2010

Climate Change, Dead Zones, and Massive Problems in the Administrative State: A Guide for Whittling Away

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INTRODUCTION

The modern administrative state does not have the luxury of many "easy cases." Consider a few well-known agency headaches:

- The U.S. Fish and Wildlife Service, which administers one of the most potent environmental laws, the Endangered Species Act (ESA), recently extended the law's protections to the polar bear,[1]

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1. *See* Determination of Threatened Status for the Polar Bear, 73 Fed. Reg. 28,212 (May 15, 2008) (to be codified at 50 C.F.R. pt. 17). The agency's decision to list the polar bear was, to say the least, controversial. It followed contentious litigation designed to force the agency to reach a decision, and while the agency did list the species as threatened, it promulgated a special rule, as authorized under section 4(d) of the ESA, that had the effect of limiting the full extent of regulatory protections available under the statute. *See* Special Rule for the Polar Bear (interim rule), 73 Fed. Reg. 28,306 (May 15, 2008) (to be codified at 50 C.F.R. pt. 17); Special Rule for the Polar Bear (final rule), 73 Fed. Reg. 76,249 (Dec. 16, 2008) (to be codified at 50 C.F.R. pt. 17). Both the listing decision and the special rule have been challenged in litigation that remains pending at the time of this writing. For background on these and related events, see J.B. Ruhl, *Climate Change and the Endangered Species Act: Building Bridges to a No-Analog Future*, 39

yet the agency is powerless to stop the leading cause of the bear's imperilment—climate change.[2]

- Every morning in cities across the nation, grumbling commuters inch along, locked in traffic gridlock, yet no local or regional planning agency can solve its cause—suburban sprawl.[3]
- Each spring, a massive slug of nutrients flows down the Mississippi River and empties into the Gulf of Mexico where it creates an enormous hypoxic "dead zone," an area so low in oxygen that aquatic life must either flee or suffocate. Yet federal agencies from the Environmental Protection Agency (EPA) to the Department of Agriculture cannot meaningfully address its primary cause—runoff of fertilizers and manure from Midwestern farms.[4]

ENVTL. L. REP. 10,735, 10,744–45 (2009).

2. At a press conference announcing the polar bear listing, Secretary of the Interior Dirk Kempthorne warned that "[w]hile the legal standards under the ESA compel me to list the polar bear as threatened, I want to make clear that this listing will not stop global climate change or prevent any sea ice from melting." News Release, U.S. Department of the Interior, Secretary Kempthorne Announces Decision to Protect Polar Bears under Endangered Species Act (May 14, 2008), *available at* http://www.doi.gov/news/08_News_Releases/080514a.html. Subsequently, in announcing his decision not to alter the previous administration's decision regarding the status of the polar bear and level of protection it will receive under the ESA, Interior Secretary Salazar proclaimed that "the Endangered Species Act is not the proper mechanism for controlling our nation's carbon emissions." News Release, U.S. Fish & Wildlife Service, Salazar Retains Conservation Rule for Polar Bears, Underlines Need for Comprehensive Energy and Climate Legislation (May 8, 2009), *available at* http://www.fws.gov/news/NewsReleases/showNews.cfm?newsId=20FB90B6-A188-DB01-04788E0892D91701. Climate change has been described as "a major threat to the survival of species and integrity of ecosystems world-wide." Philip E. Hulme, *Adapting to climate change: is there scope for ecological management in the face of a global threat?*, 42 J. APPLIED ECOLOGY 784, 784 (2005). In its *2007 Synthesis Report*, the Intergovernmental Panel on Climate Change predicted that "[t]here is *medium confidence* that approximately 20 to 30% of species assessed so far are *likely* to be at increased risk of extinction if increases in global average warming exceed 1.5 to 2.5°C," and that if warming "exceeds about 3.5°C, model projections suggest significant extinctions (40 to 70% species assessed) around the globe." INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: SUMMARY FOR POLICYMAKERS 13–14 (2007), *available at* http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf. For additional discussion of the climate change problem, see *infra* Parts II–III.

3. Florida, no stranger to sprawl, defines "urban sprawl" by regulation as

> urban development or uses which are located in predominantly rural areas, or rural areas interspersed with generally low-intensity or low-density urban uses. . . . Urban sprawl is typically manifested in one or more of the following land use or development patterns: Leapfrog or scattered development; ribbon or strip commercial or other development; or large expanses of predominantly low-intensity, low-density, or single-use development.

FLA. ADMIN. CODE ANN. r. 9J-5.003(134). There is ongoing debate about the pros and cons of this particular form of suburban development and its antidote, "smart growth." *See* ROBERT BRUEGMANN, SPRAWL: A COMPACT HISTORY (Univ. Chi. Press 2005); JULIAN CONRAD JUERGENSMEYER & THOMAS E. ROBERTS, LAND USE PLANNING AND DEVELOPMENT REGULATION LAW § 9.1B at 475–79 (Thomson-West Practitioner Treatise Series 2d ed. 2007); Nicole Stelle Garnett, *Save the Cities, Stop the Suburbs?*, 116 YALE L.J. 598 (2007). For additional discussion of sprawl, see *infra* Parts II–III.

4. According to the U.S. Geological Survey,

> [e]xcessive nutrients, in particular nitrogen and phosphorus, have resulted in the growth

If you were the administrator of the Fish and Wildlife Service, or the head of a city's planning agency, or the Secretary of Agriculture, what would you do to fulfill your agency's mandate to solve these problems, knowing that your regulatory toolkit is woefully inadequate and that any action your agency takes will likely have little effect? That question vexes agencies dealing not only with environmental and land use issues but also with concerns about widening income gaps, provision of social services, rising health care costs, rising unemployment, and a litany of other social and economic woes. Mandates that agencies solve problems like these roll easily out of the halls of legislatures but, as a practical matter, what should an agency do when legislatures and courts give only sparse guidance on how to implement the delegated authority, when the agency's solitary actions will most assuredly not solve the problem, and when any policy measure the agency might advance has the potential to engender new concerns?

The dilemma agencies face in these settings is most acute in the area of climate change. In *Massachusetts v. Environmental Protection Agency*,[5] the Court found that the EPA had erred in denying the state's rulemaking petition to regulate greenhouse gas emissions from motor vehicles[6] as an air pollutant

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> of large amounts of algae that decay and consume oxygen, thereby causing a zone of low dissolved oxygen or 'hypoxic zone' in the Northern Gulf of Mexico. This can stress and cause death in bottom-dwelling organisms, threatening the economic and ecological health of one of the nation's largest and most productive fisheries.

U.S. Geological Survey, *Mississippi River Basin and Gulf of Mexico Hypoxia*, http://water.usgs.gov/nawqa/sparrow/gulf_findings/hypoxia.html (last visited Feb. 12, 2008). The most definitive study of the causes concludes that runoff from agricultural sources contributes 70 percent of the excess nutrients. *See* Richard B. Alexander et al., *Differences in Phosphorous and Nitrogen Delivery to the Gulf of Mexico from the Mississippi River Basin*, 42 ENVTL. SCI. & TECH. 822, 822 (2007), *available at* http://pubs.acs.org/doi/pdf/10.1021/es0716103?cookieSet=1. Hypoxia from agricultural runoff and urban sewage is expanding exponentially throughout the world as well, affecting 400 estuarine systems covering over 245,000 square kilometers. *See* Robert J. Diaz & Rutger Rosenberg, *Spreading Dead Zones and Consequences for Marine Ecosystems*, 321 SCI. 926, 926 (2008); *see generally* MINDY SELMAN ET AL., EUTROPHICATION AND HYPOXIA IN COASTAL AREAS: A GLOBAL ASSESSMENT OF THE STATE OF KNOWLEDGE (2008), *available at* http://pdf.wri.org/eutrophication_and_hypoxia_in_coastal_areas.pdf (reviewing instances and the science of estuarine eutrophication from around the world). For additional discussion of agricultural runoff pollution and Gulf hypoxia, see *infra* Parts II–III and V.

5. 549 U.S. 497 (2007).

6. *See* Control of Emissions from New Highway Vehicles and Engines, 68 Fed. Reg. 52,922-02, 52,922 (Sept. 8, 2003). The EPA dismissed the petition on the broad basis that global climate change is so complicated that either Congress did not provide for greenhouse gas emissions to be subject matter for the Clean Air Act or, if Congress did so provide, the agency properly identified conflicting policy concerns as a basis for deciding not to regulate emissions. *See id.* at 52,929–31. For concise yet thorough summaries of the rulemaking petition, the EPA's decision, lower court proceedings, the Supreme Court's majority and dissenting opinions, and the likely impact of the case, see Arnold W. Reitze Jr., *Controlling Greenhouse Gas Emissions From Mobile Sources*—Massachusetts v. EPA, 37 ENVTL. L. REP. 10535 (2007); Michael Sugar, Comment, Massachusetts v. Environmental Protection Agency, 31 HARV. ENVTL. L. REV. 531 (2007).

under the Clean Air Act.[7] Among the many reasons the agency offered to justify its decision was that no "realistic possibility exists that the relief petitioners seek would mitigate global climate change and remedy their injuries."[8] In other words, the EPA's actions, no matter how draconian, could not solve the global climate change problem. The problem was just too big for one agency to handle.

The Court retorted that while the EPA could not hope to use its limited capacity to solve the climate change problem completely, this did not justify the agency's inaction and disregard of a statutory mandate to regulate one of the problem's many causes. The Court observed that agencies do not "resolve massive problems in one fell regulatory swoop. They instead whittle away at them over time, refining their preferred approach as circumstances change and as they develop a more-nuanced understanding of how best to proceed."[9] The Court was clear in ordering the EPA to "whittle away" as best it could, yet unhelpfully silent on how, exactly, the EPA should do so.[10] The Court's only guidance was its observation that the "EPA no doubt has significant latitude as to the manner, timing, content, and coordination of its regulations with those of

7. The Clean Air Act defines "air pollutant" in sweeping terms to include "any air pollution agent . . . including any physical, chemical, [or] biological . . . substance or matter which is emitted into or otherwise enters the ambient air." 42 U.S.C. § 7602(g) (2000). The Court found that "greenhouse gases fit well within [this] capacious definition." Massachusetts v. EPA, 549 U.S. 497, 532 (2007).

8. *Mass. v. EPA*, 549 U.S. at 523.

9. *Id.* at 524.

10. Given that the Court found that greenhouse gas emissions are pollutants under the statute, the Clean Air Act charges the EPA with regulating greenhouse gas emissions from motor vehicles if in the EPA's "judgment [the emissions] cause, or contribute to, air pollution which may reasonably be anticipated to endanger public health or welfare." 42 U.S.C. § 7521(a)(1). Noting that the Clean Air Act defines "welfare" to include "effects on . . . weather . . . and climate," the Court rejected all of the EPA's proffered bases for its judgment not to regulate greenhouse gas emissions. *See Mass v. EPA*, 549 U.S. at 506 (quoting 42 U.S.C. § 7602(h)). Rather, the Court concluded, under the clear terms of the Clean Air Act, the EPA can avoid taking further action to regulate carbon emissions from motor vehicles "only if it determines that greenhouse gases do not contribute to climate change or if it provides some reasonable explanation as to why it cannot or will not exercise its discretion to determine whether they do." *Id.* at 533. As its only example of a "reasonable explanation," the Court suggested that the EPA might find "the scientific uncertainty is so profound that it precludes EPA from making a reasoned judgment as to whether greenhouse gases contribute to global warming." *Id.* at 534. Yet having previously observed that "[r]espected scientists" believe greenhouse gas emissions do contribute to climate change, *id.* at 504, the Court seems to have left the EPA little wiggle room. *See* Jonathan Z. Cannon, *The Significance of* Massachusetts v. EPA, 93 VA. L. REV. IN BRIEF 53, 59 (2007), http://www.virginialawreview.org/inbrief/2007/05/21/cannon.pdf ("The Court's opinion seems to leave EPA little room in dealing with climate change."); Reitze, *supra* note 6, at 10538 ("[T]he Court's opinion pushes EPA to find that GHGs need to be regulated."). Nevertheless, as a matter of judicial restraint the Court was silent on how the EPA might go about fulfilling the decision, observing simply that "[w]e need not and do not reach the question whether on remand EPA must make an endangerment finding, or whether policy concerns can inform EPA's actions in the event that it makes such a finding." *Mass. v. EPA*, 549 U.S. at 534–35.

other agencies."[11] Simply put, the agency must figure out for itself how best to whittle.[12]

This is no small task. Of course, the EPA is not alone in whittling away at climate change. The Fish and Wildlife Service must protect a growing list of species under the ESA.[13] The Securities and Exchange Commission must determine how public companies disclose potential effects of climate change on their financial profiles.[14] The Department of Transportation must take climate change into account in setting fuel efficiency standards.[15] State and local energy, environmental, and land use agencies must consider how to account for climate change when planning infrastructure and regulating facilities.[16] How

11. *Mass. v. EPA*, 549 U.S. at 533.

12. The agency has yet to do this. In July 2008, the EPA announced it would delay its decision on endangerment in order to solicit comments on an advance notice of proposed rulemaking from the public and other federal agencies and state and local governments on options for how to proceed. *See* Regulating Greenhouse Gas Emissions Under the Clean Air Act, 73 Fed. Reg. 44,354 (July 30, 2008) [hereinafter Regulating Greenhouse Gas]. EPA later found that carbon emissions do pose an endangerment. *See* Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clear Air Act, 74 Fed. Reg. 66,496 (Dec. 15, 2009). The agency also proposed rules to regulate greenhouse gas emissions from large industrial sources in October 2009. *See* Prevention of Significant Deterioration and Title V Greenhouse Gas Tailoring Rule, 74 Fed. Reg. 55,291 (Oct. 27, 2009). No further regulatory actions have taken place as of this writing.

13. *See* J.B. Ruhl, *Climate Change and the Endangered Species Act: Building Bridges to the No-Analog Future*, 88 B.U. L. REV. 1 (2008) (describing ecological effects that climate change will cause and their implications for administration of the ESA).

14. *See* Trisha L. Smith et al., *Climate Change in SEC Disclosures: Charting a Course Through Murky Waters Without a Compass*, *in* CLIMATE CHANGE: LITIGATION, REGULATION, AND RISK 21 (2008). Several institutional investors recently petitioned the Securities and Exchange Commission to require companies to disclose more information and analysis of the financial risks they face from climate change effects and the regulation of greenhouse gas emissions. *See* California Public Employees Retirement System et al., Petition for Interpretive Guidance on Climate Change Disclosure (2007), *available at* http://www.sec.gov/rules/petitions/2007/petn4-547.pdf. Similarly, in 2008 the Attorney General of New York entered into agreements with several energy companies requiring them to disclose increased financial, regulatory, and litigation risks likely to be triggered by the impact of climate change on their plans to construct coal-fired power plants. *See* John Herzfeld, *Xcel Energy Agrees to Disclosure Plan On Climate-Related Risk for Shareholders*, DAILY ENV'T (BNA), Aug. 28, 2008, at A-8; *see, e.g.*, In re Dynegy Inc., AOD 08-132 (N.Y. Att'y Gen'l 2008), *available at* http://www.oag.state.ny.us/media_center/2008/oct/ dynegy_aod.pdf.

15. *See* Ctr. for Biological Diversity v. Nat'l Highway Traffic Safety Admin., 508 F.3d 508, 548–58 (9th Cir. 2007) (faulting the National Highway Traffic Safety Administration for failing to take climate change effects into account when promulgating fuel economy standards for light trucks and SUVs).

16. For summaries of proposed and adopted state and local climate change measures, see John C. Dernbach & Seema M. Kakade, *Climate Change Law: An Introduction*, 29 ENERGY L.J. 1, 15–20 (2008); David Hodas, *State Initiatives*, *in* GLOBAL CLIMATE CHANGE & U.S. LAW, 343–369 (Michael B. Gerrard ed., ABA Press 2007); J.R. DeShazo and Jody Freeman, *Timing and Form of Federal Regulation: The Case of Climate Change*, 155 U. PA. L. REV. 1499, 1521–30 (2007); Stephen C. Jones & Paul R. McIntyre, *Filling the Vacuum: State and Regional Climate Change Initiatives*, 38 ENV'T REP. (BNA) 1640 *passim* (2007); PEW CENTER ON GLOBAL CLIMATE CHANGE, A LOOK AT EMISSIONS TARGETS, http://www.pewclimate.org/what_s_being_done/targets (last visited Feb. 12, 2008). Many observers believe the measures are

aggressively should each of these agencies whittle away? What types of knives should they use? With all of this whittling, how do they avoid cutting each other, much less come up with an agreed upon final carving?

Climate change is as big and unwieldy a problem as they come, so it is an easy choice for poster child of the "massive problems" dilemma described by the Court. But many problems, even those smaller in scope, present no less of a challenge to public policy administration. As mentioned above, agriculture is the nation's leading source of water quality impairment, but its diffuse form of nonpoint source pollution remains almost invulnerable to regulation.[17] Urban sprawl stretches public infrastructure to its limits, yet has defied all variety of policy prescriptions.[18] Global immigration and low-cost production have altered the operation of our domestic labor market and have raised complex human rights issues.[19] The bursting of the subprime mortgage bubble has led to fingers pointing in all directions.[20] These are all massive problems with

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unrealistic. *See, e.g.*, Robert N. Stavins, *Free GHG Cuts: Too Good to be True?*, ENVTL. F., May–June 2007, at 16 (asserting that the cost estimates California is providing for its greenhouse gas reduction benchmark goals are wildly low).

17. In his comprehensive study of the problem, *Halting Hypoxia*, Jay Landers concludes that "[t]o address hypoxia in the Gulf of Mexico, the enormous amounts of nutrient entering the water body via the Mississippi River must be reduced. Achieving this goal will require an array of actions and strategies across a broad swath of America's heartland." Jay Landers, *Halting Hypoxia*, CIV. ENGINEERING, June 2008, at 54. For a legal analysis of agricultural nonpoint source pollution, see J.B. Ruhl, *Farms, Their Environmental Harms, and Environmental Law*, 27 ECOLOGY L.Q. 263, 287–91 (2000) (examining the failure of legal measures to address agricultural runoff).

18. As Robert Bruegmann concludes in his survey of sprawl's history and the efforts to arrest it, "a great many people have concluded . . . that sprawl is inevitable and that efforts to stop it are doomed." BRUEGMANN, *supra* note 3, at 220. For legal discussions of sprawl's intractability, see William W. Buzbee, *Urban Sprawl, Federalism, and the Problem of Institutional Complexity*, 68 FORDHAM L. REV. 57, 64 (1999); Henry R. Richmond, *Sprawl and Its Enemies: Why the Enemies Are Losing*, 34 CONN. L. REV. 539 (2001). For the argument against the so-called "inevitability theory" of sprawl, see Michael Lewyn, *Sprawl in Europe and America* (Aug. 1, 2008), *available at* http://ssrn.com/abstract=1194862. 17.1, p 147 and 17.2, 150.

19. *See* Lesley Wexler, *The Non-Legal Role of International Human Rights Law in Addressing Immigration*, 2007 U. CHI. LEGAL F. 359 (2007) (examining the causes and human rights implications of the "recent migration explosion").

20. One analysis concluded that "it is hard to overstate the extent of this reversal in fortunes," *Securitisation—When it Goes Wrong*, ECONOMIST, Sept 20, 2007, at 1, and another suggested that "the regulators are trying to figure out how to work around it, but the Hill is going to be in for one big surprise." Gretchen Morgenson, *Crisis Looms in Market for Mortgages*, N.Y. TIMES, Mar. 11, 2007, at 1 (quoting Josh Rosner). In a candid evaluation of how the problem reached dimensions that outstripped the capacity of regulatory agencies, a former chairman of the Securities and Exchange Commission observed that "as the markets grew larger and more complex—in scope and in products offered—the commission failed to keep pace." Julie Hirschfield Davis, *Former SEC Chief Says Agency Dropped Ball*, USA TODAY, Oct. 17, 2008, at 5B (quoting Arthur Levitt). Among the gathering swirl of theories from pundits, the popular press, and academics, a careful account of the anatomy of the rise and fall of the American subprime mortgage market and its fallout around the globe comes from a Korean financial analyst, Man Cho, who meticulously surveys the complex set of "key economic and institutional factors that boosted the rise of the market, and those that contributed to the abrupt fall in 2007." Man Cho, *Subprime Mortgage Market: Rise, Fall, and Lessons for Korea* 3 (KDI Sch. of Pub. Policy &

dimensions far beyond the capacity of any single agency to manage effectively.

In this Article we examine from both theoretical and practical perspectives what it means for agencies to whittle away at massive problems such as these. Conventional policy approaches, proposed both in administrative law scholarship and in practice, to guide the design of regulatory institutions and instruments have proven deeply inadequate when confronted by the complexities of massive problems such as climate change, sprawl, and Gulf hypoxia. A fundamentally different approach is needed, but it must be based on a far clearer understanding of the nature and challenges of massive problems.

