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Rules in the modern administrative state tend to lag behind reality, and a key contributor to this stickiness – the volume of regulated activity – is largely ignored. When legislators or agency staff initially write rules to constrain the externalities of an activity, they assume that the activity will occur at a particular scale. Based on the known impacts at this scale, policymakers and regulators balance the harms of the regulated activity against the costs of regulation to industry, striking a compromise within the chosen rule or choosing to not regulate at all.

If the activity later expands from this baseline, the harm/regulatory cost balance becomes precarious – the rules remain stuck at the baseline. Yet the growing activity sometimes produces more harms, including simple harms, each of which has an independent probability of occurring; these risks can accumulate. Expanding activities also can have effects with interdependent risks that expand disproportionately with the time, density, and location of activity. Finally, growing activities might generate uneven impacts, which are shouldered disproportionately by certain communities.

These harms, combined with a lack of adequate public law response, produce what I call regulatory diseconomies of scale – disproportionately negative effects sometimes associated with the expansion of a long-regulated activity. But this is not a one-way ratchet: although this Article focuses on diseconomies, in many cases harms might decline with increasing scale. Industry might innovate and develop new pollution control technologies or more efficient processes, thus lowering the need for regulation. Alternatively, the scale of activity might decline, thus producing fewer harms, yet old, stringent rules remain in place. The failure of rules to respond to either rising or falling harm is due largely to scale blindness in public law – our assumption that familiar activities that we already regulate do not require substantially different remedies when the scale, rather than the nature, of the activity changes.

There are clear solutions to this problem, and many of them could be applied ex ante. Laws could (and sometimes do) include harm thresholds, *which impose more or less stringent controls on individual activities as they grow (or shrink) and move closer to or further from a harm threshold. Our laws also could anticipate and avoid various confluences of events – activities occurring at high densities in sensitive environmental areas, for example. Finally, regulatory institutions could be designed to automatically grow or shrink at certain levels of regulated activity. If more regulation was needed to address disproportionately expanding harms, for example, regulated actors could pay for the added cost through higher permitting fees.*

This Article identifies and analyzes regulatory diseconomies of scale as a core failure of the modern administrative state, using oil and gas development enabled by hydraulic fracturing and older environmental challenges as examples. It then proposes solutions, suggesting how our system of public law – and the institutions that write and implement laws – must better anticipate and address this phenomenon.

INTRODUCTION

One of the most common weaknesses of the modern regulatory state is the failure of laws or institutions to anticipate and account for the expansion or decline of regulated activities. When legislatures or agencies write a rule, they nearly always assume that the regulated activity will occur at a particular scale – that there will be one thousand factories emitting a pollutant, or one million mortgages of a particular type. Based on this assumption, legislators or agency actors limit the externalities of the activity to a level that seems appropriate in light of assumed total harms as compared to the costs imposed on regulated entities and agencies by rule implementation (regulatory costs). They might, for example, impose laxer controls on regulated actors if the regulated activity is relatively benign or regulatory costs are high. Alternatively, they might decide not to regulate at all. If the regulated activity later expands in scale,[1] it

[1] I use "scale" in its traditional definitional sense to describe a simple increase in number. This is somewhat different from uses of the term in other contexts. *See, e.g.*, NEIL BRENNER, NEW STATE SPACES: URBAN GOVERNANCE AND THE RESCALING OF STATEHOOD 9 (2004) (defining geographic conceptions of scale, including, among others, "the level of geographical resolution at which a given phenomenon is thought of, acted on or studied," and "the geographical resolution of contradictory processes of competition and cooperation"); Hari M. Osofsky, *The Intersection of Scale, Science, and Law in* Massachusetts v. EPA, 9 OR. REV. INT'L L. 233, 234-35 (2007) (introducing ecological and geographical scaling concepts and using them). While the numerical expansions that I describe typically cause the activity to increase in geographic scope and to draw in more governmental actors, scaling problems in regulation can occur without these additional factors: the sheer rise in volume of regulated activity is the heart of the problem. Legal scholars tend to use scale to describe situations where effects do not match agency jurisdiction. *See, e.g.*, Alejandro E. Camacho, *Transforming the Means and Ends of Natural Resources Management*, 89 N.C. L. REV. 1405, 1423-24 (2011) (explaining that "anthropogenic climate change . . . increases the interaction of jurisdictions and the extent of

may cause harms to grow, and sometimes in a disproportionate manner – generating unusually large impacts at certain times or in particular regions. In a mirror image of this phenomenon, old, stringent rules might stick despite harms that decline as industries grow and innovate, or as industries shrink.[2] The initial balance of regulatory costs as compared to the harms of the regulated activity changes, yet the laws often do not.

The growing harms of an expanding activity, the imbalance this expansion causes, and the regulatory lag that ensues combine to create a phenomenon described here as a regulatory diseconomy of scale.[3] The over-regulation of an activity that produces shrinking harms as it grows or declines in scale is equally problematic, of course: excessive controls might block needed economic growth. But in this Article I focus on the growth of harms in a negative direction – when society might have inadequate opportunities to bargain for harm reduction and regulation does not change. Our laws and scholarship have not yet comprehensively identified[4] or adequately addressed

regulatory overlap among government authorities" and thus makes it difficult to "identify a single appropriate regulatory scale for managing natural resources"); Robin Kundis Craig, *Climate Change, Regulatory Fragmentation, and Water Triage*, 79 U. COLO. L. REV. 825, 922 (2008) (describing the complexity of watersheds and possible models for "managing interjurisdictional natural resources across regulatory scales"). Several of the scaling problems highlighted in this Article do not involve an externality-jurisdictional boundary mismatch; they are simply disproportionate expansions of an activity within one jurisdiction, to which the responsible agency is blind.

[2] A forthcoming article by J.B. Ruhl and James Salzman partially addresses the mirror image of the diseconomies problem, exploring why it is that we do not tend to put in place formal termination points or exit strategies for rules that are no longer needed, and how we might do this. *See* J.B. Ruhl & James Salzman, *Time to Say Goodbye: Exit in the Regulatory State* (2013) (unpublished manuscript) (on file with author).

[3] Other legal scholars use the term "diseconomies of scale" in different contexts. They employ this term to describe how agencies make broad rules to address large problems, thus reducing flexibility. A larger scale of regulation, as opposed to decentralized, nuanced controls, reduces the costs of enforcement but may ultimately increase the cost borne by regulatory targets. *See* Richard B. Stewart & Cass R. Sunstein, *Public Programs and Private Rights*, 95 HARV. L. REV. 1193, 1298 (1992) (discussing diseconomies of scale in the "[c]entralized public enforcement" context, which arise from "multiple layers of decision and review and the temptation to adopt overly rigid norms in order to reduce administrative costs").

[4] This Article explores a three-part problem: initial assumptions about the scale of a regulated activity, which are captured in the regulatory cost-harm balance; disproportionate harms (both independent and interdependent) caused by expanding regulated activity that throw off the initial regulatory balance; and associated regulatory lag. Scholars have addressed pieces of this larger, more pervasive problem – particularly the fact that small sources can contribute to large collective harm. For a discussion of situations in which individual activities have relatively small impacts but are collectively problematic as the "one percent problem," see Kevin M. Stack & Michael P. Vandenbergh, *The One Percent Problem*, 111 COLUM. L. REV. 1385, 1393 (2011) ("[T]he one percent problem arises when

this problem, which is pervasive in environmental law and likely extends to many other areas.

A long-used technology[5] called hydraulic fracturing, and the oil and gas development that it enables, provides one of the clearest examples of a likely

the relatively small size of low-percentage contributors is taken as a reason for exempting those contributors from regulation despite the fact that the regulatory problem cannot be solved without regulating those sources."). Other work describes "small harms," pointing to small adverse impacts to habitats that collectively have major effects on species, and has suggested the Clean Air Act's use of pollutant thresholds as a model solution for this problem. *See* Dave Owen, *Critical Habitat and the Challenge of Regulating Small Harms*, 64 FLA. L. REV. 141, 195 (2012) (explaining that under the Clean Air Act, "determining on an ad hoc, project-by-project basis what level of emissions should trigger regulation would be nearly impossible" and that the Act therefore requires states to write plans with a "comprehensive approach" through which officials consider "the aggregate consequences of all of the actions threatening the cause environmental degradation" and must ensure that emissions will "attain the ultimate air quality goal" (the National Ambient Air Quality Standard)). Earlier pieces explore individual impacts that generate collective problems. *See* Bradley C. Karkkainen, *Information as Environmental Regulation: TRI and Performance Benchmarking, Precursor to a New Paradigm?*, 89 GEO. L.J. 257, 264 (2001) (explaining that "conventional regulation has been less successful at controlling emissions from small mobile sources, such as automobiles, or diffuse sources, such [as] farms" and offering theories for the causes of this failure); William E. Odum, *Environmental Degradation and the Tyranny of Small Decisions*, 32 BIOSCIENCE 728, 728-29 (1987) (attributing declining air quality to small sources (cars) and discussing water quality problems arising from small yet numerous nonpoint sources). Others have identified the sometimes interdependent impacts of certain activities. J.B. Ruhl and James Salzman, for example, although not focusing on one type of activity that becomes collectively problematic, describe how numerous diverse sources can cause a variety of effects, including those that accrue in the future, and those that are interactive or dramatically high above a certain point. J.B. Ruhl & James Salzman, *Climate Change, Dead Zones, and Massive Problems in the Administrative State: A Guide for Whittling Away*, 98 CALIF. L. REV. 59, 75-79 (2010) (defining massive problems as including problems that "are large in scale or have significant time lags" and have "cumulative effects" that build up in different ways "over time and space" or "are subject to nonlinear tipping points").

[5] Certain aspects of this technology are new. In Texas in the late 1990s, energy companies developed a specific technique called "slickwater" fracturing that used higher volumes of water and often required horizontal drilling. *See Water Use in the Barnett Shale*, R.R. COMM'N OF TEX., http://www.rrc.state.tx.us/barnettshale/wateruse_barnettshale.php (last updated Jan. 24, 2011) ("Slick water fracing of a vertical well completion can use over 1.2 million gallons (28,000 barrels) of water, while the fracturing of a horizontal well completion can use over 3.5 million gallons (over 83,000 barrels) of water."); *see also* Jay A. Rushing & Richard B. Sullivan, *Improved Water-Frac Increases Production*, EXPLORATION & PROD. MAG. (Oct. 12, 2007), http://www.epmag.com/EP-Magazine/archive/Improved-water-frac-increases-production_661 (describing changes in gel and water-based techniques); Hong Sun et al., *A Nondamaging Friction Reducer for Slickwater Frac Applications* 1 (Soc'y Petroleum Eng'rs, Paper No. SPE 139480, 2011) ("Slickwater fracturing, different from fracturing using cross-linked fluids, has been developed and used in tight gas sand reservoirs since successful operations in the Cotton Valley Sand in East

diseconomy of scale. A combination of drilling and fracturing activity has spurred unusually high levels of unconventional fuel development in regions throughout the United States.[6] Largely as a result of this rising development, this country is poised to become one of the world's largest oil producers[7] and a major exporter of natural gas.[8] The economic benefit of this relatively new phenomenon is staggering,[9] but regulations to control the negative externalities of the growth unfortunately have not kept pace.[10] It does not appear that the cumulative costs of unconventional natural gas development, in particular, outweigh its large benefits,[11] but that is not the relevant question here. Rather, this Article suggests that the assumed balance between *regulatory* costs and harms of the activity has changed. In light of larger harms than those

Texas in 1997."). As described in more detail in Part I, however, these important technological modifications are not the primary drivers of the regulatory response that is needed in oil and gas.

[6] *See, e.g.*, Thomas W. Merrill & David M. Schizer, *The Shale Oil and Gas Revolution, Hydraulic Fracturing, and Water Contamination: A Regulatory Strategy*, 98 MINN. L. REV. 145, 157-70 (2013) (exploring the benefits in depth); *Department of Environmental Protection, Bureau of Oil and Gas Management, Wells Drilled*, PA. DEP'T OF ENVTL. PROT., http://www.dep.state.pa.us/dep/deputate/minres/oilgas/photogallery/photo13295/2010%20%20Wells%20Drilled.gif (last updated Jan. 5, 2011) (showing 1386 Marcellus wells drilled and fractured in 2010); *Department of Environmental Protection, Bureau of Oil and Gas Management, Wells Drilled*, PA. DEP'T OF ENVTL. PROT. (Dec. 31, 2008), http://www.dep.state.pa.us/dep/deputate/minres/oilgas/BOGM%20Website%20Pictures/2008/2008%20Wells%20Drilled.jpg (showing 195 Marcellus Shale wells drilled and fractured in 2008); *Newark, East (Barnett Shale) Drilling Permits Issued*, R.R. COMM'N OF TEX. (Oct. 2, 2013), http://www rrc.state.tx.us/barnettshale/drillingpermitsissued.pdf (showing a rise from 38 permits in 1993 to a peak of 4065 in 2008). Not all permits issued result in the drilling and fracturing of wells, of course. *See* Hannah Wiseman, *Risk and Response in Fracturing Policy*, 84 U. COLO. L. REV. 729, 732 n.6 (2013).

[7] INT'L ENERGY AGENCY, WORLD ENERGY OUTLOOK 106, 115 (2012) (projecting that the United States will produce 9.2 million barrels of oil per day by 2035, and that, out of the individual producing countries shown, only Russia and Saudi Arabia will achieve equally high production).

[8] *Id.* at 136 (discussing a scenario wherein U.S. gas production surpasses that of Russia by 2030).

[9] *See, e.g.*, TIMOTHY W. KELSEY ET AL., MARCELLUS SHALE EDUC. & TRAINING CTR., ECONOMIC IMPACTS OF MARCELLUS SHALE IN PENNSYLVANIA: EMPLOYMENT AND INCOME IN 2009, at 5 (2011), *available at* http://www.shaletec.org/docs/EconomicImpactFINALAugust28.pdf ("[T]he economic impact of Marcellus Shale in Pennsylvania during 2009 ranged between 23,385 and 23,884 jobs, and $3.1 and $3.2 billion in that year."); Merrill & Schizer, *supra* note 6.

[10] *See, e.g.*, Wiseman, *supra* note 6 (describing variability among state regulations that address many stages of the oil and gas process and arguing that some may inadequately address emerging yet still uncertain risks).

[11] *See* Merrill & Schizer, *supra* note 6.

previously caused by oil and gas development, somewhat higher regulatory costs are likely merited, yet have not been implemented in many instances.[12]

The regulatory lag associated with this expansion partially results from the tendency of policymakers, agencies, and stakeholders to rely upon dramatic incidents and major technological modifications – not changes in scale – as triggers of needed regulatory change, and neither of these triggers fully applies to fracturing. The oil and gas industry has used hydraulic fracturing technologies since the late 1940s,[13] although the technologies have evolved over time as they have been applied to new underground formations around the United States – and recently at much higher rates.[14] Further, there have not yet been many dramatic environmental catastrophes associated with this practice.[15]

[12] There is a legitimate argument that more stringent regulation would have slowed the expansion of fracturing in recent years. This Article does not propose, however, that we impose stringent regulations ex ante. Rather, it suggests that, ex ante, we must set acceptable thresholds for harms and the location and timing of activities, and that regulatory stringency must change along with the changing harms of an activity. If a particular harm threshold is never reached, then industry can continue growing and innovating without burdensome regulation. And indeed, our tolerance for harm may rise as the activity level rises and produces larger benefits. But having harm thresholds in place ex ante will at least force us to consider this question in a consistent way.

[13] Coastal Oil & Gas Corp. v. Garza Energy Trust, 268 S.W.3d 1, 7 (Tex. 2008) (concluding that fracturing was "[f]irst used commercially in 1949"); Jennifer L. Miskimins et al., *The Technical Aspects of Hydraulic Fracturing*, 2011 ROCKY MTN. MIN. L. INST. 1-4 ("In 1947, the first intentional fracture treatment took place in the Hugoton gas field of western Kansas.").

[14] *See supra* note 5.

[15] One potentially "catastrophic" event would be the pollution of inaccessible groundwater with hydraulic fracturing chemicals that do not quickly break down in the environment. At least in one instance, the Environmental Protection Agency believes that fracturing in an unusually shallow formation might have caused chemicals to enter groundwater. DOMINIC C. DIGIULIO ET AL., EPA, EPA 600/R-00/000, DRAFT, INVESTIGATION OF GROUND WATER CONTAMINATION NEAR PAVILLION, WYOMING, at xiii (2011), *available at* http://www.epa.gov/region8/superfund/wy/pavillion/EPA_ReportOnPavillion_Dec-8-20 11.pdf ("[W]hen considered together with other lines of evidence, the data indicates likely impact to ground water that can be explained by hydraulic fracturing."). Industry actors, however, dispute this report. *See, e.g.*, Susan Phillips, *Chesapeake Official Disputes EPA's Report on Pavilion,* [sic] *Wyo.*, STATEIMPACT (Dec. 12, 2011, 12:00 PM), http://stateimpact. npr.org/pennsylvania/2011/12/12/chesapeake-official-disputes-epas-report-on-pavilion-wyo (providing an email sent by a Chesapeake Energy employee that criticized various aspects of the EPA's report and claiming the report demonstrates how "in [its] haste to find even one exception to the industry's sterling record of responsible hydraulic fracturing, the EPA has compromised its well testing and data gathering protocols"). Wyoming has since taken over the investigation, and the EPA has suspended public comments on and peer review of its draft report. *See* Press Release, EPA, Wyoming to Lead Further Investigation of Water Quality Concerns Outside of Pavillion with Support of EPA (June 20, 2013), *available at* http://yosemite.epa.gov/opa/admpress.nsf/20ed1dfa1751192c8525735900400c30/dc7dcdb4 71dcfe1785257b90007377bf!OpenDocument; *Pavillion, What's New?*, EPA (Sept. 11,

And the few types of dramatic events caused by oil and gas development,[16] like earthquakes and rare aquifer contamination from oil and gas waste disposal, have long occurred in the industry,[17] albeit at a somewhat low level. The oil and gas industry and many regulatory agencies have thus argued that nothing is new,[18] despite the fact that the likelihood of these rare incidents occurring may be rising with the increase in well numbers.[19] The problem here is a simple yet largely unrecognized one: hydraulic fracturing has enabled the development of thousands of new wells in certain regions,[20] thus quietly but substantially expanding the long-recognized harms of conventional oil and gas development, as well as introducing some new harms.[21]

2013), http://www2.epa.gov/region8/pavillion ("EPA does not plan to finalize or seek peer review of the draft report . . . ."). For an in-depth discussion of state regulators' conclusion that hydraulic fracturing has never contaminated groundwater, see Wiseman, *supra* note 6, at 739-40 (citing *Unconventional Fuels, Part I: Shale Gas Potential: Hearing Before Subcomm. on Energy & Mineral Res. of H. Comm. on Natural Res.*, 111th Cong. (2009)); N.Y. STATE DEP'T OF ENVTL. CONSERVATION, REVISED DRAFT: SUPPLEMENTAL GENERIC ENVIRONMENTAL IMPACT STATEMENT ON THE OIL, GAS, AND SOLUTION MINING REGULATORY PROGRAM app. 15 (2011), *available at* http://www.dec ny.gov/docs/materials_minerals_pdf/ogsgeisapp2.pdf.

16 *See infra* note 33 and accompanying text (describing the pollution of the City of Midland's drinking water source caused by a disposal well).

17 *See* AUSTIN HOLLAND, OKLA. GEOLOGICAL SURVEY, EXAMINATION OF POSSIBLY INDUCED SEISMICITY FROM HYDRAULIC FRACTURING IN THE EOLA FIELD, GARVIN COUNTY, OKLAHOMA 18 (2011), *available at* http://www.ogs.ou.edu/pubsscanned/openfile/OF1_2011.pdf ("Cases of clear anthropogenically-triggered seismicity from fluid injection are well documented with correlations between the number of earthquakes in an area and injection, specifically injection pressures, with earthquakes occurring very close to the well.").

18 For example, the Oklahoma Oil and Gas Commission concluded that failed well casing has caused groundwater contamination during the well drilling process, and further found that hydraulic fracturing itself has not caused contamination and does not require new regulation. *See infra* note 133 and accompanying text. This conclusion ignores the fact that fracturing enables more drilling, and thus might heighten the traditional risks associated with drilling.

19 I have previously described many of these harms but not in the context of the diseconomies framework I provide here. *See generally* Wiseman, *supra* note 6.

20 *See* EPA, REGULATORY IMPACT ANALYSIS, FINAL NEW SOURCE PERFORMANCE STANDARDS AND AMENDMENTS TO THE NATIONAL EMISSIONS STANDARDS FOR HAZARDOUS AIR POLLUTANTS FOR THE OIL AND NATURAL GAS INDUSTRY 2-15 (2012), *available at* http://www.epa.gov/ttnecas1/regdata/RIAs/oil_natural_gas_final_neshap_nsps_ria.pdf ("The number of wells producing natural gas wells has nearly doubled between 1990 and 2009 . . . .").

21 *See, e.g.*, Theo Colburn et al., *Natural Gas Operations from a Public Health Perspective*, 17 HUM. & ECOLOGICAL RISK ASSESSMENT 1039, 1045 (2011) (expressing concerns about the chemicals used in fracturing); Daniel J. Rozell & Sheldon J. Reaven, *Water Pollution Risk Associated with Natural Gas Extraction from the Marcellus Shale*, 32 RISK ANALYSIS 1382, 1384 (2012) (describing the risks of spills associated with large numbers of drilled and fractured wells and associated well activity); *see also* EPA, EPA

Many of the individual impacts of unconventional oil and gas development have long seemed benign, and often are, depending on where and when they occur: A bit of diesel spills from a rig at one site;[22] a leaking waste pit sends salty brine into a small marsh at another site.[23] Certain, more dramatic, harms also can emerge, but these are somewhat rare.[24] Indeed, states have long regulated the effects of unconventional development,[25] and in writing oil and gas regulations, they implicitly or explicitly assumed that the development would occur at a particular intensity level.[26] But as the number of wells has rapidly expanded, thousands of once-benign effects have given way to a bigger, largely unaddressed problem. Increasing oil and gas activity has impacts that regulators appear not to have fully anticipated. Numerous violations of environmental and oil and gas regulations have occurred at well sites,[27] and a recent study estimates that even in the "best-case median risk

601/R-12/011, STUDY OF THE POTENTIAL IMPACTS OF HYDRAULIC FRACTURING ON DRINKING WATER RESOURCES: PROGRESS REPORT 174-95 (2012), *available at* http://www.epa.gov/hfstudy/pdfs/hf-report20121214.pdf (listing multiple sources that describe the potential risks); Wiseman, *supra* note 6 (describing potential new risks and the possible heightening of familiar risks).

[22] *See, e.g.*, *Oil and Gas Compliance Report*, PA. DEP'T OF ENVTL. PROT., http://www.portal.state.pa.us/portal/server.pt/community/oil_and_gas_compliance_report/20299 (follow "Oil and Gas Compliance Report" hyperlink; locate the "Unconventional Only (PF Inspections)" drop-down box and select "Yes"; enter 12/22/2010 in the "Date Inspected from" and "Date Inspected to" fields; navigate to page 2 and locate Well Permit 115-20298) (last visited Nov. 17, 2013) (describing a self-reported twenty-gallon spill from a delivery truck at a Marcellus Shale (fractured) gas well site).

[23] *See, e.g.*, *Lease Facility Inspection Report*, LA. DEP'T OF NATURAL RES. (Mar. 18, 2009), http://ucmwww.dnr.state.la.us/ucmsearch/busfunctions.aspx (search for "well permit "238585" in left-hand box; download the lease facility inspection report from March 18, 2009) (describing the release of salty "produced water" into a ditch and swampy area from a Haynesville Shale (fractured) well).

[24] *See, e.g.*, *supra* note 17 (describing the acknowledged risk of oil and gas waste disposal wells causing earthquakes).

[25] GROUND WATER PROT. COUNCIL, STATE OIL AND NATURAL GAS REGULATIONS DESIGNED TO PROTECT WATER RESOURCES 12-16 (2009), *available at* http://www.gwpc.org/sites/default/files/state_oil_and_gas_regulations_designed_to_protect_water_resources_0.pdf (providing a history of state regulation).

