of the Santa Fe Institute, see ROGER LEWIN, COMPLEXITY: LIFE AT THE EDGE OF CHAOS (1992); M. MITCHELL WALDROP, COMPLEXITY: THE EMERGING SCIENCE AT THE EDGE OF ORDER AND CHAOS (1992).

58. I am aware of snowflakes being used to describe chaotic behavior, *see, e.g.*, GLEICK, *supra* note 7, at 309–14, but I have not found published accounts of how snow resembles emergence behavior and avalanches resemble catastrophe behavior. By all their properties, however, they do appear to exhibit those respective behaviors. In all other

form according to the same deterministic rules of physics and chemistry, and yet no two snowflakes are alike. If we were to observe only snowflakes and nothing else, we might be able to support the hypothesis that the snowflake making process follows no rules. But the reason no two snowflakes are alike is that the outcome of the snowflake making rules is highly sensitive to the initial state of the process—the temperature, atmospheric pressure, trace chemicals in the water, and other factors all dictate, according to the precise rules of the process, what an individual snowflake will look like.[59] Those conditions are never *exactly* the same for any snowflakes. The result is that snowflakes are highly intricate structures, and no two are alike.

That is *chaos*: sensitive dependence on initial conditions in a system dictated by simple, deterministic rules produces what appears to be highly complicated, random system behavior. Chaos, in that sense, is "order *masquerading* as randomness,"[60] and it is the unmistakable fingerprint of a strange attractor. The rules determining the presence of chaos may be simple, but the organizing structure of the overall system, known technically as the system's "fractal curve," is not at all simple.[61] Thus, chaos "only looks complicated because you don't know what the rule is."[62] Moreover, whether chaos manifests itself depends not only on the rules

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respects the explanation of chaos, emergence, and catastrophe that follows in the text is derived largely from Casti's work in complexity theory. *See* CASTI, *supra* note 7, at 43–114, 212–59.

59. *See*, GLEICK, *supra* note 7, at 311.

60. *Id.* at 22.

61. Fractals "display the characteristic feature of self-similarity—an unending series of motifs within motifs repeated at all length scales." COVENEY & HIGHFIELD, *supra* note 3, at 362. Stated another way, "Fractals are curves that are irregular all over. Moreover, they have exactly the same degree of irregularity at all scales of measurement . . . . There are many examples of fractals in nature: ferns, clouds, lightning bolts, coastlines, river basin networks and galaxies, to name but a few." CASTI, *supra* note 7, at 232–34. Thus, a strange attractor is one that "has a fractal (fractional) dimension; it describes chaotic dynamics in dissipative dynamical systems." COVENEY & HIGHFIELD, *supra* note 3, at 365. *See also* GLEICK, *supra* note 7, at 98–118.

62. COHEN & STEWART, *supra* note 2, at 197. The boundaries between various attractors' basins of attraction generally exhibit fractal behavior and are known as fractal basin boundaries. *See* GLEICK, *supra* note 7, at 232–33. One important branch of dynamical systems theory is concerned "not with describing the final, stable behavior of a system but with the way a system chooses between competing options." *Id.* at 233. In his work on the application of chaos theory to law, for example, Hayes draws an analogy between fractal behavior and the apparent fuzziness of legal decisionmaking and precedent. *See* Hayes, *supra* note 8, at 764–72.

of motion but also on the other system structural parameters. For example, a marble in the bottom of a glass bowl obeys the same physical laws as a marble placed on the top of a bowling ball, but displace them slightly and two entirely different outcomes emerge, only one of which defies absolute prediction.[63] Altering any system parameter, therefore, may alter the manifestation of chaos.

Now consider lots of snowflakes collecting into what we call snow. Snow has qualities that would be very difficult to predict simply by observing one snowflake or the rules of snowflake making—it drifts, it packs, it hardens, and exhibits other traits of "snowness." These properties begin to emerge as the number of snowflakes collecting together increases until eventually it is more important to understand the qualities of snow than of snowflakes. As each new snowflake is added to the collection, it interacts with the "snowness"; however, the effect of that incremental interaction is small in comparison to the overall collection of snow, and is difficult to separate from the collective behavior of the snow.[64] Soon, it's the aggregated interactions of all the snowflakes, not the isolated local addition of new snowflakes individually, that are important for understanding the properties of snow.

That is *emergence*: the appearance of unforeseen qualities from the self-organizing interaction of large numbers of objects, which cannot be understood through study of any one of the objects. The key to emergence is understanding that the emergent behaviors of dynamical systems are "high-level patterns arising from the indescribably complex interaction of lower-level subsystems."[65] Hence, removing or otherwise changing any interacting

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63. *See* GLEICK, *supra* note 7, at 19, 48.

64. *See* COHEN & STEWART, *supra* note 2, at 182. Cohen and Stewart illustrate how the number of interactions quickly becomes more important than the number of components interacting by pointing out the simple reality that in a binary (yes/no or on/off) system the number of possible interactions between pairs of system components is roughly half the square of the total number of components. Hence, in a system with 10 components there are 45 possible pair interactions, whereas in a system with 1000 components there are 499,500 possible pair interactions, and a system of one million components has almost five billion possible pair interactions. *Id.* As Cohen and Stewart explain, in large systems

> if the effect of any particular interaction is tiny, we may not be able to work out what it is. We can't study it on its own, in a reductionist manner, because it's too small; but we can't study it as a part of the overall system, because we can't separate it from all the other interactions.

Id.

65. *See id.* at 397. An emergent property is "[a] global property of a complex system

component of the system potentially changes the entire system since the interactions leading to the global emergent behaviors may no longer be possible.[66] The presence or not of emergence thus depends on the condition of the system as a whole.

Lastly, we have the fate of some masses of snow—the avalanche. A particular mass of snow is generally subject to conditions that change gradually over a continuum—new snowflakes falling on the mass add weight, the mass may grow out over a precipice, the ambient temperature slowly rises, and so on. These conditions may flux over a gradual continuum; however, in some cases, the next snowflake, the next millimeter over the precipice, or the next tenth of a degree rise in temperature is the straw that breaks the camel's back. The system, one moment appearing to be moving peacefully towards or on its attractors, crashes in a sudden discontinuity burst towards entirely new conditions.

That is *catastrophe*: a sudden qualitative change in a dynamical system brought about by a continuous change in a system variable.[67] Catastrophe disturbances change the attractors of the dynamical system, and "it may take only the tiniest of changes to trigger the switch."[68] The two subtle features of catastrophe thus are that large changes in behavior can result from arbitrarily small changes in conditions, and that after the system crosses the catastrophe point it may land near or on a previously unfamiliar, or perhaps even unknown, attractor.[69]

The point of describing chaos, emergence, and catastrophe is to explain why it is that dynamical systems are unpredictable—that is, why they experience what is called "deterministic randomness."[70] The determinism that different legal theories either embrace or abhor is the determinism of classical science, which was "focused on a description in terms of deterministic, time-reversible laws."[71] Complexity theory "demolishes the centuries-old myth of

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that consists of many interacting subunits. For example, consciousness is an emergeut property of the many neurons in a human brain." COVENEY & HIGHFIELD, *supra* note 4, at 426. Self organization is "[t]he spontaneous emergence of nonequilibrium structural organization on a macroscopic level due to the collective interactions between a large number of simple, usually microscopic, objects." *Id.* at 432.

66. *See* CASTI, *supra* note 7, at 272.

67. *See id.* at 43–85; COHEN & STEWART, *supra* note 2, at 209–12.

68. COHEN & STEWART, *supra* note 2, at 212.

69. *See id.* at 211; CASTI, *supra* note 7, at 46.

70. *See* CASTI, *supra* note 7, at 88, 93.

71. COVENEY & HIGHFIELD, *supra* note 3, at 16.

predictability and time-symmetric determinism, and with it any idea of a clockwork universe."[72] Strange attractors are the reason for this result:

> Once an irreversible dynamical system has been sucked into a strange attractor, it is totally impossible to predict its long-term behavior. This is because . . . strange attractors show incredible sensitivity to the initial conditions: unless the system is started out with initial conditions of literally infinite precision, it will end up being completely unpredictable. Although the differential equations governing the way these irreversible systems evolve through time are deterministic, in the sense that knowledge of the initial conditions suffices in principle to predict the entire future behavior, their exquisite sensitivity smashes the dream of a clockwork and predictable universe.[73]

This is the deterministic randomness of dynamical systems, "when precise laws lead to apparently random behavior which is in fact minutely organized."[74] Because we have an incomplete grasp of the system's initial conditions and conditions at every *n*th state thereafter, we can never break the code of predictability.

This is a very real challenge for the physical and social sciences. Chaos, emergence, and catastrophe show up in dynamical systems everywhere. Consider a fish species that is tolerant of only a narrow temperature range. If global warming or thermal pollution were to cause the water bodies that the fish inhabits to rise gradually in temperature, initially there would be no observable effects on the fish; but after a point—the precise upper range of the species' temperature tolerance—the species would vanish over a short period. Catastrophes in ecological systems appear to occur in this manner often.[75] In other contexts the lexicon of chaos, emergence, and catastrophe theories has exploded into the physical and

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72. *Id.* at 37.

73. *Id.* at 206.

74. *Id.* at 183. Of course, there also is true random behavior, known as stochastic randomness, which consists of the "uncontrollable effects of . . . fluctuations in the external enviromnent." *Id.* at 207. Instances of catastrophe and emergence may produce what appears to be stochastically random events, and stochastically random behavior may look like chaotic randomness. Hence, "[d]ifferentiating between deterministic and stochastic chaos is one of the principal hurdles." *Id.* The key difference is that in a system of pure stochastic randomness—if such a system could exist in the real world—each point in phase space has an equal likelihood of being visited, and all points will be visited eventually. *See* CASTI, *supra* note 7, at 101.

75. *See* COHEN & STEWART, *supra* note 2, at 211.

social sciences through the application of complexity theory.[76] The analogy to the law-and-society system appears to be fitting as well.

B. *Chaos, Emergence, and Catastrophe as Powerful Forces in the Law-and-Society System Model, and as Powerful Descriptive Tools for Legal Theory—Case Studies from Environmental Law*

The first section of this Article demonstrated that the interaction of law and society can be described through analogy to dynamical systems, and we know that all dynamical systems have the potential for experiencing chaos, emergence, and catastrophe. In extension of the analogy, therefore, we are led to examine the experience of chaos, emergence, and catastrophe in the law-and-society system model, both to appreciate their value to legal theory and to assist in framing the goals of the system itself.

Indeed, law-and-society systems are under constant siege by events and evolutions that resemble the dynamical system surprise behaviors of chaos, emergence, and catastrophe. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA),[77] for example, initiated a catastrophe shift in the dynamical systems sense, not to mention in the more familiar sense to many people. The history of environmental law preceding CERCLA had moved through incremental additions of regulatory pollution control statutes.[78] The perception that this line of attack—this trajectory—was not adequately responding to the problem of abandoned waste sites led Congress to take a new approach in CERCLA,[79] and environmental law has not been the same since. In one fell swoop, CERCLA introduced principles of strict, retroactive, joint and several, and generally unforgiving liability throughout a vast universe of regulated entities—many of whom, by all reasonable interpretations, had never before been even near the environmental liability target zone.[80] The reverber-

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76. *See supra* notes 11–16.

77. 42 U.S.C. §§ 9601–75 (1988).

78. *See* Jerry L. Anderson, *The Environmental Revolution at Twenty-Five*, 26 RUTGERS L.J. 395, 410–416 (1995).

79. For a comprehensive discussion of CERCLA's legislative history, see ALFRED R. LIGHT, CERCLA LAW AND PROCEDURE 12–34 (1991); Alfred R. Light, *Deja Vu All Over Again?: A Memoir of Superfund Past*, NAT'L RESOURCES & ENV'T, Fall 1995, at 29.

80. *See* LIGHT *supra* note 79, at 94–148. CERCLA's reach even went so far as to intrude on the rather mundane world of the tax treatment of like-kind exchanges of

ations were monumental, affecting industries as removed from traditional environmental law as banking, securities, and insurance, and spawning many new industries designed to implement the remedial program. In short, enviroumental law will forever mark CERCLA as a discontinuity shift in which the whole system moved through some kind of warp field to a completely new location.[81] Regardless of what one thinks about CERCLA's merit and performance, an entirely different question is whether you believe the possibility of another event like CERCLA taking place would be the mark of a desirable law-and-society system.

Chaos also manifests itself repeatedly in environmental law in the many examples in which Congress has provided ostensibly simple rules for exercise of administrative authorities, and the agencies have produced highly complicated, random-looking results. For example, Congress defined solid waste in the Resource Conservation and Recovery Act to include "discarded material,"[82] but the EPA has taken over two pages of the Code of Federal Regulations,[83] scores of pages of the Federal Register,[84] and hundreds of pages of internal agency guidances[85] to define that simple "discarded material" concept. Few lawyers, even among the most experienced in solid waste law, really understand fully what EPA's rules mean.[86] And that is not an isolated example in environmen-

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property because of the potential for persons who wind up in a chain of title to property for even an instant to be exposed nonetheless to potential CERCLA liability. Professor Richard Schmalbeck (personal communication).

81. For a somewhat contrary view, Professor Percival describes CERCLA as "a natural adaptation of centuries of common law developments as extended by modern environmental statutes." PERCIVAL, *supra* note 49, at 288. I agree that CERCLA was a statutory adaptation of common law principles, but question whether that adaptation progressed in a "natural" manner if by that Percival means a smooth and continuous evolution, or rather was a catastrophic jump to that adaptation. The difference is in the magnitude of disruption the two behaviors cause to the system.

82. 42 U.S.C. § 6903(27) (1988).

83. 40 C.F.R. §§ 261.1 to 261.2 (1994).

84. *See* 50 Fed. Reg. 664–65 (1985); 50 Fed. Reg. 33,542 (1985); 56 Fed. Reg. 7206 (1991); 56 Fed. Reg. 32,688–92 (1991); 56 Fed. Reg. 42,512 (1991); 57 Fed. Reg. 38,564–66 (1992). For a discussion and evaluation of EPA's drafting of the solid waste/hazardous waste definition regulation, as well as the full set of original solid waste regulation implementation rules, see MARC K. LANDY ET AL., THE ENVIRONMENTAL PROTECTION AGENCY: ASKING THE WRONG QUESTIONS 89–132 (1990).

85. For a discussion of the role of guidance in EPA's solid waste regulation program, see George B. Wyeth, *The "Regulation by Guidance" Debate: An Agency Perspective*, NAT'L RESOURCES & ENV'T, Spring 1995, at 52.

86. *See* Randolph L. Hill, *An Overview of RCRA: The "Mind-Numbing" Provisions*

tal law. In EPA's twenty-five years of existence, it has amassed 12,000 pages in the Code of Federal Regulations.[87] To an outside observer, it would be difficult to divine the underlying legislative directives, or even conclude with confidence that there are any, simply by reading the administrative results. And if there is any organizing principle to all those regulations, no environmental lawyer has discovered it yet. Again, regardless of whether one believes any particular EPA regulation is sound, an entirely different question is whether a law-and-society system that leads to a recondite maze of thousands upon thousands of such regulations is a desirable system.

Emergence also produces puzzling outcomes in environmental law, not simply in the lay sense of complicatedness, but in the dynamical systems sense of unpredicted surface behaviors resulting from subsurface interactions. For example, Enactment of the Clean Water Act (CWA) and Clean Air Act (CAA) in the early 1970s focused attention for the first time on "end-of-pipe" pollutant emission control strategies.[88] We later found, however, that what no longer was coming out the pipes was going into the ground

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of the Most Complicated Environmental Statute, [1991] 21 Envtl. L. Rep. (Envtl. L. Inst.) 10,254 (May 1991). As one EPA official stated with respect to the definition of hazardous waste, which is a subset of solid waste, the regulatious are "a regulatory cuckoo land of definition . . . . I believe we liave five people in the agency who understand what 'hazardous waste' is." United States v. White, 766 F. Supp. 873, 882 (E.D. Wasli. 1991) (quoting Don R. Clay, EPA Assistaut Administrator for Office of Solid Waste and Emergency Response). EPA formed a Definition of Solid Waste Task Force in October 1992, and from its work the agency recently has stated it will publish a proposed rule change by late 1996—a four-year process to revise just one regulation interpreting two words in RCRA. *See* 26 Env't Rep. (BNA) 186–87 (May 12, 1995). In other contexts, moreover, EPA's maze-like regulations have led courts to refuse to enforce them. *See, e.g.*, General Electric Co. v. EPA, 53 F.3d 1324, 1330 (D.C. Cir. 1995) (refusing to enforce EPA's regulatory interpretation of a rule the ageucy had promulgated under the Toxic Substances Control Act because it was "so far from a reasonable person's understanding of the regulations that they could not have fairly informed [defendant] of the agency's perspective"); *In re* CWM Chemical Services, Inc., TSCA Appeal No. 93–1, 1995 TSCA LEXIS 10, at *2 (USEPA May 15, 1995) (refusing to enforce EPA's regulatory interpretation of the Toxic Substauces Control Act because of lack of "adequate notice of the conduct required or prohibited by the rule").