Part I of the Article explores what makes problems massive. The Court's observation that agencies have to whittle away at some problems is no doubt accurate, but it raises three fundamental questions: *which* agencies should be whittling, *how* should they proceed, and *what* exactly are they whittling. A great deal of scholarship has focused on the first two questions,[21] yet little touches on the last. By contrast, we focus on the *what* question as the threshold inquiry. In particular, we show that while all massive policy problems exhibit large-number and large-scale attributes, what makes some particularly difficult to address is the presence of cumulative effects—the complex accumulation of economic, environmental, and social impacts from multiple sources. Policy problems defined by large-scale cumulative effects may all appear massive from a distance. Upon closer inspection, however, it becomes clear that different combinations of causal sources, causal mechanisms, and cumulative effects lead to quite different types of massive problems, exhibiting different behavioral properties. As policy problems become even more massive due to cumulative effects, the effectiveness of policy responses can change dramatically.

In Part II, therefore, we develop a framework to identify different types of massive problems and their corresponding policy implications. Some massive problems, such as wetlands loss, are relatively simple in structure; the clear identification of sources and the proportionality of causal mechanisms lead to readily manageable effects. Whittling away at these problems is easy. Some massive problems, however, exhibit complicating factors such as highly diverse and divergent sources, feedback loops between sources and effects, nonlinear causal mechanisms, and temporal and spatial discontinuities between sources and effects. As these factors become more dominant, simple solutions become elusive. Whittling away gets harder.

When we probe the mechanisms of problems such as sprawl, we find components operating at different spatial and temporal scales, with causal feedback loops across and between scales. It is unlikely that any single level of

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Mgmt. Paper No. 08-08, 2008), *available at* http://ssrn.com/abstract=1132976. For a probing examination of the complexity of the causes and the proposed solutions, see John A. Tatom, *The U.S. Foreclosure Crisis: A Two-Pronged Assault on the U.S. Economy* (Networks Fin. Inst., Working Paper No. 2008-WP-10, 2008), *available at* http://ssrn.com/abstract=1194975.

21. For discussion of the scholarship on these questions, see *infra* Part I.A.

government is better positioned than any other to address that kind of problem. Using sprawl and other examples from environmental and land use policy, we create in Part II a typology of massive problems based on the different properties that cumulative effects can exhibit. This framework makes clear why problems that appear equally massive can differ dramatically in their core attributes, which explains why some prove relatively easy to manage and others mind-bogglingly intractable. The nature of the problem, in other words, has much to say about an agency's choice of whittling strategies.

Part III surveys how the law has addressed massive problems and their cumulative effects mechanisms. With few exceptions, regulation has been unimaginative, regarding all effects as homogeneous, linear, proportionally aggregated, and thus easily whittled away at. Heavy reliance on cost-benefit analysis, risk assessment, and predecision assessment—the mainstays of agency analysis—has not proven useful in the face of certain types of massive problems. By ignoring the particular cumulative causes of problems, therefore, agencies may be whittling away, but with a blindfold on.

If conventional approaches to massive problems have been inadequate, what should agencies do instead? In Part IV we consider strategies for whittling away at massive problems. We demonstrate that conventional prescriptions to match agency scale with problem scale and to choose instruments through cost-benefit analysis offer little hope in the face of complex massive problems. An agency acting solo with these tools will be no match for problems of massive dimension. Instead, building on recent political science scholarship in the areas of Dynamic Federalism,[22] New Governance,[23] and Transgovernmental Networks, [24] we argue that agencies whittling away at massive problems must be empowered to pool resources with other similarly charged agencies in loosely linked "weak ties" networks that connect both institutions and people within the institutions.

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22. Scholars of Dynamic Federalism theory 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," replacing it with one "in which multiple levels of government interact in the regulatory process." Kirsten H. Engel, *Harnessing the Benefits of Dynamic Federalism in Environmental Law*, 56 EMORY L.J. 159, 161 (2006). More detail on Dynamic Federalism theory is presented *infra* Part IV.B.

23. New Governance theory 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. 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). More detail on New Governance theory is presented *infra* Part IV.B.

24. 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). More detail on Transgovernmental Network theory is presented *infra* Part IV.B.

This can all sound rather abstract, so in Part V we get practical, presenting a case study of the multiagency response to Gulf hypoxia. Legislatures granted considerable policy discretion to the agencies participating in the effort, creating space in which to design coordinated multiscale, multiagency policy responses. In the absence of a legislatively issued master plan, each agency adapted its particular response to facilitate the coordinated effort while retaining full autonomy and accountability. The agencies working on solutions to Gulf hypoxia demonstrate the type of networked strategy that our model suggests is needed for agencies to best whittle away at massive problems. By contrast, case studies from water management efforts in California and the Chesapeake Bay reveal the pitfalls of coordinating through formally institutionalized conglomerates of agency resources. Between solo agency efforts and highly institutionalized multiagency coordination efforts lies the sweet spot of personalized "weak ties" interagency networks that we believe is best equipped to whittle away at massive problems. We conclude by setting out the measures needed in administrative law to develop and endorse this new form of multiagency coordination.

I
FRAMING THE MASSIVE PROBLEMS DILEMMA

It is not hard to find massive policy problems, nor is it hard to find public calls to solve them. In this respect, massive problems are as much a political challenge for legislatures as an administrative challenge for agencies. Legislatures, however, have the luxury of issuing broad mandates to agencies with equally broad delegations of discretion in implementing them.[25] Appearing to do something, *anything*, but then passing on the tough choices to the agency is an all-too-common practice in the face of policy problems of massive dimensions.[26] In this style of delegation, legislatures specify sets of institutions and perhaps instruments, but largely leave to agencies the responsibilities of developing the methodologies, such as model-building, and

25. Broad legislative delegation of authority to administrative agencies is a long-practiced component of governance in the modern regulatory state which we take as a given, leaving the normative question of whether the practice is consistent with constitutional separation of powers and theories of legislative responsibility outside the scope of this Article. For examples of the vast body of commentary on the ubiquity and inevitability of legislative delegations, see Steven P. Croley, *Theories of Regulation: Incorporating the Administrative Process*, 98 COLUM. L. REV. 1 (1998); David B. Spence & Frank Cross, *A Public Choice Case for the Administrative State*, 89 GEO. L.J. 97 (2000). For examples of contrasting views of the propriety of legislative delegations, compare David Schoenbrod, *Delegation and Democracy: A Reply to My Critics*, 20 CARDOZO L. REV. 731 (1999) (arguing against delegation), with Jerry Mashaw, *Prodelegation: Why Administrators Should Make Political Decisions*, 1 J.L. ECON. & ORG. 81 (1985) (arguing in favor of delegation).

26. *See, e.g.*, Robert L. Glicksman, *Balancing Mandate and Discretion in the Institutional Design of Federal Climate Change Policy*, 102 NW. U. L. REV. COLLOQUY 196, 197 (2008) ("Congress should vest more discretion in agencies to decide how to address climate change than it does on the question of whether to do so.").

determining the final details of implementation and adaptation.[27] Surely legislatures can do better than simply giving agencies the authority to whittle away and then hope for the best. Responding effectively to massive problems requires an understanding of which agencies to enlist, the policies they should adopt, and what specific aspects of the problems they should address—the threshold questions of who should whittle away, how they should whittle away, and what they should whittle away at.

A. The Threshold Questions of Whittling Away: Who, How, and What?

The question of *who* should whittle away falls under the broad umbrella of federalism, and has motivated heated debate over the proper allocation of federal and state authority, whether through centralization of authority in the federal government, devolution of authority to state and local governments, dualism's separation of federal and state authority, or the middle ground of so-called "cooperative federalism."[28] A central premise of these and similar analyses is that there is an appropriate level of government to take charge of the problem, the key question being which level is best for a particular set of circumstances. As Professors William Brock and Stephen Carpenter observe, however, such thinking can lead to misguided policy "panaceas" that form "when people think they have arrived at the truth regarding how the world would work under different institutional designs and the design they propose is optimal."[29]

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27. As Don Elliott describes the fate of agencies "tasked with solving emerging problems without legislative guidance," they must "adapt[] their statutes creatively to emerging problems by seizing on bits and pieces of language or legislative history." E. Donald Elliott, *Portage Strategies for Adapting Environmental Law and Policy During a Logjam Era*, 17 N.Y.U. ENVTL. L.J. 24, 25 (2008).

28. "Centralized federalism suggests that the federal government should address environmental problems on its own. Devolved federalism argues that environmental decisions are best made at the state and local level. Dual federalism posits that each level of government should have distinct and separate approaches to environmental regulation." 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, 405 (2008). "[C]ooperative federalism is a system of shared authority between federal and state governments" in which "state programs adopt environmental standards at least as stringent as the federal program. . . . [and] the federal government retains oversight authority." David E. Adelman & Kirsten H. Engel, *Adaptive Federalism: The Case Against Reallocating Environmental Regulatory Authority*, 92 MINN. L. REV. 1796, 1811–12 (2008). Scholarly and judicial discussion of these different strands of federalism theory is legion. For a thoughtful survey of "the ongoing tension between the oft-voiced judicial and scholarly preference for distinctly delineated federal and state roles and the reality of overlapping federal and state roles that one finds [in] federalism's central debates," see William W. Buzbee, *Asymmetrical Regulation: Risk, Preemption, and the Floor/Ceiling Distinction*, 82 N.Y.U. L. REV. 1547, 1551 (2007).

29. William A. Brock & Stephen R. Carpenter, *Panaceas and Diversification of Environmental Policy*, 104 PROC. NAT'L ACAD. OF SCI. 15206, 15206 (2007). For more on policy panaceas, see Elinor Ostrom, *A Diagnostic Approach for Going Beyond Panaceas*, 104 PROC. NAT'L ACAD. OF SCI. 15181 (2007).

For example, the well-known "matching principle" claims that "regulatory authority should go to the political jurisdiction that comes closest to matching the geographic area affected by a particular externality,"[30] a maxim that has gained considerable attention in administrative law scholarship.[31] This precise "problem-shed" approach would presumably subject climate change, for example, to national and global governance, yet imposing such a level of governance remains a hotly contested topic with vigorous arguments made for matching climate change to regional, state, and local government scales as well.[32] Moreover, even if a particular level of government could be identified as the optimal locus of regulatory authority, horizontal allocation of responsibilities would have to be made between federal agencies (if at the federal level), between states (if at the state level), and between state and local agencies (also if at the state level). Horizontal coordination between governments and

30. Henry N. Butler & Jonathan R. Macey, *Externalities and the Matching Principle: The Case for Reallocating Environmental Regulatory Authority*, 14 YALE L. & POL'Y REV. 23, 53 (1996).

31. *See, e.g.*, Buzbee, *supra* note 18, at 106–07 nn.202, 205; Daniel C. Esty, *Good Governance at the Supranational Scale: Globalizing Administrative Law*, 115 YALE L.J. 1490, 1493 (2006); Matthew D. Fortney, *Devolving Control Over Mildly Contaminated Property: The Local Cleanup Program*, 100 NW. U. L. REV. 1863, 1897–98 (2006).

32. *Compare* Jonathan B. Wiener, *Think Globally, Act Globally: The Limits of Local Climate Policies*, 155 U. PA. L. REV. 1961, 1962 (2007) ("subnational state-level action is not the best way to combat global climate change"), *with* Kirsten H. Engel, *Mitigating Global Climate Change in the United States: A Regional Approach*, 14 N.Y.U. ENVTL. L.J. 54 (2005) (outlining means of implementing a "regional interstate cooperative approach"), *with* Hari M. Osofsky & Janet Koven Levit, *The Scale of Networks?: Local Climate Change Coalitions*, 8 CHI. J. INT'L L. 409 (2008) (arguing the advantages of a local jurisdiction "bottom-up networking" approach). Some are of two minds, hoping for more federal regulation but recognizing the importance of local, state, and regional regulation as, at the very least, catalysts for eventual federal regulation, if not effective in their own right. *See* Randall S. Abate, *Kyoto or Not, Here We Come: The Promise and Perils of the Piecemeal Approach to Climate Change Regulation in the United States*, 15 CORNELL J.L. & PUB. POL'Y, 369, 401 (2006) (concluding that "[s]tate, regional, and local climate change initiatives may be subject to criticism, but in light of the current federal regime, such criticism may be unduly harsh."); Stephen C. Jones & Paul R. McIntyre, *Filling the Vacuum: State and Regional Climate Change Initiatives*, 30 ENV'T REP. (BNA) 1640 (2007) (comparing the paucity of federal initiatives to date with the proliferation of state and regional measures). Others reject the state catalyst theory, arguing it will lead ultimately to a less effective federal response. *See* Cary Coglianese & Jocelyn D'Ambrosio, *Policymaking under Pressure: The Perils of Incremental Responses to Climate Change*, 40 CONN. L. REV. 1411 (2008); Benjamin K. Sovacool & Christopher Cooper, *The Hidden Cost of State Renewable Portfolio Standards (RPS)*, 15 BUFF. ENVTL. L.J. 1 (2008). And yet others argue against federal preemption of state and local initiatives and in favor of a "cooperative federalism" approach under which federal legislation sets a preemptive "floor" of greenhouse gas emission standards above which states are free to regulate. *See* WILLIAM ANDREEN ET AL., CENTER FOR PROGRESSIVE REFORM, COOPERATIVE FEDERALISM AND CLIMATE CHANGE: WHY FEDERAL, STATE, AND LOCAL GOVERNMENTS MUST CONTINUE TO PARTNER (2008), *available at* www.progressivereform.org; Robert L. Glicksman & Richard E. Levy, *A Collective Action Perspective on Ceiling Preemption by Federal Environmental Regulation: The Case of Global Climate Change*, 102 NW. U. L. REV. 579 (2008); Thomas D. Peterson et al., *Developing a Comprehensive Approach to Climate Change Policy in the United States that Fully Integrates Levels of Government and Economic Sectors*, 26 VA. ENVTL. L.J. 227 (2008).

agencies at any scale presents difficult questions of institutional choice and cross-jurisdiction coordination.[33] As problems become larger in scope and complexity, crossing scales of governance and exceeding the capacity of any particular agency at any particular scale, no obvious solution to the "which agency" question presents itself. Indeed, massive problems may require an altogether different and far more flexible way of thinking about federalism in both its vertical and horizontal directions. In the terminology of Professor Hari Osofsky, problems operating on massive scales may even require a "diagonal" form of federalism.[34]

The second question—*how* agencies should whittle away at massive problems—skirted by the *Massachusetts v. EPA* Court, presents a dilemma. At one extreme, an agency could choose to act solely on its own, whittling away hard and fast through maximum exercise of its regulatory power and without any regard for other agencies. While such an agency would retain full autonomy, it would also retain full accountability. The EPA, for example, might use its Clean Air Act authority to clamp down hard on vehicles' greenhouse gas emissions. The EPA's actions undoubtedly would affect other agencies' policy measures and cause significant economic costs, yet not make a noticeable dent in global greenhouse gas emissions. Whittling away hard and fast in this way will likely not get an agency much credit for solving the problem, but instead the agency would likely receive plenty of heat for the policy and economic consequences. Why would any agency want to make so many enemies for so little practical gain?

Alternatively, an agency could seek partners—other agencies with regulatory jurisdiction over some aspect of the problem—in the hope that collaboration would lead to greater results while spreading accountability for the political and economic consequences.[35] Finely tuned, efficiently administered, strongly coordinated agency action is a worthy aspiration, but unfortunately this idealized collaborative model is not easily attained in

33. For background on horizontal federalism, or "federalism without Washington," and the cross-jurisdiction coordination challenges it presents, see Ann O'M. Bowman, *Horizontal Federalism: Exploring Interstate Interactions*, 14 J. PUB. ADMIN. RES. & THEORY 535 (2004); Allan Erbsen, *Horizontal Federalism*, 93 MINN. L. REV. 493 (2008); Noah D. Hall, *Toward a New Horizontal Federalism: Interstate Water Management in the Great Lakes Region*, 77 U. COLO. L. REV. 405 (2006).

34. *See* Hari M. Osofsky, *Is Climate Change "International": Litigation's "Diagonal" Regulatory Role*, 49 VA. J. INT'L L. 585 (2009) (suggesting greater emphasis on connections between governance institutions at different scales).

35. We use case studies of multiagency water management efforts in California (known as CalFed) and the Chesapeake Bay to demonstrate this effect in Part V, *infra*. Our focus is on collaboration primarily between numerous public agencies rather than between public agencies and private stakeholders. For one of the seminal discussions of public-private collaboration as a regulatory strategy, see Jody Freeman, *Collaborative Governance in the Administrative State*, 45 UCLA L. REV. 1 (1997). *See also* Eric W. Orts & Cary Coglianese, *Debate: Collaborative Environmental Law: Pro and Con*, 156 U. PA. L. REV. PENNUMBRA 289 (2007) (a point-counterpoint debate over public-private collaborative regulation).

practice.[36] The transaction costs of strong coordination, the differing internal incentives of each agency, the loss of autonomy, and other collective action challenges often overwhelm ambitions toward coordination. The collaboration may devolve into the tragedy of the regulatory commons—each agency, counting on others to do their part, free rides, thus leading to an ineffective combined effort.[37]

Much administrative law and political science scholarship has focused on techniques of solo and collaborative policy administration.[38] Some scholars address the solo method through economic models of optimal regulation using cost-benefit analysis;[39] some attempt to refine the collaborative method through policy models of multiagency management;[40] and some propose entirely new models.[41] While we believe there is much value in proposals that seek to increase agencies' effectiveness through efficiency and cooperation, scholars have given little attention to the challenges an agency faces when dealing with a problem with dimensions that far outstrip the agency's regulatory capacity.[42] As we demonstrate in Part IV, the crisp theories of cost-benefit analysis and collaborative regulation that abound in administrative law scholarship have no straightforward applications here.

Who should whittle away and how best to whittle away at massive problems are, of course, critically important questions. However, the third fundamental question suggested by *Massachusetts v. EPA* remains both

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36. A recent example is the collapse of the CalFed multiagency collaborative process for water resources planning in the Bay-Delta area of California. *See* Dave Owen, *Law, Environmental Dynamism, Reliability: The Rise and Fall of CALFED*, 37 ENVTL. L. 1145 (2007).

37. *See* William W. Buzbee, *Recognizing the Regulatory Commons*, 89 IOWA L. REV. 1 (2003).

38. *See* Jody Freeman & Daniel A. Farber, *Modular Environmental Regulation*, 54 DUKE L.J. 795 (2005) (reviewing different proposed approaches).

39. *See, e.g.*, CASS R. SUNSTEIN, THE COST-BENEFIT STATE: THE FUTURE OF REGULATORY PROTECTION (2002). For a comprehensive critique of cost-benefit analysis, see Sidney A. Shapiro & Christopher H. Schroeder, *Beyond Cost-Benefit Analysis: A Pragmatic Reorientation*, 32 HARV. ENVTL. L. REV. 433 (2008).

40. *See, e.g.*, Freeman & Farber, *supra* note 38.

41. *See, e.g.*, Robert Baldwin & Julia Black, *Really Responsive Regulation*, 71 MOD. L. REV. 59 (2008) (suggesting regulatory strategies that incorporate factors such as cognitive frameworks of regulated firms).

42. Professor Bill Buzbee's theory of the regulatory commons, with its attention to scale of sources and effects for complex regulatory problems, is a notable exception. *See* Buzbee, *supra* note 28, at 604–06. Climate change has, in particular, motivated increased attention to scalar properties of problems as a driver of regulatory design. *See* Robin Kundis Craig, *Climate Change, Regulatory Fragmentation, and Water Triage*, 79 U. COLO. L. REV. 825, 898–903 (2008) (using Buzbee's model to examine climate change, among other factors, as a driver of multiscalar regulatory fragmentation in coastal and marine ecosystem contexts); Hari M. Osofsky, *The Geography of Climate Change Litigation: Implications for Transnational Regulatory Governance*, 83 WASH. U. L.Q. 1789, 1791–95 (2005) (using Buzbee's model to identify an array of scalar mismatches confounding efforts to regulate climate change causes). Our purpose is to advance this line of thinking to a more formal model of how the spatial and temporal scales of cumulative effects problems operate to confound regulatory strategy, and how best to respond.

unanswered and largely overlooked by administrative law scholars—*what* exactly should the agencies be whittling? These scholars are not alone in avoiding a deeper analysis of the nature of massive policy problems. Neither did the Supreme Court articulate the characteristics that comprise massive problems, presumably assuming that one is much like another. Likewise, political scientists have long grappled with so-called "wicked" problems, their defining characteristic being that the solution of one aspect of the problem reveals another, but have seldom deeply explored what makes a problem "wicked."[43] Administrative law scholarship has only described massive legal problems as "wicked" in passing.[44] Even Professor Charles Lindblom's "incrementalism" theory from the late 1950s—the most influential critique of "one-fell-swoop" approaches in which an agency attempts to wrestle a "complex problem" under control with comprehensive policy measures—did not explore what makes a policy problem complex.[45] That massive problems exist and that the law must deal with them is taken as a given;[46] nevertheless, administrative law has given little attention, in either scholarship or application, to what exactly makes a problem "massive" (or "wicked" or "complex") and, as a consequence, so difficult to manage that agencies are resigned to whittling away.

