GENERAL DESIGN PRINCIPLES FOR RESILIENCE AND ADAPTIVE CAPACITY IN LEGAL SYSTEMS — WITH APPLICATIONS TO CLIMATE CHANGE ADAPTATION*

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As climate change begins to disrupt the settled expectations of humans, demands on the legal system will be intense and long term. Is the law up to the task? If it is, it will be at least in part because the legal system proves to be resilient and adaptive. This Article therefore explores how to think about designing legal instruments and institutions now with confidence they will be resilient and adaptive to looming problems as massive, variable, and long term in scale as climate change. Drawing from the body of resilience theory forged in natural and social sciences, this Article is the first to synthesize resilience theory in a framework relevant to lawyers and explore the general design principles it suggests for legal systems. The Article opens by examining resilience—what it is and how to design for it in legal systems. It explores the normative dimensions of resilience and makes important distinctions between resilience of legal systems, resilience of laws they produce, and resilience of the other social and natural systems law addresses. Similarly, this Article examines the theoretical context and design principles for adaptive capacity, focusing on adaptive management theory as an example for legal design. Fusing these two concepts, this Article suggests applications of these general principles to the challenge of designing law for responding to climate change, arguing that climate change adaptation law should draw from theories of adaptive management, dynamic federalism, new governance, and transgovernmental networks.

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INTRODUCTION

Climate change soon will begin to disrupt the settled expectations of humans. Rising sea levels, persistent drought where water has been abundant, longer growing seasons in some areas and invasive species elsewhere—the list of anticipated changes that will play out over the landscape for decades is long, and many inevitably will give rise to the need to formulate new policies and resolve new kinds of disputes.[1] Demands on the legal system will be intense and long term, but is the law up to the task? If it is, it will be at least in part because the legal system proves to be *resilient* and *adaptive*.

These two properties—resilience and adaptive capacity—have become central themes for researchers studying a wide array of ecological, social-ecological, and social systems under the banner of resilience theory.[2] More broadly, they are important focal points of the science of complex adaptive systems as it has been applied in natural and social sciences.[3] Legal scholars recently have begun to consider how these properties and the research from other disciplines might inform the design of laws for discrete legal application,[4] but no

1. For summaries of the legal and policy issues likely to come with climate change, including reviews and syntheses of science and law literature on the topic, see generally Robin Kundis Craig, *"Stationarity Is Dead" — Long Live Transformation: Five Principles for Climate Change Adaptation Law*, 34 HARV. ENVTL. L. REV. 9 (2010); Robert L. Glicksman, *Ecosystem Resilience to Disruptions Linked to Global Climate Change: An Adaptive Approach to Federal Land Management*, 87 NEB. L. REV. 833 (2009); J.B. Ruhl, *Climate Change Adaptation and the Structural Transformation of Environmental Law*, 40 ENVTL. L. 363 (2010).

2. *See, e.g.*, PANARCHY: UNDERSTANDING TRANSFORMATIONS IN HUMAN AND NATURAL SYSTEMS *passim* (Lance H. Gunderson & C.S. Holling eds., 2002).

3. *See* JOHN H. MILLER & SCOTT E. PAGE, COMPLEX ADAPTIVE SYSTEMS: AN INTRODUCTION TO COMPUTATIONAL MODELS OF SOCIAL LIFE 9–10, 27–31, 139–40, 236–37 (2007) (using the term "robustness" in the same manner as resilience).

4. *See generally* Barbara Cosens, *Transboundary River Governance in the Face of Uncertainty: Resilience Theory and the Columbia River Treaty*, 30 J. LAND RESOURCES &

legal scholar has undertaken a broad theoretical treatment applying resilience theory to legal systems.

Drawing from the emerging research and scholarship on resilience theory, this Article is the first to synthesize resilience theory in a framework relevant to lawyers and explore general design principles for resilience and adaptive capacity in legal systems. Part I examines resilience—what it is and how to design for it in legal systems. It also addresses the normative dimensions of resilience theory and makes important distinctions between resilience of legal systems, resilience of laws they produce, and resilience of the other social and natural systems law addresses. Part II provides the theoretical context and design principles for adaptive capacity, focusing on adaptive management theory as an example for legal design. Part III suggests applications of these general principles to the challenge of designing law for responding to climate change; it argues that climate change adaptation law should draw from theories of adaptive management, dynamic federalism, new governance, and transgovernmental networks.

I. RESILIENCE

Who doesn't want to be resilient? The ability to bounce back from illness or other setbacks is admirable in people, but what does it mean for a social system to be resilient? Even more, how can we design a social system to be resilient? To probe those questions for purposes of legal design, the following subparts outline the foundational principles of resilience theory and apply them to the legal system context.

A. *Defining System Resilience*

Although there are numerous variations, a good working definition of resilience as used in natural and social sciences is "the capacity of a system to experience shocks while retaining essentially

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ENVTL. L. 229 (2010) (applying resilience theory to the management of multijurisdictional watersheds); Pierre de Vries, *The Resilience Principles: A Framework for New ICT Governance*, 9 J. ON TELECOMM. & HIGH TECH. L. 137 (2011) (applying resilience theory to the telecommunications industry); J.B. Ruhl, *Regulation by Adaptive Management—Is It Possible?*, 7 MINN. J. L. SCI. & TECH. 21 (2005) (recommending the use of adaptive capacity theory in environmental regulation). One of the earliest uses of resilience theory in a legal context was by a philosopher studying the contrasts between the Platonic emphasis on stability and modernity's emphasis on dynamism. *See* Alicia Juarrero-Roqué, *Fail-Safe Versus Safe-Fail: Suggestions Toward an Evolutionary Model of Justice*, 69 TEX. L. REV. 1745 *passim* (1991).

the same function, structure, feedbacks, and therefore identity."[5] One hallmark of system resilience thus is the capacity to maintain a high level of consistency of behavioral structure in the face of a dynamic environment of change. In 1973 theoretical ecologist C.S. Holling introduced the idea that natural and social systems exhibiting this capacity could be described as resilient.[6] His model, as refined and applied over time,[7] seeks to explain how such systems tolerate disturbance without changing their basic structural identity.[8]

Resilience theory has coalesced around several key features of Holling's model. First, one feature of resilience is recovery—the time required for a system to return to an equilibrium or steady state following a disturbance.[9] Holling refers to this type of resilience as *engineering* resilience in order to convey that it draws on reliability, efficiency, quality control, and similar strategies to pursue a single objective—return to the equilibrium state.[10]

Engineering resilience is distinct from *ecological* resilience.[11] Ecological resilience is measured by the amount or magnitude of disturbance a system can absorb without having its fundamental

5. Brian Walker et al., *A Handful of Heuristics and Some Propositions for Understanding Resilience in Social-Ecological Systems*, ECOLOGY & SOC'Y (June 2006), http://www.ecologyandsociety.org/vol11/iss1/art13/ES-2005-1530.pdf.

6. *See generally* C.S. Holling, *Resilience and Stability of Ecological Systems*, 4 ANN. REV. ECOLOGY & SYSTEMATICS 1 (1973) (outlining the theory).

7. For a comprehensive review of the current theory of system resilience, see C.S. Holling & Lance H. Gunderson, *Resilience and Adaptive Cycles*, *in* PANARCHY, *supra* note 2, at 25, 25–62. For more concise reviews, see generally Lance H. Gunderson, *Ecological Resilience—In Theory and Application*, 31 ANN. REV. ECOLOGY & SYSTEMATICS 425 (2000), focusing on ecological resilience, and C.S. Holling, *Understanding the Complexity of Economic, Ecological, and Social Systems*, 4 ECOSYSTEMS 390 (2001), examining resilience in a variety of natural and social system contexts. Although the roots of resilience theory are in biological ecology, its influence has spread throughout natural sciences and, more recently, into the social sciences, though not with entirely uncritical reception. *See generally* Fiona Miller et al., *Resilience and Vulnerability: Complementary or Conflicting Concepts?*, ECOLOGY & SOC'Y (Sept. 2010), http://www.ecologyandsociety.org/vol15/iss3/art11/ES-2010-3378.pdf (examining criticisms of resilience theory generally). One source of tension has been how resilience theory meshes, or does not mesh, with concepts of system vulnerability forged in disciplines focused on geophysical sciences, political economy, and disaster response. *See id.* (exploring ways of harmonizing the two theoretical perspectives).

8. *See* Gunderson, *supra* note 7, at 426.

9. *See* Isabelle M. Côté & Emily S. Darling, *Rethinking Ecosystem Resilience in the Face of Climate Change*, 8 PLOS BIOLOGY 1, 1 (2010), *available at* http://www.plosbiology.org/article/fetchObjectAttachment.action?uri=info%3Adoi%2F10.1371%2Fjournal.pbio.1000438&representation=PDF.

10. *See* Gunderson, *supra* note 7, at 426; Holling & Gunderson, *supra* note 7, at 27–28.

