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Environmental Standards, Thresholds, and the Next Battleground of Climate Change Regulations

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This Article addresses a central battleground of the debate about the future of greenhouse gas regulations: the valuation of particulate matter reductions that accompany reductions in carbon dioxide emissions. The benefits from particulate matter reductions are substantial for climate change rules, accounting for almost one half of the quantified benefits of the Obama Administration's Clean Power Plan. These benefits are also significant for regulations of other air pollutants, making this issue one of far-reaching importance for the future of environmental protection.

Opponents of environmental regulation, including the Trump Administration, have recently embraced an aggressive line of attack on particulate matter benefits. They argue alternatively that these benefits are not real; are being "double counted" in other regulations; or should not be considered when they are the co-benefits, rather than the direct benefits, of specific regulations. This Article collects and analyzes for the first time the robust support for valuing particulate matter benefits. An examination of the scientific literature, longstanding agency practices under administrations of both major political parties, and judicial precedent reveals that particulate matter benefits deserve a meaningful role in regulatory cost-benefit analysis.

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INTRODUCTION

In its landmark decision *Michigan v. EPA*,[1] the Supreme Court held that the Environmental Protection Agency (EPA) is required to consider costs before deciding to regulate the hazardous air pollutant emissions of power plants through its Mercury and Air Toxics Standards,[2] which were promulgated during the Obama Administration. The Court, however, did not decide how benefits should be taken into account, and identified but left open a significant question: how to address the benefits from reductions in particulate matter beyond the levels already required under the Clean Air Act's National Ambient Air Quality Standards (NAAQS).[3] Reductions of hazardous air pollutant emissions are the direct benefits of the Mercury and Air Toxics Standards, whereas particulate reductions are the indirect benefits, also referred to as co-benefits or ancillary benefits,[4] which result from the actions that power plants are expected to take in order to comply with these standards.[5]

Courts may soon have the opportunity to address the question of how to treat particulate matter co-benefits as a result of President Trump's efforts to undo the most significant environmental regulations of the Obama Administration. In particular, a top priority of the Trump Administration is repealing the Clean Power Plan,[6] which would regulate the greenhouse gas emissions of power plants, and a proposed rule to that effect has already been published.[7]

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[1] 135 S. Ct. 2699 (2015).
[2] *See id*. at 2712.
[3] *See id.* at 2711 ("Even if the Agency could have considered ancillary benefits when deciding whether regulation is appropriate and necessary—a point we need not address—it plainly did not do so here.").
[4] *See* Samuel J. Rascoff & Richard L. Revesz, *The Biases of Risk Tradeoff Analysis: Towards Parity in Environmental and Health-and-Safety Regulation*, 69 U. CHI. L. REV. 1763, 1766 (2002). Throughout the literature, co-benefits are alternatively referred to as ancillary benefits, secondary benefits, or indirect benefits. *See* David Pearce, *Policy Frameworks for the Ancillary Benefits of Climate Change*, *in* ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT, ANCILLARY BENEFITS AND COSTS OF GREENHOUSE GAS MITIGATION 518 (2000). For simplicity, this Article uses the term "co-benefits."
[5] *See* Hazardous Air Pollutants From Coal and Oil-Fired Electric Utility Steam Generating Units and Standards of Performance for Fossil-Fuel-Fired Electric Utility, Industrial-Commercial-Institutional, and Small Industrial-Commercial-Institutional Steam Generating Units, 77 Fed. Reg. 9304, 9428 (Feb. 16, 2012) (to be codified at 40 C.F.R. pts. 60 and 63) [hereinafter MATS Rule].
[6] *See* Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units, 80 Fed. Reg. 64,662, 64,663 (Oct. 23, 2015) (to be codified at 40 C.F.R. pt. 60) [hereinafter Clean Power Plan].
[7] *See* Proposed Rule on the Repeal of Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units, 82 Fed. Reg. 48,035, 48,045-46 (Oct. 16, 2017) (to be codified at 40 C.F.R. pt.

Attacking the consideration of co-benefits is an important strategy in this quest. Indeed, it is only by completely disregarding the Clean Power Plan's principal co-benefits, particulate reductions under the level of the NAAQS, that the Trump Administration is able to conclude that the cost savings from repealing the rule exceed the foregone benefits that would result from the repeal.[8] The validity of co-benefits will certainly be at issue in the inevitable ensuing litigation.

Further, on remand from the Supreme Court in the MATS litigation, EPA evaluated the reasonableness of the rule's costs under multiple metrics and put forward two approaches to demonstrate that the rule is cost-benefit justified in a Supplemental Finding, one of which includes a discussion of co-benefits.[9] However, because this method is EPA's altnernative approach, the D.C. Circuit would need to rule on the validity of including co-benefits only if it does not uphold the rule under EPA's preferred approach. The case is now being held in abeyance[10] while the Trump Administration considers whether to modify the Supplemental Finding.[11] However, if the Trump Administration reverses itself on the inclusion of co-benefits, environmental groups would likely challenge the decision, bringing the question before a federal court.