[26] *See, e.g.*, Regulatory Determination for Oil and Gas and Geothermal Exploration, Development and Production Wastes, 53 Fed. Reg. 25,446, 25,447 (July 6, 1988) (concluding that, based on the examined oil and gas activity at the time and the wastes produced, state regulation of wastes was generally adequate, although some gaps remained, and also that federal regulation of oil and gas exploration and production wastes was not warranted).

[27] *See generally* Wiseman, *supra* note 6 (analyzing violations at well sites above shale and tight sandstone formations in Louisiana (providing examples out of a set of approximately 211 violations identified in a records request for violations from 2008 to 2011), Michigan (providing examples out of a set of approximately 497 violations identified

scenario," the volume of contaminated water from drilling and fracturing in just one shale formation – the Marcellus Shale beneath several mid-Atlantic and New England states – would contaminate a "few thousand Olympic-sized swimming pools" of water.[28] In some cases the rate of incidents associated with oil and gas development – not just the total number – is increasing along with well numbers.[29]

By expanding old harms and generating some new ones, hydraulic fracturing and the drilling of thousands of new wells creates three specific types of regulatory diseconomies of scale. First, harms with independent risks can accumulate. For example, we have a reasonable understanding of the risk of a well operator spilling fracturing or drilling materials at any one site. We also know that when there are 1000 rather than 100 sites in an area, more spills will likely occur. If existing laws already addressed spills, we might be able to maintain the harm/regulatory cost balance within that law with an expansion of enforcement efforts. But enforcement rates often do not keep pace with growing well numbers, whether due to agency inertia, limited budgets, or simple lack of political will.[30]

Second, there are diseconomies with interdependent risks, in which the harms of an activity grow disproportionately when multiple factors converge. For example, when oil and gas operators in Pennsylvania tried to withdraw water for fracturing from the same surface water system at the same time, during a period of drought, their simultaneous, activity, conducted at an inopportune time and at relatively concentrated locations, threatened to cause

in a records request for violations from 1999 to 2011), New Mexico (providing examples out of a set of approximately 77 violations identified in records requests and on agency websites from 2000 to 2011), and Texas (providing examples out of a set of approximately 62 violations identified in a records request for violations from 2007 to 2011)). For approximate numbers of violations in each state discussed in that article, see spreadsheets sent by the agencies in response to records requests and prepared by Author and Author's research assistants based on violations provided by agencies (on file with author). Note that these numbers are not comprehensive for New Mexico – we identified only a limited number of violations, many of them spills, at tight sands sites. For similar data on violations in Pennsylvania, see *Oil and Gas Compliance Report*, *supra* note 22 (follow "Oil and Gas Compliance Report" hyperlink; select "Yes" under "Unconventional Only" and "Inspections with Violations Only"; in "Date Inspected From" type 01/01/2008; in "Date Inspected To" type 12/31/2013; select "View Report") (showing approximately 4638 violations in Pennsylvania at unconventional (fractured) wells in the Marcellus shale from 2008 to 2013).

[28] *See* Rozell & Reaven, *supra* note 21, at 1391.

[29] Ctrs. for Disease Control & Prevention, *Fatalities Among Oil and Gas Extraction Workers – United States, 2003-2006*, 57 MORBIDITY & MORTALITY WKLY. REP. 425, 429-30 (2008), *available at* http://www.cdc.gov/mmwr/PDF/wk/mm5716.pdf ("A statistically significant correlation was observed between the number of drilling and workover rigs and the annual occupational fatality rate during 1993-2006 . . . .").

[30] *See infra* notes 245-47 and accompanying text (describing potentially declining enforcement in Texas despite large numbers of new Barnett Shale wells drilled).

dangerously low water levels.[31] The growth in well numbers makes this type of interdependent problem more likely by raising the likelihood of higher well densities, more development activity at a given time, and activity that pushes into sensitive environmental areas. Oil and gas waste disposal wells in seismically unstable areas have caused small earthquakes,[32] and one disposal well near an aquifer contaminated a city's drinking water source.[33] Two hundred of these same wells might have produced negligible harms elsewhere. As oil and gas operators search for more disposal options and states rush to permit more disposal wells,[34] however, the risk of developing any one well near a fragile area – and of associated interdependent effects – rises.

Finally, there are unevenly distributed harms in which the externalities of expanding development concentrate in certain areas. The channeling of certain oil and gas wastes to particular states has raised this issue – with operators in Pennsylvania sending most liquid waste from gas wells to Ohio, for example.[35] This subjects certain communities to more road damage, traffic congestion, and air pollution.

Powerful regulatory diseconomies of scale also arise in areas beyond oil and gas, and they help to explain major regulatory failures. Under the Clean Air Act, auto manufacturers must install pollution control technologies and

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[31] *See infra* note 265 and accompanying text. I am grateful to Tracey George for her suggestions on how to best conceptualize risks.

[32] OHIO DEP'T OF NATURAL RES., PRELIMINARY REPORT ON THE NORTHSTAR 1 CLASS II INJECTION WELL AND THE SEISMIC EVENTS IN THE YOUNGSTOWN, OHIO, AREA 17 (2012), *available at* http://media.cleveland.com/business_impact/other/UICReport.pdf (concluding that a disposal well likely induced seismic activity); Katie M. Keranen et al., *Potentially Induced Earthquakes in Oklahoma, USA: Links Between Wastewater Injection and the 2011 Mw 5.7 Earthquake Sequence*, GEOLOGY (Mar. 26, 2013), http://geology.gsapubs.org/content/early/2013/03/26/G34045.1 full.pdf.

[33] City of Midland's Motion for Estimation of Claims for Purpose of Allowance, Voting, and Determining Plan Feasibility, and Request for Determination that Remediation Claim Is Entitled to Administrative Expense Priority at 2, *In re* Heritage Consolidated LLC, No. 10-36484-hdh-11 (Bankr. D. Tex. Nov. 15, 2010) [hereinafter City of Midland].

[34] *See, e.g.*, Industry Guidance, W. Va. Dep't of Envtl. Prot., Gas Well Drilling/Completion, Large Water Volume Fracture Treatments 4 (Jan. 8, 2010), *available at* http://www.dep.wv.gov/oil-and-gas/GI/Documents/Marcellus%20Guidance%201-8-10%20Final.pdf ("[T]o handle the expected amount of water [from fractured oil and gas wells], many additional UIC wells will need to be permitted, drilled or converted.").

[35] *See, e.g.*, Rick McCurdy, Senior Eng'g Advisor, Chesapeake Energy, Underground Injection Wells for Produced Water Disposal, Presentation at the Hydraulic Fracturing Technical Workshop 23 (Mar. 31, 2011), *available at* http://www.epa.gov/hfstudy/21_McCurdy_-_UIC_Disposal_508.pdf (mentioning produced water "being trucked (or railed) to Ohio and West Virginia"); *see also* EPA, EPA 600/R-11/048, PROCEEDING OF THE TECHNICAL WORKSHOPS FOR THE HYDRAULIC FRACTURING STUDY: WATER RESOURCES MANAGEMENT 5, 83 (2011), *available at* http://www2.epa.gov/sites/production/files/documents/HF_Workshop_4_Proceedings_FINAL_508.pdf.

increase the fuel economy of certain vehicles,[36] but growing numbers of cars on the road and miles driven threaten to render these individual controls ineffective.[37] The Clean Water Act suffers from a similar problem with nonpoint sources of pollution – millions of new lawns, golf courses, and farms send nutrients into regional water bodies and dwarf pollution reductions from large industrial sources.[38] These "small harms" recognized by Professor Dave Owen and William Odum tend to be independent ones that can accumulate.[39] Yet they also can cause interdependent effects: Air pollution emitted within a valley on sunny days can have large impacts,[40] as can nutrients and bacteria sent to surface waters during periods of warm weather.[41]

Our system of public law could avoid these failures, which emerge when activities grow and create cumulative, interdependent, and unevenly distributed harms. Legislatures or agencies could first identify an acceptable cumulative threshold of harm caused by a particular activity that would not change regardless of whether one or one thousand actors contribute, although policymakers or agencies could modify the threshold if preferences regarding

[36] 40 C.F.R. § 600.001 (2013) (providing fuel economy standards for "2008 and later model year automobiles"); Control of Air Pollution from New Motor Vehicles: Tier 2 Motor Vehicle Emissions Standards and Gasoline Sulfur Control Requirements, 65 Fed. Reg. 6698, 6701 (Feb. 10, 2000) (codified at 40 C.F.R. pt. 80, 85, 86) ("Under the program, automakers will produce vehicles designed to have very low emissions when operated on low-sulfur gasoline . . . .").

[37] *See, e.g.*, MARICOPA ASS'N OF GOV'TS, EIGHT-HOUR OZONE REDESIGNATION REQUEST AND MAINTENANCE PLAN FOR THE MARICOPA NONATTAINMENT AREA, at ES-7 to -9 (2009) (describing how mobile sources are the largest contributor to nitrogen oxide emissions); Geoffrey L. Wilcox, *New England and the Challenge of Interstate Ozone Pollution Under the Clean Air Act of 1990*, 24 B.C. ENVTL. AFF. L. REV. 1, 20 (1996) (observing that precursor chemicals from automobiles were the "the predominant source of transported ozone in many nonattainment areas"); *Mobile Sources*, CONN. DEP'T OF ENERGY & ENVTL. PROT., http://www.ct.gov/dep/cwp/view.asp?a=2684&Q=322142&depNav_GID=1619 (last updated June 20, 2013) ("Mobile source pollution accounts for approximately fifty percent of all man-made air pollution emitted in Connecticut and throughout the Northeast.").

[38] *See* EPA, EPA 841-R-001, NATIONAL WATER QUALITY INVENTORY: REPORT TO CONGRESS, 2004 REPORTING CYCLE: FINDINGS 16, 23 (2009), *available at* http://water.epa.gov/lawsregs/guidance/cwa/305b/upload/2009_01_22_305b_2004report_2004_305Breport.pdf (showing agriculture as the leading source of stream impairment and "unspecified nonpoint sources" as the fourth largest source of impairment in bays and estuaries).

[39] *See supra* note 4 and accompanying text.

[40] *See Ground-Level Ozone*, EPA, http://www.epa.gov/glo/basic html (last updated July 30, 2013) ("Ozone is likely to reach unhealthy levels on hot sunny days in urban environments.").

[41] *Summer's Warm Weather Can Spur Blue-Green Algae Blooms*, WIS. DEP'T OF NATURAL RES. (July 30, 2013), http://dnr.wi.gov/news/Weekly/Article_Lookup.asp?id=2648 ("When conditions are favorable, usually in summer, the number of algae can increase dramatically.").

total acceptable harm changed.[42] Additionally, more localized thresholds would account for interdependent and unevenly distributed impacts: these would limit the areas into which the activity could expand and identify the times, such as periods of drought, when collective activities might have particularly large impacts. Once the thresholds were set, they would provide the needed benchmarks for regulation: controls on individual actors would vary depending on how close these actors came to reaching collective and localized harm thresholds.

Tailoring laws and regulations to address diseconomies of scale will not be adequate, though; institutions also will have to change in ways that anticipate potential diseconomies and respond to them more quickly. Legislatures could incorporate sunset provisions in agency enabling statutes that would be tied to the levels of activity the agency regulated, requiring review of the agency's mission and quality of performance at certain activity thresholds. This would better ensure that agencies did not remain stuck within old laws and missions, and would give these institutions needed authority to address the new and expanded risks associated with scale-based change. Legislatures also could create mandatory minimum agency staffing levels that would automatically rise as the regulated actors reached specified thresholds of activity. In the event that a growing activity caused interdependent effects – thus requiring disproportionately more funding than could be provided by a larger number of actors paying for permits – agencies could fund this expansion through permitting fees that rose as the quantity of activity expanded.

A few laws do incorporate these types of scaling concepts, although not fully. For example, the Clean Air Act sets acceptable levels of pollution in the ambient air using health-based standards.[43] The Act then imposes more stringent controls on industrial sources in regions that exceed this level and thus have relatively dirty air.[44] The Clean Water Act, too, requires states to

[42] Indeed, because growing regulated activities often have substantial economic benefits, people's tolerance for the harm caused by the activity might rise along with the growth of the activity.

[43] 42 U.S.C. § 7408(a) (2006) (requiring the EPA Administrator to identify "each air pollutant—(A) emissions of which, in his judgment, cause or contribute to air pollution that may reasonably be anticipated to endanger public health and welfare" when listing pollutants for which national ambient air quality standards are to be established); *id.* § 7409(b) ("National primary ambient air quality standards . . . shall be ambient air quality standards the attainment and maintenance of which in the judgment of the Administrator . . . are requisite to protect the public health.").

[44] *See id.* § 7502(a)(1)(A) (allowing the EPA Administrator to "consider such factors as the severity of nonattainment . . . and the availability and feasibility of the pollution control measures that the Administrator believes may be necessary to provide for attainment"); *id.* § 7503(a)(2) (requiring "lowest achievable emission rate" technology for new and modified major sources in nonattainment areas). In the context of enforcing laws as the number of regulated actors rises, the Food and Drug Administration also operates under a statutory regime that at least partially recognizes scale, allowing for an "annual adjustment of

develop water quality standards, and mandatory permitting of individual sources of water pollution accounts for these standards to some extent.[45] Thus, water pollution sources located near thousands of other sources emitting into one lake are likely to face more stringent controls.[46] Further, some states have sunset review requirements for certain agencies, including some oil and gas commissions; these provisions require the agencies to describe the number of inspections made, the number of wells regulated, and other activities.[47] This, in turn, might spur more careful investigation of the adequacy of the agencies' coverage. Yet scale-based approaches within laws and institutional design seem to be surprisingly rare in most areas – even in environmental and natural resources law.

This Article argues that regulatory diseconomies of scale should trigger major modifications of policies and statutes as well as institutional change, and, relatedly, that regulatory systems and institutions should be designed with potential regulatory diseconomies (or economies) of scale in mind. Part I

revenues each year beginning in FY 2009 for increases in workload for the process of the review of human drug applications." *PDUFA IV 5-Year Financial Plan (2008): Assumptions*, FOOD & DRUG ADMIN., http://www.fda.gov/ForIndustry/UserFees/PrescriptionDrugUserFee/ucm153481.htm (last visited Feb. 5, 2014).

[45] *See* 33 U.S.C. § 1311(b)(1)(c) (2012) (directing the achievement of effluent limitations for point sources, which include "any more stringent limitation [than the best practicable control technology required for most point sources], including those necessary to meet water quality standards").

[46] EPA v. California *ex rel.* State Water Res. Control Bd., 426 U.S. 200, 205 n.12 (1976) ("Water quality standards are retained as a supplementary basis for effluent limitations, however, so that *numerous* point sources, despite individual compliance with effluent limitations, may be further regulated to prevent water quality from falling below acceptable levels." (emphasis added)), *superseded on other grounds by statute*, Clean Water Act of 1977, Pub. L. No. 95-217, 91 Stat. 1566 (codified as amended at 33 U.S.C. § 1323), *as recognized in* Parola v. Weinberger, 848 F.2d 956, 961 (9th Cir. 1988).

[47] *See infra* note 199 and accompanying text. I distinguish sunset reviews from other sunset provisions or temporary legislation, which are "clauses that cause legislation to expire by its own terms." Rebecca M. Kysar, *Lasting Legislation*, 159 U. PA. L. REV. 1007, 1009 n.4 (2011); *see also* Jacob E. Gersen, *Temporary Legislation*, 74 U. CHI. L. REV. 247, 259 n.64 (2007) (describing "sunset" legislation and review generally as including clauses that "required periodic review in order to continue the legal validity of a regulatory agency" or "review of all agencies with responsibility for a class of regulation" in a definition similar to the one that I use for review); *id.* at 260 (indicating that sunset legislation programs "enact programs for finite time periods"). Although these provisions have since fallen out of favor, unlike temporary legislation, *see id.* at 259-60, they remain important, particularly in certain states. The sunset reviews that I describe as positive examples, in that they might force agencies to consider scaling impacts. But they do not directly address changes in the quantity of regulated activity because they typically require sunset reviews after the agency has operated for a certain number of years. Requiring review based on time may roughly capture expansions in scale – within a particular ten-year period, oil and gas development may have substantially expanded within a state – but it is not a perfect proxy.

explores three particular types of diseconomies of scale, including independent, interdependent, and uneven expansions of harm, and associated regulatory lag. It argues that the growth of oil and gas development strongly exhibits all three types of diseconomies and briefly describes how this problem arises in other areas of environmental law. Part II then suggests how policymakers and agencies can create better institutions and laws that specifically identify regulatory diseconomies of scale and address scale-based concerns in all three scaling scenarios.

Although this Article focuses on addressing only the negative aspects of the growth of regulated activity, the expansion of regulated activity often is highly beneficial, and sometimes can lead to fewer harms. For example, because water is scarce and waste disposal options are limited, the growing oil and gas industry is developing recycling strategies for wastewater.[48] Here, increasing regulated activity could result in important innovations and a need for less regulation of water use and disposal. Just as legislatures and agencies should anticipate changing scale and set harm thresholds at which regulation and agency resources should be ratcheted up, public law sometimes will need to evolve in the opposite direction. The Article concludes by exploring briefly how our system of public law should anticipate changing harms in both directions, thus causing regulations to expand and constrict along with the activities and harms to which they apply.

I. UNDERSTANDING DISECONOMIES OF SCALE

The common element in all regulatory diseconomies of scale is a baseline of initial regulation – the point in time at which policymakers or agencies write relatively comprehensive controls to address the harms of an activity. At this point, those tasked with regulating assume that the activity will occur at a particular scale[49] and will thus generate a certain level of harm; the merits of

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[48] *See, e.g.*, *Water Use in the Barnett Shale*, *supra* note 5 (describing wastewater recycling pilot projects).

[49] *See, e.g.*, Regulatory Determination for Oil and Gas and Geothermal Exploration, Development and Production Wastes, 53 Fed. Reg. 25,446, 25,446 (July 6, 1988) (examining waste volumes and their toxicity in a decision exempting many oil and gas wastes – even those with hazardous constituents – from the hazardous waste portion of a federal solid waste statute, and documenting only "62 damage cases"). Regulatory impact analyses that assess the effects of the proposed rule often project future volumes of activity, though regulation does not always formally allow consideration of these analyses (for example, where costs may not be considered). *See* EPA, *supra* note 20, at 2-26 (forecasting future well drilling activity in a regulatory impact analysis of new Clean Air Act regulations on fractured oil and gas wells). This Article argues that projections of future volume often are not adequately factored into the calculus behind the actual rule chosen, as perhaps shown most clearly by the 1988 exemption. Further, regulatory impact analyses often fail to accurately predict expansions in scale; five years ago, even the best scientists could not have anticipated the current rate of oil or gas development, because the actual productivity of a formation is often not known until several years of drilling activity have passed. As

imposing regulatory costs in order to control these harms are calculated accordingly. From this point of relative equilibrium, the regulated activity, which often is somewhat benign at a small scale, becomes more common – sometimes rapidly – leading to a variety of disproportionate harms. These diseconomies cause and are exacerbated by regulatory failures,[50] including the failures of enabling legislation, regulation, and agencies to fully recognize or resolve the diseconomies by either addressing them in the initial baseline law or by later modifying the laws to account for scale-based change. There are three specific manifestations of this phenomenon, including independent, interdependent, and unevenly distributed harms, and recent failures in environmental and natural resources law best exemplify these three problems.

A. *Unconventional Oil and Gas Development*

The boom in fossil fuel production from unconventional formations far below U.S. soil is the most powerful recent example of a regulatory diseconomy of scale, exhibiting all three types of harms as the activity has expanded rapidly in recent years. The United States has a long history of fossil fuel extraction,[51] and states have controlled onshore extraction for nearly a century[52] without receiving much attention from the public.[53] Energy companies recently discovered, however, that they could apply a long-used extraction process,[54] with certain technological modifications,[55] to shale and

discussed below, despite being unable to accurately predict changes in scale, it is important to initially factor the likelihood of scalar change into regulatory approaches and institutional design in order to ensure more rapid, nimble, and effective responses when scale-based changes occur.

[50] Diseconomies of scale are often simply regulatory failures to respond to problems caused by the as yet unidentified trigger of scale, but "regulatory failure" is too narrow of a term. As described in detail below, in some cases, agencies cannot adequately respond to a scalar increase because of legislation that limits their jurisdiction and their ability to hire staff.

[51] *See* LOUIS STOTZ & ALEXANDER JAMISON, HISTORY OF THE GAS INDUSTRY 76 (1938) (pinpointing August 27, 1859 as the date on which oil was struck in Titusville, Pennsylvania); C.A. WARNER, TEXAS OIL AND GAS SINCE 1543, at 22 (2007) (dating the first "real oil well completed in Texas" to 1866).

[52] *See, e.g.*, GROUND WATER PROT. COUNCIL, *supra* note 25, at 12-13 (explaining that, while "New York required the plugging of abandoned wells as early as 1879," more comprehensive regulatory efforts for the conservation of oil and gas began in 1935, followed by environmental regulations beginning in the 1970s).

[53] Attention generally focused intermittently on offshore drilling and associated activity, including the Exxon Valdez tanker spill and the BP Macondo well blowout and spill.

[54] *See* Miskimins, *supra* note 13, at 1-4 (explaining that energy companies have used hydraulic fracturing for more than sixty years). The slickwater fracturing now used in shale and tight sandstone is a more recent development. *See infra* note 61 and accompanying text.

[55] *See* Rushing & Sullivan, *supra* note 5 (describing changes in gel- and water-based fracturing techniques).

tight sandstone formations thousands of feet underground that trap massive quantities of gas and oil. As the economic benefits of this practice have exploded, so, too, have the environmental harms – largely due to scaling problems. As introduced previously, this Article does not argue that the total costs of oil and gas development outweigh its larger economic, social, and in some cases, environmental[56] benefits, but rather that the *regulatory* costs of this practice are disproporationately low in light of scale-based harms, and that certain regulation must expand.

The entities responsible for developing unconventional wells, called well "operators," command a small and temporary[57] yet intensive industrial operation to drill and fracture each well. After testing for the presence of gas and acquiring property rights and permits, an operator builds a well site and access road to the site, where all of the drilling activity will occur.[58] The operator brings water, drilling materials, rigs, trailers, and other equipment and materials to the site,[59] and then begins the drilling process. In many of the shale and tight sandstone formations currently being developed, operators drill thousands of feet below ground,[60] applying various fluids and muds as they cut through layers or rock.

Following the drilling process and initial disposal of drilling wastes, the operator hydraulically fractures the well. As part of a modified fracturing practice developed in the 1990s and now commonly used,[61] the operator withdraws millions of gallons of water from either surface waters or an underground aquifer.[62] The operator then trucks chemicals to the site and

[56] *See, e.g.*, David Spence, *Federalism, Regulatory Lags, and the Political Economy of Energy Production*, 161 U. PA. L. REV. 431, 440-42 (2013) (describing the displacement of coal-fired power plants with gas and the lower conventional and greenhouse gas emissions from gas-fired plants).

[57] *See* N.Y. STATE DEP'T OF ENVTL. CONSERVATION, REVISED DRAFT: SUPPLEMENTAL GENERIC ENVIRONMENTAL IMPACT STATEMENT ON THE OIL, GAS, AND SOLUTION MINING REGULATORY PROGRAM 5-139 (2011), *available at* http://www.dec ny.gov/data/dmn/rdsgeis full0911.pdf (describing production equipment that remains at the well pad, including pressure control equipment).

[58] *Id*. at 5-6 to 5-8.

[59] *See* NAT'L PARK SERV., DEVELOPMENT OF THE NATURAL GAS RESOURCE IN THE MARCELLUS SHALE 9 (2009), *available at* http://www.marcellus.psu.edu/resources/PDFs/ marcellusshalereport09.pdf (showing the equipment on site).

[60] *See* HALLIBURTON, U.S. SHALE GAS: AN UNCONVENTIONAL RESOURCE, UNCONVENTIONAL CHALLENGES 3-5 (2008), *available at* http://www halliburton.com/public/ solutions/contents/shale/related_docs/H063771.pdf (describing drilling and fracturing depths).

[61] *See* David F. Martineau, *Expansion of the Barnett Shale Play Fort Worth Basin – Texas*, 2004 ROCKY MTN. MIN. L. INST. 5-10 (describing the first slick water frac in 1997 in Texas).