87. *See* 40 C.F.R. pts 1–799 (1994).

88. The CWA ameuded and is a major compouent of the Federal Water Pollution Control Act, 33 U.S.C. §§ 1251–1387 (1994); the CAA, 42 U.S.C. §§ 7401–7671q (Supp. 1993), underwent extensive amendments in 1990. Pub. L. No. 101–549, 104 Stat. 2399 (1990). Enacted when "pollution coutrol technology emphasized end-of-the-pipe solutions," the original emphasis of both statutes was on regulation of discrete "point sources" of air and water pollution, which were "easier to control, both politically and administratively." PERCIVAL, *supra* note 49, at 885.

instead, and the Resource Conservation and Recovery Act (RCRA) was passed to address, among other things, land disposal of pollutants.[89] The CWA and CAA made sense for the discrete issues they were designed to solve, but their rigid, single focus approach did not anticipate the emergence of lax land disposal practices in response to end-of-pipe water and air pollution controls.[90] The dynamics of the law-and-society system played a surprise on the narrowly targeted environmental regulation efforts.

The source of emergent responses to law are not always that obvious. More recently, for example, we discovered that CERCLA has "backfired" so as to stifle redevelopment of so-called "brownfields" (i.e., abandoned or idle inner city properties of former industrial operations).[91] Because CERCLA imposes liability for contamination on present owners of such sites regardless of fault and in practice has imposed expensive remediation standards, there has been a tremendous reluctance to reuse or redevelop such properties.[92] Development thus gravitates to raw land, usually far

89. RCRA amended and is the major component of the Solid Waste Disposal Act. 42 U.S.C. §§ 6901–6992k (Supp. 1993). The legislative history of RCRA reveals Congress's realization that "the federal government [was] spending billions of dollars to remove pollutants from the air and water, only to dispose of such pollutants on the land in an environmentally unsound manner." H. R. REP. No. 1491, 94th Cong., 2d Sess., pt. 1, at 4 (1976). More broadly, it has been observed that "[t]he history of environmental law is filled with examples of air pollution problems being 'solved' by dumping the residue into the water, water pollution 'eliminated' by diverting the residues to the land, and land pollution 'cleaned up' by incineration or underground injection." RODGERS, *supra* note 6, at 59.

90. In its 1978 study of the issue, the U.S. General Accounting Office concluded that "[p]ollution control produces pollutants which must be disposed of in the air, in water, or on land. Unfortunately, environmental protection laws and programs have such single rigid control requirements that pollution control tradeoffs are not usually considered." U.S. GEN. ACCT. OFF., PUB. NO. GAO/RCED-78-148B, 16 AIR AND WATER POLLUTION ISSUES FACING THE NATION 89 (1978). *See generally* Lakshman Guruswamy, *The Case for Integrated Pollution Control*, LAW & CONTEMP. PROBS., Autumn 1991, at 41, 42 ("Limitations on discharges in one medium, such as air, . . . often do little more than shift the pollution to another medium. Such transfers can create even greater problems in the medium to which they are moved.").

91. *See* E. Lynn Grayson & Stephen A. K. Palmer, *The Brownfields Phenomenon: An Analysis of Environmental, Economic, and Community Concerns*, [1995] 25 Envtl L. Rep. (Envtl L. Inst.) 10,337 (July 1995); Bernard A. Weintraub & Sy Garza, *The Redevelopment of Brownsites*, NAT'L RESOURCES & ENVT., Spring 1995, at 57; R. Michael Sweeny, *Brownfields Restoration and Voluntary Cleanup Legislation*, 2 ENVTL. LAW. 101 (1995). The phenomenon finds a parallel in state laws. *See* OFFICE OF TECHNOLOGY ASSESSMENT, THE STATE OF THE STATES ON BROWNFIELDS: PROGRAMS FOR CLEANUP AND REUSE OF CONTAMINATED SITES 23–26 (1995).

92. CERCLA generally imposes strict liability on the present owner of a contami-

from the inner city, where potential CERCLA liability exposure is low. In the end, our zeal to return all contaminated land to pristine conditions has stunted economic development where it is needed most, and has promoted conversion of pristine land into commercial uses where such uses are needed and wanted least in terms of overall ecological management.[93] No one set out to make that happen or even thought it would; rather, unanticipated social behaviors emerge as the winners, and losers generated by the regulations respond to them in contexts outside the scope of, and often inconsistently with, the main regulatory goal.

The deeply counterintuitive and potentially invidious qualities of these feedback and feedforward loop effects are illustrated even more effectively by what Professor David Dana calls the "race to develop."[94] When environmental preservation regulations impose nonretroactive land development restrictions without hope of compensation for the landowner under the mixed-up regulatory takings doctrine, the emergent behavior of landowners is to race to develop before additional restrictions are imposed—which in turn prompts more regulation, which in turn prompts more development, and so on. The effect of not compensating landowners for

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nated property regardless of the owner's lack of involvement in the initial disposal of hazardous substances at the site or subsequent exacerbation of conditions posing a risk to human health or the environment. *See* ALFRED R. LIGHT, CERCLA LAW AND PROCEDURE § 4.5.1 (1991); Mehron Azarmehr, *Status of Joint and Several Liability Under CERCLA After Bell Petroleum*, [1994] 24 Envtl. L. Rep. (Envtl. L. Inst.) 10,250 (May 1994). The Environmental Protection Agency's regulations implementing CERCLA, *see* National Oil and Hazardous Substances Contingency Plan, 40 C.F.R. pt. 300 (1994), involve a complicated and lengthy process of site investigation, remedy selection, and negotiation between the government and responsible parties. *See* LIGHT, *supra*, at §§ 3.2.5–3.3.6. The average cost of completing an investigation and remedy selection at a CERCLA site is $1.3 million, and the average cost of implementing the remedy is around $30 million. *See* Jerry L. Anderson, *The Hazardous Waste Land*, 13 VA. ENVTL. L.J. 1, 10–11 & n.50 (1993). These factors create the conditions under which "financiers are frequently not supportive of industrial redevelopment projects. The fear of becoming involved with these properties has left historical industrial and commercial centers—often associated with industrial and port areas—with a decreasing number of sites in which new businesses can flourish, and an eroding tax base." Weintraub & Garza, *supra* note 91, at 57.

93. The EPA recently issued a "brownfields initiative" to combat the problem head on by reducing uncertainty in liability exposure at appropriate sites. *See* 60 Fed. Reg. 9684 (1995). Congress has sought to address the issue as well through measures designed to ameliorate the risks faced by redevelopment projects under CERCLA. *See, e.g.*, H.R. 2178, 104th Cong., 1st Sess. (1995).

94. *See* David A. Dana, *Natural Preservation and the Race to Develop*, 143 U. PENN. L. REV. 655–56 (1995).

the effects of environmental regulation, therefore, is to promote the very behavior we intend to restrict, perhaps thereby imposing social costs in the form of diminished resources that are far in excess of the costs of providing landowner compensation.

These are not isolated examples of emergence's element of surprise in environmental law settings: We have scores of federal environmental laws to obey and a host of agencies addressing discrete issues in overlapping, sometimes conflicting manners.[95] The sheer numbers of environmental regulations and regulated entities lead to the possibility of intricate interactions at levels far below the surface of what we believe we are regulating. Those interactions, in turn, lead to emergent behaviors that we perceive as yet more issues for regulation, and the cycle continues. And so, regardless of whether one believes RCRA, CERCLA, or any other environmental law is a useful component of environmental law, an entirely different question is whether a law-and-society system that requires adding one statutory component after another, seemingly *ad infinitum*, to combat one emergent behavior pattern after another is a desirable system.[96]

To be sure, many of the scientists who have forged the way for the study of chaos, emergence, and catastrophe in science would object to putting the issues in those normative terms—i.e,

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95. *See, e.g.*, SELECTED ENVIRONMENTAL LAW STATUTES (13th ed. 1995) (including 19 federal environmental statutes); CELIA CAMPBELL-MOHN ET AL., ENVIRONMENTAL LAW: FROM RESOURCES TO RECOVERY 80 (1993) (identifying 17 federal agencies with environmental law responsibilities). Among the various agencies "there is no clear rationale for the distribution of jurisdiction . . . except that it derives from the fragmented congressional committees." *Id.* at 79. Another paradoxical emergence that has recently come into light is that automobile manufacturers' regulatorily-imposed fleet fuel efficiency requirements have led to car manufacturers building cars with more plastics, thus making cars harder to recycle. *See* Jon Bigness, *As Auto Companies Put More Plastic in Their Cars, Recyclers Can Recycle Less*, WALL ST. J., July 10, 1995, at B1.

96. Without using the lexicon of dynamical systems theory, Professor Richard Epstein has posited the phenomenon of emergence in the law-and-society system as well as I could hope:

> Any individual case may well present appealing reasons for some new statutory intervention . . . but the combined or cumulative effect of countless legal innovations tends to be ignored in the ceaseless quest to adopt any single innovation. What appears noble in the individual case turns out to be dubious in the aggregate. By degrees, therefore, our extensive level of social ambition leads us to a very complex set of legal rules, one which only lawyers can understand and navigate, and then at very stiff fees.

EPSTEIN, *supra* note 17, at 14–15. Although we may agree on the premises, however, Epstein's solution of "simplifying" laws fails to incorporate the full message of dynamical systems theory. *See infra* notes 171–75 and accompanying text.

whether those are *desirable* qualities. Scientists do not generally ask whether, for example, the chaotic eddies and swirls of a cigarette smoke plume are desirable qualities of the plume, and certainly the plume itself would not behave differently even if such a question were posed and answered. But for the law-and-society system—a system we get the opportunity to design in large part—there is little point to identifying dynamic qualities of the system without asking the normative questions.

Of course, to pose the question may suggest more than realistically can be expected in the way of a response. Like the smoke plume, chaos, emergence, and catastrophe in the law-and-society system do not behave based on normative factors, and hence whether their manifestations are considered desirable or not in specific applications depends on the observer. Yet, as we know that future instances of chaos, emergence, and catastrophe generally are beyond our grasp to predict, it is not as if we can selectively cull out the normatively pernicious instances of them and save the good ones. Rather, the best we can hope for is to gain some measure of control generally over how frequently and intensively those behaviors occur, and to harness their normatively positive effects on a system-wide basis. The first step in that direction is using the model to understand what is happening in the system; only then can we begin to ask whether the system is on the course we desire. The descriptive value of the dynamical systems model lies in its ability to assist us in knowing where and when we may need to attempt to adjust the trajectory; the analytical value of the model lies in its ability to instruct us in how to do so.

C. *Surviving the Surprises of Chaos, Emergence, and Catastrophe—Promoting Sustainability in the Law-and-Society System*

How do dynamical systems survive the onslaught of chaos, emergence, and catastrophe, not to mention external happenstance? Some do not. Avalanches happen. Those systems that have demonstrated sustainability have somehow managed to build into their structures qualities that help them survive the surprises produced by chaos, emergence, and catastrophe. This is not to say successful systems do not experience chaos, emergence, or catastrophe, but only that they are not easily brought down by those phenomena.

Recognizing that behaviors much like chaos, emergence, and catastrophe occur in the law-and-society system model, how do we

deal with them? We can start by considering the factors that contribute to the robust sustainability or fitness that allows some dynamical systems to withstand the surprise phenomena—qualities such as stability, simplicity, and adaptability—that are themselves in flux and tension in the most robust systems. By stability, we mean the quality that allows relationships within the system at any one instant to remain close to the way they were the instant before.[97] In the law-and-society system, for example, it seems reasonable to hope that the legal relationships affecting you will be roughly the same in the morning as when you went to bed the night before. By simplicity, we mean allowing the relationships in the system to be easily determined from the system components and rules.[98] For example, legal relationships should be easily comprehensible. Lastly, adaptability involves the ability to respond through feedback and feedforward information flows to chaos, emergence, and catastrophe (as well as nonsystem happenstance).[99] For example, the law-and-society system should be able to adapt to challenges presented by new kinds of socio-legal issues. Some of the means and results of achieving these goals may be

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97. Casti explains stability as follows:

> The problem of stability is probably the most studied aspect of dynamical systems—and with good reason. In fact, it's hard to imagine how any investigation of dynamics can be started before the stability properties of the system are understood . . . . What we'd like to know is whether or not there is a discontinuous shift in the nature of the attractors as we move through [the] family [of trajectories] . . . . [T]he structural stability question is "For which members of the family do qualitative changes in long-run behavior occur?"

CASTI, *supra* note 7, at 286.

98. Casti describes several qualities of simplicity in systems: (1) predictability of behavior; (2) few interactions and feedback/feedforward loops; (3) centralized decision-making; and (4) decomposability. *Id.* at 270–73. As such, systems in which simplicity predominates tend to be very ordered and to respond well to reductionist analysis.

99. Feedback is "[a] general term for the mechanism whereby the consequences of an ongoing process become factors in modifying or changing that process." COVENEY & HIGHFIELD, *supra* note 4, at 427. Feedforward involves "[n]etworks whose architectures are such that the neurons can be divided into layers, with the neural activities in one layer only being able to influence the activity in later (not earlier) layers." *Id.* Adaptability is associated with system feedback and feedforward loops that "enable the system to restructure, or at least modify, the interaction pattern among its variables, thereby opening up the possibility for a wider range of behaviors." CASTI, *supra* note 7, at 271. Hence, "[a]daptive behavior is an emergent property which spontaneously arises through the interaction of simple components." GLEICK, *supra* note 7, at 339 n.314 (citation omitted). As such, adaptability, stability, and simplicity in systems are in tension, a necessary quality of robust systems: Emergence is necessary to produce adaptability, but the chaos that comes along with it is held in check by stability and simplicity. *See generally infra* notes 101–08 and accompanying text.

counterintuitive, just as dynamical systems frequently defy our ordinary intuition.[100] For example, stability is not necessarily promoted by having the system adopt strong or rigid rules. The friction buildup between tectonic plates can be released through a series of small tremors over a period or one big earthquake at the end of the period. The former approach seems preferable, at least for humans. So, too, can other dynamical systems, including the law-and-society system, preserve overall system stability through the use of built-in pressure relief mechanisms.[101] For example, was the sudden introduction of CERCLA necessary, or would gradual, incremental measures directed at remediation of waste sites have been more effective at producing a consensus-based, lasting approach to the issue of contaminated sites?

Similarly, simplicity is not necessarily promoted by adopting uncomplicated system rules. For example, what could be more simple to comprehend than a rule allowing everyone to drive sixty miles per hour anywhere at all times? Such a rule could result in chaotic (probably dangerous) driving behavior if applied to heavy traffic in a downtown setting. If, however, all drivers had to use the same one-lane road, it wouldn't matter very much what the speed rule says—the slowest driver would set the pace. Congress chose a simple rule—discarded material—to define solid waste, and EPA handed us a regulatory maze.[102] Congress might have provided a more "complicated" legislative directive that, in a more controlled, simplified administrative setting, could have produced more simple, comprehensible implementation regulations.

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100. Indeed, "[d]ynamical things are generally counterintuitive." GLEICK, *supra* note 7, at 292.