Perhaps a deeper understanding of the nature of massive problems is unnecessary for purposes of effective policy design. Climate change and many other policy problems appear massive from a distance, but so what? That they cover large geographic areas and have large impacts may simply make them bigger versions of smaller problems. If massive problems are no more complex

43. There is no fixed model of a "wicked" problem and no final outcome to solving the problem short of running out of time or resources. *See* Donald Ludwig, *The Era of Management Is Over*, 4 ECOSYSTEMS 758 (2001). The classic discussion is found in Horst W.J. Rittel & Melvin M. Webber, *Dilemmas in a General Theory of Planning*, 4 POL'Y SCI. 155, 160–67 (1973).

44. *See, e.g.*, Richard J. Lazarus, *Super Wicked Problems and Climate Change: Restraining the Present to Liberate the Future*, 94 CORNELL L. REV. 1153 (2009) (discussing climate change as a wicked problem for environmental lawmaking).

45. *See* Charles E. Lindblom, *The Science of "Muddling Through,"* 19 PUB. ADMIN. REV. 79 (1959) [hereinafter *Muddling Through*]; Charles E. Lindblom, *Still Muddling, Not Yet Through*, 39 PUB. ADMIN. L. REV. 517 (1979). Lindblom critiqued what he called the "rational comprehensive method" of public administration, offering in its place a model of incremental policy making focused on "continually building out from the current situation, step-by-step and by small degrees." Lindblom, *Muddling Through*, *supra*, at 81. During its first twenty years, *Muddling Through* had "been cited, re-cited, ex-cited, mal-cited, and well-cited," to the point that public administration academics and professionals considered the article's impact on public policy and administration to be "enormous." Editorial, *Here Comes Tomorrow*, 39 PUB. ADMIN. REV. 509, 509 (1979) (journal editorial introducing a symposium issue on the paper). Yet Lindblom referred to "complex problems" repeatedly—over thirty times in his two primary articles—without ever defining what makes a problem complex.

46. *See, e.g.*, A. Dan Tarlock, *Is There A There There in Environmental Law?*, 19 J. LAND USE & ENVTL. L. 213, 253–54 (2004) ("environmental law will for the foreseeable future be a messy process of adapting the contingencies and limitations of science to 'wicked' problems informed by rebuttable principles.").

than large-scale versions of small-scale problems—larger in geographic reach and economic scope but no different in causal properties—then policy models that work well at small scales can be confidently "upscaled" without loss of reliability in guiding policy design. To be sure, sheer scale does matter in terms of institutional design and instrument choice, but there is more to massive problems, we believe, than being "really big." Once one takes a closer look at the range of massive problems it becomes apparent that the causal mechanisms for the aggregation of impacts differ substantially, and thus their responsiveness to different regulatory approaches may differ substantially as well. For many problems, with increases in scale come increases in complexity of behavior. In those cases, policy models proven useful at smaller scales may be less effective, useless, or even counterproductive. The *nature* of the problem, in other words, has much to say about which agencies and methods to employ for whittling away. In Part I.B, therefore, we begin a close examination of the nature of massive problems.

B. The Attributes of Massive Problems

Consider the very names given to massive problems such as "sprawl" or "climate change." They capture the holistic sense of a *cumulative effect* arising from a multitude of actions and actors, but offer no insight into how the effect arose. What an agency really wants to know about sprawl, climate change, and other massive problems is not only who and what are causing them, but which policy responses will prove most effective in mitigating them. Any model of a cumulative effects problem, therefore, must consider its causal sources, causal mechanisms, and cumulative effects, for it is these attributes that determine policy effectiveness.

1. Causal Sources

Massive problems usually have multiple, if not a multitude of, causal sources. How responsive the sources are to policy instruments depends on a range of factors, including the sources' number, diversity, distribution, size, and incentives. Formulating solutions to any massive problem depends in part on an analysis of these source attributes. In the case of acid rain deposition, for example, natural and anthropogenic emissions of sulfur dioxide ("SO_2") and nitrogen oxides ("NO_x") react in the atmosphere with water, oxygen, and other chemicals to form various acidic compounds.[47] Prevailing winds blow these

47. According to the U.S. Environmental Protection Agency,
"acid rain" is a broad term referring to a mixture of wet and dry deposition (deposited material) from the atmosphere containing higher than normal amounts of nitric and sulfuric acids. The precursors, or chemical forerunners, of acid rain formation result from both natural sources, such as volcanoes and decaying vegetation, and man-made sources, primarily emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_x) resulting from fossil fuel combustion. In the United States, roughly 2/3 of all SO_2 and 1/4 of all NO_x come from electric power generation that relies on burning fossil fuels,

compounds across state and national borders, sometimes for hundreds of miles. In the United States, this effect has been concentrated primarily in the northeastern states, where it led to acidification of lakes and decay of building materials.[48] Almost 70 percent of nationwide SO_2 emissions comes from the generation of electric power.[49] Most of these power plants are located in the eastern half of the nation, and while there are thousands of them, a few hundred plants account for a disproportionate share of emissions.[50] In short, a significant portion of SO_2 emissions can be attributed to a small number of large, similar, clustered, and easily identified sources.

One could reasonably expect in such circumstances that the sources, being of similar size and in the same industry, would share an aligned incentive structure in terms of responsiveness to external regulation, economic conditions, and technological change.[51] Altering source behavior thus becomes a relatively straightforward policy undertaking. Indeed, one of the major success stories of environmental regulation is the market-based "cap-and-trade" emissions trading program introduced in the 1990 amendments to the Clean Air Act; this program is credited with vastly reducing SO_2 emissions from the identified sources primarily because it played effectively into the pollution sources' shared incentive structures.[52]

By contrast, what is the source of sprawl? There are many sources, each different in character, each contributing in a small way to the aggregate effect. The placement of homes, roads, businesses, schools, sewer infrastructure, water mains, and the like are both sources and manifestations of sprawl. The actors contributing to sprawl—developers, financial institutions, planners, politicians, transportation agencies, neighborhood groups, and a myriad of others—likely have different, even inconsistent, incentive structures. A particular policy measure may move interests in different directions, perhaps with offsetting effects and unintended results.[53] For example, when Florida first imposed

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> like coal. Acid rain occurs when these gases react in the atmosphere with water, oxygen, and other chemicals to form variousacidic compounds. The result is a mild solution of sulfuric acid and nitric acid. When sulfur dioxide and nitrogen oxides are released from power plants and other sources, prevailing winds blow these compounds across state and national borders, sometimes over hundreds of miles.

U.S. Environmental Protection Agency, *What Is Acid Rain?*, http://www.epa.gov/acidrain/what/index.html (last visited Apr. 23, 2008).

48. U.S. ENVIRONMENTAL PROTECTION AGENCY, ACID RAIN PROGRAM: 2004 PROGRESS REPORT 3 (2005).

49. *Id.* at 4.

50. *See id.* at 6–7.

51. *See* Jennifer Yelin-Kefer, *Warming Up to an International Greenhouse Gas Market: Lessons from the U.S. Acid Rain Experience*, 20 STAN. ENVTL. L.J. 221, 243 (2001) (discussing the strong preexisting relationships and common interests of the domestic utilities subject to the Acid Rain Program).

52. *See* Joseph Goffman, *Title IV of the Clean Air Act: Lessons for Success of the Acid Rain Emissions Trading Program*, 14 PENN ST. ENVTL. L. REV. 177 (2006). For an overview of the program's structure and operation, see Yelin-Kefer, *supra* note 51, at 234–41.

53. As Bruegmann observes, "When it comes to setting public policy about anything as

transportation concurrency measures requiring localities to limit development to areas where transportation infrastructure was adequate, developers responded by moving into rural areas where road capacity was more than adequate.[54] The sprawl-reducing intent of the policy measure actually contributed to more sprawl—an isolated but telling lesson that the source of sprawl is a complex mix of factors. Attempts to pin it down have been, in the words of one acid commentator, "remarkably varied and contradictory."[55]

We could describe similar stories for climate change, Gulf hypoxia, and other cumulative effects problems. As a general matter, the potential for policy effectiveness will increase when (1) there are fewer causal sources, (2) the sources are not very diverse, (3) the distribution of the sources is clustered, (4) the size of each source is large relative to the scope of the problem, and (5) the sources' incentive structures are uniform and aligned. These attributes are set out in Table 1 below, and map well onto both urban sprawl and acid rain.

Table 1: The Impact of Causal Source Attributes on Policy Effectiveness

Source Attribute	Higher Policy Effectiveness (e.g., acid rain)	Lower Policy Effectiveness (e.g., urban sprawl)
Number	Low	High
Diversity	Low	High
Distribution	Clustered	Dispersed
Size Relative to Effects	Large on average	Small on average
Incentive Structure	Uniform and aligned	Mixed and inconsistent

2. Causal Mechanisms

Even in the best of worlds when all source attributes line up for achieving effective policy measures, solving massive problems will not necessarily be easy. One must also consider the causal mechanisms that link sources with effects. If the causal mechanisms are large in scale or have significant time lags, or if the causal chain is complex, then designing effective policy measures may be difficult regardless of how simple it is to identify the sources.

Again, acid rain provides a nice example. As discussed above, SO_2 emissions from power plants clustered in one region of the country increased acidic compound concentration in the atmosphere, which prevailing winds

complex as sprawl . . . the 'solution' to any given problem depends on the vantage point of the person doing the proposing." BRUEGMANN, *supra* note 3, at 222.

54. Thomas G. Pelham, *A Historical Perspective for Evaluating Florida's Evolving Growth Management Process*, *in* GROWTH MANAGEMENT IN FLORIDA: PLANNING FOR PARADISE 7, 17 (Timothy S. Chapin et al., eds., Ashgate 2008). A similar "leapfrog" effect was induced by growth boundaries the city of Seattle imposed. *See* Nancy B. Grimm, *Global Change and the Ecology of Cities*, 319 SCI. 756 (2008).

55. BRUEGMANN, *supra* note 3, at 96.

carried to another part of the country. The causal area of the "problem-shed" was regionally well defined, the chemical and atmospheric conditions played out as fast as the chemical reactions and winds would allow, the relationship between SO_2 emissions and acidified conditions eventually was well-understood, and technology was readily available to reduce emissions. All of these factors reinforced the effectiveness of making a policy design based on market mechanisms.[56]

Climate change presents a far more complicated causal scenario.[57] To be sure, the fundamental causal mechanism of the "greenhouse effect" is well understood: carbon dioxide and other tropospheric aerosols allow solar energy to reach the surface but trap heat energy radiating back from the surface, leading surface temperatures to rise.[58] The causal scenario, however, extends from global to local, vastly increasing the number of governance units affected as well as the number needed to formulate effective responses. The timing of the causal mechanism, moreover, is protracted. The rising temperatures of today are the lagged result of net increases in emissions from decades ago, and the even higher amounts of emissions today will likely lead to higher temperatures well in the future.[59] For centuries after net anthropogenic emissions turn the corner toward reductions, if they ever do, this "committed warming" means surface temperatures will continue rising, making it difficult to link present, and potentially costly, regulatory measures with success.[60]

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56. *See* Yelin-Kefer, *supra* note 51, at 235–39. It is generally regarded that "[t]he SO_2 allowance trading program has performed successfully" in that "[t]argeted emissions reductions have been achieved and exceeded, and total abatement costs have been significantly less than what they would have been in the absence of trading provisions." Robert N. Stavins, *Lessons Learned from SO_2 Allowance Trading*, 20 CHOICES 53, 53 (2005).

57. For a thorough comparison of the two problems, see Yelin-Kefer, *supra* note 51, *passim*.

58. This causal chain as well as other primary and secondary drivers, both natural and anthropogenic, are covered in INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, SUMMARY FOR POLICYMAKERS, CLIMATE CHANGE 2007: THE PHYSICAL SCIENCE BASIS, CONTRIBUTION OF WORKING GROUP I TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE 10–17 (2007) [hereinafter IPCC SUMMARY], *available at* http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf.

59. *See* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, SUMMARY FOR POLICYMAKERS, CLIMATE CHANGE 2007: IMPACTS, ADAPTATION AND VULNERABILITY, CONTRIBUTION OF WORKING GROUP II TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE 19 (2007), *available at* http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-spm.pdf ("Past emissions are estimated to involve some unavoidable warming . . . even if atmospheric greenhouse gas concentrations remain at 2000 levels"); V. Ramanathan & Y. Feng, *On Avoiding Dangerous Anthropogenic Interference with the Climate System: Formidable Challenges Ahead*, 105 PROC. OF THE NAT'L ACAD. OF SCI. 14245 (2008) (estimating committed warming of 2.4°C even if greenhouse gas concentrations are held to 2005 levels); Susan Solomon et al., *Irreversible Climate Change Due to Carbon Dioxide Emissions*, 106 PROC. OF THE NAT'L ACAD. OF SCI. 1704 (2009) (estimating a thousand-year committed warming effect).

60. For an in-depth examination of this lag effect and the resistance it is likely to generate against costly policy measures that may take decades to produce results, see Eric Biber, *The Sting*

Furthermore, there are numerous sources and sinks of greenhouse gas emissions, with properties that vary in response to environmental conditions.[61] The causal chains in these sinks and sources are complex, nonlinear, intertwined, and attenuated, making it difficult to tell a simple A leads to B story of the causal mechanisms.[62]

As a general matter, then, policy effectiveness will improve when (1) the scale of causal mechanisms is more spatially confined, (2) the timing of the causal mechanisms is more temporally confined, and (3) the causal chain from source to effect is more proportional and direct. These conditions allow a smaller number of governance units to coordinate the response and test the effectiveness of policy measures under real time conditions.

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of the Long Tail: Climate Change, Backlash and the Problem of Delayed Harm (UC Berkeley Public Law Research Paper No. 1292529, 2008), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1292529.

61. *See* U.S. CLIMATE CHANGE SCI. PROGRAM, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, THE FIRST STATE OF THE CARBON CYCLE REPORT (SOCCR): THE NORTH AMERICAN CARBON BUDGET AND IMPLICATIONS FOR THE GLOBAL CARBON CYCLE 5-9 (2007).

62. *See, e.g.*, U.S. CLIMATE CHANGE SCI. PROGRAM, THRESHOLDS OF CLIMATE CHANGE IN ECOSYSTEMS (2009) (examining numerous positive feedback properties leading to nonlinear thresholds in climate change dynamics); Gordon B. Bonan, *Forests and Climate Change: Forcings, Feedbacks, and the Climate Benefits of Forests*, 320 SCI. 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. OF THE NAT'L ACAD. OF SCI. 28 (2009) (describing the nonlinear "tipping points" in the ice-albedo feedback effect); Jerome Gaillardet & Albert Galy, *Himalaya—Carbon Sink or Source?*, 320 SCI. 1727 (2008) (explaining the uncertainties of the sinks and sources of the carbon geological cycle); Steven W. Running, *Ecosystem Disturbance, Carbon, and Climate*, 321 SCI. 652 (2008) (explaining the uncertainties of ecological sinks and sources such as fires and insect epidemics). Dust, pollutant haze, and other aerosols in the atmosphere, for example, deflect incoming solar radiation and thus have a cooling effect. *See* Richard A. Kerr, *Another Global Warming Icon Comes Under Attack*, 317 SCI. 28, 28 (2007) (explaining that because "[a]erosols cool the planet by reflecting away sunlight and increasing the reflectivity of clouds," climate change models can vary widely depending on assumptions about aerosol levels). As temperatures rise on average, moreover, other positive and negative feedback effects are triggered that could amplify or impede further warming. Melting tundra, for example, releases more greenhouse gases, and researchers have found this effect is far exceeding expected levels because of its feedback properties. *See* Katey M. Walter et al., *Methane Bubbling from Siberian Thaw Lakes as a Positive Feedback to Climate Warming*, 443 NATURE 71, 71 (2006). The effect leads to a positive feedback loop in the following manner: as the greenhouse gases are released, they contribute to warming that melts the tundra faster, which releases more greenhouse gases more rapidly, and so on. *See* Katey M. Walter et al., *Methane Bubbling from Northern Lakes: Present and Future Contributions to the Global Methane Budget*, 365 PHIL. TRANSACTIONS OF THE ROYAL SOC'Y A 1657, 1671 (2007). This effect is believed to have played a significant role in the last deglaciation. *See* Katey M. Walter et al., *Thermokarst Lakes as a Source of Atmospheric CH_4 During the Last Deglaciation*, 318 SCI. 633, 633 (2007). Ecologists believe these and other transformations in the tundra "could be a one-way ticket." John Bohannon, *The Big Thaw Reaches Mongolia's Pristine North*, 319 SCI. 567, 568 (2008).

Table 2: The Impact of Causal Mechanism Attributes on Policy Effectiveness

Causal Attribute	Higher Policy Effectiveness (e.g., acid rain)	Lower Policy Effectiveness (e.g., climate change)
Scale	Local or regional	Multiscalar: local to global
Timing	Immediate	Protracted
Relationship	Proportional and direct	Nonlinear and complex

3. Cumulative Effects

Cumulative effects—the manner in which effects build up over time and space—will also influence the effectiveness of policies directed at massive problems. Some cumulative effects problems, such as Gulf hypoxia, can be shown on a map and measured with relative precision,[63] whereas others, such as sprawl, are difficult to identify and must be measured indirectly with disparate data such as commute times, traffic jams, and bike lane miles.[64] Some cumulative effects, such as the impact of climate change on ecosystems, are subject to nonlinear tipping points that punctuate changes in aggregation and disaggregation rates.[65] This nonlinear pattern makes it harder to link policy measures with changes in cumulative effects within relevant political time frames. And of course the ultimate question is how reversible the effects are, for even the simplest scenario of causal sources and mechanisms does little good if the effects are irreversible. For example, less nutrient runoff from farms in the Midwest will lead directly to less Gulf hypoxia; the effects are easily reversible. By contrast, if the tundra permafrost thaws before we turn the corner on rising surface temperatures, as it appears likely to do, there is no putting it back together the way it once was.[66]

63. *See* Diaz & Rosenberg, *supra* note 4 (analyzing over 400 hypoxia zones globally).

64. Bruegmann discusses "the difficulty of pinning down a common definition or linking it to realities on the ground." BRUEGMANN, *supra* note 3, at 3. Numerous scholarly, interest group, and media efforts have been aimed at defining a "sprawl index," with many different criteria and methodologies being proposed. *See e.g.*, George Galster et al., *Wrestling Sprawl to the Ground: Defining and Measuring an Elusive Concept*, 12 HOUSING POL'Y DEBATE 681 (2001); Russ Lopez & H. Patricia Hynes, *Sprawl in the 1990s: Measurement, Distribution, and Trends*, 38 URB. AFF. REV. 325 (2003); *see also* Haya El Nasser & Paul Overberg, *A Comprehensive Look at Sprawl in America*, USA TODAY, Feb. 22, 2001, at 1A. One interest group, Smart Growth America, issued a sprawl index report, *see* REID EWING ET AL., MEASURING SPRAWL AND ITS IMPACT (2002), and an Internet site at which people can find their metropolitan area's rank. *See* Smart Growth America, *Measuring Sprawl and Its Impact: The Character & Consequences of Metropolitan Expansion*, 2009, *available at* http://www.smartgrowthamerica.org/sprawlindex/Measuring Sprawl.pdf.

65. *See* R.B. Alley et al., *Abrupt Climate Change*, 299 SCI. 2005 (2003); Stephen H. Schneider, *Abrupt Non-linear Climate Change, Irreversibility and Surprise*, 14 GLOBAL ENVTL. CHANGE 245 (2004).

66. *See* Bohannon, *supra* note 62. For other examples of ecological thresholds of

In general, one can expect that policies will be more effective when cumulative effects are (1) easily identified and (2) measured, (3) proportional over time and (4) space, and (5) reversible. These attributes make it easier to model and evaluate different policy responses and to mobilize support for measures that are demonstrably successful across relevant spatial and temporal scales.

Table 3: The Impact of Cumulative Effects Attributes on Policy Effectiveness

Effects Attribute	Higher Policy Effectiveness (e.g., hypoxia)	Lower Policy Effectiveness (e.g., biodiversity loss)
Detection	Easy to identify	Difficult to identify
Metrics	Easy to measure	Difficult to measure
Spatial Distribution	Proportional	Patchy and disproportional
Temporal Distribution	Proportional	Punctuated and nonlinear
Reversibility	High	Low

II
CONSTRUCTING A TYPOLOGY OF MASSIVE PROBLEMS

Part I.B identified the significant attributes of massive problems. This is analytically important for two reasons. First, it shows why not all massive problems are the same. Two problems that appear equally massive in scale may be dramatically different depending on the nature of their causal sources, causal mechanisms, and cumulative effects. As a result, and second, by focusing on the particular attributes of a problem we can now understand why some massive problems are more responsive to policy interventions than others. This model says little, however, about which policies will most effectively address massive problems, returning us to the original question of what agencies should whittle away. For that, we need a different model.

Therefore, in Part II, we focus not on the attributes of massive problems but, rather, on their behavior. We examine how the cumulative effects of different kinds of massive problems manifest in the real world. Using practical examples to illustrate the analysis, we show which problems are most responsive to policy interventions and why. This Part presents a typology, summarized in the table below, which builds up from the simplest to the most complex cumulative effects problem, identifying the relevant policy implications of each.