[62] N.Y. STATE DEP'T OF ENVTL. CONSERVATION, *supra* note 57, at 5-93 to 5-94 (estimating that between 2.4 and 7.8 million gallons of water are used for each horizontal

stores them there temporarily, mixes these chemicals with the water, and injects this mixture down the well at high pressure to crack the shale or tight sandstone formation and facilitate the release of gas or oil.[63] Some of the fracturing fluid flows back up out of the well as "flowback" waste, which is also stored in a surface pit or tank, and then disposed of through a wastewater treatment plant, injection into an underground disposal well, or reuse at another fracturing job.[64]

After the well is completed and secured for long-term production, waste in the form of natural "produced water" from the formation comes out of the well over its production life.[65] This water contains high levels of salts[66] and, often, low levels of naturally occurring radioactive substances.[67] The operator stores the waste in a pit or tank on the surface of the well site, and, as with flowback, the operator disposes of the waste through underground injection, reuse, or a wastewater treatment plant.[68]

States have primary regulatory control over most of these activities. They require each operator to limit and contain erosion at well sites while they construct the site and access road.[69] At the drilling stage, operators must install strong steel lining within wells; this "casing" prevents oil and gas from seeping from the wells into aquifers below ground.[70] States also require that operators

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fractured well).

[63] *Id*. at 5-5 ("The proppant holds the fractures open, allowing hydrocarbons to flow into the wellbore after injected fluids are recovered.").

[64] EPA, PLAN TO STUDY THE POTENTIAL IMPACTS OF HYDRAULIC FRACTURING ON DRINKING WATER RESOURCES 48 (2011), *available at* http://www.epa.gov/hfstudy/HF_Study__Plan_110211_FINAL_508.pdf ("Underground injection is the primary method for disposal in all major gas shale plays, except the Marcellus Shale.").

[65] *See* Joseph Dancy, *Solid Waste Management and Environmental Regulation of Commonly Encountered Oil Field Wastes*, 35A ROCKY MTN. MIN. L. SPECIAL INST. 5-17 to 5-19 (1994) (describing produced water).

[66] *Id*. at 5-17 (describing an average total dissolved solids level that "exceeds the solids content of seawater").

[67] *See* N.Y. STATE DEP'T OF ENVTL. CONSERVATION, *supra* note 57, at 6-205 ("[P]roduction brine is known to contain elevated NORM levels.").

[68] GOV'T ACCOUNTABILITY OFFICE, GAO-12-156, ENERGY-WATER NEXUS: INFORMATION ON THE QUANTITY, QUALITY, AND MANAGEMENT OF WATER PRODUCED DURING OIL AND GAS PRODUCTION 14 (2012), *available at* http://www.gao.gov/assets/590/587522.pdf (observing that "underground injection is the predominant practice" for disposing of produced water, but that discharging it to surface waters, irrigating crops, allowing it to dry in pits, and recycling it for hydraulic fracturing also occurs).

[69] 33 U.S.C. § 1251(b) (2012); *Authorization Status for EPA's Stormwater Construction and Industrial Programs*, EPA, http://cfpub.epa.gov/npdes/stormwater/authorizationstatus.cfm (last updated Sept. 10, 2013).

[70] *See* Hannah Wiseman & Francis Gradijan, *Regulation of Shale Gas Development, Including Hydraulic Fracturing* 49-63 (Ctr. for Global Energy, Int'l Arbitration & Envtl. Law, Univ. of Tex. Sch. of Law, 2012), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1953547 (describing regulations of casing in sixteen states and collecting

store drilling and other wastes in pits or tanks to prevent pollution at the surface,[71] and that they follow certain approved disposal methods.[72] Historically, these regulations have been relatively effective.[73] With wells doubling or tripling in number over the past few years, however,[74] the harms of drilling and fracturing have become more apparent.[75] The modified type of fracturing technology used by operators has introduced some new risks, but the bulk of the problems appear to arise at the more common stages of the well development process – during drilling and the storage and disposal of wastes.[76]

1. Independent-Probability Risks that Accumulate

Many of these stages of the drilling and fracturing process have caused independent harms associated with diseconomies of scale, in which harms appear to increase relatively evenly as the activity expands. For harms with independent risks, such as the likelihood of a spill occurring at a site or a well being improperly cased, the probability of an incident occurring at any one shale gas or oil site has not, in many cases, risen substantially. Yet when one multiplies this risk by nearly 2000, as in Pennsylvania,[77] or by more than 16,000, as in the case of north central Texas,[78] more incidents are likely to occur. The risks of chemical or waste spills, air pollution, improper disposal of waste, and other incidents have grown simply because there are more wells in a given area.[79] Improperly lined wells sometimes leak methane during drilling,

sources).

[71] *See id.* at 106-11.

[72] *See id.* at 112-24.

[73] *See* N.Y. STATE DEP'T OF ENVTL. CONSERVATION, *supra* note 57, at app. 15 (describing multiple statements by state regulators indicating that fracturing had never contaminated groundwater).

[74] *See supra* note 20 and accompanying text.

[75] *See, e.g.*, EPA, *supra* note 64 (responding, in 2011, to a 2009 request from Congress that the EPA study the risks of fracturing to groundwater).

[76] *See* Wiseman, *supra* note 6, at 751 (assessing violations of state laws at drilled and fractured well sites in recent years and observing those that have been the most common).

[77] *See* Bureau of Oil & Gas Mgmt., *Wells Drilled, 2011 January-November*, PA. DEP'T ENVTL. PROT., http://www.dep.state.pa.us/dep/deputate/minres/oilgas/2011%20Wells%20 Drilled.gif (last updated Dec. 5, 2011) (showing 1751 Marcellus Shale wells drilled in 2011).

[78] *See Newark, East (Barnett Shale) Field Discovery Date – 10-15-1981*, R.R. COMM'N OF TEX., http://www.rrc.state.tx.us/data/fielddata/barnettshale.pdf (last visited Oct. 24, 2013) (describing 16,346 Barnett Shale gas wells "on RRC records and additional permitted locations").

[79] *But see* GOV'T ACCOUNTABILITY OFFICE, GAO-12-732, OIL AND GAS: INFORMATION ON SHALE RESOURCES, DEVELOPMENT, AND ENVIRONMENTAL AND PUBLIC HEALTH RISKS 4 (2012), *available at* http://www.gao.gov/assets/650/647791.pdf ("The risks identified in the studies and publications we reviewed cannot, at present, be quantified . . . .").

contaminating basements, water wells, and nearby springs.[80] Diesel from drilling or rigs and trucks occasionally spills at well sites or along access roads – sometimes entering nearby surface waters.[81] Produced water and other drilling wastes similarly spill as they are being transferred from the well,[82] or they leak from storage pits and tanks.[83] Operators at sites around the country also have spilled fracturing fluids and flowback,[84] and flowback storage units have, collectively, leaked thousands of gallons of wastes.[85]

Above the surface, higher levels of drilling and fracturing activity release more air pollution in a particular region than would be emitted from less concentrated wells;[86] rigs and other diesel equipment operating at the surface emit nitrogen oxide, carbon monoxide, and other pollutants;[87] and the fracturing process and flowback water send volatile organic compounds into the air.[88] Wells and pipelines carrying gas from the site also emit methane, a

[80] *See* Stephen G. Osborn et al., *Methane Contamination of Drinking Water Accompanying Gas-Well Drilling and Hydraulic Fracturing*, 108 PROC. NAT'L ACAD. SCI. 8172, 8175 (2011), *available at* http://www.pnas.org/content/early/2011/05/02/1100682108.full.pdf+html (identifying "leaky gas well casings" as a "possible mechanism" for "fluid [and methane] migration into . . . shallow drinking-water aquifers"); Wiseman, *supra* note 6, at 778-82 (describing methane leakage incidents identified in public records requests).

[81] *See, e.g.*, *Oil and Gas Compliance Report*, *supra* note 22 (locate Well Permit 115-20293 in search results) (reporting that at a Marcellus Shale site, after two fuel tank trucks collided at the page entrance "[t]he fuel tank was damaged and leaked approximately 15 gallons of diesel fuel"); *OCD Permitting Spill Search*, N.M. OIL CONSERVATION DIV., https://wwwapps.emnrd.state nm.us/ocd/ocdpermitting/Data/Incidents/SpillSearchResults.aspx?Api=30-039-30557 (last visited Nov. 17, 2013) (describing a fuel pump split at a tight sandstones well site that released 1000 gallons of diesel, 100 of which were later recovered).

[82] *See* Wiseman, *supra* note 6, at 799-801 (describing produced water spills).

[83] *See, e.g.*, *OCD Permitting: 30-039-25947*, N.M. OIL CONSERVATION DIV., https://wwwapps.emnrd.state nm.us/ocd/ocdpermitting/Data/WellDetails.aspx?api=30-039-25947 (last visited Oct. 16, 2013) (stating that 142 barrels of produced water spilled from a production tank and seventy barrels were recovered); *see also* Wiseman, *supra* note 6, at 788-92 (describing leaks from pits and tanks).

[84] *See* Wiseman, *supra* note 6, at 766-70 (describing flowback spills).

[85] *See id.* (concluding that the spills, measured in barrels and gallons, collectively amount to thousands of gallons).

[86] *See, e.g.*, *Air Emissions Requirements for Oil and Gas Industry*, COLO. DEP'T OF PUB. HEALTH & ENV'T, http://www.colorado.gov/cs/Satellite?c=Page&childpagename=CDPHE-AP%2FCBONLayout&cid=1251597643322&pagename=CBONWrapper (last visited Oct. 8, 2013) (making note of "emissions of volatile organic compounds [from oil and gas condensate tanks] that contribute to the formation of ozone," and targeting these emissions in the Front Range ozone nonattainment area and throughout the state).

[87] *See* N.Y. STATE DEP'T OF ENVTL. CONSERVATION, *supra* note 57, at 6-100 (showing nitrogen oxide, carbon monoxide, and other emissions from engines used at well sites).

[88] EPA, PROPOSED AMENDMENTS TO AIR REGULATIONS FOR THE OIL AND NATURAL GAS INDUSTRY: FACT SHEET 2, *available at* http://epa.gov/airquality/oilandgas/pdfs/20110728factsheet.pdf ("During a stage of well completion known as 'flowback,' fracturing fluids, water,

potent greenhouse gas.[89] The more these types of activities occur, the larger the collective harms.

Because these sorts of environmental impacts have long occurred at oil and gas sites, many regulations already address them. For example, states require spill control and response plans that instruct operators to train employees to prevent spills and to clean spills up quickly when they do occur.[90] Many states also specify that surface pits containing oil and gas wastes must be lined to prevent the pits from leaking,[91] or, more rarely, that wastes must be stored in watertight tanks rather than in pits.[92]

As discussed in more detail in Part II, despite existing laws that address many of the independent probability risks of expanding oil and gas development, agency design often has prevented states from enforcing these regulations at even rates. As well numbers rise, inspectors might not be able to visit as many new sites and might fail to issue fines or orders to remediate sites where incidents occur.[93] Indeed, although some states like Ohio and Pennsylvania have expanded staffing levels in response to the boom,[94] staffing

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and reservoir gas come to the surface at a high velocity and volume. This mixture includes a high volume of VOCs and methane, along with air toxics such as benzene, ethylbenzene and n-hexane.").

[89] For estimates of methane leakage, see, for example, David T. Allen et al., *Measurements of Methane Emissions at Natural Gas Production Sites in the United States*, 110 PROC. NAT'L ACAD. SCI. 17768, 17769 (2013), http://www.pnas.org/content/early/2013/09/10/1304880110 full.pdf; Ramón A. Alvarez et al., *Greater Focus Needed on Methane Leakage from Natural Gas Infrastructure*, 109 PROC. NAT'L ACAD. SCI. 6435, 6438 (2012); Gabrielle Pétron et al., *Hydrocarbon Emissions Characterization in the Colorado Front Range: A Pilot Study*, J. GEOPHYSICAL RES., Feb. 2012, at 1, 13-17.

[90] *See* Wiseman & Gradijan, *supra* note 70, at 95-98 (describing spill requirements and collecting sources).

[91] *See id.* at 108-09.

[92] *Id.* (showing that some states require or have proposed to require tanks).

[93] *See, e.g.*, Edward McCallister, *Insight: NY Water at Risk from Lack of Natgas Inspectors?*, REUTERS (July 29, 2011, 1:49 PM), http://www reuters.com/article/2011/07/29/us-newyork-shale-drilling-idUSTRE76S5FA20110729 ("[T]he [New York] state Department of Environmental Conservation (DEC) has only 14 well inspectors to oversee 13,000 wells. With staff and budget constraints, the agency will struggle to keep up with the flood of drilling applications expected from companies keen to develop untapped reserves should the state lift its ban."); Email from Leslie Savage, Chief Geologist, Railroad Commission of Tex. to author, Feb. 27, 2012, 9:01 AM (responding to the Author's question regarding why, in the violation data the Author received, there were "fewer enforcements for the end of 2009 through 2011" as compared to 2008). The email explained: "[The Commission] underwent a hiring freeze beginning in 2009 and lost personnel. Legal Enforcement was down two attorneys and field operations was also short of personnel." *Id.*

[94] *See* PA. DEP'T OF ENVTL. PROT., MARCELLUS SHALE: TOUGH REGULATIONS, GREATER ENFORCEMENT 1 (2013), *available at* http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-95071/0130-FS-DEP4288.pdf ("Throughout 2009 and 2010, DEP more than

numbers have remained relatively level in states like Louisiana[95] where thousands of new wells are being developed.[96]

2. Interdependent Harms

A number of incidents in unconventional gas development appear to involve activity that expands rapidly in certain regions. As well numbers grow, several risks emerge that grow interdependently; like other systemic risks,[97] they become disproportionately large due to a confluence of certain events.

For example, as wells become denser, they might be drilled at the same time and during certain weather conditions; these factors of density, location, and timing can converge to cause substantial harms. This is most apparent in the context of water withdrawals for hydraulic fracturing. Well operators cannot fully control when fracturing will occur – they must wait until they have properly drilled and tested the well, and for the contractor who conducts fracturing operations to arrive at the site.[98] If conditions combine to cause a large number of wells to be fractured in one area at the same time, numerous operators might withdraw water from one surface source – driving trucks to a river, inserting a hose, and pumping out water at high rates.[99] This activity could remove the last increment of water volume necessary to protect certain

doubled the number of inspectors. In 2011 and 2012, DEP conducted more inspections of oil and gas well sites than ever before."); *ODNR Hiring 70 Employees to Regulate Shale Wells*, WOUB PUB. MEDIA (May 8, 2012, 4:47 PM), http://woub.org/2012/05/08/odnr-hiring-70-employees-regulate-shale-wells ("The Ohio Department of Natural Resources says it is hiring 70 more employees to regulate an increase in oil and gas drilling.").

[95] *See* Hannah Wiseman, *Regulatory Risks in Tight Oil and Gas Development*, 29 NAT. GAS & ELECTRICITY 6, 8 (2012) (showing the number of Louisiana inspectors and providing sources for this information).

[96] *Louisiana State Oil and Gas Drilling Permits Issued by Type*, LA. DEP'T OF NATURAL RES., http://dnr.louisiana.gov/assets/TAD/data/facts_and_figures/table22 htm (last updated Aug. 25, 2013) (showing spikes in well permits issued from 2005 to 2008).

[97] David M. Driesen, *Climate Disruption: An Economic Dynamic Approach*, 42 ENVTL. L. REP. NEWS & ANALYSIS 10,639, 10,640 (2012) (defining systemic risks in the climate context as involving a "serious disturbance in fundamental physical systems"); Steven L. Schwarcz, *Systemic Risk*, 97 GEO L.J. 193, 204 (2008) (defining "systemic risk" in a financial context as "(i) an economic shock such as market or institutional failure triggers (through a panic or otherwise) either (X) the failure of a chain of markets or institutions or (Y) a chain of significant losses to financial institutions, (ii) resulting in increases in the cost of capital or decreases in its availability, often evidenced by substantial financial-market price volatility," but strictly limiting this to an "economic, not a political definition" used only to describe very limited types of financial risk).

[98] *See, e.g.*, *Policy on Hydraulic Fracturing Fluids*, CABOT OIL & GAS CORP., http://www.cabotog.com/pdfs/Frackingfluidpolicy.pdf (last visited Oct. 16, 2013) (describing Cabot's requirements for its contractors who conduct hydraulic fracturing).

[99] N.Y. STATE DEP'T OF ENVTL. CONSERVATION, *supra* note 57, at 6-2 ("Water for hydraulic fracturing may be obtained by withdrawing it from surface water bodies or new or existing water-supply wells drilled into aquifers.").

species in the stream.[100] This type of concern led one regional regulatory agency in Pennsylvania to shut down a number of fracturing operations during a period of summer drought[101] – in part because the agency has an unusual scale-based regulation that includes a harm threshold.[102] If states do not adequately monitor activity conducted at a particular time, they risk missing these types of interdependent harms. Indeed, in a regulatory system that demonstrates the inertia created by regulations with an inadequate harm-regulatory balance, some states currently do not even regulate water withdrawals. It appears that states fail to regulate in part because when they initially address potential harms from this activity, they assume de minimis impacts (particularly for small, individual water withdrawals);[103] water withdrawals for fracturing quickly eviscerate this assumption.

Denser oil and gas wells within a particular region also could be developed closer to fragile or unstable environments as total well numbers grow, causing another type of interdependent harm – one that differs depending on the environment in which the activity is conducted. The regional Delaware River Basin Commission worries, for example, that in the Delaware River watershed, well site construction and operation, as well as the equipment required for the extraction of water for fracturing, will send harmful sediment into the Basin's "Special Protection Waters."[104] Other stages of the well development process, including disposal of wastes, can also generate disproportionate harms due to their location. As introduced previously, in Texas, a disposal well that accepted thousands of gallons of salty oil and gas wastes from wells in the Crittendon

[100] *Cf. Natural Gas and Wildlife*, U.S. FISH & WILDLIFE SERV., http://www fws.gov/northeast/EcologicalServices/energygas html (last updated May 22, 2012) ("[W]ater withdrawals from certain streams and rivers, or at certain times of year, can harm aquatic species, including federally listed freshwater mussels.").

[101] Press Release, Susquehanna River Basin Comm'n, 64 Water Withdrawals for Natural Gas Drilling and Other Uses Suspended to Protect Streams (July 16, 2012), *available at* http://www.srbc.net/newsroom/NewsRelease.aspx?NewsReleaseID=90 ("64 separate water withdrawals approved by SRBC are suspended due to lower streamflow levels in the Susquehanna basin.").

[102] *Id*. ("Under SRBC's passby flow restrictions, when streams drop to predetermined protected low flow levels, operators who are required to meet the agency's passby requirement must stop taking water.").

[103] *See State Water Withdrawal Regulations*, NAT'L CONF. STATE LEGISLATURES, http://www ncsl.org/issues-research/env-res/state-water-withdrawal-regulations.aspx (last visited Oct. 9, 2013) (summarizing state regulations and showing that some states do not regulate withdrawals deemed "insignificant"). Most withdrawals for fracturing will exceed the significance threshold, but in states that do not require permits at all – even for large withdrawals of water – the activity remains unregulated. *Id.*

[104] DEL. RIVER BASIN COMM'N, NATURAL GAS DEVELOPMENT REGULATIONS § 7.4(d) (proposed Nov. 8, 2011), *available at* http://www.state nj.us/drbc/library/documents/naturalgas-REVISEDdraftregs110811.pdf (describing proposed safeguards to control the amount of sediment that enters "Special Protection Waters").

Field (for which it is not clear whether the wells were fractured), leaked waste into the City of Midland's nearby drinking water aquifer, polluting billions of gallons of water.[105] Similar disposal wells in Ohio, which accepted waste from fractured wells in Pennsylvania and Ohio, were located in seismically unstable zones and caused small earthquakes.[106] Disposal wells have induced seismic activity in other states,[107] yet Ohio and Arkansas appear to be the only states to have updated their disposal well construction requirements. Ohio requires formal consideration of seismic data and continuous monitoring of disposal wells post-construction,[108] and Arkansas has placed a moratorium on permanent disposal wells in certain unstable areas.[109]

Finally, interdependent effects in drilling and fracturing also emerge due to reliance on pollution treatment technologies that cannot adequately treat wastes above a certain threshold. Pollution control technologies have physical limits: they capture and treat certain types and quantities of pollutants; pollution that exceeds these physical limits is released, untreated, into the environment.[110] As gas drilling boomed in Pennsylvania, the sheer quantity of chemical-laden wastewaters produced threatened to cause this type of threshold effect at wastewater treatment plants,[111] although it is still not clear whether waste caused any measurable environmental problems.[112] The state does not have

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[105] City of Midland, *supra* note 33.

[106] OHIO DEP'T OF NATURAL RES., *supra* note 32, at 3 ("A number of coincidental circumstances appear to make a compelling argument for the recent Youngstown-area seismic events to have been induced . . . .").

[107] *See* Keranen et al., *supra* note 32.

[108] *Youngstown FAQ*, OHIO DEP'T OF NATURAL RES. 2, http://ohiodnr.com/downloads/northstar/YoungstownFAQ.pdf (last visited Oct. 16, 2013).

[109] 178-00-001 ARK. CODE R. pt. H, r. H-1(s)(2) (LexisNexis 2012); *Permanent Disposal Well Moratorium Area*, ARK. OIL & GAS COMM'N (June 20, 2011), http://www.aogc.state.ar.us/notices/Ex.%201B%20-Permanent%20Disposal%20Well%20Moratorium%20Area.pdf.

[110] *Cf., e.g.*, 33 U.S.C. § 1317 (2012) (prohibiting pollution that interferes with or otherwise impedes the operation of pollution control technologies at wastewater treatment plants).

[111] *See* Letter from Shawn M. Garvin, Region 3 Adm'r, EPA, to Michael Krancer, Acting Sec'y, Pa. Dep't of Envtl. Prot. 1 (Mar. 7, 2011), *available at* http://www.epa.gov/region3/marcellus_shale/PADEP_Marcellus_Shale_030711.pdf (expressing concerns about inadequate treatment of wastewater).

[112] *See id.* (stating that further investigations would be needed to determine the threat to water quality, if any); Letter from Michael L. Krancer, Acting Sec'y, Pa. Dep't of Envtl. Prot., to Shawn M. Garvin, Region 3 Adm'r, EPA 1 (Apr. 6, 2011), *available at* http://www.epa.gov/region03/marcellus_shale/Shawn_Garvin_Letter-April_6_2011.pdf (suggesting that no water quality standards for plants that accepted treated wastes from shale gas wells had been violated); Letter from Shawn M. Garvin, Region 3 Adm'r, EPA, to Michael Krancer, Acting Sec'y, Pa. Dep't of Envtl. Prot. 1 (May 12, 2011), *available at* http://www.epa.gov/region03/marcellus_shale/pdf/letter/krancer-letter5-12-11.pdf (expressing further concerns about the adequacy of wastewater treatment).

enough underground injection-control well capacity to accept drilling and fracturing wastes.[113] As operators drilled thousands of new wells, producing large quantities of liquid wastes containing salts and low levels of radioactive substances, operators sent the wastes to wastewater treatment plants. After the *New York Times* published an alarmist account of this situation – suggesting that plants were releasing radioactive waters into rivers[114] – the EPA took note, demanding that the State's Department of Environmental Protection (DEP) address the situation and asking operators for disposal information.[115] The DEP insisted that it tested stream waters below wastewater treatment plant discharges and found no water quality violations,[116] but the EPA continued investigating.[117] The DEP eventually discouraged operators from sending wastes to treatment plants, thus causing most wastes to be sent to Ohio injection wells.[118]

In each of these scenarios of interdependent harm, activity conducted at a different time or place, at a lower activity rate, or without reliance on a limited treatment technology, might have had simple, independent effects with predictably collective impacts. But due to unique circumstances, including the increased density of well sites in some regions, inadequate pollution control or prevention techniques, and new well locations, among other factors, even small increases in unconventional well development activity have caused environmental harm in some cases. It is not clear how common these types of events will be in unconventional oil and gas development going forward. Indeed, although some of these effects are foreseeable – for example, we know that drilling a disposal well close to an aquifer might be risky – others might be impossible to predict. Policymakers must seriously consider the potential for interdependent effects from the growth of oil and gas development, and must address this risk ex ante. If policymakers know that certain pollutants will interact, for example, they should limit the concentration of activities that generate these pollutants; if they are aware that certain activities will pose higher risks near sensitive areas, they should limit the location of these activities. In cases where the effects cannot be known in advance, agencies

[113] *See* McCurdy, *supra* note 35, at 23 (describing the "[l]ack of [s]uitable [d]isposal [i]nfrastructure" in Pennsylvania).