11. *See* Gunderson, *supra* note 7, at 426–27; Holling & Gunderson, *supra* note 7, at 28.

behavioral structure redefined,[12] a property known as resistance.[13] In contrast to engineering resilience, ecological resilience relies on adjustments to system processes as the means of managing overall system integrity.[14]

Engineering resilience, which favors recovery as the design goal, and ecological resilience, which favors resistance as the design goal, thus are alike in that both concepts envision a system that has been pushed off of its equilibrium state by a disturbance.[15] They differ, however, in terms of the mechanisms and strategies the system uses to avoid being pushed so far as to be functionally restructured. The engineering resilience strategy is to devote all system resources to staying near the equilibrium, the goal being to snap back.[16] By contrast, the ecological resilience strategy accommodates the possibility of fluctuating within a basin of attraction to equilibrium, with the goal of avoiding "flips" from one structural state to another.[17]

Resilience theorists use the heuristic of a ball in a bowl on a table to capture this distinction.[18] Engineering resilience strategies can be represented by a ball at the bottom of a tall, narrow bowl, like a vase with steep sides; ecosystem resilience strategies produce a shallow, wide bowl, like a saucer with a wide surface. At rest, the balls in both bowls sit still at the bottom, at equilibrium. As the table is jiggled, the balls roll around, but they do not roll in the same way. The ball in the tall, narrow vase stays near the bottom and has quick recovery, while the ball in the shallow, wide saucer might roll all around and reach far from the bottom but resist spilling over the rim. The objective of resilience design is to keep the balls in the bowls, but one can imagine how different disturbances might produce different results between the two bowls. A strong wind might knock over the tall vase but not the shallow saucer. An earthquake might bounce the ball out of the shallow saucer but not out of the tall vase.

To translate that heuristic back into resilience theory terminology, the bowls represent the "basin of attraction" for the balls,[19] which represent the current system behavioral state. The

12. *See* Gunderson, *supra* note 7, at 426–27; Holling & Gunderson, *supra* note 7, at 28.

13. *See* Côté & Darling, *supra* note 9, at 1.

14. *See* Holling & Gunderson, *supra* note 7, at 28.

15. *See* Gunderson, *supra* note 7, at 426–27; Holling & Gunderson, *supra* note 7, at 27.

16. *See* Gunderson, *supra* note 7, at 426.

17. *See id.* at 427.

18. *See id.*

19. The terminology described in this paragraph is widely used in resilience and

bottom of the bowl represents the "attractor" to the equilibrium state, whereas the form of the basin defines the "latitude" within which the system state can move before crossing a threshold which, if breached, makes recovery to the equilibrium state difficult or impossible. The wider the basin the greater the number of system states that can be experienced without crossing a threshold. The "precariousness" of the system defines how close the current state of the system is to such a threshold. To avoid reaching a high level of precariousness, engineering resilience strategies rely on strong attractors and limited latitude, whereas ecological resilience strategies tolerate weaker attractors in favor of more latitude.[20]

Another difference between the two strategies has to do with what resilience theory calls the response diversity of the system, which is "the diversity of responses to disturbance among species or actors contributing to the same function in the social-ecological system."[21] Because it opens up options, response diversity enhances resilience. Response diversity is more likely to be brought about, however, by ecological resilience strategies because engineering resilience strategies such as efficiency tend to remove what at the design stage are apparently wasteful redundancies.[22] If new kinds of problems arise that are not anticipated at the design stage, however, the assumptions on which the sleek system design was based could prove overwhelmed. Redundancy in the form of alternative response options, while not efficient, could prove valuable in such cases.

Engineering resilience and ecosystem resilience thus are two distinct strategies with potentially large differences in design orientation and performance outcome. Indeed, they pose "contrasts so . . . fundamental that they can become alternative paradigms whose devotees reflect traditions of a discipline or of an attitude more than of a reality of nature."[23] Yet, resilience theory literature often fails to distinguish between the two properties.[24] Before examining how they differ for legal systems, however, we must first consider when legal systems display resilience and whether it is always desirable.

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complex adaptive systems theory. *See generally* Brian Walker et al., *Resilience, Adaptability and Transformability in Social-Ecological Systems*, ECOLOGY & SOC'Y (Dec. 2004), http://www.ecologyandsociety.org/vol9/iss2/art5/print.pdf (providing a summary of resilience and adaptation theories).

20. *See id.*

21. *See* Walker et al., *supra* note 5. This feature is also known as functional redundancy. *Id.*

22. *See id.*

23. Holling & Gunderson, *supra* note 7, at 28.

24. *See* Côté & Darling, *supra* note 9, at 1.

B. *When Is a Legal System Resilient?*

Legal scholars have used terms like *resilient* and *resilience* to describe positive qualities of a legal system.[25] Although not articulating any formal theory of resilience, these scholars seem to mean what ecologists, social scientists, and complex systems researchers mean—that a resilient legal system enjoys consistency in overall behavioral structure notwithstanding continuous change of external and internal conditions. This Article performs the theoretical exercise of asking how we might map resilience theory principles onto legal systems in order to better understand when legal systems are and are not resilient.[26]

The legal system, like any system, can be defined by its structure (e.g., constitutional division of powers) and processes (e.g., administrative decision procedures). Structure and process thus define the shape of the basin of attraction (the "bowl") and produce system behavior in the form of actual decisions of executives, legislatures, courts, and agencies (e.g., the ruling in a case), which is where the "ball" is at any time. Different configurations of structure and processes—different basin shapes—produce different behavioral outcomes in response to changes in internal and external conditions. The design configuration also affects how the system withstands changes of different quality and magnitude over time. Some configurations could rely on engineering resilience strategies to build a very efficient set of reliable structural and process components, while others could use ecological resilience strategies to build

25. The classic example is from KARL N. LLEWELLYN, THE COMMON LAW TRADITION: DECIDING APPEALS 513 (1960) ("[A]n adequately resilient legal system can on occasion, or even almost regularly, absorb the particular trouble and resolve it each time into a new, usefully guiding, forward-looking felt standard-for-action or even rule-of-law."); *see also* Joni S. Charme, *The Interim Obligation of Article 18 of the Vienna Convention on the Law of Treaties: Making Sense of an Enigma*, 25 GEO. WASH. J. INT'L L. & ECON. 71, 104 (1992) (referring to "the flexibility and resilience of the international legal system"); Juarrero-Roqué, *supra* note 4, at 1777 (referring to "the resilience and adaptability of the United States' legal system"); Janet C. Neuman, *Drought Proofing Water Law*, 7 U. DENV. WATER L. REV. 92, 106 (2003) (discussing how to "improve the resilience of the system" of water law); Oren Perez, *Purity Lost: The Paradoxical Face of the New Transnational Legal Body*, 33 BROOK. J. INT'L L. 1, 48 (2007) (referring to "the resilience of the global legal system").

26. By "we" I mean the actors in the legal system. References to "actors" and "design" in resilience theory do not assume a sentient system designer. An actor in an ecosystem, for example, could be a bird, and the design of an ecosystem could be a result of purely natural processes. When aimed at social-ecological and social systems, of course, resilience theory has both the luxury and complication of being applied by humans to achieve particular normative goals.

extensive response diversity into the system. These design choices take place at different scales and for different subsystems. What the legal community calls environmental law, for example, may be different in structure and process from criminal law.

Indeed, a resilience theorist surely would interpret some features of the American legal system as displaying strong versions of engineering resilience strategies. The Constitution, for example, displays little tolerance for structural or process change. It was designed to be hard to alter in design[27] and has proven so,[28] and efforts to effect change through judicial interpretation, while persistent, remain controversial.[29] Because of its division of powers, moreover, opportunities for response diversity are at a premium in our constitutional system. To be sure, the behavioral state of constitutional doctrine has moved over the past 200 years, but the latitude allowed by the Constitution's "bowl" is more that of a vase than a saucer.[30] Yet it is resilient. Its highly engineered structure and

27. *See* U.S. CONST. art. V. For discussions of the Article V amending procedures as an obstacle to new amendments, see generally RESPONDING TO IMPERFECTION: THE THEORY AND PRACTICE OF CONSTITUTIONAL AMENDMENT (Sanford Levinson ed., 1995); JOHN R. VILE, CONSTITUTIONAL CHANGE IN THE UNITED STATES 1-13 (1994); Donald J. Boudreaux & A.C. Pritchard, *Rewriting the Constitution: An Economic Analysis of the Constitutional Amendment Process*, 62 FORDHAM L. REV. 111 (1993); Walter Dellinger, *The Legitimacy of Constitutional Change: Rethinking the Amendment Process*, 97 HARV. L. REV. 386 (1983); Kris W. Kobach, *Rethinking Article V: Term Limits and the Seventeenth and Nineteenth Amendments*, 103 YALE L.J. 1971 (1994). For a survey of procedures for amending various state and national constitutions, see Elai Katz, *On Amending Constitutions: The Legality and Legitimacy of Constitutional Entrenchment*, 29 COLUM. J.L. & SOC. PROBS. 251, 256–64 (1996).

28. There have been over 11,500 proposed amendments to the Constitution, very few of which have made it through the gauntlet of Article V. *See* JOHN R. VILE, ENCYCLOPEDIA OF CONSTITUTIONAL AMENDMENTS, PROPOSED AMENDMENTS, AND AMENDING ISSUES, 1789–2010, at xx, 344 (3d ed. 2010) (collating proposals by year).

29. *Compare* Randy E. Barnett, *Trumping Precedent with Original Meaning: Not As Radical As It Sounds*, 22 CONST. COMMENT. 257, 258–62 (2005) (favoring "original public meaning" as normatively superior to and more candid than the doctrine of precedent), *with* David A. Strauss, *Originalism, Precedent, and Candor*, 22 CONST. COMMENT. 299, 299–301 (2005) (favoring a common law notion of precedent over originalism, asserting that it provides a workable and more candid framework for full consideration of "morality, policy, [and] fairness"). *See generally* ANTONIN SCALIA, A MATTER OF INTERPRETATION: FEDERAL COURTS AND THE LAW (1997) (criticizing the use of subjective intent in judicial interpretation); DAVID A. STRAUSS, THE LIVING CONSTITUTION (2010) (subscribing to the theory that constitutional interpretation must change over time).