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irreversibility that climate change is likely to cross, see U.S. CLIMATE CHANGE SCI. PROGRAM, THRESHOLDS OF CHANGE IN ECOSYSTEMS (2009), *available at* http://www.climatescience.gov/Library/sap/sap4-2/public-review-draft.

Table 4: Typology of Massive Problems

Problem Type	Aggregation Properties	Example
Simple Aggregation	Things add up proportionally in all dimensions	Wetlands loss
Spaghetti Bowl	Different sources respond to different and potentially offsetting incentives	Ocean governance
Feedback	Different sources, causal mechanisms, or effects interact with one another	Biofuels
Discontinuity	Large, often nonlinear spatial or temporal gaps between sources and impacts	Gulf hypoxia
Policy Jungle	All these attributes mixed together	Climate change

A. Simple Aggregation Problems

The behavior of some cumulative effects is straightforward, characterized by proportionality and ease of detection and measurement. The loss of wetland resources in the United States, for example, has been a story of very small incremental losses gradually accumulating over time into a staggering loss of resources on landscape scales, first from conversion to agricultural land uses and later from conversion to urban land uses.[67] Wetlands were perceived as worthless swamps and wasted development opportunities for most of our history; as a result few Americans would shed a tear over the loss of an acre of wetlands here and another there.[68] But over time the cumulative ecological effect of these losses became significant.[69] Wetlands provide valuable services to human populations, such as flood modulation, groundwater recharge, nutrient and sediment capture, and storm surge protection.[70] As Hurricane Katrina made all too evident, cumulative wetland loss along the Gulf coast

67. The U.S. Fish and Wildlife Service has estimated that the contiguous forty-eight states lost over half their wetlands land cover from the time of European settlement until the 1990s, going from over 200,000 million acres to just over 100,000 million acres. CLAUDIA COPELAND & JEFFREY A. ZINN, CONGRESSIONAL RESEARCH SERVICE, WETLANDS: AN OVERVIEW OF ISSUES 5 (2006). Conversion to agriculture accounts for over 80 percent of those losses, but in the past several decades loss to urbanization has taken over as the leading cause of wetland resource losses. *Id.* at 14. *See also* U.S. FISH AND WILDLIFE SERVICE, STATUS AND TRENDS OF WETLANDS IN THE COTERMINOUS UNITED STATES 1998-2004 15, 47 (2006) [hereinafter STATUS AND TRENDS].

68. Consider a popular 1957 children's book, *Dear Garbage Man*, which tells the supposedly happy story of how garbage was used: "That night as the city slept, the tugboats chugged and whistled softly as they pulled the barges down the river. The trash and ashes they carried would be used to fill in swampland. Then parks and playgrounds would be built there." GENE ZION, DEAR GARBAGE MAN (1957).

69. For example, even during the period from the mid-1950s to the mid-1970s, national wetland losses exceeded 450,000 acres annually. *See* STATUS AND TRENDS, *supra* note 67, at 15.

70. *See* Brant Keller, *What We Always Knew: Wetlands Win Hands Down at Pollution Mitigation*, 27 NAT'L WETLANDS NEWSL., Sept–Oct 2005, at 12; Sandra Postel & Stephen Carpenter, *Freshwater Ecosystem Services*, *in* NATURE'S SERVICES: SOCIETAL DEPENDENCE ON NATURAL ECOSYSTEMS 195 (Gretchen C. Daily ed., Island Press 1997).

degraded these services and led to loss of life and property.[71] The ecological and economic effects of wetland resources depletion, while perhaps imperceptible at first, have become distressingly obvious in many parts of the nation.

Although the ecology of wetlands is complex, the underlying policy problem is not, and it is not necessary to understand everything about wetlands to slow or even halt their loss. We can identify and map wetlands relatively easily, and thus record their losses and gains over time.[72] We can also detect, measure, and monitor the behaviors leading to their loss—conversion to agriculture and urban land uses.[73] Restoration of stressed wetlands can reverse many of the damages suffered, and is an increasingly feasible technique.[74]

Regulatory responses need not be complex either. Regulation has restricted development of wetlands and mandated compensation for conversion of wetland resources with the goal of "no net loss" of wetlands.[75] Section 404 of the Clean Water Act ("Section 404") provides the regulatory intervention at the national level for the lion's share of wetland resources, requiring regulated entities proposing to fill wetlands to obtain a permit from the U.S. Army Corps of Engineers ("the Corps").[76] The Corps, in turn, has administered a program of compensatory mitigation, requiring permittees who fill wetlands at one location to restore or enhance similar wetlands at another location, to achieve the no net loss goal.[77] While the agency has no shortage of critics,[78] over the past thirty years the Corps's implementation of this regulatory program has achieved

71. *See* ENVIRONMENTAL LAW INSTITUTE, AFTER THE STORM: RESTORING AMERICA'S GULF COAST WETLANDS, A SPECIAL REPORT OF THE NATIONAL WETLANDS NEWSLETTER (Gwen Arnold ed., Envtl. L. Inst. 2006). Not surprisingly, the most economically destructive flooding in New Orleans was on prior coastal wetland areas that had been drained and developed. *See Nature Destroys, But It Also Can Protect*, THE ENVTL. F., Sept.–Oct. 2005, at 18.

72. *See, e.g.*, STATUS AND TRENDS, *supra* note 67, at 24–36.

73. *See id.* at 39–41.

74. *See id.* at 81–87.

75. *See* Compensatory Mitigation for Losses of Aquatic Resources, 73 Fed. Reg. 19,594, 19,594 (Apr. 10, 2008) (describing "no net loss" of wetlands as a longstanding national goal guiding federal policy).

76. 33 U.S.C. 1344(a) (2000). For background on the wetlands regulation program, see WETLANDS LAW AND POLICY: UNDERSTANDING SECTION 404 (Kim Dana Connolly, Stephen M. Johnson & Douglas R. Williams eds., American Bar Association Publishing 2005). The Corps evaluates over 85,000 permits annually. *See* COPELAND & ZINN, *supra* note 67, at 7.

77. For a history and overview of the wetland compensatory mitigation program, see ENVTL. LAW INST., BANKS AND FEES: THE STATUS OF OFF-SITE MITIGATION IN THE UNITED STATES (2002).

78. *See, e.g.*, NAT'L RESEARCH COUNCIL, COMPENSATING FOR WETLAND LOSSES UNDER THE CLEAN WATER ACT (2001); GOVERNMENT ACCOUNTABILITY OFFICE, GAO-05-898, WETLANDS PROTECTION: CORPS OF ENGINEERS DOES NOT HAVE AND EFFECTIVE OVERSIGHT APPROACH TO ENSURE THAT COMPENSATORY MITIGATION IS OCCURRING (2005). For comprehensive discussions of concerns expressed about the wetlands mitigation program, see Rebecca L. Kihslinger, *Success of Wetland Mitigation Projects*, 30 NAT'L WETLANDS NEWSL., Mar.–Apr. 2008, at 14; James Salzman & J.B. Ruhl, *Currencies and the Commodification of Environmental Law*, 53 STAN. L. REV. 607, 657–68 (2000).

considerable reductions of annual net wetland resource loss.[79]

To be sure, achieving no net loss of wetland resources has not been as easy as flipping a switch. The wetlands loss problem—though simple in terms of its causal source, causal mechanism, and cumulative effects attributes—is nonetheless massive. The sheer dimension of the problem's source attribute, many wetlands that are widely spread out, has made it unwieldy in some important respects. For example, the problem does not map perfectly onto one institutional structure, as not all wetlands are subject to federal jurisdiction[80] and state and local programs vary considerably.[81] Also, different kinds of wetlands can provide different benefits at different scales. This variability has led to debate over how to conduct the no net loss calculus[82] and to concerns that compensatory mitigation has caused an undesirable shifting of wetland resource location and a less-than-full replacement of ecological and economic values.[83]

Even relatively simple aggregation policy problems can present significant governance challenges when they reach massive scales. But the central point is that these problems are responsive to straightforward regulation if the political will is there to address them meaningfully. The specific policy responses can be refined over time to adjust to initial mistakes and to improve performance because it is easy to measure the relationship between cause and effect. With experience it may be possible to isolate attributes that cause the problem to deviate from the ideal simple aggregation model; policy can then focus on those attributes. The Corps, for example, recently took the lessons learned from the past several decades of administering compensatory mitigation and used them to overhaul the program in a comprehensive rulemaking.[84] The program's basic focus, however, remains on maintaining the quantity and quality of wetlands. The fact that this is a simple aggregation problem has made this strategy effective at reducing the rate of wetland losses.[85]

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79. Wetlands land cover saw a slight net gain during the period from 1998–2004. *See* STATUS AND TRENDS, *supra* note 67, at 46.

80. *See* Rapanos v. United States, 547 U.S. 715 (2006) (describing criteria for limiting federal jurisdiction); *see generally* Symposium, Rapanos v. United States, 22 NAT. RESOURCES & ENV'T, Summer 2007, at 1 (series of articles exploring the rationales for and potential consequences of the decision).

81. *See* Turner Odell, *On Soggy Ground—State Protection for Isolated Wetlands*, 25 NAT'L WETLANDS NEWSL., Sept.–Oct. 2003, at 7 (evaluating effectiveness of state programs in addressing nonfederal wetlands).

82. For example, the 2006 *Status and Trends* study has been criticized for including farm stock ponds, golf course ponds, and urban storm water control ponds in its count of freshwater wetland acres. *See* COPELAND & ZINN, *supra* note 67, at 5.

83. *See, e.g.*, J.B. Ruhl and James Salzman, *The Effects of Wetland Mitigation Banking on People*, 28 NAT'L WETLANDS NEWSL., Mar.–Apr. 2006, at 1.

84. *See* 73 Fed. Reg. 19,594 (Apr. 10, 2008) (codified at 33 C.F.R. pts. 325, 332; 40 C.F.R. pt. 230).

85. *See* Susan-Marie Stedman & Thomas E. Dahl, *Coastal Wetlands of the Eastern United States: 1998-2004 Status and Trends*, 30 NAT'L WETLANDS NEWSL., July-Aug. 2008, at 4, 18, 19–

B. Spaghetti Bowl Problems

The first variation on the simple aggregation model, which we call the spaghetti bowl problem, is a subtle yet significant move. Some cumulative effects are in fact an amalgam of independent, simple aggregation problem "strands." Between these strands, the sources may differ substantially in terms of incentive structure or direction of responses. To push the metaphor to its limits, it is as if the strands are all different kinds of pasta. If all the strands empty into one bowl, however, it may be difficult to identify and define the problem as something other than a pile of pasta. Moreover, because of differing and sometimes offsetting source incentive structures a policy response aimed at the most visible strand may not produce results or ground may even be lost, as it in fact matters how each individual strand behaves in response to the policy. The solution to the overall massive problem thus must take into account each of the strands.

The central policy challenge for this type of cumulative effects problem thus becomes one of perception—the ability to divide the strands into their separate identities. Once that clarity is achieved, independent policy responses may be crafted for each individual strand. This approach thus takes advantage of the feature that all strands combine their effects into one aggregate bowl. As traction is gained on each problem, the bowl of cumulative effects becomes less full and the massive problem is slowly whittled away.

An example of this kind of policy vision comes from Professor Josh Eagle's insightful treatment of one of the environment's classic "bowls" of cumulative effects—the oceans.[86] As Eagle notes, two recent high-level assessments of our nation's marine ecosystems suggest they are in grave peril, the victims of a massive problem.[87] The policy response that both assessments recommend, logically it may seem, is the "establishment of larger scale, more 'comprehensive' management bodies," on the premise that "present institutions are too narrow in their geographic and substantive scope."[88]

Eagle contends that this policy response is ill-advised because the poor condition of the oceans is largely a function of the "multiple-use" mandate under which present management agencies operate, which forces them to manage all ocean resources so as to serve a wide array of objectives and interests.[89] The problem with the multiple-use mandate, according to Eagle, is that many marine resource uses are directly incompatible, and thus balancing them into multiple-use harmony across the ocean resource is fundamentally not

20 (losses of eastern freshwater, estuarine, and marine wetlands were less than 1 percent over the six-year period).

86. *See* Josh Eagle, *Regional Ocean Governance: The Perils of Multiple-Use Management and the Promise of Agency Diversity*, 16 DUKE ENVTL. L. & POL'Y F. 143 (2006).

87. *See id.* at 143–45.

88. *Id.* at 146.

89. *See id.* at 157–58.

a viable objective.[90] Broadening the multiple-use mandate and applying it more comprehensively over the ocean resource thus "has the potential to exacerbate those problems."[91] Rather, he argues, ocean policy should rely on a set of "dominant-use" agencies, each tied to achieving a particular objective in a specified "use-priority" zone, such as fishing, recreation, or conservation.[92]

Eagle's proposal recognizes a spaghetti bowl problem. The condition of the oceans is a cumulative effects problem, but the various strands in the bowl exhibit different attributes. The metapolicy approach of comprehensive multiple-use management has tried to pick up all the strands at once, whereas Eagle is suggesting we manage the problem strand-by-strand, given their potentially offsetting incentive structures. Because the ocean is physically like a bowl, he proposes separating the strands through political demarcation of priority-use zones and institutional division of dominant-use agencies. While this surely does not solve all the details—fish can swim between zones; some of the strands may exhibit numerous low-tractability attributes; interagency coordination will be needed to achieve efficient overall expenditure of governance resources—his "agency diversity" proposal should improve the chances that policy responsive strands can be addressed and that more difficult strands can be isolated for focused policy management.

C. Feedback Problems

One of the complications with Eagle's agency diversity proposal for oceans management suggested above in Part II.B is the possibility of feedback among strands when different policy responses are applied to them. In other words, the strands may not be entirely independent from one another. Rather, there may be interrelations and interdependencies between the strands such that regulating one strand may affect the nature and tractability of others. Increased fish stocks from successful regulation of commercial fishing, for example, might prompt increased recreational fishing, and vice versa. Moreover, feedback effects may spill out of the bowl, so to speak, so that overall success in managing the bowl nonetheless leads to external policy problems. For example, regulating recreational fishing operations could affect local economies dependent on this activity for their income.

Potential feedback may be a significant complication for massive problems and responses like Eagle's "agency-diversity" approach. If there is feedback between the different strands unraveled from the spaghetti bowl, each dominant-use agency working in its priority-use zones may not see, or even care, about the feedback loops.[93] An agency that achieves "success" under a

90. *See id.* at 158–62.

91. *Id.* at 147.

92. *See id.* at 166–76.

93. This is reminiscent of the "Tunnel Vision" problem Justice Breyer has written about in risk management. STEPHEN BREYER, BREAKING THE VICIOUS CIRCLE: TOWARD EFFECTIVE RISK

dominant-use mandate may nevertheless add to the challenges that a different dominant-use agency experiences in managing its own priority-use zone. If the latter agency reacts to these new challenges and the subsequent effects of its actions spill over into the first agency's domain, the two agencies may unknowingly become engaged in a runaway policy arms race with mutually assured destruction of the base resource as the endpoint.

The nation's biofuels initiative is a current policy example with all the ingredients for this kind of feedback problem.[94] The initiative is designed to reduce dependence on petroleum and thereby reduce greenhouse gas emissions. The problem is that "biofuel sustainability has environmental, economic, and social facets that all interconnect. Tradeoffs among them vary widely by types of fuels and where they are grown and, thus, need to be explicitly considered by using a framework that allows the outcomes of alternative systems to be consistently evaluated and compared."[95] By forgoing this consideration, the initiative's initial focus on corn as the feedstock has set in motion land use changes that may actually increase greenhouse gas emissions,[96] not to mention increasing soil erosion and water use,[97] inflating world food prices,[98] inducing farmers to exit federal land conservation programs,[99] and causing other feedback effects that spill well outside the scope of the policy initiative.[100]

REGULATION (1993).

94. For background on the federal and state legislative and regulatory initiatives, see L. Leon Geyer et al., *Ethanol, Biomass, Biofuels and Energy: A Profile and Overview*, 12 DRAKE J. AGRIC. L. 61 (2007); Peter Z. Grossman, *If Ethanol Is the Answer, What Is the Question?*, 13 DRAKE J. AGRIC. L. 149 (2008); Arnold W. Reitze, *Should the Clean Air Act Be Used to Turn Petroleum Addicts into Alcoholics?*, 36 ENVTL. L. REP. 10754, 10756 (2006).

95. G. Philip Robertson et al., *Sustainable Biofuels Redux*, 322 SCI. 49, 49 (2008).

96. *See* Dan Charles, *Corn-Based Ethanol Flunks Key Test*, 324 SCI. 587 (2009) (land clearing to produce feedstock will increase greenhouse gas emissions); Joseph Fargione et al., *Land Clearing and the Biofuel Carbon Debt*, 319 SCI. 1235 (2008); Timothy Searchinger et al., *Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land-Use Change*, 319 SCI. 1238 (2008).

97. *See* NATIONAL ACADEMY OF SCIENCES, WATER IMPLICATIONS OF BIOFUELS PRODUCTION IN THE UNITED STATES (Oct 2007); David Pimintel, *Ethanol Fuels: Energy Balance, Economics, and Environmental Impacts are Negative*, 12 NAT. RESOURCES RES. 127 (2003); Stanley Mubako & Christopher Lant, *Water Resources Requirements of Corn-Based Ethanol*, 44 WATER RESOURCES RES. (2007).

98. *See* William F. Laurance, *Switch to Corn Promotes Amazon Deforestation*, 318 SCI. 1721 (2007) (discussing rising soy and beef prices).

99. *See* James Pease & Thomas Simpson, *Corn Grain Ethanol and Water Quality in the Chesapeake Bay Watershed*, 30 NAT'L WETLANDS NEWSL., Jan.–Feb. 2008, at 1 (discussing this effect).

100. These and other effects are comprehensively discussed in Rudolf M. Smaling, *Environmental Barriers to Widespread Implementation of Biofuels*, 2 ENVT'L & ENERGY L. & POL'Y REV. 287, 295–305 (2007).

D. Discontinuity Problems

If the sources are in one region but the effects are felt in another or if the impact of aggregation is not felt until long after the sources have set the causal chain in motion, then classic transboundary and intertemporal policy complications, also known as discontinuities, come into play. Discontinuities can also involve scale, such as when the sources are small and scattered but the effects are large and concentrated or when a small number of actors in one generation causes widely dispersed effects in a later generation. For example, although urban population growth over the past century has occurred on less than 3 percent of the earth's land surface, that population accounts for 78 percent of carbon emissions, 60 percent of residential water use, and 76 percent of industrial wood use.[101] As the spatial and temporal differences between cause and effect in urban growth widen, and effects of urban growth become more and more distant in time and space, it is likely to be more and more difficult for policy to regulate behavior. Indeed, at some point the spatial and temporal distances may be so great as to obscure the source-and-effect relationship entirely from policy eyes or at least make impracticable any hope of proving causation at relevant scales and with sufficient reliability for formulating policy.[102]

Discontinuity effects are particularly complex when temporal and spatial properties exhibit causal nonlinearity, which may happen when the impacts of aggregation or the benefits of policy investment are not felt until a significant threshold is crossed. For example, the reduction in storm surge protection from cumulative losses of coastal wetlands may be nonlinear and thus not detected or anticipated early in the history of such losses.[103] We may not recognize such a problem until after a disaster such as Hurricane Katrina occurs, at which point it has become dauntingly expensive to solve. Conversely, we may not know that a particular policy response will be successful unless we first spend mightily for a period with no measurable result.

Consider a spaghetti bowl scenario where many strands contribute to the cumulative effects problem characterized by nonlinear aggregation. The differences in the strands' nonlinear attributes can greatly complicate the process of effectively and fairly allocating their respective regulatory burdens and costs. The regulated targets of one strand, for example, may complain about having to share in the costs if no benefits within relevant policy time frames can be demonstrated. But if the benefit yield is nonlinear and not

101. *See* Nancy B. Grimm et al., *Global Change and the Ecology of Cities*, 319 SCI. 756, 756 (2008).

102. For a thorough discussion of this effect in the context of climate change, see Biber, *supra* note 60.

103. *See* Edward B. Barbier et al., *Coastal Ecosystem-Based Management with Nonlinear Ecological Functions and Values*, 319 SCI. 321 (2008) (examining the policy difficulties flowing from such nonlinearities).

realized until after heavy investment, imposing those costs may be crucial to achieving overall long-term traction on the cumulative effects problem. The likely political pushback from that and similar strands may induce policymakers to search for the most obvious strand, where short-term marginal returns are high due to nonlinearity at the beginning of the cost curve. However, as those low-hanging fruit opportunities are exhausted, it will become all too clear that there remains a set of sources that have been ignored and thus especially difficult to tackle.