101. Research has shown that these release valves appear in some dynamical systems through what is called "self-organized criticality," which is "[a] generic pattern of self-organized nonequilibrium behavior in which there are characteristic long-range temporal and spatial regularities." COVENEY & HIGHFIELD, *supra* note 3, at 452. An example is provided by physicist Per Bak:

> Bak asks us to consider a tabletop onto which sand is dropped at a uniform rate. As the sand piles up, it begins to slide off the edges of the table. Eventually, the system reaches a steady state at which the mean rate of dropping sand onto the pile equals the mean rate at which sand falls over the edges. At this stage, the slopes from the peak to the edges of the table are near the rest angle for sand. Bak asks the following question: If one adds a single grain of sand to the pile at a random location and thereby starts an avalanche, what will the distribution of avalanche sizes be? He finds a characteristic power-law distribution relating the frequencies and sizes of avalanches, with many tiny avalanches and few large ones.

KAUFFMAN, THE ORIGINS OF ORDER, *supra* note 7, at 255.

102. *See supra* text accompanying notes 82–87.

Lastly, adaptability does not necessarily come by responding directly to emergent phenomena with precisely tailored countervailing rules. Emergence manifests itself at high system levels and is the result of interactions taking place at lower system levels. Change the dynamics at lower system levels and the emergent behaviors change. Hence, systems that rest on flexible, adaptive lower system dynamics have a better chance of surviving higher level complexities. For example, the chasing-the-pollution history of the CWA, CAA, and RCRA[103] involved legal initiatives aimed at confronting high system level emergences—pollution *disposal*—head on with countervailing regulations. Only recently has environmental law shifted attention one level lower to pollution *prevention* measures.[104] Fully successful pollution prevention would negate much of the need for pollution disposal control and would allow us to respond to instances of pollution at their subsurface causal level rather than the surface manifestation level.[105] Similarly, creating incentives for landowners to view conservation as being more attractive than development, rather than fueling the "race to develop" fire with more regulations, could ameliorate the race to develop by reducing the tendency to produce the emergent behavior feedback and feedforward cycles.

Dynamical systems theory thus teaches us some counterintuitive lessons for promoting system sustainability. First, focus on system mechanisms that will serve as system "release valves." Second, focus on simplifying the system dynamics, not necessarily just the system rules. Finally, focus on promoting system adaptability through innovation of lower-level system dynamics, not on mechanisms designed to confront high-level emergent complexities head-on. The unifying theme of those lessons is that it is not just the rules of the system that matter but the entire system structure. Hence, legal reform directed at the goals of increasing system

103. *See supra* text accompanying notes 88–90.

104. *See generally* Symposium, *Pollution Prevention*, 29 GA. L. REV. 313 (1995) (evaluating current approaches to pollution prevention and possibilities for future action).

105. *See, e.g.*, Hon. James L. Oakes, *Developments in Environmental Law: What to Watch*, [1995] 25 Envtl. L. Rep. (Envtl. L. Inst.) 10,308 (June 1995) (observing that "much of the [environmental] law as presently constituted looks toward the disposal of hazardous waste rather than the use of hazardous products, toward the recovery phase of waters rather than the withdrawal phase, toward damages from toxic torts rather than their prevention").

adaptability must focus on working with the complete law-and-society system, not on just tinkering with laws.

So, toward what paradigm should a dynamical system be constructed to achieve sustainability? This is where we find dynamical systems theory—through its complexity theory branch—pulling the pieces of the puzzle together.[106] As noted in the previous section describing the various types of system attractors, dynamical systems theorists have explored a region exhibiting system behavior known as complexity.[107] This region is sandwiched between the periodic and chaotic states, and is defined by systems possessing a blend of fixed point, limit cycle, and chaotic attractors. The research of this region reveals that the closer such a system can get toward the chaotic state without "falling in," the more adaptable the system is to the surprises produced by chaos, emergence, and catastrophe. Complexity behavior, it appears, promotes system sustainability. Why is this so?

The answer lies in the nature of behavior that is associated with each type of attractor and in the balance[108] that can be achieved for overall system behavior by blending the influence of certain attractors. The only type of attractor that responds unpredictably in the long term to small changes in system components is the strange attractor, which produces deterministically random (chaotic) behavior. A strange attractor remembers, so to speak, that the system was perturbed in the past, and it responds by changing trajectory to adapt to the perturbation. Fixed point and limit cycle attractors, by contrast, do not allow such computation and alteration of trajectory.[109] On the other hand, fixed point and limit cycle attractors present more predictable behavior, and therefore contribute stability and simplicity to the system.

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106. Some of the leading work in complexity theory has come out of research from the fields of artificial life and evolution, thus providing an apt metaphorical background for the question of human free will and change in the dynamical law-and-society system. *See, e.g.*, SIMON HAYKIN, NEURAL NETWORKS: A COMPREHENSIVE FOUNDATION (1994); KAUFFMAN, ORIGINS OF ORDER, *supra* note 7; KAUFFMAN, AT HOME IN THE UNIVERSE, *supra* note 7; STEVEN LEVY, ARTIFICIAL LIFE: A REPORT FROM THE FRONTIER WHERE COMPUTERS MEET BIOLOGY (1992). For an excellent nontechnical discussion of the subject of artificial intelligence, see Geu, *supra* note 8, at 946–55.

107. *See supra* notes 9, 33.

108. By balance I do not mean equilibrium in the familiar sense of stasis, which would be the result of a system defined exclusively by a fixed point attractor. Complex systems—sitting on the edge of chaos—are far from that sort of equilibrium. *See* COVENEY & HIGHFIELD, *supra* note 3, at 184.

109. *See* GLEICK, *supra* note 7, at 134.

Strange attractors thus are necessary for system adaptation to take place, but fixed point and limit cycle attractors, because of their predictability, make possible extended system-wide stability and simplicity. Complexity theory research has revealed that the key in determining the blend of attractors is the degree to which system components depend on one another for knowing where to go next on the trajectory, and that there is "this completely decisive property of complexity, that there exists a critical size below which the process of synthesis is degenerative, but above which the phenomenon of synthesis . . . can become explosive."[110] When the degree of interdependence, or coupling, among the system components is sufficient to allow the three types of attractors to blend in the correct measures, optimal system adaptability therefore is achieved. That optimal system adaptability occurs in the region called complexity. Too many fixed point and limit cycle attractors drag the system into stasis. Too many strange attractors drag the system into chaos. Just the right blend of attractors keeps the system "on the edge" of chaos, capable of sustaining the surprises produced by chaos, emergence, and catastrophe as well as by the happenstance of forces external to the system. In short, "complex systems constructed such that they are poised on the boundary between order and chaos are the ones best able to adapt by mutation and selection. Such poised systems appear to be best able to coordinate complex, flexible behavior

110. LEVY, *supra* note 106, at 110 (quoting Christopher Langton, artificial life expert). Theorists call the complex region the "sweet spot," *id.*, or the "edge of chaos." KAUFFMAN, ORIGINS OF ORDER, *supra* note 7, at 31. Kauffman uses the model of networks of on/off light bulbs to explain the importance of component linkages, or what he calls coupling:

> [T]he way networks are constructed can control whether they are in an ordered regime, a chaotic regime, or a phase transition regime between these, "on the edge of chaos." One feature is simply how many "inputs" control any light bulb. If each bulb is controlled by only one or two other light bulbs, if the network is "sparsely connected," then the system exhibits stunning order. If each bulb is controlled by many other light bulbs, then the network is chaotic. So "tuning" the connectivity of a network tunes whether one finds order or chaos.

KAUFFMAN, AT HOME IN THE UNIVERSE, *supra* note 7, at 80–81. His research suggests that in a system of n components, where the number of inputs upon which each component depends is anywhere from zero to n, coupling levels at the lower end of the range lead to the most robust systems. *Id.* at 81–85. On the other hand, dropping below a sufficient coupling level leads quickly to rigidity. *Id.* Thus, he concludes that a robust system consists of "extremely complex webs of interacting elements [that] are sparsely conpled." *Id.* at 84.

and best able to respond to changes in their environment."[111] Systems in the complex region thus exist when the qualities contributing to system sustainability—stability, simplicity, and adaptability—are in harmonious balance, and chaos, emergence, and catastrophe are collapsed into instruments of system evolutionary robustness.

The great paradox of dynamical systems that complexity theory has unlocked, therefore, is that "equilibrium" in the classical science sense of stasis and linearity is not sustainable in the long term for dynamical systems. Rather, strange attractors are a key ingredient of robust systems, and thus some level of chaotic behavior is necessary to maximize system sustainability. Moreover, the blend of attractors needed to promote sustainability necessarily produces emergent behaviors as a result of interaction between the multiple components. Hence, a robust, fit, sustainable dynamical system, because of the inherent presence of some chaos and emergence, *necessarily is unpredictable.* The key is that the complex systems have turned that source of unpredictability around and channeled it into the trait of adaptiveness, allowing the system to transform disorder into organization. To find that level of sustainability, the law-and-society system also must evolve[112] toward the complex region, so as to sit "on the edge of chaos."[113]

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111. KAUFFMAN, ORIGINS OF ORDER, *supra* note 7, at 29.

112. Reference to an evolving law-and-society system brings into focus the debate, which has taken place largely among German legal theorists, regarding the autopoietic quality of the law-and-society system and whether the legal system is a closed, self-referentially evolving subcomponent of society. *See infra* text accompanying notes 146–156.

113. There has been a tendency in the legal literature on dynamical systems theory to focus on *chaos* behavior as the source of system robustness. *See, e.g.*, Hayes, *supra* note 8, at 765; Reynolds, *supra* note 8, at 1637; Scott, *supra* note 8, at 349 ("chaotic (or non-linear) processes are—because of their unpredictability—more stable than those in equilibrium (linear processes)"). Even in science "[t]here has been a recent trend of using the word 'chaos' (meaning deterministic chaos) as an explanation of everything . . . even when self-organization would be more appropriate." COVENEY & HIGHFIELD, *supra* note 3, at 207. To be sure, the presence and qualities of chaos are important, and these commentators have insightfully employed it as the way of explaining the complicated nature of the law-and-society system. In order to be sustainable, however, the system must somehow collapse chaos into complexity. Although the chaotic behavior of the strange attractor does provide it a capacity to adapt to "nudges" and is an essential quality of sustainable systems, a system made up exclusively of strange attractors—a purely chaotic system—would not exhibit nearly the degree of sustainability exhibited by systems operating in the complex region. A system requires nonchaotic attractors to make that evolution to complexity. *See generally* LEVY, *supra* note 106 (discussing the history and significance of artificial life); CASTI, *supra* note 7 (discussing the science of surprise and introducing complex systems).

III. A COMPLEXITY THEORY CRITIQUE OF THE MODERN AMERICAN LAW-AND-SOCIETY SYSTEM—REDUCTIONISM AD INFINITUMISM

The irony of the American law-and-society system is that although we may have the goal of sustainability in mind, we seem often to get amplified quantities of chaos, emergence, and catastrophe as the results. In the dynamical systems theory lexicon, we seem not to be anywhere near the region of the complex.

That is because classical American legal theory and legal institutions, like classical science, are based on the reductionist tenet that through ever finer decompositions of the system we can discover the system's governing meta-principles. Chaos, emergence, and catastrophe do not lend themselves to analysis through such dissection, and thus are "an enormous problem for reductionism."[114] Dynamical systems *do* have governing meta-principles; it's just that we will never find them by slicing up the system into smaller parts. Indeed, it is the most sustainable of systems that present the biggest challenge of that regard, for we know that an essential quality of systems that make it into the complex region is that they depend on some level of system coupling, which itself is contra-reductionist, and they sit poised on the edge of chaos, which defies prediction. American legal theory and institutions have not learned those features yet, but must do so eventually if we wish to understand and confront the dynamical qualities of the law-and-society system and swim back to the region of complexity.

A. *Fallacies of the Reductionist Creed*

Reductionism is a very powerful descriptive and analytical tool in science. But recall how little we learn about snow or avalanches by studying an individual snowflake. Newton, for example, was a reductionist, and few doubt the value of his work to our understanding of the physical world; nevertheless, Einstein proved Newton's theories did not solve everything.[115] Chaos, emergence, and catastrophe keep reductionist approaches from doing so. When

114. COHEN & STEWART, *supra* note 2, at 191.

115. "As one physicist put it: 'Relativity eliminated the Newtonian illusion of absolute space and time; quantum theory eliminated the Newtonian dream of a controllable measurement process; and chaos eliminates the . . . fantasy of deterministic predictability.' " GLEICK, *supra* note 7, at 6 (quoting an unidentified person).

reductionism has prevailed, it has prevented that insight from becoming an organizing principle of study because reductionism is premised largely on five extremely intuitive, but false, principles:

> 1. Small, gradual changes in causes give rise to small, gradual changes in effects.
> 2. Deterministic rules of behavior give rise to completely predictable events.
> 3. All real-world truths are the logical outcome of following a set of rules.
> 4. Complicated systems can always be understood by breaking them down into simpler parts.
> 5. Surprising behavior results only from complicated, hard-to-understand interactions among a system's component parts.[116]

Most behavior of virtually any dynamical system can be explained using those doctrines, and classical science has done a good job of doing so for centuries. The force of reductionism in this respect comes from its ability to provide close approximation through application of those central tenets, such that "[g]iven an *approximate* knowledge of a system's initial conditions and an understanding of natural law, one can calculate the *approximate* behavior of the system."[117] But once approximation no longer is good enough for the level of comfort we seek in our answers to the big questions, all dynamical behavior cannot be explained through these doctrines: Complexity theory represents an advancement in science because it explains why that is so in a unified theory.[118] When confronted with these dynamical system sur-

116. These are the subheadings for the second through sixth chapters from Casti's book on complexity theory. *See* CASTI, *supra* note 7.

117. GLEICK, *supra* note 7, at 15. Such "anaemic linear approximations miss all the novel non-linear features that lead to the very organizing and chaotic features which we seek to explain." COVENEY & HIGHFIELD, *supra* note 3, at 185.

118. We know from the discussion in the first two sections of this Article that catastrophe behavior defies the first premise of reductionism, chaos defies the second, and emergence defies the fourth and fifth. The third premise is a bit tricky since I have maintained already that dynamical systems do follow sets of rules. To understand why this particular reductionist premise is false requires an understanding of the mathematical theory of "incompleteness" developed through the work of Gregory Chaitin, who built on the work of Alan Turing and Kurt Goedel. *See* Gregory J. Chaitin, *A Random Walk in Arithmetic, in* EXPLORING CHAOS: A GUIDE TO THE NEW SCIENCE OF DISORDER 196 (Nina Hall ed., 1991); Gregory J. Chaitin, *Randomness in Arithmetic and the Decline and Fall of Reductionism in Pure Mathematics, in* COOPERATION AND CONFLICT IN GENERAL EVOLUTIONARY PROCESSES 109–10 (John L. Casti and Anders Karlqvist eds., 1995). In summary, this highly technical branch of mathematics proves that "[f]or every consistent

prise behaviors, reductionism in science has produced "[m]ore and more rules . . . condensed into fewer—but more abstract—general principles. The ultimate goal of reductionist science, a Theory of Everything, aims to condense the entire universe into a single system of meta-meta— . . . —meta-rules."[119] Most of the significant debates in classical science, such as how evolution works, what is an ecosystem, and how do subatomic particles behave, have been about competing sets of reductionist theorem rules aimed at dynamical system behavior that inherently defies reductionist analysis.[120] The study of dynamical systems has advanced the game beyond reductionism, for "[w]here chaos begins, classical science stops."[121] In short, "[r]eductionism, with its attempts to explain the world in terms of behavior of its microscopic components alone, is invalid."[122] And so it is too, we find, as an approach in American legal theory and legal institutions.

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formalization of arithmetic, there exist arithmetic truths unprovable within that formal system." CASTI, *supra* note 7, at 139. Hence, "[t]here exist numbers having complexity greater than any theory of mathematics can prove." *Id.* at 146. Translated into broader complexity theory principles, this means that "we'll never get at all the truth by following rules; there's always something out there in the real world that resists being fenced in by a deductive argument." *Id.* at 150. In other words, for any nonlinear dynamical system there are real world system dynamics that the system rules never reveal, thus implying the presence of strange attractors and the inability to explain all system truths through a set of rules. This reality shatters the prospect of using the self-referential qualities of formal logic systems to explain "truth" because they are necessarily limited in their capacity to explain truth by the rules upon which they are based, and those rules, *any* rules, are incapable of explaining the entire system.