30. When only one equilibrium state exists for a system, or if all other states are considered equivalent to disaster, engineering resilience strategies may be the superior design preference. *See* Gunderson, *supra* note 7, at 426.

process design is so enduring that flips to new equilibrium states—the so-called "constitutional moments"—are quite rare.[31]

By contrast, the American common law system offers an example of ecological resilience: it is a highly dispersed structure of courts throughout the nation, all working to craft doctrine under a loose set of process rules. Response diversity is high, as courts from different states may reach different doctrinal answers for the same legal issues. The result is a high capacity for swings in behavior in response to changing conditions without altering the system's basic structure and process design. Outcomes can move responsively to changed conditions, sometimes dramatically so and other times over long periods of judicial tinkering, without the system's structure and process design changing.[32]

For example, under the common law of nuisance, "changed circumstances or new knowledge may make what was previously permissible no longer so."[33] Examples of such change are numerous. At one time the United States Supreme Court declared: "If there is any fact which may be supposed to be known by everybody, and therefore by courts, it is that swamps and stagnant waters are the cause of malarial and malignant fevers, and that the police power is never more legitimately exercised than in removing such nuisances."[34] Today, by contrast, it would be unheard of for a court to condemn a wetland area as a nuisance; indeed, some courts now consider the draining or filling of a wetland to constitute a nuisance.[35] The modern science of wetland ecology changed public perceptions and encouraged a 180-degree turn in the application of nuisance law to wetlands,[36] but by no means would anyone consider the common law of nuisance to have been restructured as a system.[37]

31. *See generally* BRUCE ACKERMAN, WE THE PEOPLE: FOUNDATIONS (1991) (developing the concept of constitutional moments); Cass R. Sunstein, *Congress, Constitutional Moments, and the Cost-Benefit State*, 48 STAN. L. REV. 247 (1996) (examining the concept of constitutional moments).

32. *See* STUART KAUFFMAN, AT HOME IN THE UNIVERSE: THE SEARCH FOR LAWS OF SELF-ORGANIZATION AND COMPLEXITY 169 (1995) (pointing to these attributes of the common law as evidence of its resilience as a system).

33. Lucas v. S.C. Coastal Council, 505 U.S. 1003, 1031 (1992).

34. Leovy v. United States, 177 U.S. 621, 636 (1900).

35. Palazzolo v. State, No. WM 88-0297, 2005 WL 1645974, at *5 (R.I. Super. Ct. July 5, 2005) (finding a development that would fill a wetland a public nuisance based on "evidence as to various effects that the development will have including increasing nitrogen levels in the pond, both by reason of the nitrogen produced by the attendant residential septic systems, and the reduced marsh area which actually filters and cleans runoff").

36. For reviews of this doctrinal shift, see Michael C. Blumm & J.B. Ruhl,

There is evidence, therefore, of resilience of both types in the American legal system. A few caveats are necessary, however, before going further to consider how to design law for resilience, for I do not want to overstate what resilience theory does for law or what resilience of law means. First, to observe that a legal system is or is not resilient implies nothing about the system normatively. Resilience is a quality of a social system, but it does not make the system "good" or "bad." To be sure, a resilient legal system might depend on or lead to particular social norms, and thus the presence or absence of resiliency may tell us something about other normative features of society. Even though resilience might itself be desirable and considered normatively a good quality to promote in a legal system, the presence or absence alone of resilience in a legal system does not entitle the system to any particular normative status. What Americans might consider a contemptible legal system—feudalism, for example—might nonetheless be resilient (as it was for centuries).

Indeed, to the extent that resilience is a desired quality, it may pose tradeoffs with other normative goals of a legal system. It may be possible to have too much resilience. If, for example, a legal system is highly resilient in the engineering sense, but it is producing outcomes that are no longer normatively acceptable, its resilience is a problem, not a virtue. In such cases, it may require an extreme external disturbance or internally initiated system reformation to change the highly resilient but undesirable regime. The persistence and ultimate demise of the legal system once supporting American slavery offers an example.

Extending this reasoning further, it is important to distinguish between resilience of the legal system and resilience of other natural and social systems the law is aimed at addressing. Environmental law scholars, for example, might focus on how law can promote resilience

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Background Principles, Takings, and Libertarian Property: A Reply to Professor Huffman, 37 ECOLOGY L.Q. 805, 819–30 (2010); John Copeland Nagle, *From Swamp Drainage to Wetlands Regulation to Ecological Nuisances to Environmental Ethics*, 58 CASE W. RES. L. REV. 787, 789–96 (2008).

37. As environmental law scholar William Rodgers has suggested,

> 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.

WILLIAM H. RODGERS, JR., ENVIRONMENTAL LAW § 2.1, at 113–14 (2d ed. 1994).

of ecosystems,[38] and banking law scholars might focus on how to make the financial system more resilient,[39] but that is not the same as asking how to design resilience in law. Nor does it necessarily follow that if we successfully designed the law to be resilient that it will promote the resilience of anything else we care about.

It is also important to distinguish between the resilience of the legal system's underlying structure and processes and the stability of the substantive content of law—that is, the lifespan of particular legal system behavioral outcomes in the form of decisions by executives, legislatures, courts, and agencies. Of course, the volatility of law's substantive content is something many actors in the legal system care about, but it is a product of the legal system, not a part of its structure and process. A legal system relying heavily on ecosystem resilience strategies, for example, is likely to experience high flux in the substantive legal content it produces. The ball rolls far from equilibrium in such systems. It may very well be, however, that controlling for flux is a paramount design goal. There may be many reasons to prefer stability in the substantive content of the law, and doing so may drive or constrain choices between engineering and ecological resilience strategies for legal system structure and process.

These design choices, moreover, operate at multiple scales within and across the vast domain of the legal system. Resilience theory does not posit that a system as complex as law is entirely either a vase or a saucer; rather, it is more a set of landscapes over which we find engineering and ecological resilience strategies mixing in different blends to form topographies of various contours depending on where in the system we look.[40] Some resilience theorists refer to this multiscalar complex of topographies as a "panarchy."

> For resilience theory, it is critical to understand the scales of interest and the scale of analysis because one level of a panarchy may collapse and cascade to lower levels, but the system as a whole may be maintained.... Resilience is a property that can exist at any scale in a panarchy. A given level may not be very resilient, but the larger system may be.[41]

38. *See* Cosens, *supra* note 4, *passim*.

39. *See generally* Saule T. Omarova, *From Gramm-Leach-Bliley to Dodd-Frank: The Unfulfilled Promise of Section 23A of the Federal Reserve Act*, 89 N.C. L. REV. 1683 (2011) (exploring the effectiveness of section 23A of the Federal Reserve Act in achieving its goals in practice).

40. *See* Garry Peterson, Craig R. Allen & C.S. Holling, *Ecological Resilience, Biodiversity, and Scale*, 1 ECOSYSTEMS 6, 10–11 (1998).

41. Craig R. Allen & C.S. Holling, *Novelty, Adaptive Capacity, and Resilience*,

Environmental law, for example, has many facets, not all of which use the same blend of resilience strategies. Environmental law in turn is nestled with many other fields of regulation in the larger-scale system of administrative law, each with its own resilience landscape. Similarly, administrative law operates alongside the common law, which has different resilience properties. The legal system, therefore, has many potential equilibrium states at many different scales, each with its own set of resilience attributes. One component of the larger system—to use an all-too-real example, our financial law system—may fail, but the legal system as a whole may continue to prove resilient.

It follows from all of the foregoing that the possibility of flips from one equilibrium state to another are not necessarily undesirable in legal (or other) systems. If the resilience of natural ecosystems or the stability of legal decisions is our priority, it might be law's structure and process that have to shift to a new equilibrium state when change threatens those values.[42] For example, if one were to trace the history of what might be called the environmental law system, an unmistakable flip occurred in the 1970s as statutory regimes supplanted common law regimes as the dominant system structure.[43] This was in many ways a planned flip to a new equilibrium state, a process known in resilience theory as transformability.[44] One

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ECOLOGY & SOC'Y (Sept. 2010), http://www.ecologyandsociety.org/vol15/iss3/art24/ES-2010-3720.pdf; *see also* Walker et al., *supra* note 19 ("[B]ecause of cross-scale interactions, the resilience of a system at a particular focal scale will depend on the influences from states and dynamics at scales above and below. For example, external oppressive politics, invasions, market shifts, or global climate change can trigger local surprises and regime shifts.").

42. Most of the focus of legal scholars interested in social-ecological systems, for example, is on how law can facilitate making the social-ecological system resilient. *See* Cosens, *supra* note 4, at 255–65 (case study of Columbia River system); Glicksman, *supra* note 1, at 865–91 (federal public lands). This is different from, but not necessarily unrelated to, the question of how to make law resilient as a system. Cosens notes, for example, that "facilitation of resilience in social-ecological systems will also require changes in substantive environmental and natural resources laws by incorporating a bias for decision making that enhances resilience rather than optimization." Cosens, *supra* note 4, at 256. The question I am examining is how to make the changed legal systems themselves resilient.