[114] Ian Urbina, *Regulation Lax as Gas Wells' Tainted Water Hits Rivers*, N.Y. TIMES, Feb. 27, 2011, at A2, *available at* http://www nytimes.com/2011/02/27/us/27gas html ("The documents reveal that the wastewater, which is sometimes hauled to sewage plants not designed to treat it and then discharged into rivers that supply drinking water, contains radioactivity at levels higher than previously known, and far higher than the level that federal regulators say is safe for these treatment plants to handle.").

[115] Letter from Shawn M. Garvin to Michael Krancer, *supra* note 111, at 2.

[116] Letter from Michael L. Krancer to Shawn M. Garvin, *supra* note 112, at 1.

[117] *See* Letter from Shawn M. Garvin to Michael Krancer, *supra* note 112, at 1 (again expressing concerns about "the disposal of Marcellus Shale wastewater").

[118] *See* McCurdy, *supra* note 35, at 23 (indicating that produced water waste was trucked to Ohio and West Virginia).

must, at minimum, prepare to respond nimbly when effects are discovered, as discussed in Part II.

3. Uneven Impacts

In a third diseconomy of scale, either the independent or interdependent harms of an activity may concentrate in certain areas, thus causing uneven distributions of impacts – harms that that were unaddressed in the initial regulatory balance. This is similar to certain interdependent harms, in which well density and location matter, but the relevant question in this case is the proximity of the activity to humans rather than to a sensitive environment or unstable area. In the oil and gas context, homeowners have complained that well development on neighboring properties contaminated their property and harmed their health.[119] While their neighbors accumulate wealth from the oil and gas lease, these individuals allege that they suffer the harms of the development lease without compensation.[120]

Oil and gas development and associated activities also can disproportionately affect people who live in areas where development materials are mined or oil and gas wastes are disposed of. Fracturing companies require large quantities of sand, which they inject down the well to prop open fractures in shale formations, and communities in states like Wisconsin have experienced rapid growth in sand mining and associated water and air pollution.[121] And at the waste disposal stage, operators in Pennsylvania that could not send liquid oil and gas wastes to wastewater treatment plants shipped the waste to Ohio,[122] causing more truck traffic,[123] road damage, and congestion on certain routes.[124]

Expanding oil and gas development also affects certain communities more than others because of economic factors. Drilling rigs in areas with abundant gas will quickly move to oil-rich regions if the price of gas drops below a

[119] *See, e.g.*, Complaint at Law & in Equity at 9, Berish v. Sw. Energy Prod. Co., 763 F. Supp. 2d 704 (M.D. Pa. 2011) (No. 10 Civ. 1981) (stating that plaintiffs and their minor children, who lived near a drilled and fractured well in Pennsylvania, complained that "[p]ollutants and industrial and/or residual waste, including 'fracking fluid,' was [sic] caused to be discharged into the ground or into the waters near Plaintiffs' homes and into ground water wells").

[120] *See id.* (alleging harm to plaintiffs and their properties).

[121] *See* WIS. DEP'T OF NATURAL RES., SILICA SAND MINING IN WISCONSIN 1 (2012), *available at* http://dnr.wi.gov/topic/Mines/documents/SilicaSandMiningFinal.pdf ("Sand mining has occurred in Wisconsin for hundreds of years; however, recently there has been a dramatic increase in the number of mining proposals. This increase is attributed to a surge in *hydrofracking* . . . .").

[122] *See supra* note 35 and accompanying text.

[123] *See, e.g.*, R.R. Comm'n of Tex. v. Tex. Citizens for a Safe Future & Clean Water, 336 S.W.3d 619, 622 (Tex. 2011) (describing unrebutted evidence of "large trucks used to haul waste water" to underground injection control wells).

[124] *See id.*

certain threshold, leaving communities to suffer rapid boom and bust cycles.[125] In some cases, communities build thousands of new housing units and provide new infrastructure for rapidly growing populations of workers only to be stuck with expensive, abandoned structures as workers leave.[126]

The social sciences and environmental justice literatures have explored these types of problems in depth,[127] and these scholarly discussions are very relevant to regulatory diseconomies of scale. Many diseconomies will have independent and interdependent effects that fall within the boundaries of one jurisdiction – leading scholars like Professor David Spence to propose, in the oil and gas context, that governance of these impacts should primarily occur at the local or state level to capture these externalities more effectively.[128] Even when harms remain within one governmental boundary, they might be addressed inadequately because policymakers, despite having full authority over the problem, fail to recognize (or purposefully ignore) changing scale as a trigger

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[125] *See, e.g.*, JEFFREY JACQUET, ENERGY BOOMTOWNS & NATURAL GAS: IMPLICATIONS FOR MARCELLUS SHALE LOCAL GOVERNMENTS & RURAL COMMUNITIES 1-3 (2009), *available at* http://aese.psu.edu/nercrd/publications/rdp/rdp43/view (surveying the boomtown literature and describing boom and bust cycles in the past).

[126] *See, e.g.*, CITY OF WILLISTON, WILLISTON IMPACT STATEMENT 2012, at 5, 11, 13 (2012), *available at* http://www.willistonnd.com/usrimages/Williston_Impact_Statement.pdf (showing a six-year projection of $625.4 million in infrastructural investments to support North Dakota's booming shale oil industry, the addition of 1816 new housing units in 2012, and the addition of twelve new hotel properties since 2010).

[127] *See, e.g.*, U.S. GEN. ACCOUNTING OFFICE, GAO/RCED-83-168, SITING OF HAZARDOUS WASTE LANDFILLS AND THEIR CORRELATION WITH RACIAL AND ECONOMIC STATUS OF SURROUNDING COMMUNITIES 2 (1983) (exploring "the correlation between the location of hazardous waste landfills and the racial and economic status of surrounding communities"); Daniel A. Farber, *The B.P. Blowout and the Social and Environmental Erosion of the Louisiana Coast*, 13 MINN. J.L. SCI. & TECH. 37, 38-39 (2012) ("Long before oil began to spew into the Gulf of Mexico on April 20, 2010, the Gulf had been paying the price for unchecked development, aggressive extraction of oil and natural gas, and an attitude of indifference to environmental consequences."); Hari M. Osofsky et al., *Environmental Justice and the BP* Deepwater Horizon *Oil Spill*, 20 N.Y.U. ENVTL. L.J. 99, 115 (2012) (concluding that, because oil and gas exploration and production wastes are exempt from federal hazardous waste disposal regulation, "the oil-soaked containment booms, oil-contaminated debris, oil-contaminated soils, tar balls, tar patties, and oil-contaminated vegetative debris from the BP *Deepwater Horizon* Oil Spill were disposed of in Subtitle D municipal solid waste landfills in Gulf Coast communities"); Robert B. Wiygul & Sharon Carr Harrington, *Part One: RCRA, Communities, and Environmental Justice*, 96 W. VA. L. REV. 405, 416 (1993-1994) (explaining that these protests – which largely sparked the environmental justice movement – occurred in a rural community); *see also* COMM'N FOR RACIAL JUSTICE, UNITED CHURCH OF CHRIST, TOXIC WASTES AND RACE IN THE UNITED STATES 2 (1987), *available at* http://www.ucc.org/about-us/archives/pdfs/toxwrace87.pdf (describing civil disobedience in opposition to a proposed polychlorinated biphenyl disposal facility in a poor, black North Carolina county in 1982).

[128] Spence, *supra* note 56, at 508.

for needed regulatory change. In some cases of unevenly distributed harms, however, effects may spill beyond existing jurisdictional boundaries; these can cause regulatory-commons type problems described by William Buzbee.[129] In a regulatory commons, many government actors have control over one piece of a large problem – one that often occurs within several different jurisdictional territories – but none have full control over or the incentive to fix the entire problem.[130] This leads to major gaps in authority and requires coordination of actors, and sometimes reallocation of governmental authority, to fix the problem.[131]

4. Inadequate Regulatory Response

The disproportionate harms (as compared to regulatory costs) that appear to accompany growing oil and gas development are exacerbated by certain governments' failures – or refusals – to acknowledge the potential effects or address them. In Oklahoma, which has changed few of its substantive controls on drilling and fracturing despite expanding shale gas development,[132] this problem is apparent. In response to concerns that growing gas development might cause groundwater contamination, the Oil and Gas Commission defended existing policies rather than innovating:

> While there have been incidents of groundwater contamination associated with oil and gas drilling and production operations in the State of Oklahoma, none of the documented incidents have been associated with hydraulic fracturing. Our agency has been regulating oil and gas drilling and production operations in the state for over 90 years.[133]

With the acknowledgment that familiar processes of oil and gas production sometimes cause groundwater contamination – and that fracturing speeds up these familiar processes by allowing more wells to be drilled – one might have

[129] *See* William W. Buzbee, *Recognizing the Regulatory Commons: A Theory of Regulatory Gaps*, 89 IOWA L. REV. 1 (2003).

[130] *See id.* at 8-14, 23, 31 (describing how aquaculture, urban sprawl, and global warming provide examples of regulatory commons problems, and the limited authority and other disincentives that cause governments to inadequately address these issues).

[131] *Id.* at 56-57 (concluding that, when diverse actors cause cumulatively large harms, often throughout several jurisdictions, "[u]tilizing both more central or large units of government and small governmental units will be necessary, with different tasks allocated to each").

[132] *But see* STRONGER, OKLAHOMA HYDRAULIC FRACTURING STATE REVIEW 4 (2011), *available at* http://www.strongerinc.org/documents/Final%20Report%20of%20OK%20HF%20Review%201-19-2011.pdf (explaining that Oklahoma will include a review of hydraulic fracturing regulation in its broader, five-year strategic review of its oil and gas regulatory program).

[133] N.Y. STATE DEP'T OF ENVTL. CONSERVATION, *supra* note 57, at app. 15 (including the statement of Lori Wrotenbery, Director of the Oil and Gas Conservation Division, Oklahoma Corporation Commission).

expected the following response: "Because changes to a technology called fracturing have enabled the development of more oil and gas wells in the state, the Commission will ensure that increased rates of drilling do not cause continued groundwater contamination that has occurred in the past in association with drilling." No such assurances, however, were forthcoming.

The Railroad Commission of Texas, which regulates oil and gas extraction in Texas, has also, for the most part, ignored the fact that the simple expansion of traditional well development practices could cause new or larger problems. The Commission explains that "it has been regulating the oil and gas industry for more than 90 years" and "has in place a successful regulatory framework to ensure that all oil and gas activities, including hydraulic fracturing, do not impact groundwater or surface water."[134] Texas, like Oklahoma, has changed few of its oil and gas regulations[135] as the number of hydraulically fractured shale gas wells has boomed.[136]

Other states, facing likely booms in the near future, have come closer to recognizing and responding to the problem, but have failed to fully recognize the issue as one that involves scale. The Secretary of West Virginia's Department of Environmental Protection, describing impending development of many shale gas wells in the state, observed:

> Quite frankly, our regulatory structure is not prepared to deal with [large numbers of new unconventional wells] . . . . All of a sudden we have, basically, a brand new industry that shows up on the scene. We see a lot of things, that quite frankly, the state was not prepared for.[137]

This statement looks to the wrong problem because it inaccurately suggests that gas drilling is new to West Virginia; some stages of the fracturing process are new, but, as in other states, gas drilling has long occurred in the state.[138] As

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[134] *Hydraulic Fracturing Frequently Asked Questions*, R.R. COMM'N OF TEX., http://www rrc.state.tx.us/about/faqs/hydraulicfracturing.php (last visited Oct. 26, 2013).

[135] *But see* R.R. COMM'N OF TEX., EAGLE FORD SHALE TASK FORCE REPORT (2013), *available at* http://www rrc.state.tx.us/commissioners/porter/reports/Eagle_Ford_Task_Force_Report-0313.pdf (suggesting possible changes to regulation or oil development practices); Hannah Wiseman, *The Private Role in Public Fracturing Disclosure and Regulation*, 3 HARV. BUS. L. REV. ONLINE 49, 54-55 (2013), http://www hblr.org/wp-content/uploads/2013/02/Wiseman_The-Private-Role-in-Public-Fracturing-Disclosure-and-Regulation.pdf (describing Texas's disclosure rule for chemicals, 16 TEX. ADMIN. CODE § 3.29(c)(2)(A)(ix)-(xi) (2012), which is relatively stringent in terms of allowing appeal of trade secret status claims by operators).

[136] *See Newark, East (Barnett Shale) Drilling Permits Issued*, *supra* note 6 ("Increasing water use due to growing population, drought, and Barnett Shale development has heightened concerns about water availability in North Central Texas.").

[137] Mike Soraghan, *Oil and Gas: Protecting Oil from Water – the History of State Regulation*, GREENWIRE (Dec. 14, 2011), http://www.eenews net/public/Greenwire/2011/12/14/1.

[138] *See, e.g.*, *Office of Oil and Gas*, W.V. DEP'T OF ENVTL. PROT., http://www.dep.wv.gov/oil-and-gas/Pages/default.aspx (last visited Oct. 26, 2013) (stating that the state's oil

described in the solutions outlined in Part II, other states have directly recognized the scaling problem in the oil and gas context and have begun to address it, which suggests that the challenge is not an insurmountable one. These positive responses provide models for addressing diseconomies in other contexts.

B. *Other Diseconomies*

Oil and gas is not the only field that experiences scaling problems; they also arise under portions of the Clean Air and Clean Water Acts. These examples from environmental law show the types of diseconomies that could plague a number of other regulated activities in which actors can cause disproportionate harms as activity expands.

1. Mobile Source Pollution Under the Clean Air Act

The mobile source portion of the federal Clean Air Act, like oil and gas regulation at the state level, focuses on individual sources; it largely ignores the fact that the number of these sources rapidly increases as our population grows, and that pollution from these sources rises as we drive more miles.[139] Indeed, many regions of the United States violate federal air quality requirements due to their inability under the Act[140] to adequately control emissions from fast-increasing numbers of mobile sources.[141]

A simplified hypothetical example, using fuel content and emissions controls as constants, demonstrates the familiar problem of controlling individual sources that have relatively benign effects at a small scale but larger ones as source numbers increase.[142] When combusted in a vehicle, assume that

and gas agency "maintains records on over 55,000 active and 12,000 inactive oil & gas wells").

[139] Andrew P. Morriss, *The Next Generation of Mobile Source Regulation*, 17 N.Y.U. ENVTL. L.J. 325, 327 (2008) (observing that "there are more Americans driving, and Americans are driving more, every year" and that in the commercial sector, as a result of adding more trucks to the road, increasing total miles driven, and increasing miles driven per truck, "[b]etween 1980 and 2004, the number of gallons of fuel burned by commercial trucks went from 19.96 million gallons to 33.968 million gallons").

[140] 42 U.S.C. § 7512a (2006) (requiring that, in certain areas with bad air quality, requiring states to revise their plans for implementing the Clean Air Act to "contain a forecast of vehicle miles traveled" and "provide for the implementation of specific measures to be undertaken" if vehicle miles traveled will exceed those forecasted or if the area fails to attain national standards for quantities of carbon monoxide in the ambient air).

[141] *See* Wilcox, *supra* note 37, at 4, 20 (indicating that automobiles are "the predominant source of transported ozone in many nonattainment areas," and that, "[d]espite technological advances in pollution control, primarily through measures that reduce emissions from automobiles, increases in population and in per capita consumption of energy have kept ambient ozone levels high").

[142] This cumulative impacts problem shows the "independent" diseconomy of scale described here, in which expansions of activity with individual, independent risks that

a highly refined fuel with oxygenating additives emits one gram of pollutant per mile driven regardless of the vehicle burning it. Hypothetically, an emission control technology installed on each manufactured vehicle further reduces emissions per mile driven by 0.5 grams, causing each vehicle to emit 0.5 grams of the pollutant per mile. When there are 100 vehicles on the road, total emissions per mile from the U.S. vehicle fleet are fifty grams of pollutant. When there are one million vehicles on the road, total emissions expand to 50,000 grams per mile. While actual mobile source controls are much more complicated, this hypothetical scenario captures the core elements of the problem. Technologies and fuel content are relatively constant, and regulatory controls are occasionally ratcheted up for new model years.[143] The number of cars and miles driven, on the other hand, varies widely and has remained on an upward trajectory.[144]

As a result of this and other activity, the EPA recently predicted that despite numerous interstate rules on stationary sources of ground-level ozone and particulate matter, as well as tighter mobile source controls, "a number of areas would remain out of attainment" under current air quality standards; even with proposed tighter controls, the agency predicted that fourteen regions of the country would still be out of attainment in 2015.[145]

This problem is not simply one involving collective pollution that causes greater harms than initially anticipated within regulation; there are interdependent effects as well. When it reaches certain critical levels, air pollution has more powerful effects in certain areas and can interact with other problems, thus magnifying harms as scale rises.[146] Interdependent harms can

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accumulate can change how harms rise as compared to regulatory costs and can throw off initial baseline assumptions in regulation. For discussions of cumulative impact, see *supra* note 4 and accompanying text.

[143] *See* 40 C.F.R. § 600.001 (2013).

[144] *See, e.g.*, *NPTS: Vehicles (1995)*, BUREAU OF TRANSP. STATISTICS, RESEARCH & INNOVATIVE TECH. ADMIN., http://www.transtats.bts.gov/DL_SelectFields.asp?Table_ID=1041&DB_Short_Name=NPTS (last visited Nov. 17, 2013) (select "Annmiles"; then "Download") (showing more than forty-three billion miles, annualized, driven in 1995 by more than 75,000 U.S. drivers); *NPTS: Vehicles (1990)*, BUREAU OF TRANSP. STATISTICS, RESEARCH & INNOVATIVE TECH. ADMIN., http://www.transtats.bts.gov/DL_SelectFields.asp?Table_ID=1035&DB_Short_Name=NPTS (last visited Nov. 17, 2013) (select "Annmiles"; then "Download") (showing more than seven billion miles, annualized, driven in 1990 by more than 40,000 U.S. drivers).

[145] Michael Bradley & John Bachman, Air Quality Mgmt. Subcomm., EPA, Challenges for Air Quality Management – A Look Ahead 1-2 (Aug. 2006) (unpublished manuscript; *available at* http://epa.gov/air/caaac/aqm/200608_challenges.pdf) (describing CAIR, which has since been replaced by the transport rule).

[146] *See* James D. Fine & Dave Owen, *Technocracy and Democracy: Conflicts Between Models and Participation in Environmental Law and Planning*, 56 HASTINGS L.J. 901, 922-23 (2005) (explaining that "[t]he chemistry that creates high levels of ozone . . . involves non-linear interactions that produce surprising and counterintuitive results" and describing

arise, for example, from interactions between air pollutants emitted by cars and power plants. Nitrogen oxides and hydrocarbons mix and, when heated by sunlight, form ground-level ozone,[147] which can cause health problems; the more of these pollutants are emitted from cars and other sources, the more ozone is formed.[148]

Many air pollutants disperse quickly, but others concentrate in certain areas, causing an uneven distribution of harm. As occurs in Southern California – an area chronically plagued with air pollution – a ring of mountains can trap pollution from cars and other sources.[149] Some pollution, and particularly the nitrogen oxide released from cars, also travels long distances and, due to prevailing wind patterns, affects certain downstream states more than others;[150] this has fomented decades-long battles over interstate air pollution control.[151]

2. Nonpoint Source Pollution Under the Clean Water Act

As the U.S. population has grown, so, too have many sources of water pollution. The Clean Water Act strictly controls large, industrial pollution sources that pipe contaminants directly into surface waters.[152] These sources must obtain a permit, and permitted actors must limit the amount of pollution they emit.[153] These effluent limits have substantially improved water quality: many lakes and streams – once badly polluted – have become fishable and

meteorological and other conditions that also influence air quality).

[147] *Id.* at 914 ("[T]ropospheric ozone – one of the first air pollutants for which EPA set air quality standards . . . forms in the atmosphere when emissions of nitrogen oxides and hydrocarbons ('precursor pollutants') react chemically in the presence of heat and sunlight."); *see also* Owen, *supra* note 4, at 195 (explaining that emissions "interact in complex and nonlinear ways").

[148] Fine & Owen, *supra* note 146, at 944-46 (examining ozone formation and the factors that contribute to formation, including emissions from cars).

[149] *See, e.g.*, *Air Quality, Region 9: Southern California*, EPA, http://www.epa.gov/socal/air (last visited Feb. 1, 2014) (stating that large mountains border the Los Angeles Basin, and that "[f]requent sunny days and low rainfall contribute to ozone formation, as well as high levels of fine particles and dust").

[150] *See* EME Homer City Generation, L.P. v. EPA, 696 F.3d 7, 11 (D.C. Cir. 2012) (discussing how "[s]ome emissions of air pollutants travel across State boundaries and affect air quality in downwind States," and describing the Transport Rule for nitrogen oxides and sulfur dioxides).

[151] *See id*. at 37 (vacating the Transport Rule); North Carolina v. EPA, 531 F.3d 896, 901 (D.C. Cir. 2008) (vacating the predecessor to the Transport Rule).

[152] *See* Coeur Alaska, Inc. v. Se. Alaska Conservation Council, 557 U.S. 261, 298 (2009) ("The Act instructs EPA to establish various technology-based, increasingly stringent effluent limitations for categories of point sources.").

[153] 33 U.S.C. § 1311(b), (e) (2012) (requiring effluent limitations and that the limitations "be applied to all point sources of discharge of pollutants").

swimmable.[154] Yet many bodies of water still fail to meet water quality standards.[155]

These persistent and sometimes expanding water quality problems are due in large part to the rise of thousands of nonindustrial activities that collectively emit massive amounts of water pollution. Farms, golf courses, and lawns send fertilizers into surface waters, causing algae and plants to grow and decay and pull oxygen out of the water.[156] These "nonpoint" sources of pollution, which generate harmful runoff in the form of soil, pesticides, and other chemicals,[157] have increased in quantity as our population and lifestyles have changed. In 2000, states identified agricultural nonpoint source pollution as "the leading source of water quality impacts on surveyed rivers and lakes."[158] The Clean Water Act initially did not address this major pollution source in balancing regulatory costs against harms, and although it has since been amended to partially address the problem,[159] the Act – and its regulations – largely have failed.

In the case of nonpoint source pollution, many sources simply are not regulated, rather than regulated at a level that now fails to adequately balance regulatory costs against the harms of a growing activity.[160] In areas with severe water quality problems, for which states must establish the total amount of a pollutant that can be emitted into waters daily, agencies have established some controls.[161] But states frequently are hesitant to regulate individual activities[162]

[154] *See* William L. Andreen, *Water Quality Today – Has the Clean Water Act Been a Success?*, 55 ALA. L. REV. 537, 591 (2004) (describing progress and pointing to major pollution reductions for wastewater treatment plants and industrial sources).

[155] *See* EPA, *supra* note 38, at 9 (reporting, for example, that forty-four percent of U.S. rivers and streams are "impaired").

[156] *See* U.S. GEOLOGICAL SURVEY, 02-4130, EFFECTS OF LAWN FERTILIZER ON NUTRIENT CONCENTRATION IN RUNOFF FROM LAKESHORE LAWNS, LAUDERDALE LAKES, WISCONSIN 1, 6 (2002), *available at* http://wi.water.usgs.gov/pubs/wrir-02-4130/wrir-02-4130.pdf; *Eutrophication*, U.S. GEOLOGICAL SURVEY, http://toxics.usgs.gov/definitions/eutrophication.html (last updated May 23, 2013, 3:22 PM).

[157] *Polluted Runoff: Nonpoint Source Pollution*, EPA, http://water.epa.gov/polwaste/nps/index.cfm (last updated Oct. 17, 2013).

[158] EPA, EPA 841-F-05-001, PROTECTING WATER QUALITY FROM AGRICULTURAL RUNOFF 1 (2005), *available at* http://www.epa.gov/owow/NPS/Ag_Runoff_Fact_Sheet.pdf.

[159] Clean Water Amendments Act of 1987, Pub. L. No. 100-4, 101 Stat. 7 (codified as amended at 33 U.S.C. § 1329 (2012)) (providing for the regulation of nonpoint sources in certain contexts).