119. COHEN & STEWART, *supra* note 2, at 397 (second ellipsis in original).

120. *See generally* GLEICK, *supra* note 7, at 35–39.

121. *Id.* at 3. Casti summarizes the limits of reductionism when applied to complex system behavior as follows:

> From a reductionistic point of view, the natural temptation in studying the behavior of several bodies is to break the system up into subproblems involving a lesser number of bodies. And, in fact, it's possible to give a complete mathematical solution for what happens in the case of a two-particle system. So it's irresistibly tempting to try to solve, say, the three-body problem by piecing together somehow the solutions to three two-body problems . . . [t]he essence of the problem lies in the linkages (i.e., forces) among *all* the particles. As soon as you start ignoring any of these connections, you end up throwing out the problem with the bathwater, so to speak.

CASTI, *supra* note 7, at 266.

122. COVENEY & HIGHFIELD, *supra* note 3, at 295.

B. *The Influence of Reductionism in American Legal Theory*

American legal theory has evolved along the same reductionist path that characterizes classical science. The fixation of legal theorists on predictable and "correct" static outcomes has led naturally to a way of thinking that mirrors classical scientific thought. Legal theorists for a long time have pursued a Theory of Everything to explain the law-and-society system and, like classical science, have produced theories of law relying on voluminous, abstract, general principles that pull the theory ever deeper into the fallacies of reductionism.

Although not drawing these parallels between science and law, nor even framing the issue as the role of reductionist thought in American legal theory, Dean and Professor Robert Scott has provided a concise, albeit simplified, history of the four recent major American legal theory movements—legal formalism, legal realism, law and economics, and CLS—juxtaposed with the emergence of chaos theory.[123] What Scott describes, without doing so explicitly, is a common thread of reductionism running through the evolution of these battling, ostensibly contrary, American legal theory camps.

For example, Scott describes how initially the growth of common law courts to resolve disputes between present parties led to the need "for future parties to predicate their actions on correct, i.e. legal, behavior," which of course could only be divined through analysis of common law court decisions.[124] A predictive theory was demanded, and the Legal Formalists—or at least those who were later called the Legal Formalists—came to the rescue, portraying law in absolutely reductionist terms as "a structure of positivised, objective, formally defined rights."[125] The skeletal

123. *See* Scott, *supra* note 8, at 334–51. Scott does not take the analysis far beyond observing that the notion of chaos seems contrary to the underpinnings of traditional legal thought and may serve as an explanation of why traditional American legal theory has so much trouble with certain questions, such as the so-called "justice paradox" posed when legal policy must choose between present and future justice. For a discussion relating each of the schools of American legal theory to the classical science method and discussing the extent to which each American legal theory adopted or rejected approaches mirroring the scientific method of analysis, see Levit, *supra* note 16. Unlike Scott, Levit does not incorporate any notion of catastrophe, chaos, or emergence in her analysis; indeed, she advocates a furthering of reductionist trends in American legal theory by positing that "[a]pplication of these [scientific method] criteria to law promises to lead to more rational theory-building and to greater inquiry in decisionmaking." *Id.* at 307.

124. Scott, *supra* note 8, at 334.

125. *Id.* at 337 (quoting Elizabeth Mensch, *The History of Mainstream Legal Thought*,

precepts of this approach were that laws are commands, legal decisions can be deduced logically from predetermined rules, and the law as it is actually laid down is separate from the law as it should be.[126] Although "[t]he flesh is arranged differently by different positivists . . . [d]ifferent versions differ chiefly in their description of the fundamental test of pedigree a rule must meet to count as a rule of law."[127] The fallacies of reductionism were virtually written for the Legal Formalists, who would have enthusiastically agreed that deterministic rules lead to predictable behavior and that truth is the logical outcome of following those rules. In short, the positivism of the Legal Formalists led to a religion of rules.

Of course, because legal formalism could not see through the dynamical qualities of the law-and-society system, it required progressively more and more rules to deal with the instances in which the manifestations of behaviors analogous to chaos, emergence, and catastrophe defied explanation under the existing set of reductionist principles. Eventually, as Scott explains, the rules became more like contrivances, leading to the anti-formalist emergence of legal realism.[128] A leading brand[129] of legal realism ostensibly rejected the formal deductive method of positivism and replaced it

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reprinted in THE POLITICS OF LAW: A PROGRESSIVE CRITIQUE 18, 23 (David Kairys ed., 1982)).

126. *See* H.L.A. Hart, *Positivism and the Separation of Law and Morals*, 71 HARV. L. REV. 593, 601 n.25 (1958). Then there is always Professor Hans Kelsen's "pure" theory of law, which, as a "theory of positive law in general . . . attempts to answer the question what and how the law *is*, not how it ought to be. It is a science of law." HANS KELSEN, PURE THEORY OF LAW 1 (Max Knight trans., 2d ed. 1967). For a concise discussion of the different versions of legal positivism advanced by three leading figures in the school of what is now called legal formalism—Hart, Kelsen, and John Austin—see JOSEPH RAZ, THE CONCEPT OF A LEGAL SYSTEM (2d ed. 1980).

127. Ronald M. Dworkin, *The Model of Rules*, 35 U. CHI. L. REV. 14, 18 (1967); *see also* DUXBURY, *supra* note 3, at 22–23 (describing formalism as fundamentally reductionist in approach); *id.* at 79 ("The Langdellian legal scientist had a clear objective: to reduce legal doctrines to their core elements and thereby remove from the law all unnecessary complexity").

128. Scott, *supra* note 8, at 337. Duxbury challenges the notion that the emergence of realism can be understood principally as a revolt against formalism. DUXBURY, *supra* note 3, at 65–71. As he put it, "Legal realism, we might say, was not entirely anti-formalist; for legal formalism, often heavily disguised, persisted under the realist banner." *Id.* at 64.

129. As Karl Llewellyn proclaimed, "There is no school of realists. . . . There is no group with an official or accepted creed." Karl Llewellyn, *Some Realism about Realism—Responding to Dean Pound*, 44 HARV. L. REV. 1222, 1233–34 (1931); *see also* DUXBURY, *supra* note 3, at 4 ("There was no realist movement. Realism was nothing more than an intellectual mood.").

with the inductive search for rules "that existed in the real world of every day transactions."[130] Legal realism was based on, among other things, "[d]istrust of traditional legal rules and concepts insofar as they purport to *describe* what either courts or people are actually doing . . . . [and on the] insistence on evaluation of any part of law in terms of its effects, and an insistence on the worthwhileness of trying to find these effects."[131] The Legal Realists may thereby have challenged the positivism of the Legal Formalists; however, in so doing, legal realism did not also jettison reductionism,[132] as it gradually developed into just another branch of empiricist social science.[133] Its central focus became analysis of the "inherent . . . patterns of relationships that one could observe and record in the commercial world."[134]

Try as it might, legal realism, always "with an eye to increasing the predictability of judicial decisions,"[135] thus was prevented

130. Scott, *supra* note 8, at 338. More accurately, the leading Legal Realists knew that there was something more to the problem than just devising rules, and that reductionism would not get them there; however, they simply did not have the benefit of dynamical systems theory to put their concerns into terms that were descriptively and analytically useful. For example, Karl Llewellyn once noted that "[t]he difficulty in framing any concept of 'law' is that there are so many things to be included, and the things to be included are so unbelievably different from each other." Karl Llewellyn, *A Realistic Jurisprudence—The Next Step*, 30 COLUM. L. REV. 431, 431 (1930).

131. Llewellyn, *supra* note 129, at 1237.

132. Professor Steven Smith argues that the legal realism movement was nonreductionist. *See* Steven D. Smith, *Reductionism in Legal Thought*, 91 COLUM. L. REV. 68, 97–109 (1991). To be sure, legal realism departed from the abstract positivism of legal formalism, but the approach was fundamentally reductionist in that it was based on the premise that "[t]he prophecies of what the courts will do in fact, aud nothing more pretentious, are what I mean by the law." Oliver W. Holmes, *The Path of the Law*, 10 HARV. L. REV. 457, 461 (1887).

133. Although it may be harsh, it is not too extreme to say that "the Realists themselves ultimately shrank back from the radical consequences of their indeterminacy thesis, sileucing the ironic tone of their skepticism amidst efforts to create a 'respousible law' on the basis of empirical data gathered and interpreted with a little help from the social sciences." Günter Frankenberg, *Down by Law: Irony, Seriousness, and Reason*, 83 NW. U. L. REV. 360, 385 (1989).

134. Scott, *supra* note 8, at 341. Thus, "[f]or all that realism constituted a general seuse of unease coucerning legal formalism . . . it could not be described as an outright distaste for scientific methods." DUXBURY, *supra* note 3, at 79.

135. THEODORE M. BENDITT, LAW AS RULE AND PRINCIPLE 16 (1978). Duxbury is more direct, concluding that "[t]he prediction theory of law was to become a cornerstone of realist jurisprudence," DUXBURY, *supra* note 3, at 37, and that "[t]he essential purpose behind the realist stress on predictivism was the promotion of certainty in law." *Id.* at 130. Hence "it is thus that realism, certainly in its predictive guise, appears to attempt to discredit one formalist conception of law only to replace it with auother." *Id.* at 131.

by its ignorance of dynamical qualities of the system it was observing from understanding that it would not find the meta-principles with which to explain the law-and-society system.[136] Enter the postrealist revival of positivism through the law and economics school.[137] Law and economics was founded on the notion that "one can determine the legal implications of any choice or action by looking at the consequences, and then measuring those consequences against some normative criteria—usually efficiency or the aggregation of total social welfare."[138] Hence, "[t]he dominant theme throughout the law and economics literature . . . is the repair of market failure, primarily by structuring the law to reduce, or 'internalize,' externalities."[139] And yet, as Scott observes, law and economics soon discovered that "there is a part of the legal structure that is not susceptible to economic analysis," and hence the school of thought has naturally attempted, as did the Legal Formalists and Legal Realists before them, "to introduce complexity, detail, and context into their analyses" in an effort to come closer to explaining the unexplainable.[140]

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136. Legal realism never transcended, as one of its central tenets, the reductionist "conception of society in flux, and in flux typically faster than the law, so that the probability is always given that any portion of law needs reexamination to determine how far it fits the society it purports to serve." Llewellyn, *supra* note 129, at 1236.

137. This appears to be one instance in which I do not need to apologize for assigning a "school" label to the theory, as adherents of law and economics seem happy to rush under that banner, having formed the American Law and Economics Association, and even have a law journal named after them, *The Journal of Law and Economics*. Notwithstanding the willingness to define itself as a school, "law and economics is a subject over which controversy and confusion reign. Defining the subject is like trying to eat spaghetti with a spoon . . . [as] the subject is weighed down by a multitude of competing methodologies and perspectives which are not always easily distinguishable." DUXBURY, *supra* note 3, at 314.

138. Scott, *supra* note 8, at 343. To some extent, law and economics represents a reductionist refinement of Realism, as "[e]conomics is considered by its jurisprudential advocates to be not just any old social science, but the queen of the social sciences, the only social science capable of providing analytical models which facilitate the discovery of precise, verifiable answers to many difficult questions about legal policy and decision-making." DUXBURY, *supra* note 3, at 310. On the other hand, "modern law and economics, '[l]ike the old-fashioned formalism . . . reestablishes the lawyer as the scientist with a norm-free calculus.'" *Id.* at 303 (quoting David Gray Carlson, *Reforming the Efficiency Criterion: Comments on Some Recent Suggestions*, 8 CARDOZO L. REV. 39, 39 (1986)). Indeed, Holmes strongly advocated that "every lawyer ought to seek an understanding of economics." Holmes, *supra* note 129, at 474.

139. 1 LAW AND ECONOMICS, at xii (Jules Coleman & Jeffrey Lange, eds., 1992).

140. Scott, *supra* note 8, at 344. It has been said of law and economics and other postrealist schools of American legal theory that

We find, therefore, a common pattern in these three major American legal theory movements. Each was based on the tenet that it could derive a set of rules by disaggregating and observing a context, although each focused on a different slice of that context. Each was ignorant of the dynamical qualities of the system under study, and thus each adopted one or more of the basic fallacies of reductionism within its core theory approach. Because the real world experiences chaos, emergence, and catastrophe, each school of thought, therefore, failed to derive an absolutely predictive theory to explain all behavior in the law-and-society system model. More accurately, each failed to understand that the presence of chaos, emergence, and catastrophe in the law-and-society system model means that *there can be no such theory.* Reductionism, being as powerful a tool as it is, got each theorem 90% of the way there, but left it powerless to unravel the 10%, represented by the analogy to chaos, emergence, and catastrophe, that reductionism inherently cannot comprehend. Each theorem eventually became top heavy with intricate rules and devices to deal with that last 10%. As Scott's justice paradox story illustrates, it has been the last 10% over which the major legal theories have bickered for decades. This last 10% is important, if not occasionally critical, to system survival.

Indeed, not to slight Critical Legal Studies (CLS) as a major evolution in American legal theory, its adherents, (the "Crits") relish debate over the 10% of reality that has befuddled its predecessor legal theory schools[141] because they believe "that exposing the contradictions in law and legal institutions would lead to a leap of faith, the embrace of leftist political ideology."[142] And

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> [a]ny halfway scientific means was good enough for [them], as long as it promised to guarantee, more or less, the determinacy of judicial decisions and the autonomy of the law. To this end, the postrealists engaged in an unrestrained plundering of neighboring disciplines, where they discovered the policymaking model for jurists and the economic analysis of the law for judicial decisions.

Frankenberg, *supra* note 133, at 385.

141. Scott, *supra* note 8, at 344–45. CLS thus

> entailed many things: it meant emphasizing inconsistencies and conflicts among legal principles; it meant highlighting the fact that, owing to such inconsistencies and conflicts, legal doctrines can never provide totally satisfactory explanations of legal outcomes; it meant demonstrating the impossibility of neutral standpoints; it meant focusing on the manner in which law legitimates existing distributions of wealth and privilege.

DUXBURY, *supra* note 3, at 474 (footnotes omitted).

142. Scott, *supra* note 8, at 345. To the Crits, in other words, "[i]ndeterminacy *infects* the legal system." DUXBURY, *supra* note 3, at 459 (emphasis added). It is this aspect of

yet, "[i]f the criticism of formalism and objectivism is the first characteristic theme of leftist movements in modern legal thought, the purely instrumental use of legal practice and legal doctrine to advance leftist aims is the second."[143] Hence, "[e]ven those seemingly nonlinear thinkers . . . draw heavily on Marxist doctrine, which (at least in its traditional varieties) is as doggedly deterministic and 'scientific' in the old sense as any thinking to come out of the nineteenth century."[144] Indeed, the deconstructionism that is central to all variants of CLS "is an attempt to disassemble rationalistic constructions into their individual parts, in order to bring to light fissures, tensions, hidden components, buried tools, and compulsively simplifying antitheses."[145] The Crits are reductionists after all; it's just that they look in different places than their predecessors did for the meta-principles. They have been more willing to confront the seeming contradictions of the law-and-society system, but they have not understood those contradictions as being inescapable manifestations of dynamical system qualities that are incapable of being evaluated by the reductionist thought processes.

A development that initially showed some promise of departing from this common trait of American legal theory was the emergence of the so-called postmodern German theory of autopoietic law, also known as reflexive law, which attempts to describe the apparent ability of law to change itself in terms of the reflexive, self-generative qualities of evolution.[146] Indeed, the study of automata—systems capable of acting automatically with-

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CLS theory with which I most vehemently disagree. Although I have to hand it to them for focusing on indeterminacy in general, the Crits failed to appreciate why it exists. The Realists knew there was indeterminacy in law, but believed they could use social sciences in a classically reductionist manner to break through the uncertainty barrier and explain it all. The Crits perfected the identification of indeterminacy to an art form, believing that its presence revealed a defect in the socio-legal system and thus the invitation to usher in a leftist transformation. The Crits were even more guilty, therefore, of missing the point—i.e., that the indeterminacy of the system is there *because* the system is healthy, and that their efforts to squash it through social reform were either doomed themselves or would have doomed the system had they succeeded. By abandoning the reductionism inherent in those schools of thought, complexity theory teaches us that indeterminacy is necessary in a healthy system, and offers us a new methodology for understanding its role and behavior.