43. *See* RICHARD J. LAZARUS, THE MAKING OF ENVIRONMENTAL LAW *passim* (2004). This is by no means to suggest the common law has been displaced, or even that it has not come back a bit as an important institution in environmental law. *See generally* Symposium, *Common Law Environmental Protection*, 58 CASE W. RES. L. REV. 575 (2008) (discussing the role of common law within environmental law).

44. Walker et al., *supra* note 19 ("[Transformability is [t]he capacity to create a fundamentally new system when ecological, economic, or social (including political) conditions make the existing system untenable ... [by] creating new stability

of the facets of resilience theory thus focuses on how to manage systems that have multiple equilibrium states and how to flip between them under certain conditions.[45] Indeed, I propose in Part III a transformative flip in the administrative law system to allow it to respond more resiliently to climate change.

Finally, "[m]easuring resilience is fraught with difficulties."[46] There is no resilience meter for law or any other social system. If we form a theory of what resilience means, however, we may be better equipped to identify and broadly assess changes in resilience over time, particularly changes intended to implement our own normative goals. Thus, it is useful to move on to the question of how to design for resilience.

C. Designing for Resilient Legal Systems

Given that we can define resilience and identify its operation in many social systems including law, an obvious question follows: What is it that allows these systems to sustain such productive, aggregate patterns through so much change?[47] A starting point is to unpack the engineering/ecology resilience distinction into a more refined typology of attributes. For example, in their deep examination of resilience in complex systems, Alderson and Doyle explain that five key features of a system contribute to the capacity to endure through surrounding change: "*Reliability* involves robustness to component failures. *Efficiency* is robustness to resource scarcity. *Scalability* is robustness to changes to the size and complexity of the system as a whole. *Modularity* is robustness to structured component rearrangements. *Evolvability* is robustness of lineages to changes on long time scales."[48]

Of these five qualities, reliability and efficiency appear most in keeping with Holling's vision of engineering resilience, while scalability, modularity, and evolvability match up more closely with ecological resilience.[49] Although it would be ideal to be able to

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landscapes.").

45. Holling & Gunderson, *supra* note 7, at 29.

46. Côté & Darling, *supra* note 9, at 1.

47. MILLER & PAGE, *supra* note 3, at 28.

48. David L. Alderson & John C. Doyle, *Contrasting Views of Complexity and Their Implications for Network-Centric Infrastructures*, 40 IEEE TRANSACTIONS ON SYSTEMS, MAN, & CYBERNETICS 839, 840 (2010).

49. Holling & Gunderson, *supra* note 7, at 28 (describing engineering resilience as focusing on "maintaining *efficiency* of function," while ecological resilience "focuses on maintaining *existence* of function"); *see also* Peterson, Allen & Holling, *supra* note 40, at 11–15 (discussing ecological resilience and scalability).

maximize all five properties of resilience in a legal system, it is far more likely that tradeoffs limiting that possibility will be encountered and force difficult decisions about system design. A system that is highly efficient in using scarce resources, for example, might have less response diversity because of the lack of redundancy in important system components.[50] A recurrent system design question, therefore, is which of these properties to favor.

Holling devotes most of his work on resilience theory to answering that question in the social-ecological system context, with a decided preference for ecological resilience strategies. He and Gunderson claim, for example, that "[e]xclusive focus on the first definition of resilience, engineering resilience, reinforces the dangerous myth that the variability of natural systems can be effectively controlled, that the consequences are predictable, and that sustained maximum production is an attainable and sustainable goal."[51] The assumptions of controlled variability and reliable predictability, if true, would support focusing on strategies like reliability and efficiency of the system. Under such conditions, the predictable low-variance behavior of expected changes would make designing system components and a lean system architecture easier and less risky. But if those premises are not true, success in using engineering resilience strategies to design around a small tolerance for variability means "the system becomes more vulnerable to external shocks that previously could be absorbed."[52]

To put it another way, if it is expected that there is little capacity to predict and control a high variability of changes in internal and external conditions, engineering resilience strategies pose a higher risk of catastrophic failure. Under those conditions, system design should favor ecological resilience strategies.[53] After all, consider what scalability, modularity, and evolvability imply. Scalability allows a system to shift relevant temporal and spatial scales to adjust to changed conditions; modularity allows the system to shift functions and relationships between system components to adjust to changed conditions; and evolvability implies the capacity to keep doing both over long time periods.[54]

50. *See* Alderson & Doyle, *supra* note 48, at 840 (using the example of efficiency and reliability as possible system tradeoffs).

51. Holling & Gunderson, *supra* note 7, at 28.

52. *Id.*

53. *See* Gunderson, *supra* note 7, at 432–33.

54. *See* Alderson & Doyle, *supra* note 48, at 840.

Obvious examples of these qualities exist in enduring legal systems. The American legal system, for example, has scaled up spatially, integrating new state after state into the system. At any scale, moreover, our federalism governance model has also allowed us to configure different combinations of local, state, and federal governance units to respond to different policy challenges, and to rearrange the combinations to adjust for changing conditions. The system has done both for centuries—placing a premium on evolvability.

This is not to say that engineering resilience is not a useful design component for legal systems. We may want some foundational normative principles, such as protection of religious and speech freedoms, to stick close to equilibrium conditions. Even if we expect high variability and low predictability of the type of system stresses that potentially flow from the exercise of free speech, we may value that normative goal so much that we are not willing to tolerate the range of outcomes produced under a strong ecological resilience design. Simply put, some norms are so important that we do not want the "ball" to be able to stray far from the bottom of the bowl. And, more broadly, where the ball comes to rest on the spectrum between extreme engineering and extreme ecological resilience design is by no means an easy question. For example, a persistent debate in environmental law has focused on whether to design from fixed general principles in the mode of engineering resilience or from more flexible processes in the mode of ecological resilience.[55] As a general matter, however, the lesson from resilience theory is that conditions of high variability and low predictability point in the direction of ecological resilience strategies as the default design rule.

55. *Compare* Bruce Pardy, *Environmental Assessment and Three Ways Not To Do Environmental Law*, 21 J. ENVTL. L. & PRAC. 139, 153 (2010) ("The proper role for environmental law is to set generally applicable limits on the degree to which human activities encroach upon ecosystems.... The permissibility of proposed projects would be apparent from the application of the general rules, and there would be no justification for a process of utilitarian, discretionary, case-by-case decision making tightly held by political officials."), *with* A. Dan Tarlock, *Is There a There There in Environmental Law?*, 19 J. LAND USE & ENVTL. L. 213, 219 (2004) ("[A]n effective and long-lasting environmental law cannot be constructed around a series of abstract substantive principles.... The candidate suite of principles such as advance environmental impact assessment, polluter pays, precaution, and sustainable development are useful starting points but they can only serve as guideposts to structure a dynamic, but inevitably ad hoc, decision making process.") (footnote omitted).

II. ADAPTIVE CAPACITY

System resilience is not uniform across time, space, and conditions. Rather, "[a] system can have a property that is robust to one set of perturbations and yet *fragile* for [*a different property*] and/or [*perturbation*],"[56] and thus "a system's . . . resilience expands and contracts."[57] Tradeoffs internal to the system are not the only reason resilience is variable. Components of a system can break down in ways that undermine one or more properties of resilience, and new kinds of exogenous conditions can arise for which a system has little resistance or which pose more substantial barriers to recovery. Resilience, in other words, must be managed—the system must adapt. But it must adapt without undermining its own basic behavioral structure. This Part examines what that means in theory and what it means for a legal system.

A. *Defining System Adaptive Capacity*

Any particular combination of resilience strategies faces limits over time. Thus, a system would benefit from a protocol to identify imminent changes to components or conditions and to respond by rebalancing resilience strategies. The idea that a system might sense threats to system equilibrium and respond by changing resilience strategies without changing fundamental attributes of the system is known as the system's adaptive capacity.[58] Going back to the ball and bowl heuristic,[59] adaptive capacity allows the shape of the bowl to change to alter the balance between engineering and ecological resilience strategies. A glass bowl has little adaptive capacity; a bowl made of silly putty has a lot.

Adaptive capacity thus involves

> (i) making desirable basins of attraction wider and/or deeper, and shrinking undesirable basins; (ii) creating new desirable basins, or eliminating undesirable ones; and (iii) changing the current state of the system so as to move either deeper into a desirable basin, or closer to the edge of an undesirable one.[60]

These overall system changes are accomplished by "mov[ing] thresholds away from or closer to the current state of the system"

56. Alderson & Doyle, *supra* note 48, at 840.
57. Holling & Gunderson, *supra* note 7, at 25, 40.
58. *See* Gunderson, *supra* note 7, at 428.
59. *See supra* text accompanying notes 18–20.
60. Walker et al., *supra* note 19.

(altering *latitude*), "mov[ing] the current state of the system away from or closer to the threshold" (altering *precariousness*), "mak[ing] the threshold more difficult or easier to reach" (altering *resistance*), and "manag[ing] cross-scale interactions to avoid or generate loss of resilience at the largest and most socially catastrophic scales" (altering *panarchy*).[61]

Resilience does not necessarily require high levels of adaptive capacity. A system that relies heavily on the engineering type of resilience attributes, such as reliability and efficiency, may prove resilient without adaptation precisely because it is highly resistant to change. By the same token, such a system, because of its rigidity, may be vulnerable to large-scale disruptions if some internal failure or external disturbance breaks down the wall of resistance.[62] Flexibility may be a useful guard against this possibility.