[160] Congress knew early on that nonpoint sources posed a substantial threat but did not initially address them in the Clean Water Act. *See* ENVTL. POLICY DIV. OF THE COMM. ON PUB. WORKS, 93D CONG., A LEGISLATIVE HISTORY OF THE WATER POLLUTION CONTROL ACT AMENDMENTS OF 1972, S. DOC. NO. 93-1, at 793 (Comm. Print 1973) ("The Committee clearly recognizes that nonpoint sources of pollution are a major contributor to water quality problems.").

[161] 33 U.S.C. § 1313(d) (requiring states to identify waters in which effluent limitations

and have been slow to establish total maximum daily loads for problem waters.[163]

As with oil and gas and air pollution, the effects of thousands of sources of water pollution are not simply independent and cumulative. Due to surface topography, nonpoint source pollution often flows to a single body of water, leading to concentrated pollution in one area. Pollution from farms throughout the Midwest has created the "dead zone" in the Gulf of Mississippi, an area with oxygen levels so low that the zone cannot support life.[164] This has substantially affected the fishing industry that is vital to the economies of the Louisiana and Mississippi coasts.[165] Similar pollution from Pennsylvania, New Jersey, Maryland, and Virginia, which runs into the Chesapeake Bay, is also the primary cause of fish die-offs and rising bacteria counts in that region.[166]

One might argue that the list of diseconomies of scale is so long that the classification becomes useless – humans inevitably cause large harms, collective and otherwise, many of which cannot simply be solved by a single harm threshold, as harms often converge and have disproportionate impacts in certain regions. Yet as is commonly recognized in the environmental literature,[167] many laws focus on individual actors – and typically large actors – rather than total harms (often caused by small actors) and the dynamism of these harms. The Clean Air Act, although it stringently regulates mobile

are insufficient to "implement any water quality standard applicable to such waters"); Pronsolino v. Nastri, 291 F.3d 1123, 1133-34 (9th Cir. 2002) (allowing the EPA to set Total Maximum Daily Loads for waters "polluted only by nonpoint sources of pollution"); *see also* Coeur Alaska, Inc. v. Se. Alaska Conservation Council, 557 U.S. 261, 299 n.2 (2009) (noting that the Total Maximum Daily Load program "supplements the technology-based standards, serving to 'prevent water quality from falling below acceptable levels' even when point sources comply with effluent limitations" (quoting EPA v. California *ex rel.* State Water Res. Control Bd., 426 U.S. 200, 205 n.12 (1976))).

[162] Robert W. Adler, *The Two Lost Books in the Water Quality Trilogy: The Elusive Objectives of Physical and Biological Integrity*, 33 ENVTL. L. 29, 75 (2003) (describing "the relative failure of state-driven nonpoint source pollution control programs").

[163] J.B. Ruhl, *Ecosystem Services and the Clean Water Act: Strategies for Fitting New Science into Old Law*, 40 ENVTL. L. 1381, 1396 (2010) (explaining that states must establish total maximum daily loads (TMDLs) or face withdrawal of federal funds).

[164] Ruhl & Salzman, *supra* note 4, at 60 ("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.").

[165] *See NOAA: Gulf of Mexico 'Dead Zone' Predications Feature Uncertainty*, NAT'L OCEANIC & ATMOSPHERIC ADMIN. (June 20, 2012), http://www.noaanews noaa.gov/stories 2012/20120621_deadzone html (indicating that the dead zone "threaten[s] valuable commercial and recreational Gulf fisheries").

[166] *Chesapeake Bay*, EPA, http://www.epa.gov/oaqps001/gr8water/xbrochure/chesapea. html (last updated July 7, 2011) (explaining how many nutrients in the Chesapeake Bay originate from nonpoint sources in various states).

[167] *See, e.g.*, *infra* notes 168-70 and accompanying text.

sources, applies the most detailed and arguably heavy-handed regulations to new and modified large, industrial air pollution sources, and the Clean Water Act focuses even more closely on these big polluters.[168] This is sensible, as initial regulation of the largest contributors to a given problem focuses on solutions that are likely to make the most and quickest progress for the least cost.[169] But we have moved far beyond the low-hanging fruit in U.S. environmental regulation, and persistent problems remain. This is due in part to the challenge of adequately enforcing regulations for millions of small, individually less significant sources.[170] But the problem of diseconomies is much larger and more complex, than the familiar scenario of fewer, larger actors causing big harms: it involves the failure of regulatory and institutional design to incorporate scaling factors into the initial balance of regulatory costs and harms, and of legislators and agencies to write rules that can change nimbly, sometimes automatically, in response to scale-based concerns.

II. ADDRESSING DISECONOMIES: CHANGING LAWS AND INSTITUTIONAL DESIGN

Regulatory diseconomies of scale contribute to some of the most persistent environmental problems in the United States and, as discussed in Part I, have introduced new harms in the oil and gas context. In many cases, this failure is a direct result of the refusal of lawmakers and regulators to acknowledge that scale, rather than changing technology or a cataclysmic event, can have major effects. And even where scale-based change causes relatively cataclysmic events, responses are slow to emerge – in part because when an activity has long occurred, we tend to become familiar with these dramatic events and assume that they will remain somewhat rare.[171] As a first step to addressing

[168] *See* Amy Sinden, *In Defense of Absolutes: Combating the Politics of Power in Environmental Law*, 90 IOWA L. REV. 1405, 1437 n.134 (2005) ("The major permitting programs under both the Clean Water Act and the Clean Air Act apply to large industrial facilities.").

[169] *See* Stack & Vandenbergh, *supra* note 4, at 1393-94, 1419 (explaining that "it is often more efficient to focus on the most significant contributors to a problem" and that "a focus on high-percentage factors often concentrates effort and resources on the sources that may make the most difference at the least expense," but emphasizing the need to consider aggregate effects).

[170] *See* Karkkainen, *supra* note 4, at 264 ("We have already picked much of this low-hanging fruit, regulating the most visible pollutants and sources first. Thus far, however, conventional regulation has been less successful at controlling emissions from small mobile sources, such as automobiles, or diffuse sources, such farms, which are much more difficult to monitor.").

[171] Certain states' reactions to triggered seismicity or induced seismicity – earthquakes caused by human activity, including oil and gas underground injection control wells – exemplify this tendency to wait to address problems, or to assume that the problems will remain rare. In Oklahoma, for example, several reports indicate that underground injection control wells have caused some earthquakes. Although the state's Geological Survey has

this problem, agencies must identify areas in which diseconomies likely will emerge (or already have emerged). Then, legislatures and agencies must substantively address these problems ex ante, or, as a second-best solution, as rapidly as possible after they arise.

Not all regulatory diseconomies can be addressed or even anticipated before they occur,[172] and scholars like Thomas Merrill and David Schizer have accordingly argued in the oil and gas context that we should rely in part on ex post tort law to address the unknown harms of fracturing.[173] Indeed, David Dana and I observe in another article that many of the specific risks of unconventional oil and gas development cannot be fully addressed through ex ante command and control regulation and that insurance and bonding regimes are needed.[174] But where we can predict volumetric expansions of regulated activities and their impacts, ex ante approaches will often be far superior to haphazard ex post responses. And agencies and legislators can act without fully knowing the risks simply by setting harm thresholds – limiting the total

actively investigated these incidents, it is taking a very cautious approach to suggesting any regulatory changes. *See, e.g.*, AUSTIN HOLLAND, OKLA. GEOLOGICAL SURVEY, EXAMINATION OF POSSIBLY INDUCED SEISMICITY FROM HYDRAULIC FRACTURING IN THE EOLA FIELD, GARVIN COUNTY, OKLAHOMA 18 (2011), *available at* http://www.ogs.ou.edu/pubsscanned/openfile/OF1_2011.pdf (observing proven incidents of triggered seismicity); Katie M. Keranen et al., *Potentially Induced Earthquakes in Oklahoma, USA: Links Between Wastewater Injection and the 2011 Mw 5.7 Earthquake Sequence*, GEOLOGY (2013), http://geology.gsapubs.org/content/early/2013/03/26/G34045.1 full.pdf (describing how UIC wells likely caused earthquakes in Oklahoma); *Position Statement on Triggered or Induced Seismicity*, OKLA. GEOLOGICAL SURVEY http://www.ogs.ou.edu/earthquakes/OGSPositionInducedSeismicity.pdf (last visited Dec. 25, 2013) ("It is true that the past few years have seen a significant increase in earthquake activity within Oklahoma. While we are studying the possibility that some of this activity could be related to oil and gas operations, it is unlikely that all of the earthquakes can be attributed to human activities."). Unlike Oklahoma, which has not changed its state-administered federal permitting of oil and gas UIC wells, Arkansas has placed certain areas off limits for UIC wells in response to earthquakes, and Ohio has changed its regulations. *See supra* notes 108-09 and accompanying text.

172 *Cf. supra* note 79 and accompanying text (describing the inability to quantify certain risks of shale gas development).

173 Merrill & Schizer, *supra* note 6, at 191 ("In many cases, the evidence will not reveal exactly how the water was contaminated, and thus whether a best practices regulation addressed the relevant conduct in the case. In these circumstances, we would rely on rebuttable presumptions of causation. Specifically, if the plaintiff proves both (1) that fracturing caused the contamination and (2) that the energy company violated a best practices regulation governing a particular pathway of contamination, we would create a presumption that this was the pathway of contamination.").

174 *See* David A. Dana & Hannah J. Wiseman, *A Market Approach to Regulating the Energy Revolution: Assurance Bonds, Insurance, and the Certain and Uncertain Risks of Hydraulic Fracturing*, 99 IOWA L. REV. (forthcoming 2014) (manuscript at 24-25), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2353061.

amount of water that may be withdrawn from a stream[175] or the total amount of pollutant permitted in air or water in a given region, for example. Certainly, if and when we reach any future, legislatively imposed harm thresholds, politics, science, and attitudes will have changed. But laws that protect the general public against the externalities of a growing industry sometimes will be easier to remove or modify than to enact.[176] If we respond to diseconomies ex post rather than anticipating them ex ante, irreversible harms could emerge during the inevitable regulatory lag between the occurrence of scale-based harms and regulation of the activity causing them. This is particularly true in the oil and gas context, where operators move rapidly in and out of regions: Drilling and fracturing can be completed within a time span of months,[177] at which point harm from this activity might already have occurred if not addressed ex ante.

Furthermore, if a growing activity does not end up leading us closer to a harm threshold – for example, due to voluntarily adopted pollution treatment technologies and innovation as the industry grows – then industry would not suffer the burdens of heightened regulation. More stringent individual controls simply would not be triggered.

Even for scale-based harms that we cannot predict, general, ex ante laws that at least incorporate scaling concepts and require periodic review to identify whether scaling concerns have emerged are essential. Legislation that requires agencies to monitor the growth of regulated activities and measure their harms could allow for the earlier identification of potentially dangerous harm thresholds, and for a more rapid response.

Finally, from a political economy perspective, ex ante regulation that addresses the possibility of harms expanding along with the growth of an activity – and the need to constrain the quantity, location, and density of these harms – might be one of the only realistic means of curbing diseconomies of scale.[178] As the industry grows from an initial baseline of relatively low levels of activity, it might develop so many revolving-door relationships with regulators, and acquire so many effective lobbying resources, that efforts to modify regulation meaningfully, while avoiding inefficient capture, could become slim.

The scale-based regulations proposed in the following Section would not dictate a particular response – indeed, agencies could potentially ignore harm thresholds if they felt that politics, science, or public opinion so dictated. But

[175] *See supra* note 102 and accompanying text.

[176] *See, e.g.*, Kysar, *supra* note 47, at 1049 ("Given that many environmental, health, and safety hazards only become known after a product or activity is already well established within society, individuals may perceive the 'new risk' to be the regulatory prospect of banning or taxing the product or activity, rather than the hazard created by the product or activity itself."). *But see* Merrill & Schizer, *supra* note 6, at 159-60 (arguing that draconian environmental laws passed in response to dramatic events, some of which may be too heavy handed, are hard to remove).

[177] Dana & Wiseman, *supra* note 174 (manuscript at 11-14).

[178] I am grateful to Robert Mikos for this observation.

these regulations would provide a much needed foundation from which agencies could build.

A. *Review of Regulated Activities to Identify Scale-Based Problems*

Before agencies or legislatures can substantively address scale-based harms, they must first identify them. Yet these entities only sporadically or partly recognize scaling problems, thus leading to regulatory lag or a failure to regulate at all. This is understandable. Once a government entity has established a baseline regulation for a particular activity and has carefully balanced the harms and regulatory costs – or has chosen not to regulate in light of assumed harms – a sense of complacency emerges: the activity now operates within a set of rules (or regulators assume does not need fixing), and officials can move to the next problem. These "agency ruts" occur not only due to agency stasis, but also, possibly, as a result of declining public pressure. As Lynn Blais and Wendy Wagner have observed, "[o]nce a pollution-control standard is in place, public attention to the issue may focus elsewhere."[179]

Two requirements might prevent stasis from the outset and push policymakers and agencies to implement the substantive remedies to scaling problems proposed in the proceeding discussion.[180] Environmental review provisions, which require agencies to consider the impacts of their proposed actions, can expressly mandate considerations of scale-based harms.[181] Similarly, sunset provisions tied to the volume of regulated activity can force reconsideration of the adequacy of old regulations, particularly as an activity grows. These, too, can push agencies to identify the rise of a scale-based problem.

In many cases, policymakers and agency actors lack the information necessary to determine whether a diseconomy of scale will occur, and if so, which type. Where we cannot predict diseconomies ex ante, periodic reviews also will be important in order to identify recently-emerged diseconomies and to force agencies out of their rut.[182] This review may lead agencies to more quickly respond to harms that otherwise might have festered for years.

Environmental and sunset reviews, which could identify both likely future diseconomies and those that have emerged recently, will require certain data in order to be effective; information-forcing regulatory mechanisms therefore will be essential to these reviews. Regulated actors must produce information about

[179] Lynn E. Blais & Wendy E. Wagner, *Emerging Science, Adaptive Regulation, and the Problem of Rulemaking Ruts*, 86 TEX. L. REV. 1701, 1713-14 (2008).

[180] *See infra* Part II.B-D.

[181] *See, e.g.*, Owen, *supra* note 4, at 196 (suggesting that setting thresholds "compels" planners "to think through the implications of setting regulatory thresholds at a particular level").

[182] *See, e.g.*, Blais & Wagner, *supra* note 179, at 1714 ("[R]ational resource allocation concerns will counsel in favor of pursuing initial rulemakings rather than regular revisions, and technology- and science-based standards will get stuck in 'rulemaking ruts.'").

the various harms their activities cause, particularly as these activities expand. And although this Article focuses on the need to identify and address harms that grow disproportionately, environmental and sunset reviews would also call attention to regulatory economies of scale – circumstances where the growth of a regulated activity caused harms to disproportionately decline and where less (or no) regulation would be needed.

1. Environmental Review Tailored to Scale-Based Concerns

Environmental review is a key provision needed to force agencies to identify potential diseconomies of scale. Ideally, this review would occur before a scale-based problem emerges, although ex post review is important as a second-best strategy. In the context of "massive" problems like climate change, Professors J.B. Ruhl and James Salzman call this forward thinking review-based approach a "predecision assessment strategy" of "directly incorporating the concept of cumulative effects into an agency's decisionmaking architecture."[183] They suggest that the National Environmental Policy Act (NEPA) makes the most progress toward this goal by requiring consideration of cumulative effects.[184] Lynn Blais and Wendy Wagner similarly recommend a "contemporaneous revision-planning regime," in which "agencies would evaluate *during the original rulemaking process* the degree to which technological innovation is likely to advance in the relevant field in the future," thus allowing more stringent standards for technology-based emission controls.[185] In the context of diseconomies of scale, ex ante considerations of cumulative effects and likely technological innovation are not enough: interdependent and unevenly distributed effects are equally important and should be incorporated into ex ante review. Environmental review statutes can, and sometimes do, require consideration of these factors, and states should more consistently require these types of reviews in order to identify potential regulatory diseconomies.

NEPA and similar state-level environmental review statutes already require government actors to review certain activities, including regulation, to determine whether they will have significant environmental impacts, and if so, to consider alternatives.[186] These acts are purely procedural and require no substantive response, but they force agencies approving permits or writing new rules to think about the environmental and social effects caused by agency approval of projects. And in some cases, the agencies administering review statutes have recognized their value in the context of regulatory diseconomies, although not labeling them as such. The Council on Environmental Quality

[183] Ruhl & Salzman, *supra* note 4, at 95.

[184] *Id.* at 96 (describing NEPA as "the environmental statute that has produced the most developed body of cumulative effects law").

[185] Blais & Wagner, *supra* note 179, at 1731 (emphasis added).

[186] 42 U.S.C. § 4332(C) (2006).

(CEQ), which guides agencies conducting federal reviews under NEPA, observes:

> Evidence is increasing that the most devastating environmental effects may result not from the direct effects of a particular action, but from the combination of individually minor effects of multiple actions over time.[187]

CEQ regulations define cumulative effects as including environmental harms that "result[] from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions."[188] At minimum, this addresses concerns about the total harms of a growing activity.

Despite its progress in requiring agencies to consider total harms, NEPA has been criticized[189] as requiring inadequate consideration of cumulative effects: for example, one agency approval of one oil and gas lease on federal lands may ignore thousands of other wells.[190] And although NEPA requires some consideration of noncumulative harms – including an environmental justice component, for example – it does not directly require full consideration of the collective, interdependent, and unevenly distributed effects of a growing activity.

New York's approach to environmental review seems to have avoided this scale blindness, at least in the context of oil and gas. The New York Department of Environmental Conservation (DEC) regulates mineral development, and when it received numerous requests to drill and fracture new gas wells in New York, it refused to permit them immediately. Although the DEC already had conducted an environmental review of its oil and gas program in 1992,[191] it decided that the drilling and fracturing activities recently proposed were different and required further consideration.[192] The more than 1000-page document that resulted from these efforts – along with additional

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[187] COUNCIL ON ENVTL. QUALITY, CONSIDERING CUMULATIVE EFFECTS UNDER THE NATIONAL ENVIRONMENTAL POLICY ACT 1 (1997), *available at* http://energy.gov/sites/prod/files/nepapub/nepa_documents/RedDont/G-CEQ-ConsidCumulEffects.pdf.

[188] *Id.* (quoting 40 C.F.R. § 1508.7 (1996) (internal quotation marks omitted)).

[189] *See, e.g.*, Arnold W. Reitze, Jr., *The Role of NEPA in Fossil Fuel Resource Development and Use in the Western United States*, 39 B.C. ENVTL. AFF. L. REV. 283, 311-15 (exploring the boundaries of NEPA cumulative effects analysis, and observing that "[c]ontemplation of action, without more, is not enough to mandate the drafting of an EIS").

[190] *See, e.g.*, Theodore Roosevelt Conservation P'ship v. Salazar, 616 F.3d 497, 513 (D.C. Cir. 2010) (finding that two gas projects, for which notice of intent to prepare an Environmental Impact Statement under NEPA had been sufficient, "did not establish reasonable foreseeability of the incremental impact of those projects" and thus did not have to be considered when the Bureau of Land Management reviewed a third, nearby project).

[191] N.Y. STATE DEP'T OF ENVTL. CONSERVATION, FINAL GENERIC ENVIRONMENTAL IMPACT STATEMENT ON THE OIL, GAS AND SOLUTION MINING REGULATORY PROGRAM, at FGEIS1 (1992).

[192] N.Y. STATE DEP'T OF ENVTL. CONSERVATION, *supra* note 57, at 1-3 to 1-4.

health studies – described potential threshold effects in sensitive environments, including in upstate New York, which supplies New York City with drinking water.[193] It also explored potential impacts of drilling and fracturing in already polluted areas and disproportionate effects, both positive and negative, on certain communities within the state.[194]

Although New York has not yet allowed the development of hydraulically fractured wells without individualized review,[195] its proposed regulations appear to take into account the many scale-based considerations in the DEC's environmental review. For example, the DEC has proposed to prohibit drilling and fracturing in the watershed that contains New York City's drinking water supply.[196] In an earlier proposal, Governor Andrew Cuomo also suggested that only those communities facing severe budget constraints could allow hydraulic fracturing, thus disproportionately benefiting these communities without subjecting broader portions of the state to the potential environmental harms of this activity.[197]

Just as New York's environmental review law requires the agency or state policymakers to certain scale-type considerations into account,[198] legislatures could more fully and consistently mandate this more inclusive review. When large numbers of new polluting activities were proposed, state rules could require more careful agency consideration of the likely harms of this pollution, and mandate that these agencies craft regulations to address them ex ante.

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[193] *Revised Proposed Express Terms 6 NYCRR Parts 750.1 and 750.3*, N.Y. STATE DEP'T OF ENVTL. CONSERVATION, http://www.dec ny.gov/regulations/87445 html (last visited Oct. 27, 2013) (proposing to prohibit fracturing within, or within 4000 feet of, New York City's unfiltered water supply watersheds).

[194] N.Y. STATE DEPT. OF ENVTL. CONSERVATION, *supra* note 57, at 6-317 (describing likely changes in community character and other social impacts).

[195] *New Recommendations Issued in Hydraulic Fracturing Review*, N.Y. STATE DEP'T OF ENVTL. CONSERVATION (June 30, 2011), http://www.dec.ny.gov/press/75403 html (stating that "[t]here is no administrative or discretionary moratorium on high-volume fracturing" but that the agency may determine that fracturing is unsafe and thus will not implement the regulations allowing but constraining the impacts of fracturing).

[196] *See Revised Proposed Express Terms 6 NYCRR Parts 750.1 and 750.3*, *supra* note 193.

[197] Danny Hakim, *Cuomo Proposal Would Restrict Gas Drilling to a Struggling Region*, N.Y. TIMES, June 14, 2012, at A1, *available at* http://www.nytimes.com/2012/06/14/ny region/hydrofracking-under-cuomo-plan-would-be-restricted-to-a-few-counties html (describing Governor Cuomo's "plan to limit the controversial drilling method known as hydraulic fracturing to portions of several struggling New York counties along the border with Pennsylvania, and to permit it only in communities that express support for the technology" – a plan that was not carried out).

[198] *See* N.Y. ENVTL. CONSERV. LAW § 617.7 (Consol. 2011) (directing a state actor, when evaluating whether an action is significant, to consider, among other factors, "two or more related actions undertaken, funded or approved by an agency, none of which has or would have a significant impact on the environment, but when considered cumulatively would meet one or more of the criteria in this subdivision").

2. Sunset Provisions

Sunset provisions tied to the volume of regulated activity, like environmental review prior to agency action, can cause agencies to catch and address diseconomies before they emerge, or, as a second-best solution, to respond to them more quickly. Certain state provisions already require agencies to periodically review the adequacy of regulation and institutional capacity (and the need for the institution) through this type of review,[199] and these provisions typically are triggered by the length of time for which the agency has operated.[200] This fails to address scale directly but is a decent proxy, as some regulated activities are likely to have grown between review periods.

In Texas, the state legislature reviews institutional capacity – but not the adequacy of regulations – through periodic sunset self-reviews prepared by agencies, including the state's oil and gas agency, the Railroad Commission of Texas.[201] Within the review, the agency reports the number of regulated facilities, including, for example, pipelines and wells, the number of inspectors available to investigate these facilities, and the number of inspections actually conducted.[202] The Commission also describes the other agencies with jurisdiction over certain aspects of the activity that it regulates. It explains, for example, that a state health department regulates the handling and transfer of naturally occurring radioactive materials from oil and gas wells, whereas the oil and gas agency regulates their disposal.[203] This type of analysis can identify the need for jurisdictional changes if environmental harms from the regulated activity expand. For example, a state might decide to transfer authority over portions of the activity to a better-funded or more powerful agency, to centralize control within one agency, or to devolve authority to municipalities that might experience disproportionately large or small impacts of a growing activity, allowing the municipalities to enact more or fewer regulations as needed.

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[199] *See, e.g.*, *Sunset Advisory Comm'n*, STATE OF TEX., http://www.sunset.state.tx.us (last visited Oct. 27, 2013) ("The [Sunset Advisory] Commission is a legislative body that reviews the policies and programs of more than 150 government agencies every 12 years."). Timing legislation, which simply ends the application of certain laws within a particular time period, is now more common than sunset review. *See* Gersen, *supra* note 47, at 247 (describing "*temporary legislation* – statutes containing clauses limiting the duration of their own validity"). This Article does not advocate for the use of timing legislation.