143. ROBERTO UNGER, THE CRITICAL LEGAL STUDIES MOVEMENT 3–4 (1986).

144. Reynolds, *Chaos and the Court*, *supra* note 8, at 113.

145. Frankeuberg, *supra* note 133, at 372.

146. *See supra* note 10.

out an external motive force—has been of keen interest to complexity theory researchers as a means of studying emergence and artificial life.[147] As it has been described thus far, however, the autopoietic law theory departs significantly from complexity theory, succumbing to reductionist themes in the end. The defect in autopoietic law theories in this regard has been the role they ascribe to autopoiesis, or, more basically, to evolutionary forces, within the law-and-society system.

The autopoietic law theory is based on two central premises: (1) Changes in the body of law are manifestations of reflexive, self-generative evolution taking place within a closed legal organism that is a subset of the open social system; and (2) such a closed legal system interacts dynamically with other closed social subset systems within the open social system.[148] The basic idea, therefore, "is that in certain circumstances . . . law (and only law) defines what is and what is not law, and every law must participate in defining what is and is not law."[149] As such, the theory is a sort of hybrid between complexity theory and legal formalism, though it falls short of each in terms of explaining anything.[150]

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147. *See* WALDROP, *supra* note 57, at 109; CASTI, *supra* note 7, at 166 (describing an electronic ecosystem that evolved from "self-reproducing strings of programming-language code").

148. For example, one of the leading autopoietic law theorists describes the premises as follows:

> (1) As a result of socio-legal evolution, the legal system develops an autonomy which has to be understood as self-referential closure. Legal formalism is the structural counterpart of this autonomy. While legal formalism is an adequate expression of legal self-referentiality, it cannot satisfactorily deal with the self-referentiality of other social systems.
>
> (2) The crisis of legal formalism emerges from the problematic relation between legal and social autonomy. Instrumental law is an attempt to overcome this crisis, but its unplicit models of unilinear causality are inadequate for the problem. The task for post-instrumental law is to construct internal models of social reality that can explicitly take into account the autopoietic structure of social subsystems.

Gunther Teubner, *Autopoiesis in Law and Society: A Rejoinder to Blankenburg*, 18 LAW & SOC'Y REV. 291, 293 (1984).

149. Jacobson, *Autopoietic Law*, *supra* note 10, at 1663.

150. Teubner, for example, argues that "[l]egal formalism is indeed the doctrinal expression of legal self-referentiality." Teubner, *supra* note 148, at 296. He states that "legal formalism . . . is an adequate internal structure for the autopoietic organization of the law. Its major problem is dealing with the environment, or, more precisely, with the autopoietic organization of other social subsystems." *Id.* This is so, according to Teubner, because "autopoietic systems cannot interact directly with each other. Self-referentially closed systems only interact internally with their own elements." *Id.* Thus, says Teubner, law is a "black box" interacting with other social system black boxes:

The objective of the theory appears to be to allow reductionist, positivist examination of law through the fiction of a closed legal system while shunting explanations of all the complicating factors—i.e., the surprises produced by chaos, emergence, and catastrophe—to the supposed interaction of that closed system to other closed systems in the open, dynamical social playing space.[151]

By contrast, autopoiesis, albeit by different titles, plays a subtly different role in complexity theory, particularly within the field

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> When the actions of black boxes must be coordinated, each focuses not on the unseen internal workings of the other but on the interrelations between them. The experience gained from observing patterns of behavior is increasingly valuable even though internal causal processes remain unknown. Thus, interacting "black boxes" become mutually "whitened" in the sense that the interaction relation that develops between them achieves transparency in its regularities.

Id. at 300. Critics of this sharply dichotomous model accuse it of incoherently mixing theories of the "internal justification of law" with those focused on "external legitimation," Erhard Blankenburg, *The Poverty of Evolutionism: A Critique of Teubner's Case for "Reflexive Law"*, 18 LAW & SOC'Y REV. 273, 274 (1984), of suffering from a "secret passion for the status quo," Frankenberg, *supra* note 133, at 381, and of "embed[ding] H.L.A. Hart's 'rule of recognition' or Kelsen's 'basic norm,' which like all positivist proceduralisms fall from the heavens, in a social practice." Jacobson, *Autopoietic Law, supra* note 10, at 1663. *See also* M.B.W. Sinclair, *Autopoiesis: Who Needs It?*, XVI LEGAL STUDIES FORUM 81 (1992) (criticizing autopoiesis on the grounds that law cannot be defined as a closed system and that the principles of biology upon which it is based cannot be transferred to the law).

151. The theory has been accused of engaging in "highly selective reductions of complexity." Frankenberg, *supra* note 133, at 381. Although some of the commentators in that debate espouse notions that appear to me to approximate precepts of complexity theory, very often they turn right around and fall into reductionist thought typical of legal positivism. *See, e.g.*, Teubner, *supra* note 148, at 298 ("A remarkable point about the purposive law of the interventionist state is that its models of social reality are rather primitive in comparison with the complicated self-referential structure of the various social subsystems."); *id.* at 295 ("The legal system is autonomous if its elements—legal acts—are components in the sense that their interaction is operatively closed with respect to legal acts and recursively reproduces legal acts."). Once one starts down the path of attempting to identify and isolate the behavior of purportedly closed subcomponents of society, however, the theory to describe how particular subcomponents behave will fall into all the traps of reductionism. In particular, Chaitin's incompleteness theorem, *see supra* note 118, exposes the fallacy of autopoietic law's reliance on self-referential, formal logic as its theoretical foundation for explaining reflexive law. As noted previously, *supra* note 10, to my knowledge adherents of the autopoietic law theory have not yet opined on how complexity theory and concepts such as incompleteness fit with their paradigm, and so I will not put words in their mouths. The writing in the autopoietic law field suggests to me, however, that they have overstated the effect of autopoietic forces (i.e., emergence) in the law-and-society system in order to prop up a place for legal positivism, and have completely side-stepped the issue of incompleteness and dynamical system behaviors such as chaos and catastrophe. Autopoietic law theory thus would have to reorder itself fundamentally to accept what complexity theory tells us about the law-and-society system model.

devoted to studying biological evolution. Self-generation and evolution are the products of robust, adaptive dynamical systems—i.e., systems functioning in the complex region. Autopoiesis is no more than the quality of emergent adaptation, one of the key ingredients in such complex systems. But autopoiesis, or emergence, does not define "closed" system components in the sense of being independent of environment; rather, more specifically emergence is a defining characteristic of semi-autonomous "whole" systems and thus is one of the factors that prevents reductionism from achieving a full understanding of dynamical systems. In biological evolution, for example, the "properties of active self-maintenance, reproduction, and regeneration express a quality of autonomy in organisms: they are due to processes that occur within organisms such that the whole has characteristics distinctive to its particular species."[152] Most importantly, however, "[t]his autonomy is *not* to be understood as independence of the environment."[153] Rather, autopoiesis "is an emergent property of life that is not explained by the properties of the molecules out of which organisms are made, for molecules do not have the capacity to make a whole from a part . . . . This is a principal reason organisms cannot be reduced to their genes or their molecules."[154] As these organisms pursue life cycles,

> the dynamics of the interaction of these life cycles with their environments . . . specify whether the life cycle is stable or unstable—whether the species remains unchanged, expands in distribution, or goes extinct, and whether invasion of an ecosystem by another species can occur. This results in the dynamic image of populations moving toward attractors or away from repellers.[155]

Hence, the convergence of autopoietic law theory and complexity theory raises the question of what the relevant "whole" organism is—i.e., whether what we call law is an autonomous bubble interacting with other bubbles in society or whether both law and society are needed to explain how a unified whole system self-maintains. Autopoietic law theory thus far has been focused

152. BRIAN GOODWIN, HOW THE LEOPARD CHANGED ITS SPOTS: THE EVOLUTION OF COMPLEXITY 175 (1994).

153. *Id.* (emphasis added). For example, some newts can live in a cold water environment, but will not regenerate or reproduce. *Id.* at 175–76.

154. *Id.* at 176.

155. *Id.* at 177.

on separating law from society, which is like cutting off an arm of the organic whole, and we know arms alone do not self-maintain. The autopoietic law theorists have mistaken law's apparent ability to change itself as making it a self-contained, closed system, but that is no more accurate than to say human skin is a closed system because it appears to self-heal. Skin does not heal by itself—it needs to be part of a human—and neither is law self-maintaining by itself. Rather, law evolves as part of the law-and-society system, and that system follows its trajectory against the reference points of environmental factors such as time, death, the cosmos, and natural disaster that do not change as a response to changes in the system.[156] Complexity theory, therefore, explains to us how law and society are connected, and how together that whole system dynamically adapts, through qualities *including* autopoiesis, to the challenges of its environment. Autopoietic law theory thus commits a fallacy of reductionism at a fundamental level by severing law from society in an effort to retain some position for positivist,

156. Time, for example, is not altered by whatever trajectory the law-and-society system takes, and thus is one of the environmental factors to which that system adapts. Society, by contrast, cannot be correctly understood as law's environment rather than part of the whole system that includes law, for changes in law depend on the social setting, and vice versa. Indeed, "assuming the propriety of the autopoietic model for society, it is difficult to imagine an autopoietic *subsystem* of an autopoietic system." Jacobson, *Autopoietic Law, supra* note 10, at 1675. For example, it is difficult to disaggregate the enactment of CERCLA from the social setting framed at the time of that enactment by the Love Canal incident. *See generally supra* text accompanying notes 77–81 (discussion of CERCLA generally). One commentator has explained how the social setting contributed to the legal evolution:

> The legislative materials on Superfund give prominence to the hazardous waste dump sites that have become household words—Love Canal, [etc.]. . . . Careful historians should acknowledge that the Superfund law was well along the evolutionary path towards enactment before Love Canal burst into public prominence. Love Canal contributed to the enactment of Superfund, to be sure, but more as a reinforcer and mobilizer of official opinion than as a source of new ideas.

RODGERS, *supra* note 6, § 8.1, at 681–82. Other commentators focus on the degree to which the EPA, in its quest to bring about the legal evolution, directed media attention at Love Canal and thus fomented public panic. *See* LISA H. NEWTON & CATHERINE K. DILLINGHAM, WATERSHEDS: CLASSIC CASES IN ENVIRONMENTAL ETHICS 19 (1994). Hence, CERCLA most likely would not have looked as it did in its final enactment had it not been for the social perception of the Love Canal incident; on the other hand, the social perception of the Love Canal incident was influenced by the increasing attention legal institutions had devoted to the need for legal responses to contaminated lands in the years just prior to discovery of the Love Canal conditions. The two developments—one ostensibly legal and the other ostensibly social—happened together.

reductionist thought and to sweep the complicating factors under the carpet.

These major schools of legal theory, both modern and postmodern, thus might be collected under the banner of legal reductionism. The flaw of their approaches is the failure to accept complications, such as human free will, as being an essential part of the system and as rendering the system unpredictable. Reductionist tenets designed to isolate and marginalize free will and other complicating factors must ultimately fail because the complications will always be there, interacting in the system and producing what the theory perceives as noise and contradiction—i.e., adaptively essential dynamical system surprise behavior. Nonlinear, anti-positivist thinking alone is not enough as the way out of the mess—legal theory must abandon the reductionist premise if it is to comprehend the dynamical qualities of the law-and-society system.[157] What is needed for jurisprudence, in other words, is a theory of legal dynamism.[158] Complexity theory provides an analogical foundation for that new paradigm of legal theory.

C. *Reductionism as the Governing Approach of American Legal Institutions*

Our legal system has been fundamentally reductionist in approach as well as in theory. When it comes to the business of

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157. Indeed, even some legal commentators who have discussed dynamical systems theory have attempted to apply it in ways which appear reductionist. For example, Hayes suggests that "[c]haos theory provides a principled basis for . . . describing what law should look like once the noise and the self-contradiction have been removed," Hayes, *supra* note 8, at 765 n.78, and that "the chaos theory of law posits a legal system that exists on a complex plane of legally relevant facts in a fractal pattern of infinite detail. This fractal pattern is generated by mapping legal principles and legally relevant facts to reach specific results in cases." *Id.* at 765. As for the notion that we can determine what the law *should* look like, Chaitin's incompleteness theorem, *see supra* note 118, suggests that we will never be able to produce a map with all the possible truth outcomes on it. A fractal map of law, if one could ever be charted, would at best show the law as it is. Moreover, some of the noise and self-contradiction of which Hayes speaks include emergence-generated anomalies that are fundamentally part of the law-and-society system, and that therefore cannot be "removed." Instances of emergence, furthermore, cannot be mapped on the fractal pattern produced by chaos behavior; they are discontinuities and departures therefrom. Hayes thus is looking at only part of the system—a classic reductionist flaw—and his fractal map therefore will not produce an accurate picture of "what the law should look like."

158. Since all the other schools of legal theory have a label, I thought it appropriate to name this one, too.

making rules, Congress, the administrative agencies, and the judiciary are prolific, and they have encapsulated that process in mechanisms that drive it toward ever more reductionist approaches. As we know from dynamical systems theory, however, following the reductionist fallacies produces a system that because of its focus on more and more rules drags the system out of the complex region of adaptive system sustainability toward the ordered stasis of periodic behavior.

How does this happen? Why are regulations at some level contrary to system sustainability? Simply put, in dynamical systems theory terms, regulations are like fixed point and limit cycle attractors in that they purport by their very terms to "fix" relationships in the law-and-society system. By locking in the system options, regulations atrophy system adaptability by suppressing the use of freedoms and rights as a response to system behavior shifts and environmental happenstance events. A society conditioned to dealing with freedoms and rights, which function like a pair of antagonistic strange attractors, as the means of managing the exercise of human free will can tailor stable, simple relationship structures and work adaptively to respond to these sources of surprises. As regulations, which are intended to "simplify" that approach, increasingly supplant freedoms and rights, the system suffers an imbalanced growth of fixed point and limit cycle attractors and loss of strange attractors. We know from the complexity theory branch of dynamical systems theory that such a trend leads the system out of the complex region where sustainability is at its maximum and into the region of excessive order and simplicity, thus exposing the system to the onslaught of chaos, emergence, and catastrophe.

One can hardly imagine an analogy that more aptly describes what our legal system has done to itself. Of the three system attractors that define our methods of managing free will, we have left behind the adaptive freedoms aud rights attractors and come to rest predominantly on the nonadaptive regulations attractor in an attempt at essentially crushing the unpredictability factor out of free will. The attractive force behind this behavior is predictability; the behavioral attractor is regulation. In other words, it is in our nature to want to believe in the "tenets of reductionism" because they promise predictability, proportion, and simplicity. We retreat from the vastness and complicatedness of the law-and-society system into the deceptive safety of reductionism. The instruments of

that retreat are regulations, for they purport to provide answers, certainty, and process.

Our system now exhibits all of the traits of simplicity—increased short term predictability, decreased interaction, centralized decisionmaking, and greater decomposability—in great magnitudes, but possesses very little adaptability. Three features of the legal side of the system provide the essential support for that effect: the so-called nondelegation doctrine; the division of administration into multiple agencies with discrete jurisdictions; and the doctrines requiring legislative and judicial deference to administrative decisions. These combine to produce a highly effective rulemaking machine.[159]

1. *Congress and the Nondelegation Doctrine.* The first opening in the reductionist funnel is Congress, which has evolved into a body that no longer *makes* decisions, but rather *assigns* them to be made by agencies. Based on the fiction of "Congress . . . obtaining the assistance of its coordinate [b]ranches,"[160] delegation of legislative power from Congress to agencies has been upheld consistently unless done with "an absence of standards for the guidance of the [agency's] action, so that it would be impossible in a proper proceeding to ascertain whether the will of Congress has been obeyed."[161] That so-called "intelligible principles" test,[162] however, has supported a finding of proper delegation based on legislative directives as abstract and compassless as the "public interest, convenience, or necessity."[163] In Justice Scalia's words,

159. Professor Gary Lawson contends that "[t]he post-New Deal administrative state is unconstitutional, and its validation by the legal system amounts to nothing less than a bloodless constitutional revolution." Gary Lawson, *The Rise and Rise of the Administrative State*, 107 HARV. L. REV. 1231, 1231 (1994). Lawson identifies as the root causes of this constitutional revolution the same three factors that I contend are the manifestations of reductionism as the predominant approach in American legal institutions: the death of the nondelegation doctrine; the death of the unitary executive; and the death of the independent judiciary. *Id.* at 1237–49. By no means is this trend towards regulation unique to American legal institutions. *See, e.g.*, ROBERT BALDWIN, RULES AND GOVERNMENT 59 (1995) (noting that in the United Kingdom "[i]ucreasingly the key functions of government are carried out by means of secondary and tertiary rules").