Of course, there is a limit to how much a system adapts before it is no longer the same system. Adaptive capacity implies "system robustness to changes in resilience,"[63] meaning that the goal of adaptation is to keep the basic identity of the system intact. Indeed, an overly strong design focus on adaptability can undermine resilience. Optimizing the system to adapt to a particular set of disturbances could potentially decrease resilience to unknown disturbances.[64] Like resilience strategies, therefore, adaptive capacity strategies have tradeoffs.

B. *When Is a Legal System Adaptive?*

As with resilience, legal scholars frequently portray adaptive capacity as a positive quality in legal systems[65] but seldom expand upon what adaptive capacity means for law. The idea that adaptive capacity means managing the mix of resilience properties such as

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61. *Id.*

62. *See* Holling & Gunderson, *supra* note 7, at 28.

63. Gunderson, *supra* note 7, at 435.

64. *See* Walker et al., *supra* note 5.

65. *See, e.g.*, H.W. Arthurs, *National Traditions in Labor Law Scholarship: The Canadian Case*, 23 COMP. LAB. L. & POL'Y J. 645, 666 (2002) (referring to the "adaptive capacity of labor law systems"); Susan L. Brooks & Robert G. Madden, *Relationship-Centered Lawyering: Social Science Theory for Transforming Legal Practice*, 78 REV. JUR. U.P.R. 23, 26 (2009) (referring to "environmental changes requiring adaptive legal system responses"); Thomas D. Lambros, *The Federal Rules of Civil Procedure: A New Adversarial Model for a New Era*, 50 U. PITT. L. REV. 789, 798 (1989) (referring to "the American legal system's adaptive capacity"); Daniel Schramm & Akiva Fishman, *Legal Frameworks for Adaptive Natural Resource Management in a Changing Climate*, 22 GEO. INT'L ENVTL. L. REV. 491, 520 (2010) (asserting that countries must "assess the 'adaptive capacity' of their respective legal systems" to respond to climate change).

reliability, efficiency, scalability, modularity, and evolvability has not crept into the legal scholarship on adaptation in legal systems. The closest example to be found is in the emerging decision process theory of adaptive management in natural resources law.

Over the past two decades, natural resources policy has gravitated to a model of nested, ever-changing, complex ecosystems, the essence of which demands a management policy framework every bit as dynamic as the ecosystems it seeks to manage.[66] This rapidly solidifying framework, known as ecosystem management,[67] rejects decision making based on rigid standards and comprehensive rational planning, relying instead on experimentation using continuous monitoring, assessment, and recalibration. This decision method approach has come to be known as adaptive management.[68] Not surprisingly, its founder is none other than C.S. Holling, who shortly after forging the theory of resilience laid out the theory of adaptive management in an influential book, *Adaptive Environmental Assessment and Management*.[69]

Finding conventional environmental assessment and management methods at odds with the emerging model of ecosystem dynamics, Holling and his fellow researchers focused on the basic properties of ecological systems to provide the premises of a new assessment and management method.[70] The traditional management

66. *See* Reed F. Noss, *Some Principles of Conservation Biology, As They Apply to Environmental Law*, 69 CHI.-KENT L. REV. 893, 893 (1994) ("Among the new paradigms in ecology, none is more revolutionary than the idea that nature is not delicately balanced in equilibrium, but rather is dynamic, often unpredictable, and perhaps even chaotic."); *see also* Bryan Norton, *Change, Constancy, and Creativity: The New Ecology and Some Old Problems*, 7 DUKE ENVTL. L. & POL'Y F. 49, 49 (1996) (addressing new ecological emphases on change and dynamism); Jonathan Baert Wiener, *Law and the New Ecology: Evolution, Categories, and Consequences*, 22 ECOLOGY L.Q. 325, 326–27 (1995) (discussing the new empirically supported extensions of Darwin's evolutionary theories).

67. For the seminal works developing ecosystem management theory and policy, see generally Norman L. Christensen et al., *The Report of the Ecological Society of America Committee on the Scientific Basis for Ecosystem Management*, 6 ECOLOGICAL APPLICATIONS 665 (1996); R. Edward Grumbine, *What Is Ecosystem Management?*, 8 CONSERVATION BIOLOGY 27 (1994). The legal contours of ecosystem management are comprehensively explored in JOHN COPELAND NAGLE & J.B. RUHL, THE LAW OF BIODIVERSITY AND ECOSYSTEM MANAGEMENT 311–1035 (2d ed. 2006).

68. *See* J.B. Ruhl & Robert L. Fischman, *Adaptive Management in the Courts*, 95 MINN. L. REV. 424, 424–31 (2010).

69. ADAPTIVE ENVIRONMENTAL ASSESSMENT AND MANAGEMENT (C.S. Holling ed., 1978); *see also* Kai N. Lee & Jody Lawrence, *Restoration Under the Northwest Power Act: Adaptive Management: Learning from the Columbia River Basin Fish and Wildlife Program*, 16 ENVTL. L. 431, 442 n.45 (1986) (tracing the term "adaptive management" to Holling's book).

70. ADAPTIVE ENVIRONMENTAL ASSESSMENT AND MANAGEMENT, *supra* note 69,

approach of natural resources policy was "to attack environmental stressors in piecemeal fashion, one at a time," and to parcel decision making "out among a variety of mission-specific agencies and resource-specific management regimes."[71] Under a dynamic model of ecosystems, Holling and his colleagues concluded, management policy must put a premium on collecting information, establishing measurements of success, monitoring outcomes, using new information to adjust existing approaches, and being willing to change.[72]

The adaptive management framework thus is more evolutionary and interdisciplinary, relying on iterative cycles of goal determination, model building, performance standard setting, outcome monitoring, and standard recalibration.[73] As it has been refined over time since Holling's initial work, the full loop of adaptive management involves eight key steps: (1) definition of the problem, (2) determination of goals and objectives for management of ecosystems, (3) determination of the ecosystem baseline, (4) development of conceptual models, (5) selection of future restoration actions, (6) implementation and management actions, (7) monitoring and ecosystem response, and (8) evaluation of restoration efforts and proposals for remedial actions.[74] The last step, the evaluation process, is critical, for it "feeds directly into adaptive management by informing the implementation team and leading to testing of management hypotheses, new simulations, and proposals for adjustments in management experiments or development of wholly new experiments or management strategies."[75]

If one could produce a legal system that operated under this decision process model, management of resilience properties could be made an explicit subject of hypotheses, simulations, and adjustments in policy. It remains to be seen, however, whether federal resource management agencies can translate the theoretical descriptions of adaptive management into a regime for building adaptive capacity in

at 25–37.

71. Bradley C. Karkkainen, *Bottlenecks and Baselines: Tackling Information Deficits in Environmental Regulation*, 86 TEX. L. REV. 1409, 1439 (2008).

72. *See* ADAPTIVE ENVIRONMENTAL ASSESSMENT AND MANAGEMENT, *supra* note 69, at 1–21.

73. *See* Ruhl & Fischman, *supra* note 68, at 428–31.

74. *See* COMM. ON ENDANGERED & THREATENED FISHES IN THE KLAMATH RIVER BASIN, NAT'L RESEARCH COUNCIL, ENDANGERED AND THREATENED FISHES IN THE KLAMATH RIVER BASIN: CAUSES OF DECLINE AND STRATEGIES FOR RECOVERY 332–35 (2004).

75. *Id.* at 335.

natural resources law. As Professor Robert Fischman and I have summed up agency practice, "Rather than elaborating on the theoretical framework by providing details for implementation . . . , agencies adopting adaptive management have gone in the reverse direction [by] condensing the policy of adaptive management into the bumper-sticker sized slogan of 'learning while doing.' "[76] This has, at best, resulted in a "lite" version of adaptive management that has had mixed results in the field and in the courts.[77] But lack of will is not all to blame—agencies also lack the clear authority and resources to implement adaptive management at its most effective capacity.[78] As the next section shows, however, it is in fact a lack of design for adaptive capacity in law that has hampered the agencies' efforts as much as anything else.

C. *Designing for Adaptive Law*

Integrating the principles of resilience theory will require that agencies commit to manage resilience strategies continuously and flexibly over time. For example, the clear lesson from resilience theory is that when variability is high and predictability is low, ecological resilience strategies (scalability, modularity, and evolvability) are more likely to prove successful. Reliability and efficiency strategies, on the other hand, may prove more useful in cases where variability is low and expectations of future conditions are reliable over relevant planning horizons. Adaptive capacity is about enabling the system to move between these modes as regimes of change shift in variability and predictability—to allow changing the shape of the system's bowl. So the question for adaptation in law is how flexible to make the bowl.

For an agency seeking to apply adaptive management, the bowl is unfortunately rigid. Adaptive management theory is a response to the model of ecosystems as dynamic systems—as having high variability and low predictability to change. It is, in essence, a call for moving to ecological resilience strategies in natural resources management. The problem is that natural resources management agencies are locked in an administrative law system that places a premium on engineering resilience strategies and shows no signs of being flexible in that regard. The system's fixation on predecisional environmental assessment, cost-benefit analysis, records of decisions,

76. Ruhl & Fischman, *supra* note 68, at 431.
77. *See id.* at 441–70.
78. *See id.* at 480–83.

and judicial review litigation has pushed the system toward a "front-end" focus on reliability and efficiency that has made adaptive management exceptionally difficult to implement.[79] Consequently, it will be difficult for natural resource agencies, particularly in an era of climate change, to engage in even a "lite" version of "learning while doing" if they lack the authority and capacity to build the infrastructure necessary to implement the full scope of adaptive management. Moreover, ecosystems are not the only systems in law's management domain that exhibit high variability and low predictability. The relatively low adaptive capacity of administrative law is likely to stifle efforts in other fields of law to move toward ecological resilience strategies when variability is on the rise and prediction is unreliable. Part III examines this problem in the context of climate change.