The climate change effects observed today, for example, are caused by emissions from decades ago; the harm-causing activities "have become ingrained politically, socially, and economically, precisely because it took a long time frame for society to recognize the problems associated with those activities."[104] These activities have thus become entrenched and resistant to mitigating regulation. Moreover, even if a regulatory framework can be installed notwithstanding the entrenchment effect, the framework will be difficult to maintain "because the delayed nature of the harm virtually guarantees that there will be a time period after regulation is imposed when the harm will continue to occur—potentially leading to a 'backlash' against apparently ineffective regulation."[105]

Gulf hypoxia is a prototypical discontinuity problem. The National Research Council warned in its recent report on Gulf hypoxia, for example, that "it will require years, if not decades, to see downstream responses to nutrient control actions."[106] The sources and causes of Gulf hypoxia are well understood,[107] but the problematic multiscalar spatial and temporal discontinuities create a policy morass. First, many agricultural sources spread throughout the vast Mississippi River watershed, applying fertilizers and manure to croplands. Next, runoff carries fertilizer and manure nutrients from the land, building up in the nested watershed structure. Then, spring flooding sends a pulse of nutrients down the system and into the Gulf in one big shot far from the sources. Finally, the hypoxic event—the result of the bloom, death, and decomposition of algae feeding on the abundant nutrients—happens well after and far from where the fertilizer and manure was applied.[108] The story sounds simple, but the scale of the aggregation and its spatial and temporal

104. Biber, *supra* note 60, at 6.

105. *Id.*

106. COMMITTEE ON THE MISSISSIPPI RIVER AND THE CLEAN WATER ACT, NAT'L RESEARCH COUNCIL, NUTRIENT CONTROL ACTIONS FOR IMPROVING WATER QUALITY IN THE MISSISSIPPI RIVER BASIN AND NORTHERN GULF OF MEXICO 49 (2008) [hereinafter 2008 NRC REPORT].

107. *See id.* at 47 ("The major nutrient sources and their approximate, relative importance are well known."); *id.* at 48 ("There is scientific consensus that nitrogen is causing the northern Gulf hypoxic zone in the largest areas and for the longest period.").

108. Hypoxia generally occurs once per year, in the summer season. *See* Diaz & Rosenberg, *supra* note 4, at 926.

discontinuities have made hypoxia in estuarine systems a massive problem around the globe.[109] In the case of Gulf hypoxia, strong and conflicting regional and industry interests are likely to divide states and complicate internal federal policy formulation.[110] What must happen is straightforward: the "enormous amounts of nutrients entering the water body via the Mississippi River must be reduced."[111] Yet "[a]chieving this goal will require an array of actions and strategies across a broad swath of America's heartland," far from where the harms of hypoxia occur.[112] One prescription is to restore much of the Midwest's wetlands, but that will confront "the need for funding and an unwillingness on the part of farmers to withdraw land from production."[113] In this policy environment, it is hardly surprising that a federal and state task force described the goal of significantly reducing Gulf hypoxia by 2015 as difficult to meet and aspirational at best.[114] Discontinuity problems like climate change and Gulf hypoxia thus become massive in scale because it is difficult to draw a relationship between the problem and the solution, a factor that often makes it difficult to justify the high political and economic costs.

E. Policy Jungles—Complex Aggregation Problems

The typology thus far has described the simple aggregation problem type and three variations, each involving a complicating spin: spaghetti bowls, feedback, and discontinuities. Now we come to the policy jungles—cumulative effects problems that experience all of these types together. For example, feedback between two different strands contributing to a particular cumulative effect can be nonlinear, spatially discontinuous, and temporally discontinuous. Among dozens of strands there can be multiple sets of feedback loops crisscrossing and transcending scales. As C.S. Holling and Carl Folke have explained, climate change, ecological degradation, and problems of similar quality are

109. *See id. passim* (discussing 400 hypoxic estuarine systems).

110. In this sense Gulf hypoxia is just one of many examples of the policy fragmentation resulting from the discontinuities between land-based sources and marine-based effects and the political struggles that follow. *See* Craig, *supra* note 42, at 831 (arguing that marine ecosystems have long been ignored by the regulatory fragmentation with respect to water). Going back to Eagle's agency diversity model for oceans management, see *supra* text accompanying notes 86–92, this may be yet another complicating factor for his proposal, as some dominant-use agencies would not have control over distant but substantial sources affecting their respective priority-use zones, though that puts them in no worse position than the multiple-use agencies he advises against expanding.

111. Landers, *supra* note 17, at 54.

112. *Id.*

113. *Id.* at 63.

114. *See* MISSISSIPPI RIVER/GULF OF MEXICO WATERSHED NUTRIENT TASK FORCE, GULF HYPOXIA ACTION PLAN 2008, at 9 (2008) [hereinafter ACTION PLAN], *available at* http://www.epa.gov/msbasin/pdf/ghap2008_update082608.pdf. The task force action plan is discussed in more detail *infra* Part V.

> systems problems, where aspects of behaviour are complex and unpredictable and where causes, while at times simple (when finally understood), are always multiple. They are nonlinear in nature, cross-scale in time and in space, and have an evolutionary character. This is true for both natural and social systems. In fact, they are one system, with critical feedbacks across temporal and spatial scales.[115]

They are, in short, the kind of phenomena modeled in complex adaptive systems theory—the study of systems characterized by a macroscopic, heterogeneous set of autonomous agents interacting and adapting in response to one another and to external environment inputs.[116]

Cities and their sprawl are "the example par excellence of complex systems: emergent, far from equilibrium, requiring enormous energies to maintain themselves, displaying patterns of inequality spawned through agglomeration and intense competition for space, and saturated flow systems that use capacity in what appear to be barely sustainable but paradoxically resilient networks."[117] As research from economics,[118] ecology,[119] sociology,[120] and other disciplines makes clear, it is simply not possible to unravel the tangled strands of such complex adaptive systems, trace the feedback loops, nonlinearities, and discontinuities, and snip with surgical precision the undesirable causal chains.[121] Such a system's internal mechanisms and emergent properties defeat attempts to regulate it. Furthermore, small misjudgments about the system's dynamics have the potential to produce wildly inaccurate predictions of the system's trajectory over time.[122] Accurate

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115. C.S. Holling et al., *Science, Sustainability, and Resource Management*, *in* LINKING SOCIAL AND ECOLOGICAL ECOSYSTEMS 342, 352 (Filkret Berkes & Carl Folke eds., 1998).

116. There is no universally applied definition for complex adaptive systems. A comprehensive overview is provided in JOHN H. MILLER & SCOTT E. PAGE, COMPLEX ADAPTIVE SYSTEMS: AN INTRODUCTION TO COMPUTATIONAL MODELS OF SOCIAL LIFE (2007). For applications in environmental law settings, see Daniel A. Farber, *Probabilities Behaving Badly: Complexity Theory and Environmental Uncertainty*, 37 U.C. DAVIS L. REV. 145 (2003); J.B. Ruhl, *Thinking of Environmental Law as a Complex Adaptive System: How to Clean up the Environment by Making a Mess of Environmental Law*, 34 HOUS. L. REV. 933 (1997).

117. Michael Batty, *The Size, Scale, and Shape of Cities*, 319 SCI. 769, 769 (2008). *See also* MICHAEL BATTY, CITIES AND COMPLEXITY: UNDERSTANDING CITIES WITH CELLULAR AUTOMATA, AGENT-BASED MODELS, AND FRACTALS 1–8 (2007).

118. *See* ERIC D. BEINHOCKER, THE ORIGIN OF WEALTH: EVOLUTION, COMPLEXITY, AND THE RADICAL REMAKING OF ECONOMICS (2006); Robert M. May et al., *Ecology for Bankers*, 451 NATURE 893 (2008).

119. *See* SIMON LEVIN, FRAGILE DOMINION: COMPLEXITY AND THE COMMONS (1999).

120. *See* R. KEITH SAWYER, SOCIAL EMERGENCE: SOCIETIES AS COMPLEX SYSTEMS (2005).

121. This is because "complexity arises when the dependencies among the elements become important. In such a system, removing one such element destroys system behavior to an extent that goes well beyond what is embodied by the particular element that is removed." MILLER & PAGE, *supra* note 116, at 9. Thus "work is needed on distinguishing the complex . . . from the just complicated in the presence of many possible explanatory models and imperfect data." Nicholas W. Watkins & Mervyn P. Freeman, *Natural Complexity*, 320 SCI. 323, 324 (2008).

122. *See generally* Ruhl, *supra* note 116, at 943–53 (discussing this insensitivity property of complex systems, under which small changes in the system properties can lead to vastly

cost-benefit analysis in such an environment is difficult to achieve. As Bruegmann observes about sprawl, which he characterizes as "infinitely complex,"[123] it is

> difficult to draw up such a [cost-benefit] balance sheet. Information available at the time of any assessment is usually out of date by the time it is fully collected and analyzed. Conclusions are almost invariably based on the evidence of an insufficiently long time span and on too few variables.[124]

Similarly, as climate change research increasingly points to nonlinear positive and negative feedback loops operating at multiple spatial and temporal scales,[125] it becomes excruciatingly difficult to construct accurate models of global climate and ecological trends over long time periods.[126] Indeed, as we learn more about the climate's highly coupled processes, we will likely realize with even greater clarity the difficulty of predicting its long-term behavior. As a recent commentary in the journal *Science* explained, "The envelope of uncertainty in climate projections has not narrowed appreciably over the past 30 years, despite tremendous increases in computing power, in observations, and in the number of scientists studying the problem."[127] In other words, greater knowledge about the climate system does not necessarily mean greater predictive specificity about global climate patterns. In such a policy environment, techniques such as risk assessment and cost-benefit analysis become alarmingly fragile and dependent upon highly speculative assumptions about the future.[128]

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different trajectories, making prediction over the long term difficult).

123. BRUEGMANN, *supra* note 3, at 18. As he elaborates, "Trying to understand the reciprocal relationships among city, suburbs, and exurbs is like trying to focus the eye simultaneously on numerous objects ricocheting wildly around a confined space." *Id.*

124. *Id.* at 222.

125. These and other findings are discussed in IPCC SUMMARY, *supra* note 58, at 10–17.

126. *See* Douglas Fox, *Back to the No-Analog Future*, 316 SCI. 823 (2007). At the global level, one significant limitation for modeling projection accuracy is the obvious fact that we have no experience with a global climate operating at temperatures like those predicted. In short, "[o]nce the world has warmed by 4°C, conditions will be so different from anything we can observe today (and still more different from the last ice age) that it is inherently hard to say when the warming will stop." Myles R. Allen & David J. Frame, *Call Off the Quest*, 318 SCI. 582, 582 (2007).

127. Gerard H. Roe & Marcie B. Baker, *Why Is Climate Sensitivity So Unpredictable?*, 318 SCI. 629, 629 (2007). The emerging assessment is that things will not get better in this respect: "[I]t is evident that the climate system is operating in a regime in which small uncertainties in feedbacks are highly amplified in the resulting climate sensitivity. We are constrained by the inevitable: the more likely a large warming is for a given forcing (i.e., the greater the positive feedbacks), the greater the uncertainty will be in the magnitude of that warming." *Id.* at 632. *But see* M.D. Meyers et al., *USGS Goals for the Coming Decade*, 318 SCI. 200, 200 (2007) (expressing optimism that the agency can "increase its capability to provide output from predictive and empirical models for managers to test adaptive strategies, to reduce risk, and to increase the potential for hydrological and ecological systems to be self-sustaining, resilient, or adaptable to climate change and related disturbances.").

128. *See* Farber, *supra* note 116, at 156–72. Estimates of the economic impact of climate

Regulating a small piece of any such problem, as the Supreme Court charged the EPA to do with automobile emissions in *Massachusetts v. EPA*, thus opens up daunting complications. It is easy to command the EPA to whittle away, but far less easy to tell the agency how and what the consequences will be. For example, numerous other federal agencies warned the EPA that its decision to regulate automobile greenhouse gas emissions could reverberate with unintended consequences throughout the economy and possibly hamper other agencies' efforts to stem emissions.[129] Perhaps not wishing to be the target of such criticism, the Fish and Wildlife Service, which added the polar bear to the list of endangered species in early 2008, proposed rules specifically to limit the regulatory effect of the ESA over greenhouse gas emission sources.[130]

Indeed, no federal agency has yet seemed eager to dive into regulating its small corner of greenhouse gas emissions. One reason is undoubtedly that the agencies understand that neither individually nor together can they reliably predict the costs and benefits of possible policy responses, much less solve the problem of climate change. Ironically, the one thing they can accurately assess is the political heat they will likely take. Even when agencies are eager to wrestle such massive problems, as many state and local governments have tried with sprawl, success often seems ephemeral at best and comes with undesirable tradeoffs, such as the inherent tension between growth limits and affordable housing.[131]

We are not advocating despair, but rather a more realistic and reasoned approach to cumulative effects problems. Some cumulative effects problems are relatively simple in structure, while others are more complex. Some problems owe their complexity to a single, dominant trait, such as strong feedback between two causal strands or a sharp spatial discontinuity between sources and effects. A few problems, such as climate change and sprawl, seem to be impenetrable jungles of complications. The nature of the problem and in particular how cumulative effects accumulate, says a great deal about how the problem will respond to policy interventions. To be sure, we are not the first to recognize cumulative effects as a target for law and regulation, but as the next

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change, the cost of investment in technology and deployment needed to cut greenhouse gas emissions, and the effect of either on gross economic productivity are all over the board. *See* INTERNATIONAL ENERGY ASSOCIATION, ENERGY TECHNOLOGY PERSPECTIVES—SCENARIOS AND STRATEGIES FOR 2050 (2008); Nicholas Stern, *The Economics of Climate Change*, 98 AM. ECON. REV. 1 (2008).

129. *See* Regulating Greenhouse Gas Emissions Under the Clean Air Act, 73 Fed. Reg. 44,354, 44,356–96 (July 30, 2008) (to be codified at 40 C.F.R. ch. I).

130. *See* 73 Fed. Reg. 47,868 (Aug. 15, 2008) (to be codified at 50 C.F.R. pt 402).

131. *See* Charles E. Connerly, *Affordable Housing in Florida: Why Haven't Florida's Growth Management Laws Met the Challenge of Adequately Housing All Its Citizens?*, *in* GROWTH MANAGEMENT IN FLORIDA: PLANNING FOR PARADISE 261 (Timothy S. Chapin et al., eds., Ashgate 2008); ARTHUR C. NELSON ET AL., A GUIDE TO IMPACT FEES AND HOUSING AFFORDABILITY 3–5 (2008).

Part shows, the law has so far responded with only rudimentary design principles that fail to differentiate between types of massive problems.

III
CUMULATIVE EFFECTS AND THE LAW

In order for agencies to whittle away at massive problems, the law must begin to address the cumulative effects that make these problems so massive in scope and complexity. To be sure, judges, legislators, and agency officials have long recognized the special challenge of using the law to address cumulative effects. The overall impact of many separate actions may require regulation even if any single act taken individually seems innocuous. For example, a court in the early 1900s sustained a federal antitrust conspiracy indictment over the objection that none of the individual acts involved had a direct effect on interstate commerce, observing that "the law looks not at any particular act, but at the aggregate effect of all the acts. The whole series of transactions is to be judged by its fruit, and not by the legal significance of any one occurrence."[132]

Likewise, concern about cumulative effects has had a particularly long history in connection with judicial interpretation of federal power over interstate commerce. Many cases involving the "negative" (or "dormant") Commerce Clause doctrine, which restricts states from interfering with interstate commerce, evaluate the cumulative effects of state and local regulations and taxes.[133] More famously, starting in the New Deal era, the Supreme Court devised the "aggregate effects" doctrine to sustain a substantially broadened federal regulatory agenda.[134] This doctrine, more recently referred to as the "cumulative impacts" doctrine[135] and the "cumulative effects" doctrine,[136] holds that "a single activity that itself has no discernible effect on interstate commerce may still be regulated [federally] if the aggregate effect of that class of activity has a substantial impact on interstate commerce."[137]

132. United States v. MacAndrews & Forbes Co., 149 F. 823, 833–34 (C.C.N.Y. 1906).

133. *See, e.g.*, Am. Trucking Ass'n, Inc. v. Scheiner, 483 U.S. 266, 284 n.16 (1987). Justice Jackson once warned that "[our] danger, as the forefathers well knew, is from the aggregate strangling effect of a multiplicity of individually petty and diverse and local regulations." Duckworth v. Arkansas, 314 U.S. 390, 401 (1941) (Jackson, J., concurring).

134. The doctrine's origin is Justice Black's famous observation that the federal civil rights legislation could reach isolated, purely intrastate acts of discrimination because of the "aggregate effect of a great number of such acts of discrimination." Heart of Atlanta Motel, Inc. v. United States, 379 U.S. 241, 276 (1964) (Black, J., concurring).

135. *See, e.g.*, Solid Waste Agency of N. Cook County v. U.S. Army Corps of Engineers, 191 F.3d 845, 850 (7th Cir. 1999).

136. United States v. Lopez, 514 U.S. 549, 606 (1995) (Souter, J., dissenting).

137. Solid Waste Agency of N. Cook County v. U.S. Army Corps of Engineers, 531 U.S. 159, 166 (2001) (quoting Solid Waste Agency of N. Cook County v. U.S. Army Corps of Engineers, 191 F.3d 845, 850 (7th Cir. 1999)).

The concept of cumulative effects has since reached more expansively across the law,[138] a result, one could reasonably conclude, of the broadened federal interstate commerce power that the "aggregate effects" doctrine enabled. Many of the applications suggest, as did the "aggregate effects" doctrine, a judicial appreciation that the cumulative effects of many actions can be substantial and therefore warrant federal regulation. The vast majority of judicial references to cumulative effects occurred in cases decided after 1960,[139] a strong indication that the burgeoning of federal regulation over social, economic, and environmental realms has catalyzed attention to cumulative effects problems. As a consequence, the concept of federal regulation has spread to many fields. For example, agency regulations employ the cumulative effects concept in fields as varied as banking law,[140] securities law,[141] and disability law.[142] Hundreds of judicial opinions examining the concept of cumulative effects concern agency regulations promulgated under three environmental laws:[143] the National Environmental Policy Act ("NEPA"),[144] the ESA,[145] and Section 404.[146] Employment discrimination cases also abound with references to cumulative effects as being important to deciding the impact of employment practices and employer statements.[147] In reviewing these and other legal approaches to cumulative effects problems, however, three basic strategies have been employed, each with significant limitations: the "things add up" strategy, the predecision strategy, and the adaptive management strategy.

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138. Although the concept, whether called cumulative effects, aggregate effects, cumulative impacts, or some other variant, is rarely mentioned in codified federal statutes, it appears more frequently in federal agency regulations. Based on Westlaw searches in the CFR, SCT, and ALLFEDS libraries, the terms are mentioned in over 100 Supreme Court opinions and over 8700 federal lower court opinions. Many of these references are to trivial matters, such as to the cumulative effect phrases in a jury instruction may have on the jury. *See, e.g.*, Victor v. Nebraska, 511 U.S. 1, 36 (1994) (Ginsburg, J., concurring). For further exploration of the use of cumulative impacts in legal contexts, see Joseph H. Guth, *Cumulative Impacts: Death-Knell for Cost-Benefit Analysis in Environmental Decisions*, 11 BARRY L. REV. 23 (2008).

139. Only 556 of the 8842 documents returned in the ALLFEDS library search predated 1960, and only 576 predated 1970.

140. *See, e.g.*, 12 C.F.R. § 620.11 (2005) (addressing the cumulative effect of changes in accounting principles).

141. *See, e.g.*, 17 C.F.R. § 229.302 (2008) (addressing the cumulative effect of changes in accounting principles).

142. *See, e.g.*, 20 C.F.R. § 220.14 (2002) (recognizing that multiple impairments can have a cumulative effect).

143. Over 800 cases returned in the ALLFEDS library search involved one or more of these three environmental laws.

144. 42 U.S.C. §§ 4321–4370f (2000).

145. 16 U.S.C. §§ 1531–1544 (2006).

146. 33 U.S.C. § 1344 (2006).

147. *See, e.g.*, Nat'l R.R. Passenger Corp. v. Morgan, 536 U.S. 101, 115 (2002) (explaining that hostile workplace environment claims "are different in kind from discrete acts" because they "are based on the cumulative effect of individual acts").

A. The "Things Add Up" Strategy

Courts, agencies and legislatures have primarily taken what we refer to as the "things add up" strategy to cumulative effects problems, treating them as simple aggregation problems. The core assumption underlying this strategy is that there exists a linear, proportional aggregation from source to effects. For example, in *Wickard v. Filburn*,[148] the case that opened the cumulative effects door to interstate commerce power jurisprudence, the Court found that although farmer Wickard's personal consumption of wheat would have a trivial effect on the interstate market, "his contribution, taken together with that of many others similarly situated, is far from trivial," and therefore would, indeed, interfere with the market.[149]

This rudimentary model of cumulative effects poses two shortcomings. The first is breadth. The "aggregate effects" doctrine can be easily applied to a wide variety of circumstances. After all, almost all things in modern, developed economies do add up one way or another.[150] As federal regulation after regulation was bootstrapped on superficial "things add up" arguments, respect for this theory dwindled. And appropriately so—if every activity contributes to interstate commerce, then the Commerce Clause loses all meaning. The backlash to this doctrinal emptiness has been palpable, with the Court's reformed jurisprudence, forged in *United States v. Lopez*, leading the way.[151] The second shortcoming, as explained below in Part III.B, is that many cumulative effects problems do not add up simply.