[200] *See* Gersen, *supra* note 47, at 247.

[201] *Id.*

[202] *See* R.R. COMM'N OF TEX., SELF-EVALUATION REPORT 79, 97 (2009), *available at* http://www rrc.state.tx.us/about/divisions/RRCSelfEvaluationReport2009.pdf (describing 44,000 liquefied natural gas and similar facilities, ten inspectors assigned to these facilities, and more than 12,500 inspections conducted annually; and describing the 125 inspectors assigned to land-based oil and gas wells).

[203] *Id.* at 13.

3. Information-Forcing Regulations

To locate and predict growing activities and their harms within environmental or sunset reviews, agencies need specific information on the effects of the activities they regulate, and how harms change as these activities grow. Legislatures and agencies thus should develop information-forcing mechanisms that reveal the extent of the harm of a growing activity – requiring actors to report the location of their activity, total quantities of wastes produced and resources used, and any pollution events that occur, for example.

Although most state and federal actors have not directly recognized the regulatory diseconomies problem, many have begun to require regulated industries to produce this type of information; these examples serve as limited models for the specific types of data that should be consistently produced in order to identify diseconomies of scale. The federal Clean Air and Clean Water Acts require certain polluters to monitor their emissions and report them,[204] for example, but this extensive data collection only occurs for large, centralized sources of pollution – typically ignoring individual emissions from mobile sources of air pollution[205] and nonpoint water pollution sources with large collective and interdependent harms.[206] As Daniel Esty and Marian Chertow have observed, advances in technology allow us to monitor nearly all emissions, including emissions from small sources.[207] Requiring measurement and reporting from these sources will be essential if we are to fully understand diseconomies of scale, where they occur, and the areas in which they may cause threshold or uneven effects.[208]

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[204] *See, e.g.*, 42 U.S.C. § 7651k(a) (2006) (requiring sources of sulfur dioxide and nitrogen oxide emissions subject to acid rain trading program requirements to conduct continuous emissions monitoring).

[205] *But see* 40 C.F.R. § 86.010-.018 (2013) (requiring certain emission control systems on trucks to be monitored for malfunctions); Air Emissions Reporting Requirements, 40 C.F.R. § 51.15(b) (requiring states with nonattainment areas to conduct emission inventories for all sources, including on-road and nonroad mobile sources).

[206] *But see* L.A. Cnty. Flood Control Dist. v. Natural Res. Def. Council, Inc., 133 S. Ct. 710, 710-11 (2013) (referring to “downstream monitoring stations” that measure the collective runoff from certain cities required to limit their stormwater runoff).

[207] Daniel C. Esty & Marian R. Chertow, *Thinking Ecologically: An Introduction*, *in* THINKING ECOLOGICALLY: THE NEXT GENERATION OF ENVIRONMENTAL REGULATION 1, 5 (Marian R. Chertow & Daniel C. Esty eds., 1998).

[208] There is a broad literature exploring the power of data monitoring to improve environmental performance in contexts far beyond scale and the current dearth of adequate information in environmental regulation. *See, e.g.*, Karkkainen, *supra* note 4, at 267-68 (arguing that “risk-based regulation has been abandoned in a number of statutes” because of the lack of adequate data that supports risk-based analysis that would establish, for example “‘safe’ (or acceptable) threshold levels of human exposures or environmental concentrations,” and calling for better information production). *See generally* Wendy E. Wagner, *Commons Ignorance: The Failure of Environmental Law to Produce Needed Information on Health and the Environment*, 53 DUKE L.J. 1619 (2004) (describing the lack

In the oil and gas context, states have begun to require this type of reporting from small sources that could collectively cause a variety of harms. In states like Pennsylvania,[209] Colorado,[210] and West Virginia,[211] each operator – at each of the thousands of oil and gas sites in the state – must submit a waste disposal or waste reduction plan indicating the quantity of waste likely produced at each well and how the operator plans to handle it. Texas requires reporting of the volumes of water used to fracture each well.[212] And throughout the country, operators have also begun to voluntarily report the chemicals and quantity of water used for hydraulic fracturing at each well site, although not all operators have chosen to participate.[213] States also increasingly require chemical disclosure,[214] and others mandate baseline testing of groundwater near wells to identify the contaminants already in the water prior to oil and gas operations.[215] These types of information collection should be required more consistently to illuminate specific mechanisms underlying diseconomies of scale and to support improved substantive responses.

of scientific data necessary to support better regulation).

[209] 25 PA. CODE § 95.10(b) (2010) (requiring site operators to develop wastewater source reduction strategies in accordance with other provisions in the regulation).

[210] 2 COLO. CODE REGS. § 404-1:216(c)(5) (2009) (requiring "[a] plan for the management of exploration and production waste").

[211] W. VA. CODE ANN. § 22-6A-7 (LexisNexis 2009 & Supp. 2013) (requiring a description of "planned management and disposition of wastewater after completion from fracturing, refracturing, stimulation and production activities").

[212] 16 TEX. ADMIN. CODE § 3.29(c)(2)(A)(viii) (West 2012) (mandating disclosure of "the total volume of water used in the hydraulic fracturing treatment(s) of the well or the type and total volume of the base fluid used in the hydraulic fracturing treatment(s), if something other than water").

[213] *See, e.g.*, AM. PETROLEUM INST., REP. NO. 4122330215, HYDRAULIC FRACTURING FLUID PRODUCT COMPONENT INFORMATION DISCLOSURE (2011) (on file with author) (showing total water volume in gallons and chemical contents in an example of a Fracfocus disclosure).

[214] *See generally* Wiseman, *supra* note 135 (describing many of the disclosure regulations).

[215] *See, e.g.*, Statewide Groundwater Baseline Sampling and Monitoring, 2 COLO. CODE REGS. § 404-1:609 (2013) (requiring baseline testing of groundwater near oil wells, gas wells, multi-well sites, and injection wells). Pennsylvania and West Virginia strongly incentivize baseline testing through presumptions that oil and gas operations caused water contamination within a certain distance and time. *See* 58 PA. CONS. STAT. ANN. § 3218(c) (West 1996 & Supp. 2013) (creating a rebuttable presumption that oil and gas operations cause water contamination within 2500 feet of an unconventional (fractured) well within twelve months of well completion or other activities); W. VA. CODE ANN. § 22-6A-18 (LexisNexis 2009 & Supp. 2013) (creating a rebuttable presumption that drilling is the cause of contamination of "a fresh water source or supply within one thousand five hundred feet of the center of the well pad for horizontal well").

B. *Harm Thresholds and Institutional Expansion to Address Independent-Probability Harms*

Identifying diseconomies of scale is only the first step of a needed multipart solution. Having acknowledged that diseconomies will occur or have already emerged, policymakers and agencies must develop effective rules for addressing them, and the very structure of agencies must change. Here, the type of diseconomy will influence the needed substantive approach. Independent harms that accumulate, for example, can be addressed by drawing a threshold of maximum acceptable harm. Assuming that existing regulations are tailored to control individual sources in a way that avoids this threshold, agencies will need to maintain steady enforcement rates by expanding staff numbers and inspections as the activity grows.

1. Setting Overall Harm Thresholds

The clearest solution to growing activities that cumulatively cause major harm – and particularly those that have independent effects – is to constrain the collective impact of the activity. If harm expands consistently with rising activity volumes, a simple cap on total cumulative harm, established ex ante, can cause regulatory costs on individual actors to rise along with harms. And as growing activities move closer to the total harm threshold, each new individual activity will be more stringently regulated in order to avoid exceeding the threshold.[216] Provided that enforcement rates remain steady, this strategy might effectively control expanding harms.

One portion of the Clean Air Act provides an excellent model for this approach, and this should be expanded, with modifications, to address many diseconomies of scale. In the context of predicting and addressing cumulative harms, Dave Owen describes this ex ante threshold strategy as a "comprehensive approach"[217] to environmental problems – the establishment and enforcement of a cap on impacts. This both provides agencies with the "opportunity to consider the aggregate consequence of all of the actions threatening to cause environmental degradation,"[218] and to carefully consider where the threshold should be set. Under the Clean Air Act, when a new, stationary source of air pollution is proposed in a region, regulators first look to the total amount of pollution in the air in that region.[219] Areas with dirty air, which tend to host large numbers of air pollution sources, are called

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[216] *See, e.g.*, 42 U.S.C. § 7503 (2006) (requiring a highly stringent technology-based emissions limitation based on the lowest achievable emission rate).

[217] Owen, *supra* note 4, at 195. Professor Owen views a comprehensive approach as including both a definitive line above which cumulative impacts may not move and a coordinated agency approach, which sometimes combines federal and state efforts to achieve the threshold. *Id.*

[218] *Id.* at 196.

[219] 42 U.S.C. § 7409(a) (requiring the EPA to publish national ambient air quality standards – the acceptable concentration of pollutants in the air).

nonattainment areas,[220] and those that meet national air quality standards are in attainment.[221] Sources adding new pollution in nonattainment areas face the strictest technology-based emissions controls[222] and must ensure that through this technology or additional controls, they offset their new emissions of a regulated air pollutant.[223]

As discussed above, the Clean Air Act does not take this approach with mobile sources: rather than starting with an overall cap, it directs the EPA to set technology-based "end of tailpipe" pollution limits on cars and, in some cases, to improve fuel economy standards over time.[224] Although the caps that apply to stationary sources also affect mobile sources – states must consider how mobile sources contribute to nonattainment problems, for example – they are not the central component of mobile source regulation. Tailpipe regulations should, like stationary source controls, take into account the overall amount of pollution caused, even if for political reasons the EPA might later choose to regulate these sources less fully. The agency likely would not, after all, force people to stop driving cars if additional cars would cause exceedances of pollution thresholds. The default still should be to address scaling effects rather than to ignore them, however, leaving agencies the future flexibility to moderate the impacts of stringent regulation if politics, science, or preferences have changed since the initial setting of cumulative and local thresholds.

The Clean Water Act, to a limited extent, also looks to collective harms. The Act directs the states to establish water quality standards based on desired uses of those waters,[225] and the EPA establishes effluent limits for types of industrial sources; these limits are designed to achieve these water quality standards.[226] If the effluent limitation is inadequate to ensure that water quality goals will be met, the Act specifically empowers the EPA to establish additional, water quality based controls within the permit of each industrial

[220] *Id.* § 7407(d)(1)(A)(i) (requiring nonattainment designation for any area that "does not meet (or that contributes to ambient air quality in a nearby area that does not meet) the national primary or secondary ambient air quality standard" for a pollutant).

[221] *Id.* § 7407(d)(1)(A)(ii) (requiring attainment designation for "any area . . . that meets the national primary or secondary ambient air quality standard" for a pollutant).

[222] *Id.* § 7503(a)(2) (requiring new stationary sources in nonattainment areas to comply with the lowest achievable emission rate).

[223] *Id.* § 7503(a)(1)(a) (allowing the issuance of permits for new stationary sources in nonattainment areas only if "total allowable emissions from existing sources in the region, from new or modified sources which are not major emitting facilities, and from the proposed source will be sufficiently less than total emissions from existing sources" so as to represent "reasonable further progress" in reducing air emissions).

[224] *See supra* note 36 and accompanying text.

[225] 33 U.S.C. §1313(a)(3)(A), (c)(2)(A) (requiring states to adopt water quality standards and providing that any "revised or new water quality standard shall consist of the designated uses of the navigable waters involved and the water quality criteria for such waters based upon such uses").

[226] *See supra* note 45.

source.[227] Finally, in areas that suffer from persistent violations of water quality standards despite the effluent and water quality limitations within permits, states are to establish caps on total pollution, called "total maximum daily loads" (TMDLs).[228] Once a state has established this load, it works backwards: If the maximum amount of phosphorous that may be emitted daily into a lake is 100 grams, and there are 100 emitters in the lake, each may be limited to one gram of daily phosphorous emissions.

Congress has tried to draw nonpoint sources beneath this cap – asking states to control these sources when they contribute to water quality problems.[229] As introduced above, however, states have been reluctant to intrude into farmers' and homeowners' property rights,[230] and would face major enforcement challenges even if they did attempt to regulate these individual sources of pollution. Accounting for scale in earlier Clean Water Act regulation might have prevented this nearly wholesale omission of nonpoint sources from pollution controls; although agencies would still have been hesitant to severely limit pollution from these sources, they might have included them in a plan to limit overall contributions to major water quality problems. And at minimum, state agencies might have begun to monitor these sources more closely. Indeed, although keeping track of thousands of small sources is difficult, local officials already conduct building code reviews of individual properties; while local officials investigate unsafe stairs or crumbling foundations, they could similarly observe fertilizers flowing from front yards. Alternatively, agencies could place small monitors at points within neighborhoods where runoff collects – as already occurs for stormwater in some urban areas, which flows from city streets and parking lots into sewers and surface waters at discrete points.[231]

Unlike in the air and water context, setting one impact cap for oil and gas activities likely will be impossible. The process of drilling and fracturing a well involves many stages and affects soil, air, and water;[232] it also fragments

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[227] 33 U.S.C. § 1312 (requiring the EPA Administrator to establish additional effluent limitations, including "alternative effluent control strategies" when, in the Administrator's judgment, the discharges that complied with the technology-based effluent limitations in 33 U.S.C. § 1311 "would interfere with the attainment or maintenance of that water quality in a specific portion of the navigable waters").

[228] *Id.* § 1313(d).

[229] *See id.* § 1329(b)(1) (directing states to submit to the EPA a nonpoint source management program for sources contributing to waters for which TMDLs have been established).

[230] *See* Adler, *supra* note 162, at 75 (observing that there has been a "relative failure of state-driven nonpoint source pollution control programs").

[231] *See* L.A. Cnty. Flood Control Dist. v. Natural Res. Def. Council, Inc., 133 S. Ct. 710, 710-11 (2013) (describing "downstream monitoring stations" that measure the collective runoff from certain cities required to limit their stormwater runoff).

[232] *See* Wiseman, *supra* note 6 (describing impacts on soil, air, and water caused by violations of state environmental and oil and gas laws during well development).

habitats[233] and causes a number of other harms, such as road damage, that might be difficult to quantify or define with a threshold. Setting a total acceptable amount of soil erosion from well sites in a given area, for example, would pose the same monitoring and enforcement problems that arise for other nonpoint sources. Despite this difficulty, the Delaware River Basin Commission, although not establishing a cap on total erosion and runoff from well sites, proposed (so far unsuccessfully) to stringently limit emissions from by requiring detailed erosion control measures at each site.[234] And caps already exist for certain other oil and gas impacts. As Colorado has done, states can pull oil and gas wells within their existing, capped air regulation regimes, reducing emissions from each individual well in order to keep regions in attainment with respect to air quality goals.[235]

Establishing multiple harm thresholds in oil and gas would not only be difficult from the perspective of drawing the appropriate line. It also would require the involvement of agencies at several jurisdictional levels. State wildlife agencies likely would address habitat fragmentation and species impacts. Environmental departments that decided to cap air pollutant emissions from wells would pull these sources into a federal program, thus avoiding the setting of a new cap but involving the EPA, at least indirectly. Regional water quality commissions could set maximum water withdrawal levels for different weather conditions, and a cap on nonpoint source pollution from well sites. This would inevitably involve state actors, as well, because some of these actors already regulate water withdrawals[236] and issue permits requiring the control of erosion from well sites.[237] These jurisdictional overlaps are not impossible to handle, though. The Delaware River Basin Commission's proposed regulations of shale gas development, for example, specify whether oil and gas operators must comply with a state or regional standard within the

[233] *See* N.M. DEP'T OF GAME & FISH, OIL AND GAS DEVELOPMENT GUIDELINES 2 (Aug. 2007), *available at* http://www.wildlife.state.nm.us/documents/oilandgasguidelines.pdf (asserting that "fragmentation and degradation of habitat" can result from oil and gas development).

[234] *See* DEL. RIVER BASIN COMM'N, *supra* note 104, at 53 (requiring site-specific plans to "satisfy Commission and host state erosion and sedimentation control requirements").

[235] *See Air Emissions Requirements for Oil and Gas Industry*, *supra* note 86.

[236] *See* 58 PA. CONS. STAT. ANN. § 3211(m)(2) (West 2012) (mandating detailed review for water withdrawals in Pennsylvania); *Sources of Water for Hydraulic Fracturing Fluids*, OHIO ENVTL. PROT. AGENCY, http://www.epa.state.oh.us/Portals/0/general%20pdfs/sources%20of%20water%20for%20hydraulic%20fracturing%20fluids.pdf (last visited Oct. 31, 2013) (describing registrations of water withdrawals and potential review required in certain cases).

[237] *See* Wiseman & Gradijan, *supra* note 70, at 131-32 (describing stormwater runoff permitting requirements and collecting sources for Pennsylvania and the states that form the Delaware River Basin Commission).

regulations.[238] In other cases, the regulations instruct operators to follow whichever directive – state or regional – is more stringent.[239]

Allocating responsibility for the formation and implementation of multiple caps would be difficult but could be beneficial. As Jody Freeman and Jim Rossi have observed, overlap and redundancy of authority – as would occur if agencies were to cap erosion from well sites, for example – can ensure that actors with different areas of expertise address a problem from different angles and, potentially, regulate it more effectively.[240] Inefficient capture by industry, which could lead to inadequate regulation, might also be less likely with more dispersed authority,[241] and agencies could avoid certain administrative costs of overlap by better coordinating their regulatory activities.

2. Changing Agency Structures

When the harms of a growing, regulated activity expand independently with the costs of regulation and accumulate, this, to some extent, preserves the balance initially captured within a regulation. Agencies initially determined that a particular cost to industry was merited to control the harms associated with industrial activity, and if these harms rise predictably, the balance should remain.[242] Where there is an existing regulation, agencies that recognize rising independent-probability harms that accumulate might be able to maintain the harm/regulatory cost balance by adding staffing resources and maintaining previous enforcement rates, although they still must ensure that harm does not exceed a particular cumulative threshold. Yet many agencies fail to do this. As a result of constrained state budgets, institutional inertia, or perhaps a lack of desire on the part of agencies or legislatures to expand regulation, agencies

[238] *See, e.g.*, DEL. RIVER BASIN COMM'N, *supra* note 104, at 65 (providing that certain oil and gas wastes "must either be beneficially reused off-site in accordance with applicable state regulations or disposed of at an appropriate waste treatment and/or disposal facility approved by the host state").

[239] *See, e.g.*, *id.* at 52 ("The reduction in the amount of the approved withdrawal from a discharge may not cause the stream flow below the point of withdrawal to be less than the Q7-10 flow or a more stringent value recommended by the appropriate host state agency.").

[240] Jody Freeman & Jim Rossi, *Agency Coordination in Shared Regulatory Space*, 125 HARV. L. REV. 1131, 1142 (2012) ("[I]t is . . . possible that some members of Congress vote to disperse authority because they recognize that social and economic problems are complex, and they wish to harness the unique expertise and competencies of different agencies.").

[241] *See* Garrick Pursley & Hannah Wiseman, *Local Energy*, 60 EMORY L.J. 877, 928 (2011) (observing that, in the renewable energy context, "local governments, compared to the state and federal governments, appear less likely to be targeted by the influential utility and carbon fuel lobbies that might vehemently resist" certain regulation because lobbyists "cannot be everywhere all of the time").

[242] If agencies initially failed to regulate an activity at all, though, as has occurred with certain water withdrawals, a new regulation will, of course, be necessary.

sometimes maintain the same staffing numbers despite rapid expansions of regulated activities.[243]

This problem is particularly apparent in the oil and gas context. In Texas, for example, the total number of shale gas wells rose from approximately 10,000 in 2008 to 15,000 in 2010,[244] yet in 2009 there were only 87 inspectors.[245] As the number of fractured gas wells rose, enforcements of state laws at fractured well sites also appeared to decline.[246] As the chief geologist of the Railroad Commission of Texas explained: "We underwent a hiring freeze beginning in 2009 and lost personnel. Legal Enforcement was down two attorneys and field operations was also short of personnel."[247] And in New York, the DEC has strong political backing for a comprehensive new regulatory approach to proposed drilling and fracturing, but its capacity to write and enforce these regulations effectively is similarly limited. The DEC's Commissioner has explained that sixty staff members are currently working to address 60,000 comments received on the DEC's proposed environmental impact statement, and New York has allocated no funds for additional staff.[248] The Commissioner has also indicated that the DEC's current staffing level constrains its ability to regulate potential fracturing.[249]

In addition to receiving inadequate funding, agencies might fail to hire more staff or ramp up inspections due to traditional problems of institutional inertia, the limits of political capital, or the motivations of individual agency actors. Existing agency staff sometimes closely guard their turf and might view any change – even the addition of more inspectors, and particularly those from another department – as negative.[250] Further, even if agencies recognize

[243] *See supra* note 93; *infra* notes 247-49 and accompanying text.

[244] *Newark, East (Barnett Shale) Well Count*, R.R. COMM'N OF TEX., http://www rrc.state .tx.us/barnettshale/barnettshalewellcount_1993-2013.pdf (last visited Nov. 17, 2013).

[245] R.R. COMM'N OF TEX., SUNSET ADVISORY COMMISSION FINAL REPORT 31 (2011), *available at* www.sunset.state.tx.us/82ndreports/rct/rct_fr.pdf.

[246] The results from a public records request submitted by the Author revealed fewer enforcement actions from 2009-2011 than from 2007-2008. Email from Leslie Savage, Chief Geologist, R.R. Comm'n of Tex. to author (Feb. 27, 2012, 9:01 AM).

[247] *Id.* (responding to the question: "There seem to be fewer enforcements for the end of 2009-through [sic] 2011. Should I just chalk this up to fewer violations occurring during this time, or did something else change?").

[248] Casey Seiler, *DEC Commissioner: No Staff Funds for Hydrofracking Enforcement*, TIMES UNION (Feb. 7, 2012), http://www.timesunion.com/local/article/DEC-commissioner-No-staff-funds-for-3125842.php (reporting that "DEC's most immediate tasks include sorting through more than 60,000 comments sent in response to the latest draft of its environmental impact statement" and that at the time, "[a]bout 60 workers" were assigned to this task).

[249] *Id.* ("'We're not rushing,' [the state's environmental agency head] told reporters after his testimony. 'We can only do what we can with the staff we have . . . .'").

[250] *See* Bradford C. Mank, *The Environmental Protection Agency's Project XL and Other Regulatory Reform Initiatives: The Need for Legislative Authorization*, 25 ECOLOGY L.Q. 1,

scaling problems and the need to grow their capacity, they have limited power to influence the legislature and the executive that directs agency priorities, and agencies must reserve this power for the issues their staff deem most important.[251]

Some states with pending proposals for expanded well development, or that are experiencing high drilling rates, have stepped up staffing numbers despite these obstacles, and have conducted thousands of new site inspections. Pennsylvania, for example, more than doubled the number of oil and gas inspectors in its Department of Environmental Protection[252] as the number of Marcellus Shale gas wells drilled nearly doubled between 2009 and 2010.[253] West Virginia went even further by attempting to ensure that staff numbers matched rising well numbers. In a comprehensive overhaul of oil and gas regulation enacted in 2011, the state legislature required the Secretary of the Department of Environmental Protection to "[d]etermine the number of supervising oil and gas inspectors," inspectors, and other staff needed to carry out new regulatory requirements.[254] It is not clear, however, that these needed inspectors have been hired.

The examples from Pennsylvania and West Virginia provide good starting points to ensure that enforcement rates remain consistent as regulated activity grows. More is needed, though. Within agency enabling legislation, expansions in scale should trigger automatic increases in agency staffing: policymakers should estimate the likely impacts of a rapidly growing activity regulated by

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40 (1998) (concluding that "agency staff and managers" are "too concerned with protecting their program's turf against other departments or agencies" and sometimes fail to focus adequately on long-term needs); Mark Seidenfeld, *Why Agencies Act: A Reassessment of the Ossification Critique of Judicial Review*, 70 OHIO ST. L.J. 251, 262 (2009) (observing that regulatory agency "staff members may share an interest in making their jobs as secure or easy as possible").

251 *See, e.g.*, Seidenfeld, *supra* note 250, at 263 (arguing that "deciding how to prioritize various goals of the program" is an incremental and complex endeavor for an agency).