III. ENVISIONING RESILIENT AND ADAPTIVE CLIMATE CHANGE ADAPTATION LAW

If high variability and low predictability are the design challenge for resilience and adaptive capacity in legal systems, then climate change will present an unprecedented set of challenges. Climate change will cause numerous natural and social systems to depart from settled patterns and ranges of variability, and thus to behave in ways beyond the control or prediction of many legal instruments and institutions. Climate change adaptation law design will thus need to lean heavily on ecological resilience strategies and to tolerate high levels of adaptive capacity.

For the first proposition—that climate change will violate known variability of natural and social systems in unpredictable ways—consider how natural resource managers view the likely effects.[80] As noted above, resource management has evolved well past conceptions of nature as static and "balanced," as the trend over the past half-century has been to focus more on the complex flux qualities of ecosystems and to place less emphasis on conceptions of stasis and natural stability.[81] Nevertheless, even the "dynamic equilibrium" model that is now firmly in place in ecology is based on the

79. For an extended discussion of this thesis and literature supporting it, see generally J.B. Ruhl, *Regulation by Adaptive Management—Is It Possible?*, 7 MINN. J. L. SCI. & TECH. 21 (2005), which explores impediments to adaptive management posed by the administrative law system.

80. For an extended discussion of this proposition, on which the short summary here is based, see Ruhl, *supra* note 1, at 392–97.

81. *See supra* note 66 and accompanying text.

assumption of "stationarity," which is "the idea that natural systems fluctuate within an unchanging envelope of variability."[82] Although ecologists understand that the envelope can be stretched by natural and anthropogenic events, "justifiably or not, they generally have considered natural change and variability to be sufficiently small to allow stationarity-based design."[83] Thus, many natural resource conservation programs to this day depend heavily on the strategy of setting aside habitat reserves in order to preserve the status quo.[84] Even newer, more flexible conservation orientations, such as ecosystem-based management, depend strongly on the stationarity premise and its appeal to "natural" and "native" models of ecosystem dynamics.[85]

But the stationarity premise is on thin ice in the era of climate change. Ecologists now warn of the no-analog future—ecological variability unprecedented in the history of ecology, riddled with nonlinear feedback and feed-forward loops, previously unknown emergent properties, and new thresholds of irreversible change.[86] The

82. P.C.D. Milly et al., *Stationarity Is Dead: Whither Water Management?*, 319 SCIENCE 573, 573 (2008).

83. *Id.*

84. *See generally* Holly Doremus, *The Endangered Species Act: Static Law Meets Dynamic World*, 32 WASH U. J.L. & POL'Y 175 (2010) (reviewing this quality of traditional conservation programs).

85. *See generally* Grumbine, *supra* note 67, at 27 (advocating management of ecosystems for their "native" properties); Bruce Pardy, *Ecosystem Management in Question: A Reply to Ruhl*, 23 PACE ENVTL. L. REV. 209, 213–14 (2005) (proposing management of ecosystems for "natural" conditions). For arguments against retaining these conceptions of "nature" as the policy driver in environmental law, see generally J.B. Ruhl, *The Myth of What Is Inevitable Under Ecosystem Management: A Response to Pardy*, 21 PACE ENVTL. L. REV. 315 (2005), and J.B. Ruhl, *The Pardy-Ruhl Dialogue on Ecosystem Management, Part IV: Narrowing and Sharpening the Questions*, 24 PACE ENVTL. L. REV. 25 (2007), both of which argue for ecosystem management.

86. *See generally* Peter Cox & David Stephenson, *A Changing Climate for Prediction*, 317 SCIENCE 207, 207 (2007) (explaining why current climate change models are unreliable); Matthew C. Fitzpatrick & William W. Hargrove, *The Projection of Species Distribution Models and the Problem of Non-Analog Climate*, 18 BIODIVERSITY & CONSERVATION 2255 (2009) (explaining difficulties in predicting future species distributions); Douglas Fox, *Back to the No-Analog Future?*, 316 SCIENCE 823, 823 (2007) (discussing the "no-analog" problem of climate change); Douglas Fox, *When Worlds Collide*, CONSERVATION, Jan.–Mar. 2007, at 28 (same). The scientific literature exploring these complex dynamics and exposing our lack of understanding about what lies ahead as temperature rises is legion. *See generally* U.S. CLIMATE CHANGE SCI. PROGRAM, U.S. GEOLOGICAL SURVEY, THRESHOLDS OF CLIMATE CHANGE IN ECOSYSTEMS (2009), *available at* http://downloads.climatescience.gov/sap/sap4-2/sap4-2-final-report-all.pdf (examining numerous positive feedback properties leading to nonlinear thresholds in climate change dynamics); Almut Arneth et al., *Clean the Air, Heat the Planet?*, 326 SCIENCE 672 (2009) (examining the feedback effects between conventional air pollution control and climate change mitigation, concluding that complex positive and negative

"envelope" of variability will not merely grow in size—it will change in basic structure, and no analog exists for predicting its new ground rules.[87] These shifts in ecological systems, along with their impacts on social systems, have the potential for massive swings not only in the quality of the risks humans face, but also in their magnitude and manifestations.[88]

The question, therefore, is how far we can stretch from the current behavioral states of different natural and social systems, and of the legal system in particular, before resilience fails and the system flips into a vastly different future. The lesson we should take from resilience theory in such cases is to move away from engineering resilience strategies and toward ecological resilience strategies and to build adaptive capacity into the system. Indeed, I previously have outlined several principles for climate change adaptation law that now strike me as resonating in this resilience theory theme. I outline

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feedback links exist and that, on balance, the evidence and models suggest that "air pollution control will accelerate warming in the coming decades"); Gordon B. Bonan, *Forests and Climate Change: Forcings, Feedbacks, and the Climate Benefits of Forests*, 320 SCIENCE 1444 (2008) (explaining the complex and nonlinear forest-climate interactions); I. Eisenman & J.S. Wettlaufer, *Nonlinear Threshold Behavior During the Loss of Arctic Sea Ice*, 106 PROC. NAT'L ACAD. SCI. 28 (2009) (describing the nonlinear "tipping points" in the ice-albedo feedback effect); Jerome Gaillardet & Albert Galy, *Himalaya—Carbon Sink or Source?*, 320 SCIENCE 1727 (2008) (explaining the uncertainties of the sinks and sources of the carbon geological cycle); Steven W. Running, *Ecosystem Disturbance, Carbon, and Climate*, 321 SCIENCE 652 (2008) (explaining the uncertainties of ecological sinks and sources such as fires and insect epidemics).

87. For more extensive examinations of the reasons for, and policy consequences of, the erosion of the stationarity premise, see Craig, *supra* note 1, at 31–39; Glicksman, *supra* note 1, at 851–56; Ruhl, *supra* note 1, at 392–97.

88. Carolyn Kousky and Roger Cooke of Resources for the Future describe this "unholy trinity" of fat tails, tail dependence, and micro-correlations:

> These are distinct aspects of loss distributions, such as damages from a disaster or insurance claims. With fat-tailed losses, the probability declines slowly, relative to the severity of the loss. Tail dependence is the propensity of dependence to concentrate in the tails, such that severe losses are more likely to happen together. Micro-correlations are negligible correlations between risks which may be individually harmless, but very dangerous when aggregated. These three phenomena—types of catastrophic and dependent risks—undermine traditional approaches to risk management.

Carolyn Kousky & Roger M. Cooke, *The Unholy Trinity: Fat Tails, Tail Dependence, and Micro-Correlations* 1 (Res. for the Future, Discussion Paper No. 09-36-REV, 2009), *available at* http://www.rff.org/documents/RFF-DP-09-36-REV.pdf; *see also* Carolyn Kousky & Roger M. Cooke, *Climate Change and Risk Management: Challenges for Insurance, Adaptation, and Loss Estimation* 6 (Res. for the Future, Discussion Paper No. 09-03-REV, 2009), *available at* http://www.rff.org/RFF/Documents/RFF-DP-09-03-REV.pdf (applying these concepts specifically to climate change adaptation).

each principle here briefly[89] and then tie them into what has been learned from resilience theory.

First, legal systems most likely to be stressed by climate change, such as environmental law and water law, must be unshackled from comprehensive rational planning and other "front-end" decision process methods such as predecisional environmental assessment and cost-benefit analysis.[90] These methods depend too heavily on assumptions of stationarity and predictability to respond effectively to the realities of climate change. Recognizing these limitations, legal scholars already have begun to question the efficacy of using these methods in climate change adaptation decisions.[91] The critical component of the alternative approach is to deemphasize the front-end focus, which assumes all effects can be predicted and assessed before the decision, and introduce formal follow-up mechanisms demanding that the decision maker integrate new information into an ongoing decision adjustment process.[92] Professor Daniel Farber offers an example in the dynamic, learning-oriented decision process he calls "climate impact assessments."[93] More broadly, and not surprisingly, the trend in climate change scholarship is increasingly calling for empowering adaptive management in practice to live up to its theory.[94]

89. For a more thorough discussion of these principles, see Ruhl, *supra* note 1, at 416–31.

90. *See id.* at 416–23.