160. Mistretta v. United States, 488 U.S. 361, 372 (1989).

161. Yakus v. United States, 321 U.S. 414, 426 (1944).

162. *See* J. W. Hampton, Jr., & Co. v. United States, 276 U.S. 394, 409 (1928) (stating that Congress must "lay down by legislative act an intelligible principle to which the person or body authorized to [exercise the delegated authority] is directed to conform").

163. *See, e.g.*, National Broadcasting Co. v. United States, 319 U.S. 190, 194 (1943).

therefore, "[w]hat legislated standard, one must wonder, can possibly be too vague to survive judicial scrutiny, when we have repeatedly upheld, in various contexts, a 'public interest' standard?"[164] The so-called nondelegation doctrine—a misnomer if ever there was one—thus opens the door for Congress to assign the search for meta-principles to the agencies.

2. *Atomized Agencies.* Congress does not toss its frisbees of delegated authority to just a few agencies; rather, reductionism permeates our legal system down to its structural approach of dividing the administration function into many discrete agencies with specific missions. Congress has disaggregated the law-and-society system into tiny parts at the organizational level so that we have agencies to handle "environmental" issues, some for "housing" issues, others for "civil rights," and so on *ad infinitum.*[165] Most agencies are themselves split into divisions, branches, offices, and so on. Cross-cutting emergent issues, such as environmental justice and biodiversity conservation, are then sliced up and the resulting parts doled out to "appropriate" agencies and divisions, each of which solves its "part" and then participates on a "task force" with all the other agencies and divisions involved in the search to glue the answers back together into one meta-solution.[166] The result of these purported coordination efforts often is

164. *Mistretta*, 488 U.S. at 416 (Scalia, J., dissenting).

165. In the environmental law field, for example, there are over 15 congressional committees, over 50 executive branch agencies, and at least 8 independent agencies, each with some jurisdiction over a defined set of environmental issues. NATIONAL WILDLIFE FEDERATION, 1993 CONSERVATION DIRECTORY IV (38th ed. 1993).

166. For example, federal policy on biodiversity conservation—the management of complex ecosystems so as to maximize natural diversity of species—has been so atomized by divided agency jurisdictions as to have no comprehensible theme. *See* David Farrier, *Conserving Biodiversity on Private Land: Incentives for Management or Compensation for Lost Expectations?*, 19 HARV. ENVTL. L. REV. 303, 307–23 (1995). At least a dozen federal statutes and the same number of agencies have their hand in biodiversity policymaking, which presently is being "coordinated" through a White House Interagency Task Force. *See* J.B. Ruhl, *Biodiversity Conservation and the Ever-Expanding Web of Federal Laws Regulating Nonfederal Lands: Time for Something Completely Different?*, 66 COLO. L. REV. 555, 557–79 (1995). At the same time this policy of ecosystem management is being forged, we continue to experience massive federal subsidy of habitat destruction administered by a multitude of agencies through a variety of programs, such as below-market grazing, mining, and logging fees on public lands, agriculture payment programs, and the like. *See* Oliver A. Houck, *Reflections on the Endangered Species Act*, 25 ENVTL. L. 689, 694–97 (1995); Karl Hess, Jr., *Grazing at the Public Trough*, WALL ST. J., July 12, 1995, at A14. Congress has provided no unified statement of biodiversity con-

incoordination bordering on pandemonium.[167]

3. *Insulating the Outcomes Through Deference to Agencies.* The last ingredient necessary to put this burgeoning administrative state firmly in place is deference to administrative outcomes by Congress and the courts. In other words, the two bodies that might be in the best position to cut through reductionist administrative approaches have had their hands tied. Congress constrained the courts with the "substantial evidence" and "arbitrary and capricious" standards of review prescribed in the Administrative Procedure Act (APA);[168] the courts constrained Congress with the rejection of the legislative veto mechanism;[169] and the courts constrained themselves with the so-called *Chevron* doctrine requiring deference to administrative interpretation of legislative directions.[170] Through these constraints, the system has

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servation policy to serve as a coordinating umbrella, leaving the issue instead to the uncoordinated, conflicting jumble of "agency expertise."

167. As Professor Jerry Anderson has observed,

> [E]nvironmental law is hopelessly muddled because Congress focused on individual environmental problems rather than the environment as a whole. The piecemeal approach—responding to each separate crisis and treating distinct resources separately and differently—simply has not worked very well. Environmental law cries out for coordination and integration in order to be more effective.

Anderson, *supra* note 78, at 410. Perhaps in reaction to that quality of environmental law, recently there has been more attention to "reinventing" EPA, *see, e.g.*, NATIONAL ACADEMY OF PUBLIC ADMIN., REPORT TO CONGRESS, SETTING PRIORITIES, GETTING RESULTS: A NEW DIRECTION FOR THE EPA (1995), and the calls for a unified environmental law statute have become louder. *See Group Says EPA Reinvention Falls Short, Calls for Unified Environmental Statute*, 26 Envt. Rep. (BNA) 705 (1995); *Single Environmental Statute May Emerge from Reform Debate, Former Official Says*, 26 Envt. Rep. (BNA) 501 (1995).

168. 5 U.S.C. §§ 551–706 (1994); *see generally infra* text accompanying notes 203–05. Section 706 of the APA requires that except where *de novo* judicial review is provided by statute, courts when reviewing administrative action must limit substantive review to the question whether the agency's decision was "arbitrary [or] capricious" or "unsupported by substantial evidence." 5 U.S.C. § 706(2)(A), (E). This standard has been likened to the rather minuscule quantum of evidence needed "to justify, if the trial were to a jury, a refusal to direct a verdict." Consolo v. Federal Maritime Comm'n, 383 U.S. 607, 620 (1966) (quoting Labor Board v. Columbian Enameling & Stamping Co., 306 U.S. 292, 300 (1938)).

169. *See* INS v. Chadha, 462 U.S. 919 (1983). *See generally infra* text accompanying notes 210–12. In *Chadha*, the Supreme Court found that Congress violated the Constitution's Presentment Clauses, U.S. CONST. art. I, § 7, cl. 2–3, and bicameralism requirement, *id.* §§ 1, 7, when reserving the right to nullify an administrative regulation through either a single- or dual-chamber resolution. 462 U.S. at 954–55. The decision invalidated over 200 such legislative veto provisions. *Id.* at 967 (White, J., dissenting).

170. *See* Chevron, U.S.A., Inc., v. National Resources Defenses Council, Inc., 467 U.S.

assured that whatever emanates from the agencies' reductionist-bred black boxes is virtually assured of surviving all but the most probing legislative and judicial scrutiny.

4. *The Result—The Modern American Administrative State.* We cannot reasonably expect the administrative branch when structured in this atomized manner, then given abstract missions, and then insulated from meaningful review, to be competent in responding to dynamical behaviors such as chaos, emergence, and catastrophe. Rather, just as have the classical scientists and the classical legal theorists, the administrative state responds to the surprises of dynamical system behavior by producing more rules exhibiting increasingly abstract complicatedness.

The statistics in this regard are staggering. For example, Professor Richard Epstein reports that the annual pages of the Federal Register have grown in number from 2,411 in 1936 to 67,716 in 1991; the annual pages of the Federal Reporter have grown from 6,138 to 49,907 during the same period; and the annual Federal Supplement pages have grown from 5,179 to 42,727 during the same time.[171] Professor Jerry Anderson reports, presumably based on first-hand experimentation, that "[i]f you stack on the floor the volumes of the Code of Federal Regulations that contain environmental regulations, they measure over three and a half feet high."[172] Professor William H. Rodgers reports that EPA's RC-

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837 (1984). *See generally infra* text accompanying notes 206–09. In *Chevron*, the Supreme Court held that when a court reviews an agency's construction of a statute, the court must apply the clear language of the statute if Congress has spoken therein to the precise question in issue; but otherwise, "if the statute is silent or ambiguous with respect to the specific issue, the question for the court is whether the agency's answer is based on a permissible construction of the statute." 467 U.S. at 843. The ruling has been cited frequently, and affirmances of agency interpretations of statutes have increased substantially since it was decided. *See* Peter H. Schuck & Donald Elliot, *To the* Chevron *Station: An Empirical Study of Federal Administrative Law*, 1990 DUKE L.J. 984, 1057. For a comprehensive overview of the decision and legal literature analyzing the decision as well as a thorough empirical analysis of the effects of the decision on lower court and Supreme Court behavior, see Linda R. Cohen & Matthew L. Spitzer, *Solving the* Chevron *Puzzle*, LAW & CONTEMP. PROBS., Spring 1994, at 65.

171. *See* EPSTEIN, *supra* note 17, at 7.

172. Anderson, *supra* note 78, at 413. He reports further that "EPA alone published almost 3500 pages of proposed and final regulations in the Federal Register during the first six months of 1994." *Id.* at 413. Also, the many federal agencies with some environmental jurisdiction combined "churn out over 35 pages of new or proposed regulations every working day." *Id.* To its credit, EPA recently announced that it would eliminate or modify regulations which are obsolete or produce little environmental benefit—the agency

RA program fills 697 pages of the Code of Federal Regulations and 19,500 pages of informal guidance.[173] Mirroring this trend on the social side—and confirming that law is a context for society—the number of trade associations serving the winners and losers under all those rules has increased from 4,900 in 1956 to 15,000 in 1980 to 23,000 in 1994.[174] I could go on, but others already have done so at length.[175]

In short, "[r]egulatory law is where we are at, and it is not an altogether pretty sight."[176] More to the point, Professor Thomas Sargentich has observed:

> Agencies are not open, democratic institutions. They are hierarchically ordered entities designed to generate an authoritative decision at the top (or one ratified, explicitly or implicitly, at the top). Such organizations are prone to protect their secrets, to shield their decisional processes from external review, and to seek maximum freedom of action given political constraints on their behavior.[177]

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believes that it's effort will cull *10%* of its existing rules at a savings of *billions* of dollars to the regulated community. *See* Solid Waste, Hazardous Waste, Oil Discharge and Superfund Programs: Removal of Legally Obsolete Rules, 60 Fed. Reg. 33912 (June 29, 1995) (final rule). *See generally Hundreds of "Legally Obsolete" Regulations Covering Air, Water, Waste Deleted by Agency,* 26 Env't Rep. (BNA) 518–19 (1995) (stating that about 250 rules had been removed from the Code of Federal Regulations); *EPA Regulatory Reform*, [1995] 25 Envtl. L. Rep. (Envtl. L. Inst.) 10,385–86 (July 1995).

173. *See* William H. Rodgers, *Environmental Law Trivia Test No. 2*, 22 B.C. ENVTL. AFF. L. REV. 807, 812, 816 (1995) (citing James T. Hamilton & Christopher H. Schroeder, *Strategic Regulators and the Choice of Rulemaking Procedures: The Selection of Formal vs. Informal Rules in Regulating Hazardous Waste*, LAW & CONTEMP. PROBS., Spring 1994, at 111).

174. *See* EPSTEIN, *supra* note 17, at 5.

175. For a light, provocative, and somewhat depressing essay on the pervasive impact of this sheer volume of laws, see PHILIP K. HOWARD, THE DEATH OF COMMON SENSE: HOW LAW IS SUFFOCATING AMERICA (1994). I hope, however, not to be lumped into the crowd of Howard's and others' commentaries that appear to lay blame for the regulatory state on the regulators. I doubt that decisionmakers at EPA, for example, have hatched some evil plot to riddle the land with regulations. Rather, they are acting rationally in response to what Congress has given them in the way of duties (many) and guidance (very little). Ultimately, it is the broad social preference for predictability that motivates Congress to use regulatory approaches as the default position. To the extent the predictability preference dominates the goals of adaptability, we can only expect the behavioral response of government to favor the regulations attractor. Hence, to the extent I join in the chorus bemoaning the current state of affairs, I am out of tune in the sense that I lay blame on the way the system is structured, not on the persons who run it.

176. Oakes, *supra* note 105, at 10,308.

177. Thomas O. Sargentich, *Teaching Administrative Law in the Twenty-First Century*,

Creatures of that nature are unlikely, probably the least likely, to unlock and adapt to the qualities of a dynamical law-and-society system.[178] As a result, the complexity theory model tells us we are in a tight orbit around the regulations attractor because more regulation is the ouly way we know how to feel comfortable when faced with chaos, emergence, and catastrophe. But more such regulation, because its motivation and structure are the products of reductionist approaches that predominate under the system we have adopted, leads us only further from understanding those surprise behaviors.

D. *Where Reductionism Leads Legal Reform Efforts*

There does appear to be a current of thought emerging in recent years that questions the complicated infrastructure of regulations we have lumped upon ourselves. Unfortunately, within both American legal theory and legal institutions, the fallacies of reductionism continue to prevail even in the approaches of reform efforts.

For example, Professor Epstein's reformist theory in *Simple Rules for a Complex World*[179] is predicated on his assertion that he has devised "the substantive legal rules that are necessary to form a legal system that is both simple in its operation and durable enough to meet the demands of the complex modern society that it serves."[180] His secret is to keep the rules "simple" because "the opposite of simplicity is complexity."[181] Thus, he concludes, his seven simple rules[182] "go a long way toward establishing a

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1 WIDENER J. PUB. L. 147, 158 (1992) (footnote omitted).

178. As Professor Richard Epstein observes, "[C]oercive systems of regulation are the worst possible way to achieve uniform social outcomes in the face of social disagreement." EPSTEIN, *supra* note 17, at 278.

179. *See* EPSTEIN, *supra* note 17.

180. *Id.* at 16.

181. *Id.* at 24. Of course, by complexity Epstein means a complicated system *structure*. Complexity in the lexicon of dynamical systems theory is a comment on the system's *behavior*, and in that context simplicity is an ingredient of complexity, not its opposite. The two sets of concepts are not the same, and if dynamical systems theory catches on in American legal theory the distinction will be important to make.

182. They are "individual autonomy, first possession, voluntary exchange, control of aggression, limited privileges for cases of necessity, and just compensation for takings of property." *Id.* at 307. Epstein takes 331 densely written pages to explain these seven simple rules.

stable legal order largely impervious to variations in behavior, custom, and practice within and across societies."[183] Epstein thus monumentally commits several of the fallacies of reductionism. First, he disaggregates the law from "the complex modern society that it serves"[184] in the mistaken assumption that rules are separate from the system. All of the classical legal theorists committed this mistake, and they all fell off the cliff into reductionism. Then, in positivist fashion, Epstein assumes that "simple" rules will avoid—indeed, will be "impervious to"—complex system outcomes. To be sure, like many reductionist-bred theories, there is gold to be mined in Epstein's work, but it will not get the system all the way where he says it will. In the end, chaos, emergence, and catastrophe will befuddle Epstein into having to add layers and permutations to his seven simple rules.

Similarly, we have the 104th Congress come to the rescue with "risk-benefit" analysis, a notion that is supposed to simplify the system by, ironically, adding a complex step of essentially reductionist analysis to all administrative rule makings.[185] Examples of these initiatives include House Bill 9, which, for any proposed or promulgated rule designed to protect human health, safety, or the environment, would require the promulgating agency to prepare "[a]n analysis of the incremental costs and incremental risk reduction or other benefits associated with each alternative strategy identified or considered by the agency."[186] To be sure,

183. *Id.* at 112. The fallacy that simple rules lead to stable, simple system behavior is illustrated by Langton's Ant, a hypothetical computer model "ant" programmed (first by Chris Langton) to march through cells according to predetermined rules. Thus, for example,

> [s]uppose all the cells of a particular ant universe begin in one of two possible states, designated 0 and 1 (or white and black when visualized on a computer screen). Initially, the virtual ant sits on a cell, facing in one of the four compass directions. The ant then moves in that direction to the adjacent cell.
>
> When it arrives at its new location, the ant is programmed to change its heading by 90° to the left if it lands on a 0 cell or 90° to the right if it lands on a 1 cell. As it leaves, it causes the cell's state to switch from 0 to 1 or from 1 to 0.