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148. 317 U.S. 111 (1942).

149. *Id.* at 128.

150. For example, a judge in one case found that the Endangered Species Act could extend federal regulation to land development affecting the habitat of a protected fly, notwithstanding the fact that the fly was found only in a small area of California and had never been the subject of interstate commerce, because the species contributed to the aggregate of the Earth's biodiversity and that biodiversity in general substantially affects interstate commerce. Nat'l Home Builders Ass'n v. Babbitt, 130 F.3d 1041, 1052–54 (D.C. Cir. 1997). Several commentators have argued that this application of the "aggregate effects" doctrine, which essentially makes every living organism a part of interstate commerce, goes well beyond the principles of *Wickard v. Filburn* and the Court's other New Deal cases forging the doctrine. *See, e.g.*, John Copeland Nagle, *The Commerce Clause Meets the Delhi Sands Flower-Loving Fly*, 97 MICH. L. REV. 174, 199–204 (1998) (arguing that this logic would allow federal regulation of any human activity).

151. *See* 514 U.S. 549 (1995). In *Lopez*, the Court accepted the validity of the "aggregate effects" doctrine but attached to it the requirement that the regulation must address economic activities which, "viewed in the aggregate, substantially affect[] interstate commerce." *Id.* at 561. In a subsequent holding, the Court rejected "the argument that Congress may regulate noneconomic, violent criminal conduct based solely on that conduct's aggregate effect on interstate commerce." United States v. Morrison, 529 U.S. 598, 617 (2000). However, in 2005 the Court appeared to restore some vitality to the doctrine in approving federal criminal prosecution of home-consumed marijuana. *See* Gonzales v. Raich, 545 U.S. 1 (2005). The evolution of the "aggregate effects" doctrine is meticulously traced in Jim Chen, *The Story of* Wickard v. Filburn*: Agriculture, Aggregation, and Commerce*, in CONSTITUTIONAL LAW STORIES 69–118 (Michael C. Dorf, ed., 2d ed., 2008), and Bradford Mank, *After* Gonzales v. Raich*: Is the Endangered Species Act Constitutional under the Commerce Clause?*, 78 U. COLO. L. REV. 375 (2007).

B. The Predecision Assessment Strategy

The predecision assessment strategy is far more sophisticated. It involves directly incorporating the concept of cumulative effects into an agency's decisionmaking architecture. Before making a particular decision, the agency must predict the future cumulative effects of some identified set of actions and integrate these effects into the decision in some prescribed manner. Accordingly, such an approach would recognize the attributes that prevent sources from simply adding up, and integrate this more sophisticated understanding into the formulae for decisions. However, although this approach accommodates a more realistic conception of cumulative effects than the simple "things add up" model, it is difficult to predict cumulative effects when they are not linear and proportional over time and space. Therefore, there are significant shortcomings here as well.

For example, environmental laws contain the most advanced versions of the predecision assessment strategy. As mentioned above, an extensive body of the law of cumulative effects has been developed under three environmental statutes: NEPA, ESA, and Section 404. Of these, only Section 404 mentions cumulative effects in the statutory text. However, all three programs have seen extensive agency development of the concept through regulations and policies. All three, moreover, adhere closely to the predecisional strategy for cumulative effects. For instance, regulations promulgated under the ESA provide for consultations between the Fish and Wildlife Service ("FWS") and other federal agencies about the effects of their actions on protected species. These regulations require the FWS to "evaluate the effects of the action and cumulative effects" and decide "whether the action, taken together with cumulative effects, is likely to jeopardize the continued existence of listed species."[152] Section 404 similarly requires the Corps to predict future cumulative effects and to integrate that prediction into its decision whether or not to permit wetlands development.[153]

This approach puts the Corps and the FWS in a precarious position because the standards do not say how they should take cumulative effects into perspective. The agencies could adopt the simple "things add up" model and in doing so risk missing the mark widely where the cumulative effects do not follow linear, proportional aggregation. Or, the agencies could attempt to

152. 50 C.F.R. §§ 402.14(g)(3)–(4) (2008). The agency defines cumulative effects as "those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area." 50 C.F.R. § 402.02 (2008).

153. Statutory policies allow the Corps to issue general permits for disposal of fill material in navigable waters covering classes of activities the agency determines "are similar in nature, will cause only minimal adverse environmental effects when performed separately, and will have only minimal cumulative adverse effect on the environment." 33 U.S.C. § 1344(e)(1) (2006). Corps regulations for project-specific fill permits require the agency to conduct "an evaluation of the probable impacts, including cumulative impacts, of the proposed activity." 33 C.F.R. § 320.4(a)(1) (2002). See *supra* note 152 for the agency's definition of "cumulative effects."

devise complex models of cumulative effects, which often would merely reveal the utter uncertainty of how the effects aggregate.

The predecision dilemma has risen to the top of the policy reform debate regarding NEPA, the environmental statute that has produced the most developed body of cumulative effects law. NEPA requires all federal agencies to

> include in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible official on—(i) the environmental impact of the proposed action [and] (ii) any adverse environmental effects which cannot be avoided should the proposal be implemented.[154]

The Council on Environmental Quality ("the CEQ"), responsible for issuing regulations implementing NEPA's mandated environmental impact statement ("EIS") procedure for federal agencies, requires agencies to consider the impacts of direct effects, indirect effects, and cumulative impacts.[155]

The CEQ's conception of how to adjust for cumulative effects goes well beyond the simple "things add up" approach. The agency's 1997 guide on considering cumulative effects explains that "determining the cumulative environmental consequences of an action requires delineating the cause-and-effect relationships between the multiple actions and the resources, ecosystems, and human communities of concern. Analysts must tease from the complex networks of possible interactions those that substantially affect the resources."[156] The guide advises analysts to "gather information about the cause-and-effect relationships between stresses and resources" and to develop "a conceptual model of cause and effect . . . . Networks and system diagrams are the preferred methods of conceptualizing cause-and-effect relationships."[157]

Applying these essential features of the NEPA assessment procedure to massive cumulative effects problems like global climate change involves relatively straightforward reasoning. Namely, if greenhouse gas emissions

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154. 42 U.S.C. § 4332(2)(C)(i)–(ii) (2000). This provision also requires statements on alternative actions, short- and long-term implications, and "any irreversible and irretrievable commitments of resources." *Id.* at § 4332(2)(C)(iii)–(v).

155. The CEQ has defined *direct effects* as effects "which are caused by the action and occur at the same time and place," 40 C.F.R. § 1508.8(a) (2008), *indirect effects* as effects "which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable," *id.* § 1508.8(b), and *cumulative impacts* as

> the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

Id. § 1508.7.

156. COUNCIL ON ENVIRONMENTAL QUALITY, CONSIDERING CUMULATIVE EFFECTS UNDER THE NATIONAL ENVIRONMENTAL POLICY ACT vi (Jan. 1997).

157. *Id.* at 38.

contribute to global climate change, then actions having the potential, directly or indirectly, to cause greenhouse gas emissions could contribute to a direct, indirect, or cumulative impact of climate change. Thus, the question of whether those effects significantly affect the quality of the human environment arises, therefore requiring an EIS. Indeed, in 1997 the CEQ issued draft guidance stating that "the NEPA process provides an excellent mechanism for consideration of ideas related to global climate change."[158] As the agency explained:

> Specifically, federal agencies must determine whether and to what extent their actions affect greenhouse gases. Further, federal agencies must consider whether the actions they take, e.g., the planning and design of federal projects, may be affected by any changes in the environment which might be caused by global climatic change. [159]

The CEQ circulated its draft guidance; however, no administration has shown any interest in adopting the suggested approach.[160] NEPA, in other words, anticipates an impact assessment process that is sufficiently flexible to engage nonlinear problems such as climate change, but it has not been directed toward this goal in practice. In fact, doing so has proven politically infeasible.

C. The Adaptive Management Strategy

A final approach, the adaptive management strategy, traces its origins to C.S. Holling's critique of predecisional approaches in his influential book from the late 1970s, *Adaptive Environmental Assessment and Management.*[161] Holling and his colleagues found conventional environmental management methods, particularly the environmental impact assessment process under NEPA, at odds with the emerging model of ecosystems as complex, dynamic systems. Under the dynamic model of ecosystems, they concluded, management policy must put a premium on collecting information, establishing

158. Draft Memorandum from Kathleen A. McGinty, Chairman, Council on Envtl. Qual., to Heads of Fed. Agencies 1 (Oct. 8, 1997).

159. *Id.* at 4.

160. It is worth noting that some courts have gone in the direction suggested by the CEQ draft policy. For example, the court in *Border Power Plant Working Group v. Department of Energy* found that, in preparing an EIS in connection with the issuance of permits and rights-of-way allowing two utilities to build electricity transmission lines to connect power plants in Mexico to the power grid in Southern California, the federal agencies had to consider the carbon emissions from the Mexican power plants. 260 F. Supp. 2d 997 (S.D. Cal. 2003). In December 2009, the CEQ informed Senate members that it is considering issuing such guidance, concluding there is "no basis" for excluding greenhouse gas emissions from NEPA assessments. *See* Letter from Nancy H. Sutley, Chair, CEQ, to Honorable James M. Inhofe and Honorable John Barrasso (Dec. 29, 2009), *available at* http://www.eenews.net/public/25/13847/features/documents/2010/01/15/document_gw_02.pdf.

161. ADAPTIVE ENVIRONMENTAL ASSESSMENT AND MANAGEMENT (Crawford 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).

measurements of success, monitoring outcomes, using new information to adjust existing approaches, and possessing a willingness to change.[162] Attempting to predict all the consequences of an action before deciding to go forward and then never looking back, they argued, was at odds with the adaptive management strategy.

Adaptive management is inherently a strategy for whittling away. It rejects NEPA's premise that the cumulative effects caused by and affecting an action over time can be reliably predicted at the time the action is designed. Yet effective adaptive management involves more than just passively waiting and seeing; rather, it involves a more active "learning while doing."[163] Thus an adaptive management plan must address how to handle new information and contingencies; for example, it must have a robust working model of the causal mechanisms of cumulative effects problems likely to occur.[164] However, before choosing which agencies should be given responsibility to adaptively whittle away at a massive problem and how they should do so, it is necessary to develop a more informed understanding of the nature of the massive problems that the agencies are whittling away at. In the next Part, therefore, we explore how our cumulative effects model can guide the design of agencies' adaptive management strategies.

IV
THEORETICAL FOUNDATIONS FOR WHITTLING AWAY

In Part I, we explained why agency management of massive problems is important, yet also difficult and poorly understood. We identified the significant attributes of cumulative effects problems, showing that there are very different types of massive problems, some more responsive to policy then others. In Part II, we examined the behavior of massive problems, creating a typology of problems from simple aggregation to policy jungles. In Part III, we

162. For background on the adaptive management model, see Holly Doremus, *Adaptive Management, the Endangered Species Act, and the Institutional Challenges of "New Age" Environmental Protection*, 41 WASHBURN L.J. 50 (2001); Bradley C. Karkkainen, *Panarchy and Adaptive Change: Around the Loop and Back Again*, 7 MINN. J.L. SCI. & TECH. 59 (2005); J.B. Ruhl, *Regulation by Adaptive Management—Is It Possible?*, 7 MINN. J.L. SCI & TECH 21 (2005).

163. NAT'L RESEARCH COUNCIL, PANEL ON ADAPTIVE MANAGEMENT FOR RESOURCE STEWARDSHIP, COMMITTEE TO ASSESS THE U.S. ARMY CORPS OF ENGINEERS METHODS OF ANALYSIS AND PEER REVIEW FOR WATER RESOURCES PROJECT PLANNING, ADAPTIVE MANAGEMENT FOR WATER RESOURCES PROJECT PLANNING 22 (2004).

164. The National Research Council panel explains:

> Adaptive management is not a "one size fits all" or a "cookbook" process, as experience with the concept and its related procedures to date is limited and evolving. There are multiple views and definitions regarding adaptive management, but elements that have been identified in theory and in practice are: management objectives that are regularly revisited and accordingly revised, a model(s) of the system being managed, a range of management options, monitoring and evaluating outcomes of management actions, mechanisms for incorporating learning into future decisions, and a collaborative structure for stakeholder participation and learning.

Id. at 2. For a thorough description of adaptive management theory and protocol, see *id.* at 19–32.

reviewed the limited strategies that the law has taken to manage massive problems, and explained these strategies' shortcomings. Here in Part IV, we look forward, considering the most promising strategies for agencies to whittle away at massive problems while at the same time gaining, as the Court recommended in *Massachusetts v. EPA*, "a more-nuanced understanding of how best to proceed."[165]

We have suggested throughout this Article that agencies need to understand the nature of a massive problem before determining how and where to address the problem. The exercise would be unnecessary if all massive problems were simple aggregations, with effects adding up in a straightforward manner, allowing agencies to easily decide how hard to whittle based solely on the size of the problem. But this is not the case for many policy problems, not by a long shot. Rather, as problems become increasingly complex, each agency responding to the problem must be increasingly aware of how its policy measures will potentially help or hinder other agencies' efforts or lead to yet other undesirable effects. The following table reviews the specific concerns an agency faces for different types of cumulative effects problems.

Table 5: Agency Concerns by Massive Problem Type

Problem Type	Aggregation Properties	Agency Concerns
Simple Aggregation	Things add up proportionally in all dimensions	None—we're the experts; we just whittle away to solve the problem
Spaghetti Bowl	Different sources respond to different and potentially offsetting incentives	Our policy measure aimed at one strand may undermine policy measures aimed at different strands
Feedback	Different sources, causal mechanisms, or effects interact with one another	Our policy measure may set in motion responses that complicate or offset our or other agencies' policy measures
Discontinuity	Large, often nonlinear spatial or temporal gaps between sources and impacts	Our policy measure may be based on an incomplete grasp of the scale of the problem; our policy measure may be ineffective at managing the problem due to our lack of control over sources, causal mechanisms, or unaddressed effects
Policy Jungle	All these attributes mixed together	We face all of the above problems and have limited capacity to model the effects of our policy measure over space and time

165. Massachusetts v. EPA, 549 U.S. 497, 524 (2007).

The core message is that agencies that treat all massive problems as if they were simple aggregation phenomena will have only limited success, potentially causing more problems than they solve. Instead, it is helpful to recognize how different problem properties can lead to different policy pitfalls. With this basic point in mind, we return to the question that opened the Article—what should the head of an agency do when faced with the task of whittling away at a massive problem?

A. The Limits of Cost-Benefit Analysis and Matching Principle Theories

If you asked a room full of administrative law scholars to identify the most influential strategies for addressing policy problems, both massive and minor, odds are that the short list would include cost-benefit analysis and the matching principle. Cost-benefit analysis is the straightforward concept that the costs and benefits of each policy alternative should be assessed and compared with the absolute and relative costs and benefits of the other alternatives.[166] Some might argue that the analysis should address distributional effects and relative risk more prominently, but the fundamental idea remains that agencies should take actions that maximize social benefits and minimize social costs.[167] The other common strategy, the matching principle, is the similarly straightforward idea that the scale of governance should be matched to the scale of externalities associated with the policy issue.[168] Local problems are best managed by local authorities, global problems by global authorities.

Using these two principles as a starting point, one might assume that agencies should base their whittling strategies on these two rules: (1) determine the scope of authority based on the matching principle, and (2) determine the policy instrument using cost-benefit analysis. However, while this presumption makes sense for some policy problems, unfortunately, it is not applicable to many others.

To be sure, the driving premise of the matching principle—that the appropriate level of government is the one closest in scale to the externality to be regulated—dissolves in the context of all but the simplest cumulative effects problems. Externalities in complex aggregation problems have no fixed scale; they are multiscalar, with positive and negative feedback across scales that evolve over time. For example, the sources of greenhouse gases are varied in nature and unevenly distributed around the planet, whereas the greenhouse gases themselves are evenly distributed around the planet, but have different effects locally.[169] Similarly, the sources of sprawl are not necessarily confined to the city experiencing the sprawl; decisions made in nearby or even distant

166. *See* Shapiro & Schroeder, *supra* note 39, at 446–48.

167. *See id.*

168. *See supra* text accompanying note 30.

169. For a comprehensive analysis of the multiscalar attributes of climate change and the corresponding need for multiscalar policy responses, see Osofsky, *supra* note 34.

cities, or by entirely different scales of government, may influence how sprawl emerges and behaves at any discrete location.[170] Perhaps the most confounding example is Gulf hypoxia. Given that there is no governance unit precisely matching the scale of the Mississippi Valley watershed basin, is the federal government more appropriate than the basin's state governments? Would either be more effective at regulating the activity of individual farms than the local governments?

The solution cannot simply be to disaggregate externalities into multiple scales and match them with multiple governance units. For example, sprawl's traffic jam externality might match with local governments, its air pollution externality might match with state governments, its endangered species habitat externality with the federal government, and so on. But even if the smartest policy minds thought for a moment they had meta-matched all the externalities of a cumulative effects problem to the array of government levels perfectly, with neat lines of authority drawn to demarcate exclusive scopes of jurisdiction, as soon as the governments began whittling away at their respective externality domains the system of interrelated externalities would change. The once efficient lines of authority would begin to lose their "matches." The scales of externalities in cumulative effects problems are not static; thus neither can be the configuration of governmental responses. Ultimately, the matching principle, no matter how meticulously applied, is no match for an evolving cumulative effects problem.

Matching the scale of problem with the appropriate scale of authority seems simple, especially compared to the challenge of conducting a meaningful cost-benefit analysis in the face of complex cumulative effects problems. Once one moves beyond simple aggregation problems, difficulties of feedback, nonlinearity, and other attributes reduce cost-benefit analysis to estimation exercises with enormous margins of error. In addition to the critiques that cost-benefit analysis is subject to politicization, results have been distorted based on choice of discount rate and other model assumptions, and bias in complex policy settings.[171] For example, cost-benefit analyses of proposed policy responses to climate change have produced widely varying and controversial results.[172]

The following table summarizes the obstacles that the matching principle and cost-benefit analysis face when applied to cumulative effects problems. As the table suggests, the more complex the problem, the less utility these strategies hold.

170. *See* Buzbee, *supra* note 37, at 10 ("sprawl exceeds the reach of local governments").

171. *See* Michael A. Livermore, *Cause or Cure? Cost-Benefit Analysis and Regulatory Gridlock*, 17 N.Y.U. ENVTL. L.J. 107, 114–19 (2008); Shapiro & Schroeder, *supra* note 39, at 450–62.

172. *See* Daniel H. Cole, *The* Stern Review *and Its Critics: Implications for the Theory and Practice of Benefit-Cost Analysis*, 48 NAT. RESOURCES J. 53 (2008).

Table 6: Utility of Common Strategies by Massive Problem Type

Problem Type	Matching Principle	Cost-Benefit Analysis
Simple Aggregation	Scale of externalities may change	Total costs and benefits will change from the time of assessment (relative costs and benefits and distribution ratios, however, will remain the same)
Spaghetti Bowl	Scale of externalities of each strand may change; scale of externalities of entire bowl may change	Same as simple aggregation, but applied to each strand; total bowl cost-benefit assessment may mask distorted cost-benefit ratios of particular strands
Feedback	Scale of any one externality may be disproportionate to the scale of its feedback network	Absolute and relative costs and benefits and their distribution ratios will change from the time of assessment; costs and benefits associated with feedback affecting policies outside the studied policy problem may not be detected
Discontinuity	Externalities distant in time and space from the sources require transboundary and intertemporal matching	Scale of the discontinuity (particularly temporal), may make cost-benefit assessment impractical; if analysis conducted on one side of a nonlinear threshold, assessment of absolute and relative costs and benefits and their distribution ratios may be wildly wrong once the threshold is crossed
Policy Jungle	All scales may be relevant and interconnected; different scales dominate different facets of the policy problem	Absolute and relative costs and benefits and their distribution inherently evolve over time in response to internal and external conditions; changes, including changes from alternative policy measures, cannot be predicted; defining the relevant sets of costs and benefits associated with the policy issue is difficult

B. Guidance from New Theories

Despite the limitations of cost-benefit analysis and the matching principle when confronting massive problems, a dull blade is surely better than none at all, particularly when an agency has no choice but to whittle. Hence, we do not recommend rejecting these strategies outright. The question, then, is in addition

to these strategies, where else can an agency look for a guide to whittling away? There has been a great deal of recent scholarship on federalism, instrument choice, and multiagency coordination that, taken together, sets out promising alternative strategies.

1. Dynamic Federalism

Climate change, more than any other massive problem, has fueled renewed interest in theories of federalism. At times, the burgeoning scholarship seems a law review version of *Goldilocks and the Three Bears*, full of competing arguments for the "just right" balance between federal, state, and local authority.[173] If our analysis of cumulative effects problems suggests anything, however, it is that there is no one right balance. Therefore, we believe that settling on the sole approach of centralized federal power versus devolved state power, dual federalism, or cooperative federalism is unproductive.[174] A more nuanced approach is needed, similar to that embodied in what has become known as the "Dynamic Federalism" theory.