91. *See generally* Daniel A. Farber, *Adaptation Planning and Climate Impact Assessments: Learning from NEPA's Flaws*, 39 ENVTL. L. REP.: NEWS & ANALYSIS 10,605 (2009) (environmental impact assessment); Robert L. Glicksman, *Global Climate Change and the Risks to Coastal Areas from Hurricanes and Rising Sea Levels: The Costs of Doing Nothing*, 52 LOY. L. REV. 1127 (2006) (cost-benefit analysis); Douglas A. Kysar, *Climate Change, Cultural Transformation, and Comprehensive Rationality*, 31 B.C. ENVTL. AFF. L. REV. 555 (2004) (cost-benefit analysis).

92. Ruhl, *supra* note 1, at 420.

93. *See* Farber, *supra* note 91, at 10,607–14; *see also* Caleb W. Christopher, *Success by a Thousand Cuts: The Use of Environmental Impact Assessment in Addressing Climate Change*, 9 VT. J. ENVTL. L. 549, 592 (2008) (proposing adaptive approaches for environmental impact assessment in the climate change context). To be sure, there remains considerable value in retaining a front-end component of environmental impact assessments to anticipate climate change impacts, particularly to the extent doing so helps to increase public awareness and internalize consideration of climate change impacts in federal agencies and state, local, and private actors. *See* Catherine J. LaCroix, *SEPAs, Climate Change, and Corporate Responsibility: The Contribution of Local Government*, 58 CASE W. RES. L. REV. 1289, 1291 (2008).

94. *See* Carl Bruch, *The End of Equilibrium*, ENVTL. F., Sept.–Oct. 2008, at 30, 32–33 ("Incorporating adaptive management into laws and institutions can enhance the capacity of governance systems and ecosystems to adapt to changing climatic conditions, to develop and deploy new technologies and techniques."); Alejandro E. Camacho, *Adapting*

Second, a growing number of environmental law scholars have gravitated to new governance theory, which turns "away from the familiar model of command-style, fixed-rule regulation by administrative fiat, and toward a new model of collaborative, multi-party, multi-level, adaptive, problem-solving" governance.[95] The central organizing principles of new governance theory are stakeholder participation, collaboration among interests, diversity of and competition between instruments, decentralization of governance structures, integration of policy domains, flexibility, and an emphasis on noncoerciveness and adaptation.[96] Rigidly relying on fixed, uniform regulatory instruments, such as technology standards and regulatory prescriptions, forecloses adaptation to the kind of evolving, complex problems climate change adaptation will present. Governance institutions will need a broader array of instruments—ranging from "hard" prescriptive mandates to "soft" incentive- and information-based tools—to test for leverage over the more tractable attributes of climate change adaptation problems over time.

Third, although the roles of states and the federal government in addressing climate adaptation have not yet been established,[97] the case for local and regional governance in adaptation policy is

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Governance to Climate Change: Managing Uncertainty Through a Learning Infrastructure, 59 EMORY L.J. 1 *passim* (2009); Craig, *supra* note 1, at 65–67 (utilizing the heading "Be Serious About Using Adaptive Management—and Change Both Natural Resources and Administrative Laws to Allow for It"); Glicksman, *supra* note 1, at 868 ("The land management agencies, in the planning process as well as in other contexts, must *rely heavily* on the management technique known as *adaptive management*.").

95. Bradley C. Karkkainen, *"New Governance" in Legal Thought and in the World: Some Splitting as Antidote to Overzealous Lumping*, 89 MINN. L. REV. 471, 473 (2004). For a sweeping overview of new governance theory, see generally Orly Lobel, *The Renew Deal: The Fall of Regulation and the Rise of Governance in Contemporary Legal Thought*, 89 MINN. L. REV. 342 (2004). For additional scholarship developing and applying new governance principles, see generally THE TOOLS OF GOVERNMENT: A GUIDE TO THE NEW GOVERNANCE (Lester M. Salamon ed., 2002); Cristie L. Ford, *New Governance, Compliance, and Principles-Based Securities Regulation*, 45 AM. BUS. L.J. 1 (2008); Alana Klein, *Judging as Nudging: New Governance Approaches for the Enforcement of Constitutional Social and Economic Rights*, 39 COLUM. HUM. RTS. L. REV. 351 (2008); Lester M. Salamon, *The New Governance and the Tools of Public Action: An Introduction*, 28 FORDHAM URB. L.J. 1611 (2001); Jason M. Solomon, *Law and Governance in the 21st Century Regulatory State*, 86 TEX. L. REV. 819 (2008); Michael Waterstone, *A New Vision of Public Enforcement*, 92 MINN. L. REV. 434 (2007); Robert F. Weber, *New Governance, Financial Regulation, and Challenges to Legitimacy: The Example of the Internal Models Approach to Capital Adequacy Regulation*, 62 ADMIN. L. REV. 783 (2010).

96. *See* Lobel, *supra* note 95, at 371–404.

97. *See* Daniel A. Farber, *Climate Adaptation and Federalism: Mapping the Issues* 1 (Univ. of Cal. Berkeley, Pub. Law Research Paper No. 1,468,621, 2009), *available at* http://ssrn.com/abstract=1468621 (follow "One-Click Download" hyperlink).

strengthened by the variations in climate change impacts across the landscape.[98] On the other hand, it is not as if the federal government has no stake in climate change adaptation as a matter of national interest.[99] Attempting to resolve this tension to find the just-right scale of governance for adaptation would be a futile undertaking—adaptation policy must operate at all scales in an interconnected network of decision making. Although the emerging theory of dynamic federalism has not been focused on climate change adaptation policy, it matches well with the multiscalar qualities of climate change. Under dynamic federalism, "federal and state governments function as alternative centers of power and any matter is presumptively within the authority of both the federal and the state governments."[100] The theory thus explicitly calls for overlapping federal and state (and, through states, local) jurisdictions.[101] Scholars of dynamic federalism reject the "minimal overlap" model in which there is a "particular allocation of at least primary regulatory authority between the states and the federal government."[102] Instead, they use a model "in which multiple levels of government interact in

98. For discussions of climate change adaptation policy at local and regional scales, see generally Lara Whitely Binder, *Preparing for Climate Change in the U.S. Pacific Northwest*, 15 HASTINGS W.-NW. J. ENVTL. L. & POL'Y 183 (2009); Alejandro E. Camacho, *Climate Change and Regulatory Fragmentation in the Great Lakes Basin*, 17 MICH. ST. J. INT'L L. 139 (2008); Colin Crawford, *Our Bandit Future? Cities, Shantytowns, and Climate Change Governance*, 36 FORDHAM URB. L.J. 211 (2009); John C. Dernbach, *Toward a Climate Change Strategy for Pennsylvania*, 12 PENN ST. ENVTL. L. REV. 181 (2004); Ileana M. Porras, *The City and International Law: In Pursuit of Sustainable Development*, 36 FORDHAM URB. L.J. 537, 591 (2009).

99. *See, e.g.*, Robin Kundis Craig, *Climate Change, Regulatory Fragmentation, and Water Triage*, 79 U. COLO. L. REV. 825 *passim* (2008) (focusing on national policy for marine environment adaptation).

100. Kirsten H. Engel, *Harnessing the Benefits of Dynamic Federalism in Environmental Law*, 56 EMORY L.J. 159, 176 (2006). For additional scholarship developing and applying dynamic federalism theory and related principles, see generally David E. Adelman & Kirsten H. Engel, *Adaptive Federalism: The Case Against Reallocating Environmental Regulatory Authority*, 92 MINN. L. REV. 1796 (2008); Robert B. Ahdieh, *From Federalism to Intersystemic Governance: The Changing Nature of Modern Jurisdiction*, 57 EMORY L.J. 1 (2007); Renee M. Jones, *Dynamic Federalism: Competition, Cooperation and Securities Enforcement*, 11 CONN. INS. L.J. 107 (2005); Robert A. Schapiro, *From Dualist Federalism to Interactive Federalism*, 56 EMORY L.J. 1 (2006); Robert A. Schapiro, *Toward a Theory of Interactive Federalism*, 91 IOWA L. REV. 243 (2005) [hereinafter Schapiro, *Toward Interactive Federalism*].

101. Benjamin K. Sovacool, *The Best of Both Worlds: Environmental Federalism and the Need for Federal Action on Renewable Energy and Climate Change*, 27 STAN. ENVTL. L.J. 397, 448 (2008).