Ivars Peterson, *Travels of an Ant*, SCIENCE NEWS, Oct. 28, 1995, at 280. Notwithstanding those simple rules, the travels of such an ant are exceedingly complicated and often beyond explanation. *Id. See generally* COHEN & STEWART, *supra* note 2, at 212–14.

184. EPSTEIN, *supra* note 17, at 16.

185. System-wide risk-benefit analysis was introduced previously with President Reagan's Executive Order 12,291, which required all agencies to include with each rule a "regulatory impact analysis" to be reviewed and approved by the Office of Management and Budget. Exec. Order No. 12,291 § 3, 3 C.F.R. 128–30 (1981), *reprinted in* 5 U.S.C. § 601 note (1995).

186. H.R. 9, *supra* note 53, § 421(a)(2); *see also* S. 343, 104th Cong., 1st Sess. (1995)

the administrative branch of experts has produced supposedly risk-reducing regulations, the costs of which often are wildly out of line with the benefits conferred by the regulation, and hence a strong empirical case can be made for imposing system-wide risk-benefit analysis.[187] In the few contexts in which such hyperanalysis is already required by statute, however, it has been nightmarishly complicated for the agencies to produce any sort of organizing principle for what this means and how to do it—i.e., how finely to slice up society for impact analysis, how widely to look for costs and benefits, what to count as costs and benefits, and so on.[188] And the estimates are sure to be wrong many times, as the rules derived from risk-benefit analysis themselves undoubtedly will produce catastrophes, chaotic results, and emergent behaviors that the agency could never have anticipated with its reductionist blinders on, and yet may have tremendous risk-benefit results. Imposing system-wide risk-benefit analysis may decrease the volume and rate of new regulation simply because it is a complicated, abstract process—possibly the underlying motive of House Bill 9—but it will certainly not lead to a more simplified system for producing regulation, and it may in fact produce rules that are more complicated. Risk-benefit analysis addresses a symptom of the administrative

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(leading Senate proposal sponsored by Sen. Dole). *See generally* John Pendergrass et al., *The Environment and the Contract*, [1995] 25 Envtl. L. Rep. (Envtl. L. Inst.) 10,350, 10,352–57 (July 1995); *Compromise to Address "Supermandate" Adopted by Senate in Regulatory Bill*, 26 Env't Rep. (BNA) 566 (1995).

187. *See, e.g.*, Richard H. Pildes & Cass R. Sunstein, *Reinventing the Regulatory State*, 62 U. CHI. L. REV. 1 (1995); John D. Graham, National Center for Policy Analysis, Comparing Opportunities to Reduce Health Risks: Toxic Control, Medicine and Injury Prevention Pol'y Rep. No. 192 (1995). *See generally* RISK VERSUS RISK: TRADEOFFS IN PROTECTING HEALTH AND THE ENVIRONMENT (John D. Graham & Jonathan Baert Wiener eds. 1995) (examining problems with and possible remedies for governmental risk regulation); CENTER FOR RISK ANALYSIS, REFORM OF RISK REGULATION: ACHIEVING MORE PROTECTION AT LESS COST (Harvard School of Public Health, March 1995).

188. As Professor David Schoenbrod has observed, risk-benefit analysis "sounds sensible, but putting it into practice is another story. The costs and benefits of any given environmental regulation depend upon many highly uncertain variables. Requiring an agency to 'prove' that its regulations pass the cost-benefit test makes no practical sense; it can't be done." David Schoenbrod, *On Environmental Law, Congress Keeps Passing the Buck*, WALL ST. J., Mar. 29, 1995, at A13. *See also* Mark E. Shere, *The Myth of Meaningful Environmental Risk Assessment*, 19 HARV. ENVTL. L. REV. 409 (1995) (criticizing current trend toward increased use of risk assessment because of that methodology's reliance on untestable assumptions); Corrosion Proof Fittings v. EPA, 947 F.2d 1201 (5th Cir. 1991) (providing what can fairly be called a judicial roasting of EPA's efforts to justify a broad prohibition on asbestos products under the Toxic Substances Control Act's cost-benefit standard for regulations).

state, but does not ameliorate the fundamental illness of an atomized, specialized, empowered, insulated administrative structure brought about by Congress's excessive delegation of authority.

Legal reform aimed at "getting government off our backs" has failed so far to extract reductionist approaches from the system. Many of the proposals may in fact get government off our backs by sending the law-and-society system out of its regulations attractor orbit, but we will not fundamentally understand why so, much less where the system is headed. Legal reform must be built around the dynamic qualities of the law-and-society system model in order to provide us such insights.

IV. A COMPLEXITY THEORY PARADIGM FOR REFORMING THE MODERN AMERICAN LAW-AND-SOCIETY SYSTEM—A THREE-STEP PROGRAM TOWARDS RECOVERY

With a greater appreciation of the dynamical system model of law and society comes the dilemma of knowing that the system can be changed, but that we cannot be sure whether for better or worse. The very qualities of chaos, emergence, and catastrophe are such that we can make the system do something different from what it would otherwise do, but if we do, we will never know what it would otherwise have done.[189]

If we are going to take our chances, however, it is preferable to do so with the dynamical qualities of the system in mind rather than continuing blindly down the reductionist path. The great lesson of dynamical systems theory for law reform, therefore, is that it is the *system* that counts as much as the *rules*, and that we cannot effectively change only one variable of that equation and expect the others to remain static. *Ceteris paribus* doesn't exist.[190]

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189. *See* GLEICK, *supra* note 7, at 21 ("It would be like giving an extra shuffle to an already well-shuffled pack of cards. You know it will change your luck, but you don't know whether for better or worse.").

190. As cybernetician W. Ross Ashby observed about the "all other things being equal" approach:

> Science today stands on something of a divide. For two centuries it has been exploring systems that are either intrinsically simple or that are capable of being analyzed into simple components. The fact that such a dogma as "vary the factors one at a time" could be accepted for a century, shows that scientists were largely concerned in investigating such systems as allowed this method; for this method is often fundamentally impossible in the complex systems.

CASTI, *supra* note 7, at 172 (quoting ASHBY W. ROSS, AN INTRODUCTION TO CYBERNETICS (1956)).

Our legal institutions, however, have become prolific producers of rules of conduct, and our legal theory has focused for the most part on divining the meta-rules to explain those rules. We need some attention to the system at the structural level.

Assuming agreement on the goals of such attention—promoting sustainability of the system—it is difficult to say what will work in that regard. Drastic changes to the system carry high unpredictability. For example, there is no telling how the system would respond to replacing an appointed federal judiciary with an elected judiciary. Maybe there would be very little change felt; maybe the whole system would crash—it's hard even to conceive where that approach would take the system. Similarly, it is difficult to conceive how subtle changes to the system, such as term limits in Congress or caps on punitive damages, would have dramatic effects, but dynamical systems theory teaches us otherwise. So, what are we to do?

The approach I suggest is to reverse the reductionist funnel that has produced our regulatory state. That funnel operates on the presumptions that administrative regulation will be used as our means of first resort for dealing with socio-legal issues, that Congress and the courts will upset the administrative outcomes only infrequently, and that the common law operates on the fringes where regulation has not reached. I propose reversing that hierarchy of presumptions.

Doing so requires only several shifts in emphasis, and the entire package could produce a redirection away from the regulations attractor toward a more balanced orbit around freedoms, rights, and regulations spheres. The aim is to return us to a sufficiently coupled system—just enough but not too much—and the region of complexity that comes with it so as to promote maximal system adaptability. The plan has three interlocking components: (1) make common-law, rights-based solutions the approach of first resort for managing exercise of freedoms; (2) where regulation is necessary, require that Congress provide as much substantive decisioumaking and information as possible, leaving agencies as principally Congress's research and monitoring arm; and (3) where substantive discretion is required to allow administrative agencies to act in that limited capacity, minimize the amount of required judicial and legislative deference to the agency outcomes. Although, as I note in my descriptions, each of these proposals has been made in some form elsewhere in the literature, none has

been made for the reasons I offer, and the three rarely appear as the unified package I propose is necessary to reverse course.

I cannot predict what rules will emanate from the system if altered as I propose—whether there will be more or fewer rules (my hunch is fewer), or whether they will be simple or complicated (my hunch is simple)—but that is not the point. The point is to devise a system that is more coupled than the present system allows, and that thus is more likely to produce rules that make sense given the dynamical qualities of the law-and-society system. Because it would go a long way toward reversing the strong reductionist bias of the present socio-legal structure, my proposed reform package would increase the chances of hitting that mark.

A. *Make Common Law, Rights-Based Legal Solutions Our First Resort*

The Legal Realists were on to something with their devotion to common law systems as their laboratory. As Professor Lon Fuller put it, the common law "mirrors the variety of human experience; it offers an honest reflection of the complexities and perplexities of life itself."[191] The Legal Realists understood that the great obstacle to American legal theory has been the dynamical nature of the law-and-society system—what they called "complexities and perplexities." They did not have the tools of dynamical systems theory at their disposal, but translating their vision into the lexicon of dynamical systems theory is easy—the rights-based attractor of our law-and-society system is adaptive, and the common law is the best approach for keeping us there. Indeed, Professor Richard Epstein has suggested more recently that "traditional judge-made conceptions of common law are, if anything, more attuned to a complex modern world than to the simpler bygone age in which they were formulated."[192] By contrast, we seldom hear any serious argument made that more emphasis on regulation is the answer.

Several inherent features of the common law approach may explain its inherent attractiveness as a mechanism for keeping the

191. LON L. FULLER, ANATOMY OF THE LAW 106 (1968).

192. EPSTEIN, *supra* note 17, at 16. It strikes me as elitist, however, to characterize our present society as more "complex" (meaning complicated) than was the society of our ancestors, especially when we use the self-proclaimed complexity of our present life as an excuse for regulation.

system in the region of complexity, leading some legal commentators to posit an "analogy between pure chaos theory and the common law."[193] First, the common law changes slowly and incrementally; it is less prone to catastrophe. The administrative state may appear at times to move slowly, but consider EPA's track record of zero to 12,000 pages of rules in just twenty-five years. That growth could hardly be called incremental, orderly, or the result of a logical progression of ideas and principles. The common law, by contrast, does not grow by itself. It is limited by the dimension of rights as exercised and enforced, and thus can evolve in approximate step with the components of the law-and-society system.[194]

Second, the common law is structurally more coupled than is the administrative state. It does not slice the law-and-society system into a multitude of subsets, divide problems into corresponding subsets, assign parts of problems accordingly, and thereby attempt to divine the simple rules. The common law takes issues as they come, keeps them whole, and decides them in their context. There is much less opportunity for incomprehensible outcome in the common law.

On the other hand, the common law is adaptive and thus possesses some chaotic qualities. For example,

> even though the outcome of any given legal case is unpredictable, cases do develop trends and patterns . . . . Further, case outcomes are unpredictable even though the results (at least in theory) are generated by the application of relatively simple legal principles or "rules" to a given set of facts, and the importance of facts can be analogized to initial conditions to which chaotic systems have extreme sensitivity.[195]

Finally, the common law operates at the component interaction level, whereas the administrative state functions on the upper surface, taking on the problems the lower levels' interactions toss

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193. Geu, *supra* note 8, at 941.

194. In the context of environmental law, for example,

> [a] striking aspect of nuisance law is its stasis (long term stability), recorded in familiar modes of judicial expression, common analytical techniques, and custom-bred indicators of decision. . . . The key to nuisance law, one might suppose, is found in the empirical lessons of its application recorded over time, less so in the articulated rules of decision.

RODGERS, *supra* note 6, § 2.1, at 113–14.

195. Geu, *supra* note 8, at 942.

up like ping pong balls. Agencies tackle "problems" and do so ever more increasingly in an abstract, high-system-level setting. Courts acting in common law capacities resolve disputes between real parties. The common law thus is more likely to "see" the component interactions before the administrative state does and to adapt to them more efficiently. The result is that the common law, because of its evolutionary qualities, is focused more on system structure and process than on producing prescriptive rules, thus allowing it to avoid falling into the stasis of fixed point and limit cycle attractors that define the modern administrative state.[196]

Hence, there is much to be said for a system that relies on common law, rights-based solutions as a predominant, if not preferred, approach. Doing so would return some proportionality to the balance between freedoms, rights, and regulations. To be sure, the common law is not immune to reductionism, as the process of applying law to facts often involves that brand of approximation, but these are local facts in local settings. Overall, the fundamental qualities of the common law appear more suitable to the goal of adaptability than do those of the administrative state.

B. *Where Regulation Is Necessary, Require Congress to Provide All We Need to Know*

Even an avid devotee of the common law must acknowledge that it will not provide complete answers to all our socio-legal agenda. For example, taxes were not a common law invention, and their administration does not appear to be susceptible to the common law approach. It is also unlikely that the common law alone would ever have achieved a meaningful degree of protection of endangered species. Accepting, therefore, that some measure of

196. *See* FREDERICK SCHAUER, PLAYING BY THE RULES 177–78 (1991). Schauer explains that

> [w]hat is central to the common law is the way in which what had previously been thought to be the rule is a rule only in a very peculiar sense, for it will be applied to new cases if and only if that application is consistent with the full array of policies and principles that, in a more complex rule system, occupy the same place that justifications occup[y]. . . . The common law appears consequently to be decision according to justification rather than decision according to rule. It abounds with rules of thumb, but avoids the use of rules in a strong and constraining sense.

Id. at 178. Legal formalism sought to suppress these qualities, and legal realism sought to divine them. To the reductionism of legal formalism and legal realism, of course, these qualities are what prevented a full understanding of the common law.

regulation is necessary for global issues, we can at the very least attempt to construct a system that is more likely to operate within the dynamical qualities of our law-and-society system model than our reductionist administrative state seems capable. I have accused the lax enforcement of the nondelegation doctrine of being one of the conspirators in that regard, and hence I propose more energetic enforcement of that doctrine as a means of reversing the trend.

By all appearances, of course, the nondelegation doctrine has been somewhere between critical and dead for some time.[197] More recently, however, Congress has tested the Court's tolerance for abstract legislative guidance,[198] and legal commentators have posited a stronger role for a more demanding standard.[199] It is no longer heresy to suggest that Congress has abdicated its important function as decisionmaker and that the nondelegation doctrine is the means of restoring the order.

To do so, moreover, would not obliterate the role of administrative agencies. The point is not to make Congress run the entire government, but rather to have Congress make the decisions necessary so that the day-to-day functions of government can be run by Congress's delegates without them having to make yet more decisions. As is demonstrated in the rare instances in which Congress recently has made the tough decisions, the agencies would continue to serve an important role under this approach as Congress's research and monitoring arm.[200] For example, rather

197. *See supra* text accompanying notes 160–64.

198. Chief Justice Rehnquist has opined that "[w]e ought not to shy away from our judicial duty to invalidate unconstitutional delegations of legislative authority solely out of concern that we should thereby reinvigorate discredited constitutional doctrines of the pre-New Deal era." Industrial Union Dept. v. American Petroleum Inst., 448 U.S. 607, 686 (1980) (Rehnquist, J., concurring); *see also id.* at 645–46 (Stevens, J., plurality opinion) (observing that the statutory requirement that the agency establish worker chemical exposure standards which reduce harm to the extent feasible, if not interpreted by the Court to require the agency first to make a finding of significant risk, might be unconstitutional); American Textile Mfrs. Inst. v. Donovan, 452 U.S. 490, 547, 548 (1981) (Rehnquist, J., dissenting) (finding that the authority to decide how much chemical exposure risk to allow in the workplace is a "'quintessential legislative' choice" which was "unconstitutionally delegated . . . to the Executive Branch").