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 state governments."[175] The theory is not radical—it does not suggest overhauling the basic federal-state-local structure of governance. Rather, it explicitly calls for overlapping federal and state (and, through states, local) jurisdictions.[176] Scholars of Dynamic Federalism reject

173. *See supra* note 32.

174. Indeed, most people agree that all levels of government hold some level of responsibility for responding to climate change. A 2008 survey of Virginians, for example, found that "86 percent of respondents believe that the federal government is responsible on this issue. At the same time, 85 percent of respondents also believe that state governments have some degree of responsibility and 77 percent have a similar view of local governments." BARRY RABE & CHRISTOPHER BORICK, MILLER CENTER OF PUB. AFF., UNIV. OF VA., REPORT OF THE VIRGINIA CLIMATE CHANGE SURVEY 11 (2008), *available at* http://webstorage3.mcpa.virginia.edu/panels/pdf/panel_ 2008_1021_borick.pdf.

175. Engel, *supra* note 22, at 176. As Kirsten Engel explains, "Alternatively named 'empowerment federalism,' 'polyphonic federalism,' 'interactive federalism,' 'dynamic federalism,' and even 'vertical regulatory competition,' this reconceptualization has come in the form of a cluster of theoretical proposals, all rejecting dual federalism and all emphasizing the benefits of overlapping federal and state power." *Id.* For additional scholarship developing Dynamic Federalism and related principles, see Adelman & Engel, *supra* note 28; Robert B. Ahdieh, *Foreign Affairs, International Law, and the New Federalism: Lessons from Coordination* (Emory Law and Econ. Research Paper No. 08-30, 2008), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1272967; 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 (2004); Robert A. Schapiro, *From Dualist Federalism to Interactive Federalism*, 56 EMORY L.J. 1 (2006) [hereinafter *Dualist Federalism*]; Robert A. Schapiro, *Toward a Theory of Interactive Federalism*, 91 IOWA L. REV. 243 (2005) [hereinafter *Interactive Federalism*].

176. Sovacool, *supra* note 28, at 448. Of course, overlap of authority can occur under dual federalism if federal and state authorities independently regulate the same problem, and under cooperative federalism when the federal government employs (or more accurately, coerces) state

the "minimal overlap" model in which there is a "particular allocation of at least primary regulatory authority between the states and the federal government," replacing it with one "in which multiple levels of government interact in the regulatory process."[177] As a result, Dynamic Federalism "reject[s] the traditional static optimization model for an adaptive one."[178] As Professors David Adelman and Kirsten Engle explain, in a Dynamic Federalism strategy,

> neither [the] federal nor [the] state governments limit themselves to what many legal scholars have deemed to be their appropriate domains. The federal government continues to regulate local issues, such as remediation of contaminated industrial sites, which have few direct interstate connections and few benefits from federal uniformity. At the same time, state and local governments are not content to confine their attention to issues of local concern, but are developing policies on environmental issues of national or even international scale, such as global climate change. Nor do environmental issues "stay" in the control of any particular level of government, but rather tend to pass back and forth between them like a proverbial football.[179]

Some Dynamic Federalism scholars identify the "interconnected" attributes of environmental problems as reasons to employ Dynamic Federalism,[180] thus resonating with our cumulative effects model.[181] But proponents of Dynamic Federalism have primarily focused on models of governance as the justification for this strategy,[182] pointing to its advantages of

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governments to implement federal standards. By contrast, overlap of authority under Dynamic Federalism is neither accidental nor coerced. Adelman and Engel explain that cooperative federalism

> fares somewhat better with the dynamic school. The overlapping authority, although asymmetric, at least has the trappings of a dynamic system. Cooperative federalism nonetheless falls short from the point of view of the dynamic school. The federal laws and regulations are often, but not always, so comprehensive as to exclude for all practical purposes alternative approaches by the states.

Adelman & Engel, *supra* note 28, at 1812–13. Still, many commentators express faith in the ability of traditional cooperative federalism governance to respond effectively to massive problems such as climate change. *See, e.g.*, Holly Doremus & W. Michael Hanemann, *Of Babies and Bathwater: Why the Clean Air Act's Cooperative Federalism Is Useful for Addressing Global Warming*, 50 ARIZ. L. REV. 799 (2008).

177. Engel, *supra* note 22, at 161.

178. Adelman & Engel, *supra* note 28, at 1798.

179. *Id.* at 1796.

180. *See, e.g.*, Sovacool, *supra* note 28, at 408.

181. *See* Adelman & Engel, *supra* note 28, at 1799–1800.

182. An important exception is the work of Adelman and Engel, who emphasize the complexity and multiscalar attributes of environmental problems in developing and distinguishing the variant of Dynamic Federalism they call Adaptive Federalism. *See id.* at 1814–18, 1827–28. They focus their attention, however, less on developing and learning from a model of environmental problems than on exploring differences they have with Dynamic Federalism scholars over the status of states in the multijurisdictional overlap of authorities, with their preference being for a strong but not overpowering federal role. *See id.* at 1830–40.

plurality, dialogue, redundancy, accountability, and economies of scale.[183] The key point relating to massive problems 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 whittling away at the same externality,[184] the built-in redundancy of Dynamic Federalism can provide significant benefits. It gives the overall system of governance more space to track the evolving scales of externalities.[185] It allows governance adaptation to transpire more quickly and with less political jockeying than static, exclusive jurisdiction models such as the matching principle, under which neat divisions of authority would have to be constantly redrawn. Having multiple agencies working within overlapping scales can also promote synergy between the agencies.[186] Finally, the ability to adjust which agencies are involved allows greater flexibility to craft place-based coalitions of agencies responsive to the shifting and discontinuous spatial and temporal scales of the externalities—a flexibility that makes it possible to pass around the proverbial football as a complex cumulative effects problem changes form over time.

What Dynamic Federalism scholarship does not address in any detail, however, is which knives the whittlers should use; it lays out only who should hold the knives. Climate change is also fueling debate in the environmental policy arena about instrument choice, with prescriptive regulation of greenhouse gas emissions squaring up against carbon taxes and market-based cap-and-trade programs for policy dominance.[187] Most multicriteria assessments of instrument choice in environmental policy, however, conclude that no particular instrument is superior to any other across the board.[188] Moreover, consistent with the model of cumulative effects problems, studies find that employing several instruments, or hybrids of them, may be necessary to address multiple externalities associated with some environmental

183. *See* Adelman & Engel, *supra* note 28, at 1808; Schapiro, *Interactive Federalism*, *supra* note 175, at 292–93; Sovacool, *supra* note 28, at 448–51.

184. *See* Jacob E. Gersen, *Overlapping and Underlapping Jurisdiction in Administrative Law*, 2006 SUP. CT. REV. 201, 214 (2006).

185. *See* Adelman & Engel, *supra* note 28, at 1817–18.

186. *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).

187. *See generally* Abate, *supra* note 32 (exploring the role of litigation); Victor B. Flatt, *Taking the Legislative Temperature: Which Federal Climate Change Legislative Proposal Is "Best"?*, 102 NW. U.L. REV. COLLOQUY 123 (2007) (comparing cap-and-trade proposals); Lisa Heinzerling, *Climate Change and the Clean Air Act*, 42 U.S.F. L. REV. 111 (2007) (emphasizing regulation); Symposium, *Global Warming*, 22 NAT. RESOURCES & ENV'T 1 (2008), at 3–55 (series of articles exploring a wide range of instruments).

188. A recent comprehensive study by Goulder and Parry, for example, uses cost-effectiveness, distributional equity, risk minimization, and political feasibility as evaluation criteria for a broad array of incentive-based, regulatory and cost comparison policy tools, concluding that no single instrument is clearly superior along all the criteria. *See* LAWRENCE H. GOULDER & IAN W.H. PARRY, INSTRUMENT CHOICE IN ENVIRONMENTAL POLICY 1 (Apr. 2008).

problems.[189] Employing multiple instruments may be necessary for other complex cumulative effects problems, as well. These concerns are reflected in emerging scholarship on New Governance theory, which, like Dynamic Federalism in its rejection of static governance configurations, rejects "uniform one-size-fits-all rules" associated with conventional prescriptive regulation.[190]

2. New Governance

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.[191] Rigidly relying on fixed, uniform regulatory instruments, such as technology standards and regulatory prescriptions, forecloses adaptation to evolving, complex cumulative problems; indeed, if anything the problems are more likely to adapt to and eventually work around the fixed rules.[192] 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 cumulative effects problems over time. New Governance theory resonates with that theme.

New Governance's emphasis on instrument diversity and flexibility also fits well with Dynamic Federalism's emphasis on overlapping authorities working in concert to address cumulative effects problems. Instrument diversity in the hands of one agency, or in the hands of several agencies separated by precise lines of authority, offers less than when in the hands of multiple overlapping authorities. Overlapping authorities are more likely to discover which instruments most effectively respond to particular externalities of a cumulative effects problem. Overlapping authorities also may be more adept at passing instruments around as the cumulative effects problem evolves and its

189. *See id.* at 3.

190. *See* Karkkainen, *supra* note 23, at 480. For a sweeping overview of New Governance theory, one which Karkkainen reviews, see Orly Lobel, *The Renew Deal: The Fall of Regulation and the Rise of Governance in Contemporary Legal Thought*, 89 MINN. L. REV. 342 (2004) [hereinafter *The Renew Deal*]. For additional scholarship developing New Governance principles, see THE TOOLS OF GOVERNMENT: A GUIDE TO THE NEW GOVERNANCE (Lester M. Salamon ed., 2001); Christie 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); Orly Lobel, *Setting the Agenda for New Governance Research*, 89 MINN. L. REV. 498 (2004) [hereinafter *Setting the Agenda*]; Lester M. Salamon, *The New Governance and the Tools of Public Action: An Introduction*, 28 FORDHAM URB. L.J. 1611 (2001); Michael Waterstone, *A New Vision of Public Enforcement*, 92 MINN. L. REV. 434 (2007). The thesis of New Governance theory is explored more fully *infra* in Part IV.B.

191. *See* Lobel, *The Renew Deal*, *supra* note 190, at 371–404.

192. For a discussion of how complex, evolving policy problems can adapt around fixed prescriptive rules, see Ruhl, *supra* note 116, at 967–91.

externalities change in form, intensity, and scale.

Inherent in the feedback, nonlinearity, and discontinuities of complex cumulative impacts problems, however, is the potential for any policy measure to spin off its own unanticipated consequences, some good and some not. Adopting Dynamic Federalism's federalist structure and New Governance's instrument diversity does not make self-evident how to plan for and respond to these unanticipated effects. Indeed, the potential for backfire may increase with the number of agencies and instruments thrown at the problem, leading to "a glorious mess."[193] Other federalism models make very clear who is in command of what, whereas Dynamic Federalism introduces the ambiguity of overlapping authority. Conventional prescriptive regulation uses a small set of inflexible tools of policy, whereas New Governance, by embracing experimentation, collaboration, and diversity, may increase uncertainty. The advantages of Dynamic Federalism and New Governance, however, would be undermined if governance structures were locked into place and if instrument choices were restricted and difficult to change. To be sure, a coordination method is needed, but it cannot be one that undermines the project it is coordinating.

3. Transgovernmental Networks

Transgovernmental Network theory fits well within the coordination demanded by Dynamic Federalism and New Governance.[194] The theory was forged initially in the context of international law, where nation states, while still the most important actors, have increasingly disaggregated into component institutions sharing roles with nonsovereign bodies.[195] Transgovernmental Network theory emphasizes the nonhierarchical horizontal and vertical networks that are built among the *officials* of those national and international institutions to exchange information, identify best practices, harmonize

193. In a different context, Congressman John Dingell threatened that failure to create a federal cap-and-trade program for greenhouse gases would lead to agency regulations and "a glorious mess." John Dingell, Op-Ed., *"A Glorious Mess,"* WALL ST. J., Apr. 12, 2008, at A8.

194. The seminal and still most comprehensive discussion of Transgovernmental Network theory is found in ANNE-MARIE SLAUGHTER, A NEW WORLD ORDER (2004). For additional scholarship developing Transgovernmental Network principles, see 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 (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 (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).

195. *See* SLAUGHTER, *supra* note 194, at 18, 22–23.

approaches, and enforce the overall international policy program.[196] The movement toward Dynamic Federalism and New Governance at domestic federal and state scales portends the same conditions that are giving rise to such networks in international contexts.[197]

The interagency networks are not fixed, legally codified, or uniform. They are established through practice, based on the needs of the agencies as they address the policy problem. While they may be memorialized through planning agreements, they depend as much or more on personal relationships and reputations as on formal institutional relationships and legalistic channels of communication.[198] A scientist or policymaker in an agency might be a member of many such semiautonomous networks addressing different problems, one link in a set of "weak ties" that facilitate information flow across and between social networks.[199] As many people in many agencies build these ties, the overlapping authorities structure becomes less a mangle and more an organism.[200] As a result, the networked agencies are better equipped to follow the evolution of cumulative effects problems because people in the network, as opposed to entire institutions, can more adeptly transfer information, confer about trends, identify and raise alerts about unintended consequences of policy measures, and so on.

196. *See id.* at 19–22.

197. *See* Freeman & Farber, *supra* note 38, at 899 ("It is intriguing to see the supposedly hierarchical world of domestic regulation evolving in a direction reminiscent of modern international relations.").

198. *See* Levit, *supra* note 24, at 182.

199. Network theory is proving of increasing use and value in the social sciences. *See generally* Stephen P. Borgatti et al., *Network Analysis in the Social Sciences*, 323 SCI. 892 (2009) (reviewing advancements and applications of network theory in social sciences). Some social network theorists have suggested that wide networks of small-scale "weak" interactions form efficient large-scale patterns of information flow, whereas narrow networks of intense "strong" ties can isolate interpersonal relations. Thus, as Mark Granovetter famously suggested, "weak ties, often denounced as generative of alienation are . . . indispensable to individuals' opportunities and to their integration into communities; strong ties, breeding local cohesion, lead to overall fragmentation." Mark S. Granovetter, *The Strength of Weak Ties*, 78 AM. J. SOC. 1360, 1378 (1973). Although the literature debating the merits of weak and strong ties is legion (Granovetter's article is cited over 7000 times), few social theorists contend that weak ties are not important. *See* Daniel Z. Levin & Rob Cross, *The Strength of Weak Ties You Can Trust: The Mediating Role of Trust In Effective Knowledge Transfer*, 50 MGMT. SCI. 1477, 1478 (2004) (surveying the literature). Digital records, faster computers, and more robust mathematical models have allowed network theorists to study larger and more complex social networks, with many studies confirming the important role of weak ties. *See, e.g.*, John Bohannon, *Tracking People's Electronic Footprints*, 314 SCI. 914 (2006).

200. Or, as Nan Hunter puts it, "a circulatory system rather than a set of defined partnerships." Nan D. Hunter, *"Public-Private" Health Law: Multiple Directions in Public Health*, 10 J. HEALTH CARE L. & POL'Y 89, 103 (2007).

V
WHITTLING AWAY IN ACTION

These proposed strategies for agencies to more efficiently whittle away are all very theoretical. Massive problems, though, are all very real. Therefore, this Article would be of limited use if agencies could not assess practical examples of what we recommend. Accordingly, to ground our proposal in practice, in Part V we examine a series of case studies that employ various aspects of our recommendations, identifying both the successes and remaining challenges.

A. Case Study in "Weak Ties" Agency Coordination Networks: The Gulf Hypoxia Task Force

We start with the Gulf Hypoxia Action Plan ("the Action Plan"). The Action Plan was formulated by the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force ("the Gulf Hypoxia Task Force" or "the Task Force"), a network of federal and state agencies that organized to devise a coordinated strategy for responding to the Gulf hypoxia syndrome.[201] The Action Plan demonstrates the convergence of Dynamic Federalism, New Governance, and Transgovernmental Networks theories in addressing a massive cumulative effects problem, as well as the potential shortcomings of such an approach.

The Task Force is an unusual creature in administrative law. Participant agencies retain their independent autonomy and authority as defined by their respective federal and state organic statutes, but they have stepped outside the solo agency policy response mode by entering into a form of networked resource pooling. On one hand, each agency ultimately answers to its respective legislature, citizens, and courts, but on the other hand, each designs its particular policy response with the objective of executing the multiscalar, multiagency coordinated strategy. This flexible networked approach frees participant agencies to determine how best to whittle away at Gulf hypoxia, but

201. *See* ACTION PLAN, *supra* note 114. In the Harmful Algal Bloom and Hypoxia Research Control Act of 1998, Congress identified eleven federal agencies to participate in the effort and charged them with providing for "Federal cooperation and coordination with and assistance to the coastal States, Indian tribes, and local governments in the prevention, reduction, management, mitigation, and control of hypoxia and its environmental impacts." Coast Guard Authorization Act of 1998 § 603(b)(2)(B), 16 U.S.C. § 1451. The Task Force began as a federal interagency working group coordinated through the White House Office of Science and Technology Committee on Environment and Natural Resources. *See* U.S. Envtl. Protection Agency, *Mississippi River Basin Watershed Nutrient Task Force*, http://www.epa.gov/msbasin/taskforce.htm. Its first major work product was the 2001 ACTION PLAN FOR REDUCING, MITIGATING, AND CONTROLLING HYPOXIA IN THE NORTHERN GULF OF MEXICO (2001), *available at* http://www.epa.gov/msbasin/tfproducts.htm. The 2008 report is the Task Force's effort to "track progress, update the science, and adapt actions to improve the effectiveness of the efforts." *See* ACTION PLAN, *supra* note 114, at 4. The work of the Task Force can be followed at its website, http://www.epa.gov/msbasin/ (last visited Dec. 1, 2008).

as we shall see it also presents novel issues for administrative law.

The Action Plan recognizes that the causal mechanisms of Gulf hypoxia involve interactions between nutrient flows, landscape changes, river channelization for navigation and impoundments for water reservoirs, water diversions from the system, and a multitude of natural and anthropogenic sources of nitrogen and phosphorous nutrient loads.[202] In other words, the Action Plan is premised on a model of Gulf hypoxia as a complex, multiscalar, massive cumulative effects problem dominated by dispersed sources and spatial and temporal discontinuities.

Clearly, planning a comprehensive solution to Gulf hypoxia is beyond the capacity of any one agency or group of agencies. As the 2008 National Research Council ("NRC") report on the problem acknowledges, "A comprehensive plan involves scientific, water quality, social, political, and economic considerations that will take years to understand better, and hence any comprehensive plan will remain a work in progress for at least several decades."[203] The NRC thus called on federal and state agencies to begin using their existing range of regulatory tools to whittle away, urging that "[i]f progress is to be seen within these water quality problems, initial actions must be taken somewhere, at some time." [204] The NRC further explained that these "initial actions are part of an adaptive approach that is essential to addressing a long-term, large-scale problem like water quality management across the Mississippi River basin and into the northern Gulf of Mexico."[205]

Wisely, given the complexity of Gulf hypoxia, the Task Force did not try to match the problem with one mega-agency or to divide it into a patchwork quilt of smaller, nonoverlapping matching solutions. Rather, the Task Force, consisting of representatives from five federal agencies and ten state agencies from states within the thirty-one-state watershed,[206] recognized that "[i]mplementation of the Action Plan will require a significant level of commitment from the Federal agencies and State and local governments."[207] True to Dynamic Federalism, therefore, the Action Plan espouses the continuing need for "[a] reassessment of the roles and responsibilities assigned to Federal agencies, the States, Tribes, and the Sub-Basin Committees."[208]

Eschewing matching principle rhetoric and formulations, each of the Task Force's eleven proposed "next steps" action items specifies a set of agencies that will "take the lead" and another set that "will help."[209] The lists of lead and helper agencies vary considerably in their mixes of constituent federal and state

202. *See* ACTION PLAN, *supra* note 114, at 22.
203. 2008 NRC Report, *supra* note 106, at 49.
204. *Id.*
205. *Id.*
206. ACTION PLAN, *supra* note 114, at 9, 60.
207. *Id.* at 33.
208. *Id.* at 5.
209. *Id.* at 30–58 (introducing and then describing each of the eleven action items).

agencies, with no single federal agency dominating and with federal agencies in general sharing roles with the state agencies.[210] Furthermore, the states are organized into a basin-wide coalition and several sub-basin committees.[211] The resulting proposal is a mosaic of overlapping agency responsibilities with every agency having a role in many of the identified next step agenda items and no agency an island of authority over any externality or need of the project.

In terms of instrument choice, the Action Plan adopts the New Governance model, recognizing that "no single approach to nutrient reduction would be effective in every state."[212] Instead, the Action Plan advises using a mix of instruments including incentives, technical assistance, planning, research, education, land conservation, and voluntary and mandatory best management practices.[213] The Action Plan also emphasizes collaboration with nutrient sources,[214] including technological innovation to help reduce nutrient emissions from farms and industrial facilities.[215]

As the Action Plan approach suggests, the convergence of Dynamic Federalism and New Governance is about employing more whittlers and giving them more knives. This directly contrasts the matching principle's approach of finding one whittler for each problem and the cost-benefit analysis approach of finding just the right knife. This seems all for the good in theory, but it raises the question of how it will work in practice. Namely, how will the agencies coordinate how they go about whittling?