102. Engel, *supra* note 100, at 161.

the regulatory process."[103] As a result, dynamic federalism "reject[s] the traditional static optimization model for an adaptive one."[104]

Finally, these climate change law prescriptions resonate with the emerging theory of transgovernmental networks, which scholars have forged initially in the context of international law.[105] Nation-states, while still the most important actors, have increasingly disaggregated into component institutions that share roles with nonsovereign bodies.[106] Transgovernmental networks theory emphasizes the nonhierarchical horizontal and vertical networks that are built among the *officials* of those institutions to exchange information, identify best practices, harmonize approaches, and enforce the overall policy program.[107] A scientist or policymaker in an agency might be a member of many such semi-autonomous networks addressing different problems, serving as one link in a set of ties that facilitate information flow across and between social networks. As many people in many agencies build these ties, the overlapping structure of authorities becomes less a mangle and more an organism.[108] As a result, the networked agencies are better equipped to fulfill the feedback function because people in the network, as opposed to

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103. *Id.*

104. Adelman & Engel, *supra* note 100, at 1798.

105. Transgovernmental networks theory emphasizes the role of "networks of similarly situated technocrats" who work in many different governance units, and "conceive[s] of lawmaking as an organic enterprise, harnessing the technical expertise of bureaucrats who do not possess heady titles but nonetheless intimately understand the practical exigencies of their particular issue areas." Janet Koven Levit, *A Bottom-Up Approach to International Lawmaking: The Tale of Three Trade Finance Instruments*, 30 YALE J. INT'L L. 125, 182 (2005). For the seminal and still most comprehensive discussion of transgovernmental networks theory, see generally ANNE-MARIE SLAUGHTER, A NEW WORLD ORDER (2004). For additional scholarship developing and applying transgovernmental networks principles, see generally Neil Craik & Joseph DiMento, *Environmental Cooperation in the (Partially) Disaggregated State: Lessons from the Security and Prosperity Partnership of North America*, 8 CHI. J. INT'L L. 479, 484–92 (2008); Patrick X. Delaney, *Transnational Corruption: Regulation Across Borders*, 47 VA. J. INT'L L. 413 (2007); Eleanor D. Kinney, *The Emerging Field of International Administrative Law: Its Content and Potential*, 54 ADMIN. L. REV. 415, 425–27 (2002); Kal Raustiala, *The Architecture of International Cooperation: Transgovernmental Networks and the Future of International Law*, 43 VA. J. INT'L L. 1 (2002); Anne-Marie Slaughter, *The Accountability of Government Networks*, 8 IND. J. GLOBAL LEGAL STUD. 347 (2001); Jenia Iontcheva Turner, *Transnational Networks and International Criminal Justice*, 105 MICH. L. REV. 985 (2007); Christopher Whytock, *A Rational Design Theory of Transgovernmentalism: The Case of E.U.-U.S. Merger Review Cooperation*, 23 B.U. INT'L L.J. 1 (2005).

106. *See* SLAUGHTER, *supra* note 105, at 18, 22–23.

107. *See id.* at 19–22.

108. *See* Nan D. Hunter, *"Public-Private" Health Law: Multiple Directions in Public Health*, 10 J. HEALTH CARE L. & POL'Y 89, 103 (2007).

entire institutions, can more adeptly transfer information, confer about trends, identify and raise alerts about unintended consequences of policy measures, and so on.

So let us compare two models of climate change adaptation law structure and process against the principles of resilience theory. One model, what I will call the "business as usual approach," is typified by the modern administrative state described above. The approach relies on comprehensive predecisional assessment and planning for its decision process and deploys a limited suite of centralized prescriptive instruments, hierarchical federalism, and insular administrative agencies for its underlying structure. It depends heavily on predictive capacity, reliable implementation through agencies, efficiency through division of authorities, and a limited set of regulatory instrument options. The other model, what I will call the "resilience approach," relies on the adaptive management decision process described above and a broad array of policy instruments from markets to regulations to common law, dynamic multiscalar federalism, and networked agencies and other actors for its underlying structure. The business as usual model corresponds fairly well with engineering resilience strategies, and the proposed model comes much closer to meeting the principles of ecological resilience strategies.

Proponents of dynamic federalism, for example, have primarily focused on its advantages of plurality, dialogue, redundancy, accountability, and economies of scale.[109] The key point relating to the federalism question in climate change adaptation policy is the theory's overlapping, flexible distribution of authority between federal, state, and local agencies. Namely, while it may appear inefficient to have several agencies at different scales working away on some mutual climate change adaptation policy problem, the built-in redundancy of dynamic federalism can provide significant benefits. First, it gives the overall structure of governance more rather than less policy space,[110] which surely will be needed for climate change adaptation. Second, having multiple agencies working on a problem within overlapping scales can also promote synergy between the agencies and the formation of informal networks.[111]

109. *See* Adelman & Engel, *supra* note 100, at 1808; Schapiro, *Toward Interactive Federalism*, *supra* note 100, at 292–93; Sovacool, *supra* note 101, at 448–51.

110. *See* Adelman & Engel, *supra* note 100, at 1817–18.

111. *See id.* at 1809–10 (summarizing literature suggesting that overlapping authority can promote initiative at one governance scale and spark other scales to follow promising policy innovations).

In short, while it may not be as efficient as a tightly hierarchical federalism system in which scales of authority are insular, dynamic federalism nevertheless builds scalability, modularity, and response diversity into the system,[112] all of which are likely to enhance resilience for a legal system aimed at responding to climate change. Similarly, new governance principles build response diversity by broadening the array of regulatory instruments. Transgovernmental network principles enhance adaptive capacity to respond with scalar and modular adjustments to system organization by keeping decision makers at all scales structurally linked and information flowing between them.[113] And adaptive management, by extending the decision-making process from solely the front end to a continuous learning process, promotes adaptive capacity by allowing decision makers to continue molding the "bowl" of resilience domains.

To be sure, a legal system using this model may appear to be an inefficient, continuous work in progress, but it would be intentionally designed for those qualities precisely to respond to the high variability and low predictability of what it is addressing. It might not be the legal system model we would design for other purposes, particularly if variability and predictability of change were reliably known for particular legal applications. Indeed, it is the only governance model that offers the United States hope of managing the impacts of climate change.

That is quite a bold claim, and skeptics may ask, if this model is so great, why hasn't it been adopted? To some extent it has, as agencies adopt adaptive management[114] and climate change adaptation policy is being forged at multiple governance scales.[115] But there are many constraints on the transformation from the business as usual engineering resilience model to the proposed ecological resilience model. For one thing, we are only beginning to see evidence of the demise of stationarity in ecological systems, so the prospect of higher variability and lower predictability in natural and social systems is still very much a contingency in terms of timing and intensity. Calls for transformation of the legal system to respond to

112. *See* Cosens, *supra* note 4, at 239–42.

113. *See generally* David E. Booher & Judith E. Innes, *Governance for Resilience: CALFED as a Complex Adaptive Network for Resource Management*, ECOLOGY & SOC'Y (Sept. 2010), http://www.ecologyandsociety.org/vol15/iss3/art35/ES-2010-3404.pdf (pointing to governance structures representing transgovernmental networks, also known as complex adaptive network governance, as examples of resilience in application).

114. *See* Ruhl & Fischman, *supra* note 68, at 441–70.

115. *See* Ruhl, *supra* note 1, *passim*.

the perceived no-analog future thus are likely to face resistance from entrenched interests.[116] In addition, climate change law is just one subsystem of a vast legal system, many other parts of which rely successfully on engineering resilience strategies. Why abandon an approach that has worked well in many applications and offers reliability and efficiency as its premiums? In short, moving climate change law in the direction of ecological resilience strategies, while a move supported by resilience theory, will be no small feat in application. The bet we have to make now, therefore, is whether climate change will disrupt our conceptions of variability and predictability so much as to require a fundamentally different set of legal structures and processes. I am placing my money on the need to transform.

CONCLUSION

When climate change brings a new regime of high variability and low predictability in natural and social systems, the law must be ready. This Article addresses this issue in the same way resilience theorists probe other natural and social systems, and it suggests that mapping resilience theory onto the legal system is a fruitful exercise both in general and in particular applications such as to prepare law for climate change. Several important themes come out of doing so.

First, the dichotomy between engineering resilience and ecological resilience offers a useful model for sorting out the properties of and tradeoffs between strategies familiar to legal design: reliability, efficiency, scalabilty, modularity, and evolvability. Second, where variability of the change regime facing a legal system is high and predictability is low, the higher response diversity qualities of ecological resilience strategies (scalability, modularity, and evolvability) offer an important resilience enhancement, making them the default rule for design purposes. Third, whether a legal system is resilient or not implies nothing about its normative performance, and vice versa. Resilience is simply a property of the legal system. Fourth, as a property of the legal system, resilience may face tradeoffs with normative goals we specify for law, such as promoting the resilience of natural and social systems, ensuring the stability of law's substantive content, or protecting highly valued norms such as freedom of speech from too broad a range in outcomes. Fifth,

116. *See generally* Eric Biber, *Climate Change and Backlash*, 17 N.Y.U. ENVTL. L.J. 1295 (2009) (discussing weak support for regulations where the targeted harms are delayed).

adaptive capacity allows a system to recalibrate the balance between different resilience strategies but has its tradeoffs as well—too much capacity to reshape a system may undermine resilience.

This Article by no means has purported to venture much further than to outline these themes as general design principles for legal systems. The case study of climate change offers only an opening into the kind of dialogue that might be possible for legal design using resilience theory principles. In particular, most accounts of climate change describe a no-analog future of high variability and low predictability, suggesting that ecological resilience strategies will enhance the resilience of the legal system designed to respond to it. Drawing from theories of adaptive management, new governance, dynamic federalism, and transgovernmental networks, I offer a package of structural and process designs geared toward that approach. It may be difficult to activate that assembly of design strategies, but climate change may give us little choice but to try if resilience is a valued feature of the legal system.

Resilience theory may offer legal design nothing in the way of strategies legal scholars have not already covered. Legal scholars did not need resilience theory to develop the concepts underlying dynamic federalism, for example, or the Constitution. Resilience theory does, however, provide a coherent set of questions and analytics for stepping back to assess how to coordinate and apply those strategies to design a legal system that is durable in the face of change. And whether we like it or not, climate change will present a rich laboratory for experimentation with the theory of resilience of legal systems.