199. Lawson, *supra* note 159, at 1237–41.

200. Professor David Schoenbrod, for example, has proposed that "[l]awmakers should take direct responsibility for laws by enacting them themselves. If they aren't sure what regulations to enact, they can tell the agency bureaucrats to hold hearings and make proposals." Schoenbrod, *supra* note 188. Professor Glenn Harlan Reynolds observes that the nondelegation doctrine "prevented Congress from ducking important questions (and the responsibility for important decisions) by assigning them to administrative agencies,

than leaving it entirely to EPA to decide whether to regulate certain high volume waste streams as hazardous waste, Congress required EPA to defer such regulation until it had investigated the consequences of different regulatory options and reported thereon to Congress.[201] Such an approach applied more broadly would make reality out of the nondelegation doctrine's fiction that Congress does not really delegate legislative powers, but rather merely seeks the assistance of its coordinate branches.

It is fashionable to complain about Congress's decisions as well, but placing the primary decision making responsibility in that legislative body is likely to promote more adaptability than we experience under the administrative state. Congress is an elected body, and thus presumably reflects the evolving social agenda the same way the common law mirrors social phenomena. By contrast, agencies, particularly when unencumbered by legislative or judicial oversight, are supertanker bureaucracies that can plow far off course before society can steer them back. Moreover, Congress has plenary jurisdiction that can tap into the low-level system interactions, whereas agencies apply "agency expertise" to their respective slivers of the socio-legal dimension. Congress, in short, is more dynamically in tune with the law-and-society system than one can imagine any modern agency being. Placing the primary decision making responsibility in Congress, therefore, is more likely to promote adaptability.[202]

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along with the consequent growth in power of unelected bureaucrats." Reynolds, *Is Democracy Like Sex?*, *supra* note 8, at 1652. He believes, based on a complexity theory analysis, that the relaxed nondelegation doctrine thus led to "a growth in the power of unelected officials to make decisions and an increased opportunity for special interests to influence those decisions." *Id.*

201. *See* RCRA § 3001(b)(3), 42 U.S.C. § 6921(b)(3) (1988).

202. Geu posits a "Complexity Model of Legislation" in which "legislation could be seen as emerging from shifting networks of individual legislators who, in turn, have been influenced by shifting networks both within and outside their constituents (i.e., special interest groups)." Geu, *supra* note 8, at 986. To be sure, I do not believe that Congress actually behaves in this manner today; indeed, what prevents it from doing so institutionally is its current practice of attempting to shuffle decision making to agencies and to peripheral legislative spheres (as it does, for example, with appropriations bills). My belief, however, based perhaps as much on blind faith as on the promise of complexity theory's lessons, is that by returning decision making responsibilities to Congress in its own right, the legislative organism itself will transform into something closer to the ideal Geu describes.

C. *Where Substantive Administrative Discretion Is Necessary, Minimize Judicial and Legislative Deference to Administrative Decisions*

It would be impractical to expect Congress to make all the substantive regulatory decisions necessary to run the law-and-society system. For example, Congress could not itself inspect all facilities subject to its environmental regulations and make judgments as to compliance in all such cases. But where it is necessary to expand administrative functions beyond those of research and monitoring, is it wise to elevate the agency's decision beyond the reach of courts and Congress? We have done so, and we have paid the price of deference to "administrative expertise" by creating just that: narrowly focused expert agencies ignorant of and inappropriately responding to the dynamical qualities of the law-and-society system. Reversing the mechanisms that produced that condition would not be difficult.

1. *Modify the Standards of Review.* Congress could go a long way toward unraveling the administrative state by adopting a less deferential standard of judicial review of administrative action than the "substantial evidence" and "arbitrary and capricious" standards now employed by the APA.[203] Those standards have defied concise, uniform application, as courts have wrestled with how much of a "hard look" is required.[204] By putting an increased burden on agencies—perhaps requiring agencies to sustain a "preponderance of the evidence" burden based on the administrative record—agencies could be required to convincingly articulate the factors on which they base their decisions. Doing so would keep agencies more in tune with the broad socio-legal agenda rather than their own. As Judge Bazelon observed in this light:

> Strict adherence to that requirement is especially important now that the character of administrative litigation is changing. As a

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203. *See generally supra* text accompanying note 168.

204. The Supreme Court has sent mixed messages to the lower courts on whether they should engage in the "hard look" or a "soft glance." *Compare* Citizens to Preserve Overton Park, Inc. v. Volpe, 401 U.S. 402 (1971) (hard look), *with* Vermont Yankee Nuclear Power Corp. v. Natural Resources Defense Council, Inc., 435 U.S. 519 (1978) (soft glance). It is not too far fetched to suspect that "the grand synthesizing principle that tells us whether the court will dig deeply or bow cursorily depends exclusively on whether the judge agrees with the result of the administrative decision. This harsh descent to legal realism—and a cynical version at that—does not lack empirical ammunition." RODGERS, *supra* note 6, § 1.8, at 91.

> result of expanding doctrines of standing and reviewability, and new statutory causes of action, courts are increasingly asked to review administrative action that touches on fundamental personal interests in life, health, and liberty. These interests have always had a special claim to judicial protection. . . . To protect these interests from administrative arbitrariness, it is necessary . . . to insist on strict judicial scrutiny of administrative action.[205]

It is difficult, however, for a court to subject agency decisions to that "hard look" when the substantial evidence test is staring the court in the face. The burden should be on agencies to make the "hard sell" instead.

2. *Reverse* Chevron. The *Chevron* doctrine of judicially self-imposed deference to administrative interpretations of supposedly "ambiguous" legislative directions defeats stability, simplicity, and adaptability by shifting decision making power back to the administrative branch and thus reducing Congress's responsibility to make decisions in the first place.[206] Rather, "it is ordinarily for courts to say what the law is, and the case for deference to agency interpretations of law must therefore depend in the first instance on the law in the form of congressional instruction."[207]

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205. Environmental Defense Fund v. Ruckelshaus, 439 F.2d 584, 597–98 (D.C. Cir. 1971) (citations omitted).

206. *See generally supra* note 170 and accompanying text.

207. CASS R. SUNSTEIN, AFTER THE RIGHTS REVOLUTION 143 (1990). Professor William Rodgers has observed that *Chevron* "diminishes the role of the courts in protecting the policies behind the statutes . . . [and] squeezes the courts out of their important role as evolutionary-adjusters of legislation that is often distorted by changes in time and circumstance." RODGERS, *supra* note 6, § 1.8, at 98. Judge Patricia Wald, on the other hand, posits that *Chevron* actually promotes closer attention to legislative detail by Congress, for if Congress "had to face up to the fact that once the law left the halls of Congress, its ability to control what happened was essentially confined to specific directives in the law itself, perhaps it would try to cover more details and be clearer about its principal goals." Hon. Patricia M. Wald, *Regulation at Risk: Are Courts Part of the Solution or Most of the Problem?*, 67 S. CAL. L. REV. 621, 654 (1994). It is not clear, however, why such an indirectly coercive solution would be superior to the more direct approach of simply putting teeth back in the nondelegation doctrine. If the answer is that Congress "does not have the time (or the political will) to indulge in such microlegislation," *id.* at 652, then Judge Wald's approach will not get anywhere either, and indeed it will only exacerbate the quandary. If nonaction is Congress's only mode, then the question is whether it is better to live in a state with few regulations because Congress cannot figure out what it wants and how to say so, or in a state with a plethora of unchallengeable regulations emanating from an unelected, specialized, insulated cadre of bureaucrats. Simply from the perspective of promoting stability, simplicity, and adaptability of the law-and-society system, the former approach appears more likely to

Chevron reverses that principle by making legislative *ambiguity* an indicia of delegation of legislative power. By insulating the agencies from judicial scrutiny of how they use that power, *Chevron* creates an anti-majoritarian force within agencies and allows them to move policy away from the actual policy intended by Congress.[208] By forcing agencies to explain why their interpretations are the best policy in light of legislative intent rather than requiring courts to accept any "rational" policy that emanates from the administrative mind, we would restore the courts in their role as primary interpreters of statutes and thus take advantage of the more dynamical qualities of judicial experience.[209]

3. *Reverse* Chadha. Lastly, reversing the *Chadha* doctrine's prohibition of the legislative veto mechanism[210] would allow Congress to police agency action more directly and thereby take advantage of its superior dynamical responsiveness. Indeed, as would the strengthening of the nondelegation doctrine, allowing the single- or two-house legislative veto would fulfill the notion of Congress merely seeking assistance of the administrative branch when delegation is necessary. Although *Chadha*, unlike the APA and *Chevron*, purportedly is grounded in the constitutionally

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minimize the impact of surprises from chaos, emergence, and catastrophe.

208. *See* William N. Eskridge, Jr. & John Ferejohn, *Making the Deal Stick: Enforcing the Original Constitutional Structure of Lawmaking in the Modern Regulatory State*, 8 J.L. ECON. & ORG. 165, 187 (1992).

209. *See* Mark Seidenfeld, *A Syncopated* Chevron: *Emphasizing Reasoned Decisionmaking in Reviewing Agency Interpretations of Statutes*, 73 TEX. L. REV. 83 (1994). As Justice Scalia's shifting positions on *Chevron* illustrate, it may not be necessary to reject the doctrine in order to undermine it. Although initially a strong proponent of *Chevron*, *see, e.g.*, NLRB v. United Food & Commercial Workers Local 23, 484 U.S. 112, 133 (1987) (Scalia, J., concurring) (noting continuing vitality of *Chevron*), he has since taken the approach of finding unambiguous legislative directions in most statutes involved in *Chevron* settings, so that administrative interpretation is not permitted to enter into the picture. *See, e.g.*, Antonin Scalia, *Judicial Deference to Administrative Interpretations of Law*, 1989 DUKE L.J. 511, 512–20 (observing that courts should rarely find statutes ambiguous). In Professor Richard Pierce's view, however, such an approach encourages "hypertextualism" and simply leads to courts writing law rather than Congress. *See* Richard J. Pierce, Jr., *The Supreme Court's New Hypertextualism: An Invitation to Cacophony and Incoherence in the Administrative State*, 95 COLUM. L. REV. 749 (1995). I have to agree with Pierce, although I am led to different conclusions given his support of *Chevron*. The best approach is to enforce the nondelegation doctrine so that Congress is not ambiguons in the first place and to require agencies to defend their interpretations when Congress nonetheless leaves room for interpretation.

210. *See generally supra* note 169 and accompanying text.

required procedures for law making, a forceful argument can be made that the Constitution requires no such shackling of legislative control. As Justice White observed in *Chadha*, "If Congress may delegate lawmaking power to independent and Executive agencies, it is most difficult to understand Art. I as prohibiting Congress from also reserving a check on legislative power for itself."[211] In a world tolerant of excessive delegation of legislative power by Congress, *Chadha* is the icing on the cake for an administrative state divorced from accountability.[212] Hence, reversing *Chadha*, along with the two other proposed administrative review reforms, would cinch the package of structural changes designed to reverse the reductionist funnel our administrative state has become.

CONCLUSION—SALVATION FOR THE "PURE" POSITIVIST

Dynamical systems theory—in particular, complexity theory—has offered the physical and social sciences a new way of looking at familiar problems. Those who cling to classical reductionism in science may accuse complexity theory of being tautological—of explaining everything while predicting nothing. But "failure to predict does not mean failure to understand or to explain."[213] Indeed, we don't need to predict, or even know, the details in order to "build theories that seek to explain the generic

211. INS v. Chadha, 462 U.S. 919, 986 (1983) (White, J., dissenting).

212. As Peter B. McCutchen has posited, "[T]he legislative veto is a legitimate second-best solution to the triggering error of excessive delegation of legislative power to administrative agencies." Peter B. McCutchen, *Mistakes, Precedent, and the Rise of the Administrative State: Toward A Constitutional Theory of the Second Best*, 80 CORNELL L. REV. 1, 23 (1994). McCutchen accepts that open-ended delegations of legislative power are unconstitutional, *id.* at 31–36, but believes that the "institutional reliance interests that have built up around [that] particular practice" justify its continuation in order not to upset the "wealth transfers and regulatory activity that have become integral to economic and social expectations in our society." *Id.* at 36. Reversing *Chadha*, therefore, is McCutchen's "second-best" solution. *Id.* at 37–40. My position, by contrast, is that it is the very wealth transfers and regulatory activity made possible by tolerating unconstitutionally excessive delegation that are the manifestations of a system so out of control that there no longer can be any stable economic and social expectations in our society. Reversing *Chadha* without strengthening enforcement of the nondelegation doctrine may be second best, but only by a long shot.

213. KAUFFMAN, AT HOME IN THE UNIVERSE, *supra* note 7, at 17. Indeed, prediction alone is not all that illuminating. For example, "[a] table of the tides predicts but does not explain." *Id.* at 16. Prediction is, after all, a stab at a shortcut to living out the game. "The shortest way to predict what [a] real physical system will do is just to watch it." *Id.* at 22.

properties."[214]

This Article has demonstrated that dynamical systems theory offers the same insight by way of analogy for legal theory and legal institutions. Law and society interact together, and can be thought of as doing so in a nonlinear dynamical manner. The law-and-society system model in this sense exhibits qualities similar to those which scientists have observed in other natural and social systems. For legal theory and legal institutions to ignore the findings of dynamical systems theory, therefore, is to remain ignorant of the underlying qualities and evolution of the law-and-society system model.

In this Article, I have made the case that American legal theory should not ignore dynamical systems theory any longer. The learning curve ahead is steep and long, as it has been for other disciplines that sought to draw from dynamical systems theory far earlier than legal theory has. The first step—the focal point of this Article—is withdrawing from the reductionist-bred molds that have predominated in American legal theory and institutions and have led to stasis through over-regulation, so that we can begin to see dynamical behavior in the law-and-society system for what it is.[215]

I have also taken a risk, probably long before an appreciation of the full dynamical dimensions of the law-and-society system model so justified, and posited the first steps for reforming the system toward nonreductionist structures intended to carry the law-and-society system toward the region of dynamical complexity. It is not as if complexity theory, because it says we cannot predict, advises us to throw up our hands and take whatever comes. Rather, the concept of tuning the coupled nature of the system's struc-

214. *Id.* at 17.

215. Using biological evolution as his example, Kauffman describes three levels of dynamical system behavior revealed through complexity theory: community, coevolution, and evolution of coevolution. *Id.* at 208–24. Community describes how "species assemble and make their livings in the niches each provides the others." *Id.* at 208. Coevolution has to do with describing the evolutionary "fitness landscape" of each member, and how the "fitness landscape of one species changes because the other species that form its niche themselves adapt on their own fitness landscapes." *Id.* Evolution of coevolution focuses on how "[t]he coevolution of organisms alters both the organisms themselves and the ways organisms interact." *Id.* This Article, besides laying out the case for applying complexity theory generally as an analogical foundation for legal theory, focuses principally on describing the socio-legal community. I hope in the future to address the other two levels of socio-legal system evolution revealed through complexity theory.

ture[216] suggests that we can adjust the degree to which the system exhibits complexity and thus the ability to adapt. Of course, I confess—as any adherent of dynamical systems theory must—that I cannot predict the outcome of those reforms with precision, but rather can only expect with some level of confidence gained from dynamical systems theory that they will allow us, by finely tuning the level of system coupling, to manage chaos, emergence, and catastrophe more effectively than does the modern administrative state.

Indeed, the whole point of my exercise has been to demonstrate that the reductionist premises that characterize the major American schools of legal theory, and that manifest themselves as the structural products of our present day legal institutions, are a fantasy. In particular, the emergence of dynamical systems theory in science has put legal positivism and its derivatives in a bind: to posit that scientific method can produce a viable doctrinal basis for legal theory leads inexorably to the sad (for them) conclusion that no absolutely predictive legal theory is possible because of the (necessary) presence of chaos, emergence, and catastrophe. To avoid that conclusion, legal positivists would have to turn a blind eye to chaos, emergence, and catastrophe, notwithstanding that those qualities—or at least behavior that looks very much like their mathematical constructs—appear in the law-and-society system model routinely. Those "halfway" positivists—willing to accept only the reductionist stream of classical scientific theory—will wallow forever in increasingly complicated, ultimately nonpredictive legal theory. The "pure" positivists, on the other hand, who want legal theory and institutions to use all that modern science has to offer, should be thankful for the discovery of chaos, emergence, and catastrophe in scientific theory. Now they can end their search for the Holy Grail and live comfortably knowing that if they are correct that science applies to law, science itself has proven there is no absolutely predictive legal theory.

216. *See supra* note 107.