An immediate concern is how Dynamic Federalism and New Governance strategies will avoid creating a Tower of Babel effect, with a mangled swarm of well-meaning knives lunging in at all angles. Unfortunately, neither Dynamic Federalism nor New Governance scholarship offers clear answers. Dynamic Federalism scholars call for "a more modular conception of the agency, a conception in which the agency is not a lone monolith, but is embedded in a network of relationships with other agencies—relationships that must be coordinated, managed, and steered."[216] Similarly, New Governance scholars envision "network[s] of stakeholders working together to achieve outcomes, management by negotiation, and dispersed networks rather than traditional methods of command and control."[217] As a practical matter, however, it advances the ball little to suggest that many agencies using many regulatory knives should coordinate—that much seems obvious.

To address this coordination challenge the Action Plan incorporates the "weak ties" approach of Transgovernmental Networks. For example, a major

210. *See id.*
211. *See id.* at 17.
212. *Id.* at 32.
213. *Id.* at 18, 32–33, 37.
214. *See id.* at 5.
215. *Id.* at 24–25.
216. *See* Freeman & Farber, *supra* note 38, at 837.
217. Hunter, *supra* note 200, at 101.

theme of the Action Plan is that "[t]he States and Federal agencies must coordinate efforts across organizations and programs and use adaptive management to modify the strategies as new information and innovative solutions are acquired."[218] State sub-basin committees have "worked to coordinate actions in the sub-basin states" and "have opened the discussion to include many stakeholders not represented on the Task Force, including additional basin states, state agencies, and interested parties and organizations."[219] Next-step agenda items include "coordinat[ing], consolidat[ing], and improv[ing] access to data collected by State and Federal agencies"[220] and "track[ing] interim progress on the actions to reduce nitrogen and phosphorous by producing an annual report on federal and state program nutrient reduction activities and results."[221]

Following this lead, the NRC report on Gulf hypoxia proposed that the EPA and the Department of Agriculture create an interagency research center to "represent the nexus of federal interagency, federal-state, and interstate cooperation."[222] The proposed center would "coordinate and facilitate" management of a basinwide water quality monitoring, assessment, and nutrient control program.[223] The NRC urged that participation of other federal and state agencies would "be vital to the center's operations and functions."[224] Neither the Action Plan nor the NRC's vision of the research center suggests that coordination would come by command coming from on high or would be left to spontaneous bottom-up initiative. Instead they rely on a tangible, yet legally informal, network with high expectations for coordination. Indeed, this seems to be the inevitable coordination arrangement for any governance structure depending on Dynamic Federalism's overlapping authorities and New Governance's diversity of instruments.

B. Next Steps for Administrative Law: Endorsing New Forms of Multiagency Coordination

Within a "weak ties" network such as the Gulf Hypoxia Task Force, how does each agency know what to do? The Task Force, after all, is not a supra-regulatory body with authority over its members. It is not even a free-standing institution. Having agreed to participate in the multiagency efforts, once the members of the Task Force go home to their respective agencies with copies of the Action Plan in hand, what next? Agencies and local planning offices face this precise question any time they are charged with whittling away at massive

218. ACTION PLAN, *supra* note 114, at 33.
219. *Id.* at 17.
220. *Id.* at 48.
221. *Id.* at 50.
222. 2008 NRC Report, *supra* note 106, at 4.
223. *Id.* at 4–5.
224. *Id.* at 4.

problems and turn to interagency coordination as a strategy for developing policy responses.

As with any system of agency decision making, the driver behind this set of issues is the balance between agency autonomy and agency accountability.[225] The *solo* versus *collaborative* models of agency alternatives discussed in Part I define a spectrum along which agencies guard autonomy and retain accountability to varying degrees. Agencies can attempt to spread accountability through coordination with other agencies, but only at the expense of autonomy. It would be quite a trick, in other words, if an agency could spread accountability to other agencies while retaining complete decision-making autonomy. Administrative law is justifiably wary of such strategies.

1. Limits of the Solo Strategy

Administrative law is built primarily around the solo strategy, in which each agency operates as an autonomous unit and is accountable as an autonomous unit to its respective legislature, public, and courts. In that context, an agency engages in interagency coordination largely to gain information, allowing other agencies to provide input but preventing them from intruding on agency autonomy or interfering with agency-specific accountability mechanisms such as public participation and judicial review. NEPA, for example, requires that any federal agency engaged in an environmental impact assessment must consult with all other federal agencies that have "jurisdiction by law or special expertise with respect to any environmental impact involved."[226] However, the statute imposes no formal, substantive coordination duties—everything about NEPA operates from the perspective of a specific agency and the consequences of its decision.

This solo approach has obvious advantages in terms of autonomy and accountability: (1) it requires each agency to take full responsibility for its decisions, (2) it aligns agency incentives according to specific legislative directives, (3) it insulates agency autonomy from external agency encroachment, and (4) it precisely delineates the scope of agency accountability. When massive problems far exceed the scope and capacity of any agency, however, the solo strategy is a recipe for failure. By keeping each agency insulated from others with jurisdiction to address the problem and linking them only through information exchange programs, the solo strategy puts blinders on each agency's capacity to "see" the cumulative effects behavior of the problem.

In the spaghetti bowl scenario, for example, each agency could be assigned a particular strand that contributes to the cumulative effects. With the focus permitted by the solo strategy, each agency could find itself in a strong

225. Professors Freeman and Farber, for example, identify agency autonomy and accountability as significant issues for their conception of "modular" multiagency environmental regulation. *See* Freeman & Farber, *supra* note 38, at 900–09.

226. 42 U.S.C. § 4332(2)(C) (2000).

position to manage the causal mechanisms of its strand. But how would any one agency see the entire bowl of effects or the effects from strands that are assigned to other agencies? And if the problem is more complex than the spaghetti bowl scenario, suffering from feedback and discontinuity problems, how would any one agency detect feedback loops coursing through the system of sources and causal mechanisms, nonlinear thresholds affecting different causal properties, and temporal and spatial discontinuities reaching outside its scope of vision? Most importantly, how would any one agency learn that its policy measures were interfering with those of other agencies?

An extreme reaction to these concerns might join all agencies with some jurisdiction over a massive problem into a formal coordinated entity. Each agency would yield some of its autonomy to the coordinated entity, but each would also shift some of its accountability to that entity. This is precisely how the entity known as CalFed has operated, and precisely why its history has been riddled with problems.[227]

2. Case Studies in Multiagency Coordination Failure

a. CalFed

CalFed is a formal multiagency coordination effort comprising twenty-five federal, state, and local agencies, each with some jurisdiction over the Bay-Delta watershed and estuary (the "Bay-Delta") in northern California. The Bay-Delta is critically important both as a source of drinking and irrigation water and as a home to hundreds of species. It also suffers from a host of resource degradation problems.[228] The challenges of the Bay-Delta are great. When solo agency efforts failed to produce solutions, all eyes focused on bringing about a coordinated approach.

CalFed was no ordinary multiagency coordination undertaking, however. As Professor David Owen describes it, CalFed operated "[o]n a grand and expansive scale," employing "a set of complex strategies for allowing increasing water consumption from an estuary where scarcity is common and variability endemic."[229] Although legal scholarship has described CalFed's innovations as "models of creative pragmatism," Owen concludes that those innovations have not succeeded.[230] In his comprehensive assessment of CalFed's accomplishments, he finds that "[d]espite many advantages—regulatory creativity and cooperation, sometimes substantial funding, attention from high-level officials, and an impressive confluence of government and

227. For background on CalFed and its rise and fall, see Freeman & Farber, *supra* note 38, at 837–76; Owen, *supra* note 36, *passim*.

228. For a brief but compelling survey of the problems the area faces, see Robert F. Service, *Delta Blues, California Style*, 317 SCI. 442 (2007).

229. Owen, *supra* note 36, at 1149.

230. *Id.*

private expertise—the federal-state programs designed to redress the Bay-Delta's resource conflicts have so far produced a fiasco."[231]

What went wrong? Although many factors must be considered, Professors Jody Freeman and Dan Farber home in on strong institutionalized coordination and shifted agency accountability as key traits of CalFed, traits that underlie many of the bumps in the difficult road that CalFed has traveled. They describe CalFed as an "intensive collaboration"[232] ensconced in federal and state law and featuring

> both formal and informal tracks of stakeholder participation (including the Public Advisory Group and many informal opportunities for contact with both the Authority members and agency staff); a rigorous Science Program that independently reviews each aspect of program implementation; Annual Work Plans requiring detailed updating by agencies; . . . a package of commitments to renew balanced implementation of the key elements of the plan; and an Authority created to coordinate agency actions, which themselves remain subject to . . . applicable administrative law requirements. In the face of such overlapping and complementary features, it would be misleading to suggest that this process of checks and balances is "unaccountable."[233]

With this dramatic transfer of autonomy and accountability necessary for CalFed collaboration, however, came significant challenges. As Freeman and Farber explain, efforts like CalFed suffer because agencies resist transferring their autonomy to the collective entity and because legislatures and public constituents are concerned about the diffusion of accountability.[234] The agencies jockey for power and money, and everyone else wants to know which entity to blame if the effort fails.

In essence, CalFed has been an attempt to create a formal, institutionalized, strongly coordinated, multiagency entity, the scope of which, it was hoped, would match that of the Bay-Delta resource issues. The program is a testament to the allure of using the matching principle to design "one-fell-swoop" responses to massive problems: if a single agency cannot be formed to wrap around the problem, then fuse many agencies into a proxy for such a behemoth. But it also demonstrates how difficult it is to fuse agencies accustomed to autonomy and accountability into a strongly coordinated entity. Even in the best of funding environments, which CalFed enjoyed, any such effort is likely to become top-heavy with process and light on product. As Owen concludes, the CalFed approach is too dependent on faith that "regulatory brilliance" will emerge from the strongly coordinated collective entity.[235]

231. *Id.*
232. Freeman & Farber, *supra* note 38, at 907.
233. *Id.* at 908–09.
234. *See id.* at 900–01, 906–07.
235. *See* Owen, *supra* note 36, at 1215.

b. Chesapeake Bay Program

A similar story from the opposite coast can be told about the multistate effort to control pollution in the Chesapeake Bay. Lauded at its inception in 1983 as a triumph of political will,[236] and cited frequently in its early days as a model of interagency coordination,[237] the Chesapeake Bay Program ("the Program") has become a poster child for highly institutionalized and bureaucratized coordination. In her probing study of the Program, Professor Annecoos Wiersema cites insiders as observing that "any accurate representation of the Program's structure would have to have many dotted lines running between various committees and subcommittees."[238]

Indeed, the "Program is renowned for being complex in the sense that the relationship among the committees and subcommittees is not always a straightforward hierarchy."[239] The Program, in other words, has supplanted its participants in an attempt to achieve an institution sized to match the scale of the problem. Thus the Program, not the participants, "operates at multiple scales," but only in the sense that the Program itself has become a myriad of nested committees and subcommittees.[240] Although all of its structure and focus is built around adaptive management of the many problems facing the Chesapeake Bay—a massive problem with aspects of both sprawl and hypoxia —as with CalFed, the participant agencies have coordinated through a separate institutionalized structure that has absorbed the accountability and obscured the autonomy of the separate, participating state and federal agencies.[241] Like CalFed, people speak of whether the Program is a success or failure. Recent assessments point more towards the latter.[242]

3. Designing Multiagency Coordination Success

So, under what whittling-away strategy is regulatory brilliance most likely to emerge? The solo strategy keeps each agency locked in its own myopic

236. *See* Harry R. Hughes & Thomas W. Burke, Jr., *The Cleanup of the Chesapeake Bay: A Test of Political Will*, 11 NAT. RESOURCES & ENV'T 30, 31 (Fall 1996).

237. *See* Jon Cannon, *Choices and Institutions in Watershed Management*, 25 WM. & MARY ENVTL. L. & POL'Y REV. 379, 380 (2000).

238. Annecoos Wiersema, *A Train Without Tracks: Rethinking the Place of Law and Goals in Environmental and Natural Resources Law*, 38 ENVTL. L. 1239, 1272 (2008).

239. *Id.*

240. *Id.* at 1274.

241. In their recent study of the Chesapeake Bay Program, which involved numerous interviews with staff, Rena Steinzor and Shana Jones found the lack of clear accountability mechanisms as a primary obstacle, along with a slow-moving collaborative structure. *See* RENA STEINZOR & SHANA JONES, CENTER FOR PROGRESSIVE REFORM, AN ACCOUNTABILITY MECHANISM FOR THE CHESAPEAKE BAY 2–3 (2008).

242. *See generally* U.S. GOV'T ACCOUNTABILITY OFFICE, CHESAPEAKE BAY PROGRAM: IMPROVED STRATEGIES ARE NEEDED TO BETTER ASSESS, REPORT, AND MANAGE RESTORATION PROGRESS, GAO-06-96 (2005) (reviewing program management difficulties and performance shortfalls).

world, blind to the full scope of the problem and to the interaction of its policy measures with those of other agencies. At the other extreme, strong institutionalized multiagency coordination strategies like CalFed and the Chesapeake Bay Program can lead to a tail wagging many dogs.

By contrast, the Gulf Hypoxia Task Force represents a promising middle ground, but one in need of more aggressive endorsement and direction by legislatures and courts. Through self-organization at the prodding of Congress, the Task Force agencies have achieved far more coordination than could reasonably be expected under the solo strategy. The agencies not only exchanged information but also agreed on the nature of the problem, identified promising policy responses, and allocated policy tasks among multiagency clusters. Yet this was achieved without the transfer of autonomy or the shifting of accountability inherent in the strong coordination strategy taken by CalFed and the Chesapeake Bay Program. No agency has yielded to group decision-making authority, and each has remained responsible in a very real sense to its legislative, public, and executive constituencies. Unlike CalFed and the Chesapeake Bay Program, the Task Force is avoiding the temptation to devise a master plan for coordination of the agency network. In short, the Task Force has resisted the impulse to "match" its way toward a "one-fell-swoop" solution.

While it was wise of the Task Force to take this approach, the weak-ties approach is not without its own risks. There may be additional bureaucratic transaction costs, lack of authority to implement actions decided by the network, and conflicting agency mandates that frustrate attempts at collective action. Agencies can play politics as well as any legislature, and could simply use a task force as a cover for inaction.[243]

Thus, as with any institutional arrangement, the Task Force's success depends on political will, adequate funding, and long-term commitment. These will not simply flow from good intentions and adoption of the Task Force's network model. Indeed, the Task Force's unusual composition exposes it to a unique set of challenges in administrative law. To succeed, multiagency network projects such as the Gulf Hypoxia Task Force need help from administrative law to move their coordination schemes past the "we shall coordinate" mantra while avoiding the master planning trap. We believe four measures will be critical in providing this support.

First, legislatures must endorse and encourage participation in multi-agency network projects or task forces. They must clearly express that agency participation, while expected, poses no risk of loss of autonomy. The task force must exist solely to coordinate agency responses, not to control them.

Second, each legislature must provide to its respective agency participant a clear statement of authority, overarching goals, and benchmark performance

243. Terry M. Moe, *The Politics of Bureaucratic Structure*, *in* JOHN E. CHUBB AND PAUL E. PETERSON, CAN THE GOVERNMENT GOVERN? 285 (1989).

standards. These parameters will serve as accountability mechanisms constraining an agency's exercise of discretion. As a result, each agency must enter the network with a clear understanding of its range of discretion and expected performance benchmarks, even if generally stated and even if, as is likely, they touch on only part of the overall problem being addressed through the network.

Third, the task force or other collective entity should be designed to signal that no accountability rests with the collective entity. This means that direct public participation in task force process should be limited and direct judicial review of task force products disallowed. This removes significant institutional disincentives for agencies to participate in the network. Furthermore, it facilitates the task force serving as a safe harbor for open sharing of information, insights, and strategies among the participating agencies. By retaining full autonomy, however, each participant agency also retains full accountability for its decisions. Each agency will answer to public participation and judicial review mechanisms according to its organic law, not through the task force as proxy.

Fourth, agency participation in the network should be accorded judicial deference. Agency decisions grounded in the findings and recommendations of the task force should be given the same judicial deference as if the agency made the findings itself. Both should be regarded as the product of the expert agency's deliberation. When an agency decides how to whittle away at a massive problem—which knife to use and where and how to cut—basing its decisions on what it has learned from the task force should be just as acceptable as relying completely on its own assessment of the problem.

The objective of these proposals is to make agency participation in the multiagency network an attractive proposition and to avoid having the task force become the tail wagging many dogs. As the task force does not exist in any formal accountability sense, agencies participating in the network are held accountable through the ties people forge, not solely through formal institutional relationships. Each agency retains full institutional autonomy and accountability and thus is insulated from the derivative risk that challenges to or failure of a more formal institutional arrangement could present. Participation in this form of networked task force structure therefore costs each participant agency little more than the commitment of personnel time, but potentially reaps significant policy benefits at both the single agency and multiagency scales.

Our institutional model has yet to be tested against a massive problem in practical application. The Gulf Hypoxia Task Force, as much as it seems to embrace the theoretical underpinnings of the model, has itself predicted that addressing Gulf hypoxia meaningfully will not come quickly. Massive problems plagued by deeply embedded feedback loops, discontinuities, and system complexities are unlikely to be easily uprooted even by the most thoughtful combinations of Dynamic Federalism, New Governance, and

Transgovernmental Networks theories. That said, the experiences of CalFed and the Chesapeake Bay Program make clear that what is needed is *not* more agencies working solo, or more "strong ties" efforts to coordinate multiple agencies into one collective superentity, but rather an environment facilitating more "weak ties" networks among the people within the agencies working on massive problems. While this approach may not produce regulatory brilliance every time, it seems to us far more likely to meaningfully address massive problems than will the solo or strong coordination approaches.

CONCLUSION

Regulation in the modern administrative state touches almost all facets of our daily lives and has done a remarkably good job of improving our safety, our productivity, and our quality of life. Yet the general success that regulation has enjoyed over time has relied largely on its ability to identify and attack social and economic problems with relatively discrete sources and apparent cause-and-effect mechanisms. In retrospect, these have been, as Nobel Laureate Thomas Schelling described, the "easy cases . . . in which the aggregate is merely an extrapolation from the individual."[244] The significant problems that remain on the horizon for regulatory law, and which thus far have proven intractable, involve the "hard cases" in which the cumulative effects of decisions and actions taken by multitudes of persons, businesses, governments, and other entities acting with no deliberate coordination, or even a common purpose, lead to aggregate consequences of huge dimension. It is the combination of a large, loose network of diverse actors, a complex causal chain, and spatial and temporal discontinuities that make these cumulative effects problems such a snarl for the administrative state.

In this Article, we have developed a model to help agencies that are tasked with whittling away at such problems but given no guidance on how to do so. By defining policy problems more carefully than simply saying they are "complex," "massive," or "wicked," our analysis has matched promising regulatory strategies with specific types of massive problems.

For the most difficult problems, "policy jungles" with cumulative effects confounded by feedback loops and discontinuities, our analysis has pointed toward greater reliance on multiagency, multi-instrument policy responses. This recommendation comes with a caution, however.[245] The quest for a comprehensive solution is tempting in the face of a cumulative effects problem—whatever the problem is called, create an agency, name it after the problem, and set it loose to regulate. After more than thirty-five years of that approach in environmental law, and even longer in other fields, none of the big

244. THOMAS C. SCHELLING, MICROMOTIVES AND MACROBEHAVIOR 13 (1978).

245. In complex social systems, "[s]tability, security, and equilibrium . . . can be deceptive, for they are but momentary eddies in an endlessly complex and turbulent flux." MARK C. TAYLOR, THE MOMENT OF COMPLEXITY: EMERGING NETWORK CULTURE 3 (2001).

problems have gone away and some have grown worse. It is no accident that the Gulf Hypoxia Task Force, comprised of people who have long wrestled with the problem under the conventional model, eventually emerged as a loosely-bound, multiagency, multi-instrument approach.

Ultimately, however, our central message is that whittling away at massive problems is as much about the individual agency as it is the networked multiagency task force. On one hand, the solo agency strategy is a futile undertaking, leaving all agencies with jurisdiction over a piece of the massive problem yet blinded to its full scope. On the other hand, the strong coordination strategy pits agencies against each other and the coordinated entity as they fight to retain autonomy and shift accountability. Regulatory brilliance is unlikely to emerge from either strategy. By contrast, the "weak ties" task force approach presents a powerful balance. It helps to align many agencies addressing a cumulative effects problem and to facilitate interagency cooperation by supporting rather than supplanting each agency's authority and responsibility to act. Even the "weak ties" approach, though, is no panacea, for it offers no guarantee that effective actions will follow.

To the head of an agency dealing with a massive problem, the Supreme Court's pithy advice in *Massachusetts v. EPA* thus is insightful on one point and unhelpful on another. The Court is dead right that agencies must whittle away, however daunting the task. What is unhelpful, however, is the Court's implication that "massive problems" come in only one variety and present no special problems for administrative law. As we have shown, massive problems come in many forms, some amenable to casual whittling and others resistant to the sharpest blade. It is these hard problems, made difficult because of cumulative effects, where innovations in agency coordination are most needed and will prove most effective.