252 *See* PA. DEP'T OF ENVTL. PROT., MARCELLUS SHALE: TOUGH REGULATIONS, GREATER ENFORCEMENT 1 (May 2013), *available at* http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-95071/0130-FS-DEP4288.pdf ("Throughout 2009 and 2010, DEP more than doubled the number of inspectors."); Sabrina Shankman, *New Gas Drilling Rules, More Staff for Pennsylvania's Environmental Agency*, PROPUBLICA (Feb. 9, 2010, 12:44 PM), http://www.propublica.org/article/new-gas-drilling-rules-more-staff-for-pennsylvanias-environmental-agency (reporting that inspector numbers increased from 35 in 2008 to 76 in 2009).

253 *Compare* Pa. Dep't of Envtl. Prot., Bureau of Oil & Gas Mgmt., WELLS DRILLED, http://www.dep.state.pa.us/dep/deputate/minres/oilgas/BOGM%20Website%20Pictures/2009/2009%20%20Wells%20Drilled.jpg (last updated Jan. 25, 2010) (indicating that 768 Marcellus Shale wells were drilled in 2009), *with* Pa. Dep't of Envtl. Prot., Bureau of Oil & Gas Mgmt., WELLS DRILLED, http://www.dep.state.pa.us/dep/deputate/minres/oilgas/photogallery/photo13295/2010%20%20Wells%20Drilled.gif (last updated Jan. 5, 2011) (reporting that 1386 Marcellus Shale wells were drilled in 2010).

254 W. VA. CODE ANN. § 22-6-2(c)(2) (LexisNexis 2009 & Supp. 2013).

the agency and should require staffing increases at various points of volumetric change.

In light of already severe agency budget constraints, the enabling legislation should fund this automatic staffing increase through fees on the regulated industry: for each threshold level of activity requiring new staff, the legislation could provide for a higher per-well permitting fee. This is a relatively simply calculation: 500 new wells would require a new annual salary of, for example, $40,000, thus demanding an $80 permitting fee increase for each well. Indeed, although few if any states mandate the automatic permit fee increases proposed here,[255] federal agencies in other contexts benefit from scale-based revenue structures, and several states experiencing booming oil and gas activity have, ex post, raised the fees associated with well development approvals and penalties at well sites.[256]

If harms are simply cumulative, higher permitting fees might not even be necessary; each additional regulated actor will add money to the existing pot, thus funding new inspectors as needed.[257] But where harms are interdependent, or where the cost of hiring inspectors increases – as occurs when agency staff are lured away by lucrative oil and gas jobs[258] – automatic fee expansions might be needed to fund additional staff.

C. *Time- and Location-Based Limits and Jurisdictional Changes to Address Interdependent and Uneven Harms*

Policymakers can address certain diseconomies by setting cumulative harm thresholds and matching agency enforcement rates with activity expansion rates, but this approach will often fail to adequately address interdependent and uneven effects. No matter how many agency staff inspect sites and issue notices of violation of existing laws, the rapid expansion of some activities will have problematic effects depending on combined factors like weather

[255] *See, e.g.*, R.R. COMM'N OF TEX., *supra* note 245, at 24 (observing that in Texas, most fees for oil and gas permitting, rule exceptions, and other activities "have not been raised in nine or more years").

[256] *See supra* note 44 (describing a Food & Drug Administration revenue increase based on workload); W. VA. CODE ANN. § 22-6A-7(g) (imposing a permit fee of $10,000 for the first horizontal well drilled at a site and $5000 for additional wells at the same site); Press Release, R.R. Comm'n of Tex., 2012: Year of Railroad Commission Accomplishments (Dec. 28, 2012), *available at* http://www.rrc.state.tx.us/pressreleases/2012/122812.php ("The Commission strengthened its oil and gas enforcement actions by adopting penalty guidelines based on risks posed and a violation's severity. Additionally, the Commission assigned higher penalties for repeat violators."); *Changes to Underground Injection Control Regulations*, OHIO DIV. OF MINERAL RES. MGMT., http://oilandgas.ohiodnr.gov/industry/underground-injection-control#news (last visited Nov. 4, 2013) (explaining that Ohio's legislature increased the state's underground saltwater injection control permit application fee from $100 to $1000 and raised fees per barrel of brine injected).

[257] I am grateful to Felix Mormann for this observation.

[258] I am grateful to Joshua Fershee for this observation.

conditions and the number of operators within an area. Harms will also concentrate in certain locations.

Three improvements are necessary for these more complex scaling problems. First, where an expanding activity will create disproportionate harms because it occurs at a sensitive location, at a particular time, or as a part of high-density activity, statutes or regulations must draw time- or place-based boundaries that constrain or ban activity within certain areas or seasons. These could be similar to the "community risk caps" intended to limit certain concentrated harms that Daniel Farber and others have proposed.[259] These types of localized thresholds will be particularly important when regulated activities rapidly increase; as thousands of entities compete for new space in which to construct well sites, for example, they have proposed (and in some cases, have begun) drilling in state parks, wildlife refuges, and other sensitive areas.[260] Setting an ex ante threshold for this type of activity is possible. Although interdependent harms may be more difficult to predict than independent, cumulative ones, we already know that drilling an oil and gas waste disposal well in a seismically unstable area, or near a city's aquifer, likely is not a good idea.

Second, where limited pollution control technologies produce unusually powerful effects – a problem sometimes encountered at wastewater treatment plants, for example[261] – states must review existing permits to ensure that technologies can accommodate and adequately treat new waste. Because some state agencies will have strong disincentives to conduct this review, policymakers must establish clear numerical thresholds above which technological review is mandated.

Finally, where direct and indirect effects of oil and gas development expand beyond the well site or concentrate at discrete locations, in some cases unevenly affecting certain populations, legislatures might need to force relatively rapid shifts of jurisdictional authority to a broader or more localized level. State agency control over certain aspects of hydraulic fracturing and gas development, for example, might need to shift to a regional level through congressional approval of a regional compact. Alternatively, municipalities might need to have more authority to regulate more or less stringently depending on the harms they experience.

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[259] Daniel R. Faber et al., *Solving Environmental Injustices in Massachusetts: Forging Greater Community Participation in the Planning Process*, 3 PROJECTIONS 109 (2002).

[260] *See, e.g.*, *Impacts of Leasing Additional State Forest Land*, PA. DEP'T OF CONSERVATION & NATURAL RES. (last visited Nov. 4, 2013), http://www.dcnr.state.pa.us/cs/groups/public/documents/document/d_000603.pdf (reporting that 700,000 out of 1,500,000 acres of state forest land on the Marcellus Shale had been leased for natural gas extraction).

[261] *See supra* notes 111-12 and accompanying text.

1. Time, Location, and Density-Based Harm Limits

Growing industries that rely on finite resources like land often push new actors into sensitive environments. They might also cause a number of actors to converge on one region simultaneously, and all of these actors might demand the same resources, causing temporary scarcity and, sometimes, large harms. Policymakers therefore must sometimes constrain ex ante the volume of activity that expands into certain areas or occurs at particular times, locations, and densities – particularly where large or irreversible harms could arise.

Some states and regional agencies already have begun to anticipate these problems in the oil and gas context. Pennsylvania, for example, recently increased required setbacks between wells and potentially sensitive resources, such as streams and wetlands.[262] West Virginia established new setbacks and increased existing ones,[263] and New York has gone further, proposing that no high-volume fracturing occur in the watershed that supplies New York City's drinking water.[264] In an ex post approach to scale-based change, agencies have also addressed certain unusual conditions on a case-by-case basis: as introduced previously, in the summer of 2012 the Susquehanna River Basin Commission (SRBC) halted sixty-four previously-approved water withdrawal permits for gas drilling "and other uses" due to "lower streamflow levels in the Susquehanna basin."[265] It did this because of an unusual harm-based threshold that required water withdrawals – even previously permitted withdrawals – to stop if stream flow dropped below a certain level.[266] Ideally, other agencies would similarly establish these thresholds before the fact to avoid the inevitable circumstances in which agency officials fail to notice changing conditions and attendant threats.

The Clean Water Act and Clean Air Act, and agencies that implement them, should similarly anticipate conditions in which the effects of additional activities will have particularly high costs. Cities already do this to some extent by encouraging commuters to carpool or reducing public transportation fees on particularly hot "ozone code red" days, for example.[267] If conditions become sufficiently dangerous, however, states, as part of their regulations that

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[262] *See, e.g.*, 58 PA. CONS. STAT. ANN. § 3215(b)(1) (West 2013) (requiring a minimum of 100-foot setbacks for wells and well sites from streams and wetlands).

[263] W. VA. CODE ANN. § 22-6A-12(b) (LexisNexis 2013) (requiring setbacks for well drilling of 250 feet from water sources and 625 feet from dwellings or certain structures used to house cattle or poultry).

[264] N.Y. STATE DEP'T OF ENVTL. CONSERVATION, *supra* note 57, at 20 ("[H]igh-volume fracturing activity is not consistent with the preservation of the [New York City and Syracuse] watersheds as an unfiltered drinking water supply.").

[265] *See supra* note 101 and accompanying text.

[266] *See supra* note 102 and accompanying text.

[267] *See, e.g.*, *Air Quality Forecast*, WASH. CNTY., MD., http://www.washco-md.net/air_qual.shtm (last visited Nov. 4, 2013) ("Maryland averaged 10 Code Red days a summer during the 1990's [sic].").

implement the Clean Air Act, might need to specify temperatures at which automobile driving must decline substantially. Similarly, for seasons when nonpoint pollution flows combine with cloudy weather (which reduces microbial-killing UV rays) to produce particularly dangerous bacterial or algae conditions in surface waters,[268] states might need to temporarily prohibit farmers from spreading manure or landowners from applying fertilizers to lawns.

Activities that concentrate in certain areas – thus disproportionately affecting certain communities – are more difficult to address through boundary drawing. States like New York have proposed to make certain areas entirely off-limits to shale gas development,[269] and at one point considered allowing only economically distressed communities to develop their shale.[270] But individuals within off-limits communities will object that they have given up millions of dollars in potential profits, while others living in economically distressed communities that experience both booming development and environmental externalities might be similarly unhappy. This will be particularly true for individuals who lack their own mineral rights but suffer the harms of development on neighboring lands.[271]

In many cases, the participatory and compensation-based proposals already well developed in the environmental justice literature could help to address these scale-based harms. Local zoning processes that required oil or gas wells to be sited somewhere within a town[272] but gave neighbors input regarding the ultimate location of the well, for example, would help. Fort Worth, Texas, which has nearly 2000 wells within its city limits as a result of the shale gas boom, already does this.[273] For communities disproportionately affected by

[268] *See* Amir M. Abdelzaher et al., *Presence of Pathogens and Indicator Microbes at a Non-Point Source Subtropical Recreational Marine Beach*, 76 APP. & ENVTL. MICROBIOLOGY 724, 730 (2009) ("Sunlight and UV light are known to inactivate microbes in water.").

[269] *See* N.Y. STATE DEP'T OF ENVTL. CONSERVATION, s*upra* note 57 (describing areas in which high-volume fracturing would be prohibited, including within the watershed of New York City's water supply).

[270] *See* Hakim, s*upra* note 197.

[271] *See, e.g.*, Complaint at Law & in Equity, *supra* note 119, at 9 (describing neighbors' complaints regarding contamination).

[272] This could be modeled from the siting scheme for cell phone towers in the Telecommunications Act, which Ashira Ostrow and Patricia Salkin suggest could be effectively applied to other necessary yet locally undesirable land uses. *See* Patricia E. Salkin & Ashira Pelman Ostrow, *Cooperative Federalism and Wind: A New Framework for Achieving Sustainability*, 37 HOFSTRA L. REV. 1049, 1092 (2009) (proposing a wind turbine siting policy based on the Telecommunications Act that would "(a) prohibit local governments from banning wind energy facilities; (b) require local governments to make decisions on wind siting within a reasonable period of time; and (c) require such decisions to be made in writing and supported by substantial evidence").

[273] *See, e.g.*, *Gas Drilling Review Committee Minutes*, CITY OF FORT WORTH 10-11 (June

drilling booms, Pennsylvania allows towns to vote to establish a fee[274] on drilled and fractured wells; the proceeds go to a state fund and are redistributed to municipalities for road, bridge, and other infrastructural repairs; environmental remediation; and other projects that address oil and gas development impacts.[275]

2. Setting Numerical Limits at Which States Must Review Pollution Treatment Technologies

As introduced above, some interdependent effects arise when pollution from an expanding activity must be treated prior to disposal. In the oil and gas context, for example, some wastes can be pumped untreated underground into injection wells, but others flow through wastewater treatment plants, where they must be filtered and otherwise treated before being sent to surface waters.[276] Treatment technologies have physical limits, though, and sometimes are unable to accept certain types or quantities of new wastes.[277] Wastewater treatment plants operating under state-issued Clean Water Act permits are supposed to demonstrate that the plants' systems can adequately treat the pollution that they receive,[278] and states are supposed to monitor and enforce this requirement. The Act and EPA guidance, however, fail to fully define the events that should trigger states to check permits and ensure that plants are equipped to accept new wastes.[279] As old, permitted plants in Pennsylvania accepted millions of gallons of new wastes from drilled and fractured wells, the Pennsylvania DEP did not review all of these plants' permits, leading the EPA to intervene.[280] After substantial EPA pressure, the DEP finally issued a

28, 2012), http://fortworthtexas.gov/uploadedFiles/Gas_Wells/GDRC/12_June_GDRC.pdf (describing one resident's concerns voiced at a meeting regarding a proposed well location).

[274] 58 PA. CONS. STAT. § 2302(a) (2012) ("The governing body of a county that has a spud unconventional gas well located within its borders may select whether to impose a fee on unconventional gas wells that have been spud in the county.").

[275] *Id.* § 2314(g).

[276] N.Y. STATE DEP'T OF ENVTL. CONSERVATION, s*upra* note 57, at 6-58 (stating that oil and wastewater "may only be discharged utilizing all treatment processes within" the publicly owned treatment works).

[277] *See* Letter from Shawn M. Garvin to Michael Krancer, *supra* note 111, at 2 (expressing concerns about inadequate treatment).

[278] *See* 33 U.S.C. § 1317 (2012) (requiring pretreatment standards for "new sources of pollutants into publicly owned treatment works" in order "to insure [sic] that any source introducing pollutants" into the wastewater treatment plant "will not cause a violation of the effluent limitations established for any such treatment works," and requiring these pretreatment standards to "prevent the discharge of any such pollutant" into the treatment plant that would "interfere with," or be incompatible with, the treatment technology).

[279] *See id.* (lacking detailed direction for states regarding enforcement of treatment plans for plants).

[280] *See* Letter from Shawn M. Garvin to Michael Krancer, *supra* note 111, at 1-2 ("I believe it is critical to investigate these substances in the treated drinking water in affected

request, not a mandate, that gas operators stop sending wastes to these old plants.[281]

Although the EPA – alerted by a *New York Times* article[282] – prevented potential problems in Pennsylvania, the threat that beyond a certain threshold large quantities of wastes will overwhelm treatment technologies should not be addressed by case-by-case responses. Agencies set effluent limitations after conducting extensive review of technologies used in particular industries;[283] they should therefore be able to determine the limits of these technologies and the specific scale-based changes that should spur agency review. Accordingly, regulations should more clearly define the quantity and types of new wastes that should trigger review and modification.

3. Requiring Periodic Revisions of Laws and Thresholds

Setting boundaries regarding where and when activities may occur, as well as thresholds of total acceptable harm, will not always solve long-term scale-based problems, as policymakers establishing ex ante regulations inevitably will misjudge certain effects, and some effects are unknowable ex ante. Just as sunset reviews can force agencies to consider volumetric changes in the activities that they regulate – and thus to identify diseconomies[284] – legislatures, through similar sunset review provisions, can force agencies to periodically consider revising laws. The Clean Air Act, although failing to fully address the scale-based effects of mobile air pollution sources, requires the EPA Administrator to "from time to time revise" emission standards for vehicles, thus anticipating that the EPA will need to modify its regulatory response for a variety of reasons.[285] For all types of air pollution, whether caused by stationary or mobile sources, the EPA also must consider revising the total "safe" levels of pollutant concentrations in the air every five years.[286]

Revising overall thresholds, however, will not be effective if expansions of individual sources threaten exceedance of these thresholds. Shorter expiration

watersheds . . . [t]o augment these actions, EPA will be taking additional steps directly using our authorities.").

[281] Press Release, Commonwealth of Pa. Dep't of Envtl. Prot., DEP Calls on Natural Gas Drillers to Stop Giving Treatment Facilities Wastewater (Apr. 19, 2011), http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=%2017071%20&typeid=1 ("At the direction of Governor Tom Corbett, acting Department of Environmental Protection Secretary Michael Krancer today called on all Marcellus Shale natural gas drilling operators to cease by May 19 delivering wastewater from shale gas extraction to 15 facilities that currently accept it under special provisions of last year's Total Dissolved Solids (TDS) regulations.").

[282] *See* Urbina, *supra* note 114.

[283] *See* 33 U.S.C. § 1311(b)(2)(A) (describing effluent limitations set best available control technologies economically achievable for a "category or class" of industry).

[284] *See supra* Part II.A.2.

[285] 42 U.S.C. § 7521(a) (2006).

[286] *Id.* § 7409(d)(1).

dates for individual source permits – the documents that give industrial sources the permission to operate and to pollute at a certain level – therefore might be important, particularly where legislatures or agencies anticipate rapid change within an industry.

4. Changing or Expanding Jurisdictional Authority to Address Uneven Effects

When the majority of effects of an expanding activity concentrate in certain areas, broader solutions than enhanced enforcement or harm limits are needed. Some of the uneven costs caused by scaling changes are reminiscent of problems already identified in the literature, and may require similar remedies. In William Buzbee's "regulatory commons," a problem crosses boundaries and, although many agencies have some control, no one agency has full authority or incentive to address the externalities.[287] This creates a space in which a number of regulators act – even with an appearance of overregulation – but still inadequately control the externalities of the regulated activity. The traditional concept of scaling as it is typically used in the legal literature (but not in this Article), provides similar lessons for the scaling described here, explaining that agency control should, but often does not, match the scope of externalities generated by the regulated activity.[288]

Oil and gas development, in particular, most powerfully affects the municipalities and states where wells are located,[289] thus producing externalities wholly within existing regulatory boundaries. Although policymakers and agencies must change substantive rules and institutional resources to address these expanding harms, they need not shift jurisdictional boundaries or formally coordinate with other government actors, aside from, perhaps, learning useful approaches from those actors. But all three examples of diseconomies of scale within this Article,[290] including mobile sources of air pollution, nonpoint water pollution sources, and oil and gas development, sometimes create transjurisdictional problems. Pollutants from oil and gas drilling and other nonpoint source activity, for example, can collect within watersheds,[291] which cross municipal and sometimes state lines, and certain air pollutants from mobile sources drift downwind across state boundaries.[292] In many cases, U.S. state and federal agencies lack the jurisdictional reach needed

[287] Buzbee, *supra* note 129, at 1.

[288] *See* Osofsky, *supra* note 1, at 242-43.

[289] *See, e.g.*, Spence, *supra* note 56, at 478 ([A]n examination of what we know about fracking's environmental impact suggests that much of that impact is local.").

[290] *See supra* Part I.A.1-3.

[291] *See, e.g.*, *supra* note 104 and accompanying text (discussing concerns about the impact of gas drilling and fracturing within the watershed of specially protected Delaware River waters).

[292] EME Homer City Generation, L.P. v. EPA, 696 F.3d 7, 11 (D.C. Cir. 2012).

to match these externalities, thus allowing these problems to affect certain areas disproportionately.

The EPA has federal control over air pollution and thus can address air emissions that cross jurisdictional boundaries, but states have continued to argue over whether the agency has correctly assessed and accounted for downwind effects, causing major delays in regulation.[293] Many mobile source problems, such as urban sprawl that increases total vehicle miles driven,[294] are beyond the control of the EPA or even any one state or municipality. Additionally, regional coalitions have not, for the most part, been formed to address these problems – in part due to municipal resistance to ceding control, as well as coordination problems.[295] Although regional water basin commissions address oil and gas drilling and nonpoint source pollution in some areas,[296] their authority often is not sufficient to address all activity that affects water quality. The Susquehanna River Basin Commission, for example, limits withdrawals of water from the river – including for oil and gas development – but does not govern well site development in the watershed, an activity that can send harmful sediment into the river.[297]

The Clean Air Act, although generally failing to address the scale-based effects of mobile sources of air pollution, also provides a useful model in shifting jurisdictional controls. The federal government primarily limits tailpipe emissions from mobile sources so that auto manufacturers need not follow fifty different emissions standards.[298] In nonattainment areas with dirty air, however – areas that typically have large numbers of stationary and/or mobile sources – the Clean Air Act allows states, with EPA permission, to avoid federal preemption of mobile source emissions controls and adopt

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[293] *See, e.g.*, *id.* at 12 (agreeing with the state plaintiffs that the EPA had improperly promulgated transport rules intended to address "good neighbor" issues).

[294] *See* ANDRES DUANY ET AL., SUBURBAN NATION, THE RISE OF SPRAWL AND THE DECLINE OF THE AMERICAN DREAM 85-87 (2000) ("[Our] country's fundamentally misguided approach to transportation planning as a whole . . . explain[s] why our country faces both an urban and environmental crisis.").

[295] *See, e.g.*, MARILYN A. BROWN ET AL., BROOKINGS INST., SHRINKING THE CARBON FOOTPRINT OF METROPOLITAN AMERICA 8 (2008) (describing increasing vehicle miles traveled); Buzbee, *supra* note 129, at 8 (discussing governance challenges to fixing urban sprawl).

[296] *See Chesapeake Bay*, *supra* note 166 (detailing EPA monitoring of nonpoint source pollution that reaches Chesapeake Bay).

[297] *See Frequently Asked Questions, SRBC's Role in Regulating Natural Gas Development*, SUSQUEHANNA RIVER BASIN COMM'N, http://www.srbc.net/programs/natural_gas_development_faq htm (last visited Oct. 15, 2013) (describing regulations of water withdrawals but not well site development).

[298] 42 U.S.C. § 7543(a) (2006) ("No state or any political subdivision thereof shall adopt or attempt to enforce any standard relating to the control of emissions from new motor vehicles or new motor vehicle engines . . . .").

stricter controls identical to California's.[299] These types of jurisdictional flexibility – allowing more localized governments to address certain environmental harms that concentrate in particular areas, and expanding jurisdiction to a regional level where harms cross boundaries – will be exceedingly important in preventing and mitigating regulatory diseconomies of scale.

D. *Justifying Ex Ante Harm Limits*

The substantive thresholds proposed here, including prevention of cumulative harm and harm that occurs at particular times in certain locations, might seem onerous and insufficiently flexible – particularly in light of the fact that science, political tolerance for harm, and economic priorities will change in the future. But several factors will weaken these objections.

First, I do not propose a comprehensive approach to regulating the activity; instead, I suggest a partial and relatively early approach to problems that might later expand. Specifically, the ex ante thresholds proposed here involve harm limits, and certain individualized controls that will be triggered as we near harm limits. These individualized controls need not always be command-and-control-type regulations, but rather an assurance that the actor, by whatever means acceptable, will not cross the harm threshold. A prohibition on oil and gas drilling in a protected habitat might cause operators to select another well location, or to drill a well at a distant surface point and then drill laterally thousands of feet below the surface. A restriction on clustered fracturing in a particular region during drought[300] might similarly delay drilling in that region, but will not prohibit it altogether. Further, as introduced above,[301] various harm thresholds might never be reached despite the activity growing, in which case there will be few costs to industry because more stringent limitations on individual actors will not be triggered. Many actors will still view this as onerous and comprehensive, but it is, in the grand scheme of regulation, somewhat incremental.

As Jonathan Gilligan and Michael Vandenbergh have observed, there is a "panacea bias" in the literature, which errs toward comprehensive solutions hashed out over a long period of time because it assumes that incremental solutions will be problematic.[302] This bias also tends to ignore the political difficulty of implementing these solutions, which is not a problem if we have plenty of time to address the harms of the regulated activity; we can wait for

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[299] *Id.* § 7507.

[300] *See, e.g.*, Press Release, Susquehanna River Basin Comm'n, *supra* note 101.

[301] *See supra* note 12 and accompanying text.

[302] Jonathan M. Gilligan & Michael P. Vandenbergh, *Accounting for Political Feasibility in Climate Instrument Choice* 3-4 (Vanderbilt Univ. Law Sch., Working Paper No. 13-7, 2013), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2220788.

the hoped-for comprehensive rule to emerge without irreversible effects occurring in the meantime.[303]

For many diseconomies of scale, we may have the luxury of waiting, and we could potentially aim for a broader regulatory scheme. Indeed, with the infusion of considerations of scale in the initial regulation, comprehensive approaches might eventually emerge. But trying to wait and regulate comprehensively would not be advisable in certain areas, including in the oil and gas context. Some irreversible effects might occur while we wait – for example, an aquifer polluted by an oil and gas waste disposal well is incredibly difficult to clean up.[304] And incremental, politically tolerable ex ante limits might be necessary in light of the inevitable push by those most affected by regulation – the regulated actors themselves – to prevent the establishment of new, more onerous regulation later on.[305] Relatively quick responses will be needed in the event that the harm threshold is reached, and rapid enactment of regulation might be effectively blocked by those with the most concentrated interests against it; in the regulatory lag that ensues, permanent harm could occur.

Perhaps the strongest objection to ex ante thresholds is that they simply will not work – we cannot predict the harms or even the direction that growth will take, as has been argued in the land use field and broader regulatory contexts.[306] But even for changing regulated activities that are harder to predict, such as technological innovation, agencies can sometimes estimate the

[303] *Id.* at 3 ("Exclusion of political feasibility concerns is a minor problem if delays are not important for assessing the performance of policy instruments, but it is a vital concern if delay matters.").

[304] *See, e.g.*, Dancy, *supra* note 65, at 18 (observing in the oil and gas context that "[o]nce a fresh water aquifer is damaged, in many instances it is economically impossible to restore that aquifer to its original condition in any meaningful time period"); *Ground Water Cleanup at Superfund Sites*, EPA (Dec. 1996), http://www.epa.gov/superfund/health/con media/gwdocs/brochure htm (explaining in the Superfund context, which involves hazardous waste sites that have likely suffered far more environmental damage than would an improperly constructed and managed oil and gas site, that "[s]ometimes, depending on the type of contamination, the ground water cannot be restored").

[305] *See* Nicholas Bagley & Richard L. Revesz, *Centralized Oversight of the Regulatory State*, 106 COLUM. L. REV. 1260, 1286-88 (2006) (describing industry fears that environmental groups will capture government agencies and cause "overzealous agency regulation," but concluding that these fears are "implausible" because environmental groups are diffuse and large).

[306] *See, e.g.*, Lon L. Fuller, *Freedom – a Suggested Analysis*, 68 HARV. L. REV. 1305, 1308 (1955) ("We have not discovered in human behavior mechanical or mathematical relationships that will enable us to predict invariant happenings."); Charles E. Lindblom, *The Science of "Muddling Through*,*"* 19 PUB. ADMIN. REV. 79, 85 (1959) ("Non-incremental policy proposals are . . . typically not only politically irrelevant but also unpredictable in their consequences.").

likely emergence of affordable pollution control technologies, for example,[307] and scale-based harms should be even more predictable. For independent harms that increase evenly, we can reasonably estimate total spill risk when wells expand from 100 to 1000. Establishing ex ante thresholds of total acceptable harms – as well as locations and times at which certain activities should not occur – is not an impossible task, although not an easy one.

E. *Deciding Who Decides*[308]

A number of major legal and administrative modifications will be required if scale-based change is to trigger rapid and effective response. We need governments to identify and address diseconomies of scale, and to do so nimbly, and this will raise important questions about institutional competency and the risks of inaction. Locating the best institution to address regulatory diseconomies of scale will depend largely on the scale-based effects involved, the lack of will within certain branches of government, and concerns relating to inefficient capture of the relevant governing entity.[309]

In terms of the substantive goals of scale-based regulation, addressing anticipated changes ex ante will be crucial. Setting cumulative harm thresholds, delineating areas where impacts must be constrained or prohibited, and defining times or seasons during which certain activities may not occur will provide these needed ex ante boundaries. To address concerns that conditions will later change – thus eviscerating the usefulness of predetermined thresholds – flexibility of implementation is necessary to allow agencies to tailor regulation specifically to the problem that emerges. This will require legislatures to grant agencies broad discretion for implementation, as already occurs through many cooperative federalist schemes in environmental law.[310] The setting of the threshold itself likely should be left to the agency, with sufficient congressional guidance to avoid nondelegation problems.[311]

[307] *Cf.* Blais & Wagner, *supra* note 179, at 1732 (providing an illustration of a technology-based standard for water pollution, which would ratchet down allowed pollution if the "the technology was expected to improve significantly").

[308] For a similar phrase in the fracturing context, see John R. Nolon & Victoria Polidoro, *Hydrofracking: Disturbances Both Geological and Political: Who Decides?*, 44 URB. LAW. 507 (2012).

[309] For a comprehensive analysis of the best level of government to address oil and gas development, see Spence, *supra* note 56.

[310] *See, e.g.*, William W. Buzbee, *Asymmetrical Regulation: Risk, Preemption and the Floor/Ceiling Distinction*, 82 N.Y.U. L. REV. 1547, 1578 (2007) (exploring cooperative federalism and its nuances, including whether the federal government should set a maximum or minimum level of stringency which states may not exceed or fall below in their regulations).

[311] *See, e.g.*, Whitman v. Am. Trucking Ass'ns, 531 U.S. 457 (2001) (rejecting a nondelegation challenge to Congress's directive to the EPA to set "ambient air quality standards the attainment and maintenance of which in the judgment of the administrator" are necessary to achieve health-based goals).

Agency actors are likely best suited to implement carefully researched and scientifically based regulations to control expanding harms, particularly if information-forcing regulations provide the agency actors with needed data. The accountability deficit problem is particularly acute in this case, though, because decisions about acceptable levels of harm are highly political. Legislatures should require heightened participatory opportunities in these rulemaking processes – multiple public hearings in addition to written comments, for example – to help close the accountability gap.

Despite the expertise of agencies, there is a concern that they will be insufficiently motivated to act, either before or after scale-based harms occur. As Mark Seidenfeld has observed, a variety of factors affect agency agenda setting.[312] While agency heads might look to the instructions of current legislators or the demands of future ones[313] – both of which might not recognize scale – they also might receive inaccurate information from agency staff or even from a particular department.[314] This information could inaccurately portray scaling problems.

Legislation allowing citizen suits to compel agency action can help address this problem. Legislatures should place nondiscretionary duties on agencies to address certain scale-based problems; as they already do for a number of environmental laws,[315] they should also allow individuals to sue when harmed by agencies' failures to perform their duties, such as considering a harm threshold rule, or to enforce existing rules.

Policymakers, too, could remedy agencies' failure to address scale-based change by taking on the challenge themselves. Legislatures in West Virginia[316] and Pennsylvania,[317] for example, passed relatively comprehensive acts modifying oil and gas laws, although certain agencies – particularly in Pennsylvania – were also very active in modifying their own regulations.[318] West Virginia specifically directed its oil and gas agency to study the effects of drilling and fracturing, determine the number of new staff needed to address this growing practice, and write new substantive regulations.[319] In Colorado, on the other hand, the Oil and Gas Conservation Commission took up the charge itself and comprehensively amended all of its oil and gas rules in the midst of a drilling and fracturing boom.[320]

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312 *See* Seidenfeld, *supra* note 250, at 258-68.

313 *Id.* at 261.

314 *Id.* at 264.

315 *See, e.g.*, 42 U.S.C. § 7604(a) (2006) (allowing citizens to sue the EPA Administrator for a failure to perform a nondiscretionary duty under the Clean Air Act).

316 W. VA. CODE ANN. § 22-6-2 (LexisNexis 2009).

317 58 PA. CONS. STAT. § 2301-81 (2012).

318 41 Pa. Bull. 805, 815 (Feb. 5, 2011) (codified at 25 PA. CODE § 78.73).

319 W. VA. CODE ANN. § 22-6-2 (LexisNexis 2009).

320 *See COGCC Amended Rules Redline*, COLO. OIL & GAS CONSERVATION COMM'N (Dec. 17, 2008), http://cogcc.state.co.us/RuleMaking/FinalRules/COGCCFinalRule

Whether certain members of the legislature, the agency, or both have the will to address scale-based change, the rules that actually emerge will, of course, depend largely on politics. In many cases, legislative bodies might be satisfied by the general tendency of agency actors, and everyone else, for that matter, to forget that existing, regulated activities can cause large, new harms as they grow. After all, the economic benefits of booming development often flow directly to state coffers in the form of sales taxes, direct taxes on resources extracted, and other revenues.[321] Agencies, too, might be tempted to ignore scale-based change, because it consistently produces more work for them and angers the regulated actors with which agencies sometimes have revolving door relationships.[322]

Despite their potential penchant for ignoring scale-based harms due to political pressure, legislatures might be the best institutions to initially act in the face of general inertia in this area. Since they are not directly tasked with implementing the laws – and can pass the blame for stringent laws to the agencies that write the implementing regulations – these representative institutions might have more motivation to address scale-based change, at least in the abstract. Provided that they have a long-term vision of the needs of citizens in the state, they might anticipate problematic boom and bust cycles that will suddenly deplete state coffers, or contamination events that could require expensive clean-up. And they might provide general directives to agencies to consider and address such problems.

Either agencies or legislators addressing scale-based change could, of course, be subject to undue influence from the actors with the most to lose or gain from statutory or regulatory changes, while ignoring the needs of those with scattered, diffuse interests that are collectively large.[323] And it is not always clear whether there is more of a threat of capture at the agency or the legislative level – in oil and gas, in particular, agencies are known for their

Amendments_121708.pdf (reflecting comprehensive revisions).

[321] *See, e.g.*, CHARLES COSTANZO & TIMOTHY W. KELSEY, PENN STATE COLL. OF AGRIC. SCIENCES, STATE TAX IMPLICATIONS OF MARCELLUS SHALE: WHAT THE PENNSYLVANIA DATA SAY FOR 2010 (2011), *available at* http://pubs.cas.psu.edu/FreePubs/pdfs/ua468.pdf ("State tax collections in counties with significant activity related to Marcellus shale on average had larger increases in sales and personal income tax collections and less precipitous declines in realty transfer tax collections than did other Pennsylvania counties.").

[322] *See, e.g.*, Hannah Wiseman, *Untested Waters: The Rise of Hydraulic Fracturing in Oil and Gas Production and the Need to Revisit Regulation*, 20 FORDHAM ENVTL. L. REV. 115, 138 (2009) (exploring potential industry influence in an EPA report that supported a congressional exemption for hydraulic fracturing).

[323] *See* Pursley & Wiseman, *supra* note 241, at 923 ("The classical objection is that interest groups that favor lax environmental regulation and have high individual stakes in regulatory outcomes – paradigmatically industry groups – tend to be small and cohesive, but groups favoring stricter environmental regulation tend to be more diffuse and less organized.").

frequent interactions with industry and, in some cases, for potentially bending scientific results in response to agency pressure.[324] But legislators, too, hear frequently from industry lobbyists and have been known to give unusually beneficial exemptions to them.[325] Environmental and other interests, however, might have sufficient organizational powers in this area to overcome the transaction costs of collecting thousands of diffuse interests – and they may meaningfully or possibly disproportionately influence legislative and administrative outcomes.[326] Indeed, it appears that powerful and wealthy environmental interests, in addition to certain widespread citizen concern, influenced Governor Cuomo's decision to continue delaying the approval of fracturing operations in New York.[327]

Perhaps the lower the level of lawmaking, the less chance there is for capture, thus suggesting that we should not ask whether agencies or legislative bodies are more likely to be captured, but which level of government, generally, might best avoid repeat interactions with one special interest or another. In this case, local regulation of scale-based change might be preferable, as industry actors and powerful interest groups cannot be everywhere at once.[328] And this might militate against state preemption of local oil and gas drilling[329] – although excessive local control could also lead to insufficient levels of development due to NIMBYist (not in my backyard) concerns, as well as inadequate control of effects that spill over boundaries.[330] The possibility that more diffuse and numerous governments addressing one issue are less likely to be captured might also support the cooperative federalism scheme already used in environmental regulation, which allows

[324] EPA, EPA 816-R-04-003, EVALUATION OF IMPACTS TO UNDERGROUND SOURCES OF DRINKING WATER BY HYDRAULIC FRACTURING OF COALBED METHANE RESERVOIRS 7-5 (2004) (concluding that further study of the risks of fracturing was not merited); Wiseman, *supra* note 322, at 138 (describing how industry might have encouraged the EPA to reach this conclusion).

[325] *See* Wiseman & Gradijan, *supra* note 70 (exploring the federal exemptions in depth).

[326] *But see* Bagley & Revesz, *supra* note 305, at 1286-88 (arguing that the theory that well-organized environmental groups will "capture" agencies is "wholly implausible," and noting the massive funding advantage of industry groups and the relatively small number of members within each industry group (and thus their ease of organization)).

[327] *See, e.g.*, Danny Hakim, *Shift by Cuomo on Gas Drilling Prompts Both Anger and Praise*, N.Y. TIMES (Sept. 30, 2012), http://www nytimes.com/2012/10/01/nyregion/with-new-delays-a-growing-sense-that-gov-andrew-cuomo-will-not-approve-gas-drilling.html?pagewanted=all ("The governor has been influenced by the unshakable opposition from a corps of environmentalists and celebrity activists who are concerned about the safety of the water supply.").

[328] *See* Pursley & Wiseman, *supra* note 241, at 934-35.

[329] 58 PA. CONS. STAT. §§ 3303-3309 (2012), *held unconstitutional by* Robinson Twp., Wash. Cnty. v. Pennsylvania, 2013 WL 6687290 (Pa. Dec. 19, 2013).

[330] *Cf.*, Nolon & Polidoro, *supra* note 308, at 523-25 (describing municipal bans on fracturing in New York that were upheld by the state's lower court).

states to determine how to keep certain pollutants within their boundaries below federally designated thresholds.[331] Regardless of the level of government or institution chosen, the most effective ways for resisting the undue influence of any one group in the decisionmaking must continue to be explored.

Not all of the harms of scale-based change will be predictable, however, thus necessitating an ex post role for courts. Indeed, nuisance law is essentially a threshold scaling response: even when actors comply with public law limits, courts may still deem their activities unacceptable – particularly when the activities expand into particular areas. As the courts have recognized, a pig in the parlor is problematic.[332] Although enlisting hundreds of individual court cases to address a growing problem is likely far less efficient than modifying one regulation to address the problem, courts allow individuals experiencing disproportionate effects of a regulated activity to raise their specific complaints and potentially have them addressed.

Legislation is important in the court context, too, so that individuals can make specific complaints as harms expand into certain regions. In many cases, plaintiffs will have difficulty proving causation or gathering the necessary evidence to support other claims. In Pennsylvania, property owners and neighbors claiming alleged contamination from oil and gas development have used statutes with relatively broad hazardous cleanup regulations, as well as state common law principles for medical monitoring,[333] to better argue their case. It appears, however, that no plaintiff has yet persuaded a court that damages are owed as a result of oil and gas drilling and fracturing.[334] Thomas Merrill and David Schizer have proposed a solution, outlining a comprehensive system through which courts would address fracturing-related claims – even those for which causation is difficult to establish.[335]

[331] *See* 42 U.S.C. § 7410 (2006) (directing states to write "State Implementation Plans" to ensure the achievement of federal air quality standards within state boundaries).

[332] Euclid v. Ambler Realty Co., 272 U.S. 365, 388 (1926) ("A nuisance may be merely a right thing in the wrong place, like a pig in the parlor instead of the barnyard."). *But see* Merrill & Schizer, *supra* note 6 (proposing a regulatory compliance defense where the risk of a particular oil and gas development activity is relatively well known, establishing causation is not too difficult, and industry has complied with regulation that requires state of the art industry practices).

[333] *See, e.g.*, Fiorentino v. Cabot Oil & Gas Corp., 750 F. Supp. 2d 506, 513 (M.D. Pa. 2010) (initially rejecting, in a case that later settled, a motion to dismiss plaintiffs' claims for medical monitoring funds under Pennsylvania's common law).

[334] *See* SMITA WALAVALKAR, COLUMBIA LAW SCH. CTR. FOR CLIMATE CHANGE LAW, DIGEST OF HYDRAULIC FRACTURING CASES (2013), http://www.law.columbia.edu/null/download?&exclusive=filemgr.download&file_id=622373 (collecting cases).

[335] Merrill & Schizer, *supra* note 6 (proposing the use of res ipsa loquitur and other doctrines, which would create something close to strict liability for industry actors, for certain impacts for which risks are "not yet well understood" and causation may be difficult to show).

As with most regulatory challenges, scale-based problems require a combination of actors – local, state, regional, and federal officials – and a mixture of judicial, legislative, and agency action. These actors must make a number of changes to laws and institutions. Agencies must grow as their regulated activity grows, and this might require automatic increases in permitting fees or other revenues to fund this expansion. Agency jurisdiction might need to change rapidly as growth expands into certain areas, necessitating quick action by legislatures to form new regional agencies or to shift authority to an entirely new level. Regulations must set acceptable levels of harm and constraints on activities where harms could have disproportionate effects. They also must provide for adequate compensation of individuals in areas that are most disproportionately affected by these harms. Pieces of many of these solutions already reside within the environmental justice, regulatory commons, cooperative federalism, and "massive problems" literature.[336] In the regulatory diseconomies context, however, these pieces require careful tailoring and integration to address scale-based change comprehensively, which contributes to many of our lingering environmental problems.

CONCLUSION

The most qualified, hard-working, and diligent agency actors and policymakers might strive to predict the intensity of industrial activity, but often they will not succeed. Ten years ago, most geologists or state oil and gas agencies would not have projected that the United States could become the world's largest oil producer and a major exporter of oil and gas.[337] But even when we do not know whether and how rapidly certain activities will grow, we can establish the total harms that we are likely to tolerate from this activity and write policy and regulations with these harms in mind. In other cases, we can be relatively certain that convenient activities like driving cars will grow, and we can directly predict many of the harms associated with this growth. Despite these forward-looking abilities in the scale-based context, a core failure of legislation, regulation, and the implementation of regulation by agencies is the lack of attention to scale. When drafting legislation and forming agencies, Congress and state legislatures operate under core assumptions about the level of intensity of a regulated activity, and these become ingrained within legal and institutional structures.

To remedy this fundamental failure in public law, we must write laws and form agencies with both scale and flexibility in mind. We must require agencies (and, ideally, policymakers) to consider the likely effects of expanding scale through, for example, carefully-tailored environmental review provisions; we also should encourage them to track changing volumes of

[336] *See supra* note 127 and accompanying text (introducing some of the environmental justice literature); *supra* note 183 and accompanying text (introducing "massive" problems); *supra* note 310 and accompanying text (exploring aspects of cooperative federalism).

[337] *See supra* notes 7-8.

regulated activity and the adequacy of agency control through modified forms of sunset review. To allow policymakers and agencies to both identify emerging scale-based problems and those that already have occurred, information-forcing regulations must require agency actors to disclose data that further illuminates the risks.

Substantively, where we can predict the effects of a growing activity, we should set static, ex ante thresholds that prevent certain levels of harm from occurring, or that constrain the timing or location of certain activities. If we later decide that the benefits of the growing activity justify even higher harm levels, then we can modify those thresholds when we reach that point; in the meantime, the established limits will prevent potentially irreversible harms. And finally, institutionally, we must ensure that agencies have adequate staff to enforce these harm limits if the activity grows, triggering personnel expansions at particular thresholds of regulated activity. We also must more effectively and rapidly respond to scale-based problems ex post when it is difficult to predict these harms.

This proposal is, in part, simply another pitch for regulatory nimbleness; the more quickly the intensity of an activity changes and the harm it causes increases, the more danger of major harm as policymakers and agencies formulate a response. But it is also largely a proposal for forming better law at the outset: the administrative law literature has already explored the propensity of laws to become dangerously entrenched.[338] Another factor, which we have largely ignored, makes this stasis even more problematic. If we are stuck within laws that assume a certain level of oil and gas development, driving of cars, or agricultural production, and that set the level of regulatory control based on assumptions of this level of harm, then our regulation will soon be badly off balance.

This Article proposes that we transfer lessons from the few state and federal environmental laws that incorporate scaling considerations to the many areas of law that currently suffer from scale-based problems. Indeed, although the rapidly growing oil and gas industry best demonstrates diseconomies of scale, it, too, has begun to provide vital lessons; some states have already started to regulate with an eye toward scale-based concerns, and these leaders provide models for several of the solutions proposed here. In light of concerns about earthquakes caused by oil and gas waste disposal wells drilled in or near fault

[338] *See, e.g.*, Buzbee, *supra* note 129, at 22-27 (discussing the potential inadequacy of regulation due to a mismatch between regulatory opportunities and agency jurisdiction); Thomas O. McGarity, *Some Thoughts on Deossifying the Rulemaking Process*, 41 DUKE L.J. 1385, 1387 (1992) (observing "that it is much harder for an agency to promulgate a rule now than it was twenty years ago" and describing judicially imposed factors, and other factors, contributing to this problem); Seidenfeld, *supra* note 250, at 289-93 (hypothesizing that agencies might not act (and thus might leave old rules in place or pursue a relatively unaggressive agenda) due to a variety of internal dynamics and psychological factors – including status quo bias and omission bias – the tendency to prefer no action to the taking of action).

zones, for example, Arkansas prohibits oil and gas disposal wells in certain areas, at least for now,[339] and Ohio requires continuous monitoring of these wells for potential seismic problems.[340] New York is conducting a comprehensive review of the potential effects of large numbers of hydraulically fractured wells, and it has proposed limits to prevent certain potential harms, including the prohibition of fracturing within New York City's watershed.[341] Other states, however, have lagged behind, thus threatening to allow unacceptable harms to accrue. And oil and gas regulation is not the only culprit; many other areas of the law might suffer from similar diseconomies.[342] With simple attention to the fact that regulated human activities, even seemingly benign ones, could cause disproportionate harm at a certain scale, we might avoid many of the tragic pitfalls of our current system of public law.

Many growing activities do not, of course, cause these types of harms. Indeed, as this Article emphasizes, the expansion of domestic gas production appears to be a net positive when comparing total costs and benefits as opposed to regulatory costs and harms. The great challenge of ex ante scale-based regulation is to avoid stifling the growth of activities with net benefits and allowing innovation while simultaneously ensuring that these activities do not cause unacceptable harms. This can be done with carefully tailored regulations that set reasonable harm thresholds; avoidance of more stringent controls on individual actors when it appears that we are not close to reaching harm thresholds; ratcheting *down* regulation when it appears that the activity produces fewer harms as it grows; and periodically revisiting regulation and institutional size to determine needed changes in either direction. Scaling

[339] 178-00-001 ARK. CODE R. pt. H, r. H-1(s)(2) (LexisNexis 2012); *Permanent Disposal Well Moratorium Area*, ARK. OIL & GAS COMM'N (June 20, 2011), http://www.aogc.state.ar.us/notices/Ex.%201B%20-Permanent%20Disposal%20Well% 20Moratorium%20Area.pdf.

[340] *See supra* note 108 and accompanying text.

[341] *See supra* Part II.A.1.

[342] For example, the mortgage crisis seemed to escalate when numerous firms simultaneously realized the true value of risky trades. *See* Mark J. Roe, *Clearinghouse Overconfidence*, 101 CALIF. L. REV. 1641, 1645 (2013) ("The crisis attacked the economy when financial markets rapidly revalued mortgage securities owned throughout the financial system, not when a single firm, or small number of firms, failed."). I am grateful to Jay Kesten and Manuel Utset for discussions involving the possible diseconomies of scale resulting from derivatives and other aspects of the mortgage crisis. Online gambling and betting, too, could potentially exhibit diseconomies of scale. As millions of people gain access to easier betting outlets, harms might be expanding in disproportionate ways – potentially through interdependent harms associated with networked transactions. *See* Keith C. Miller, *The Internet Gambling Genie and the Challenges States Face*, 17 J. INTERNET L. 1, 23 (2013) (suggesting that "the social problems that are inherent in gambling will have an expanded base" if online gambling grows). I am grateful to Dr. Ryan Rodenberg for discussions regarding the potential diseconomies of scale associated with the growth of internet gaming.

considerations involve one small, yet very important, tool within an increasingly large set of strategies to improve public law.