How courts ultimately respond to challenges of the reliance on co-benefits of particulate reductions below the NAAQS will have far reaching consequences for climate change regulations, as well as for public health rules more generally, because co-benefits of particulate

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60), https://www.gpo.gov/fdsys/pkg/FR-2017-10-16/pdf/2017-22349.pdf [hereinafter Clean Power Plan Proposed Repeal].

[8] *See* Clean Power Plan Proposed Repeal, *supra* note 7, at 48,045-46. EPA presents the net benefits of repeal under different scenarios: rate-based and mass-based implementation. At a 3% discount rate, net benefits of the repeal are negative in the year 2030—meaning that the foregone benefits from the Clean Power Plan (or, put differently, the costs of repeal) are higher than the benefits from repeal in every scenario, except where all $PM_{2.5}$ benefits below the NAAQS fall to zero.

EPA also presents calculations of benefits at a 7% discount rate, but that figure is out of line with economists' practice. *See* Richard G. Newell, *Unpacking the Administration's Revised Social Cost of Carbon*, RESOURCES FOR THE FUTURE (Oct. 10, 2017), http://www.rff.org/blog/2017/unpacking-administration-s-revised-social-cost-carbon ("It is clearly inappropriate . . . to use such modeling results with OMB's 7 percent discount rate, which is intended to represent the historical before-tax return on private capital . . . Practically speaking, the use of such a high discount rate means that the effects of our actions on future generations are largely unaccounted for in the new analysis. This is incompatible with the long-lived nature of greenhouse gas emissions in the atmosphere, and the fact that damages from emissions today will continue to be felt for generations to come.").

In order to justify the repeal, EPA also needs to significantly downplay the direct benefits of carbon dioxide reductions. *See* Niina Heikkinen, *EPA Revises the Social Cost of a Potent Greenhouse Gas*, SCI. AM. (Nov. 20, 2017), https://www.scientificamerican.com/article/epa-revises-the-social-cost-of-a-potent-greenhouse-gas.

[9] *See* Supplemental Finding That It Is Appropriate and Necessary To Regulate Hazardous Air Pollutants From Coal- and Oil-Fired Electric Utility Steam Generating Units, 81 Fed. Reg. 24,420, 24,420 (Apr. 25, 2016) (to be codified at 40 C.F.R. pt. 63). EPA's preferred approach weighed the costs of compliance against the volumetric reduction in hazardous air pollutants. *See id.* at 24,426. In turn, the agency's alternative approach compared the costs against the quantified benefits, including co-benefits and unquantified benefits. *See id.* at 24,427, 24,437-42.

[10] *See* Murray Energy Corp. v. EPA, No. 16-1127 (D.C. Cir. Apr. 27, 2017).

[11] *See* Respondent EPA's Motion to Continue Oral Argument, No. 16-1127 (D.C. Cir. filed Apr. 18, 2017). It seems highly likely that the Trump Administration will reverse the EPA's position on the use of co-benefits: in an early iteration of this litigation, EPA Administrator Scott Pruitt, then the Attorney General of Oklahoma, filed a brief, together with a number of other state Attorneys General and industry groups, strongly arguing that the particulate reduction co-benefits were not cognizable for the purposes of evaluating the permissibility of EPA's decision to regulate hazardous air pollutant emissions of power plants. *See* Opening Brief of State and Industry Petitioners at 41-55, Murray Energy Corp. v. EPA, No. 16-1127 (D.C. Cir. filed Nov. 18. 2016).

reductions under the NAAQS are a substantial portion of the total benefits from regulating the emissions from stationary sources, and, strikingly, a substantial portion of the benefits of all federal regulation.

Indeed, EPA rules accounted for 61-80% of the monetized benefits from *all* major federal regulations over the past ten years, and 98 to 99% of those monetized benefits come from air quality rules.[12] And, the large estimated benefits of air quality rules "are mostly attributable to the reduction in public exposure to fine particulate matter."[13]

Furthemore, as the Mercury and Air Toxics Standards and the Clean Power Plan illustrate, a highly significant proportion of these reductions come from the co-benefits of particulate reductions. The Mercury and Air Toxics Standards, in particular, have the second-highest quantified benefits of all of EPA's 22 clean air rules of the past decade.[14] EPA estimated $4 to $6 million in direct quantified benefits under the Mercury and Air Toxics Standards from the target hazardous pollutants,[15] in addition to significant unquantified benefits,[16] but quantified benefits of $37 to $90 billion in health co-benefits from particulate reductions.[17] For the Clean Power Plan, EPA under President Obama calculated $20 billion in climate benefits, and an additional $13 to $30.3 billion from particulate reduction co-benefits.[18]

The bulk of these particulate co-benefits come from reductions below the NAAQS. For example, in the case of the Mercury and Air Toxics Standards, EPA notes that a small percentage

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[12] *See* Office of Management and Budget, *2016 Draft Report to Congress on the Benefits and Costs of Federal Regulations and Agency Compliance with the Unfunded Mandates Reform Act*, at 2, 7-8, 11-12 (2016), https://obamawhitehouse.archives.gov/sites/default/files/omb/assets/legislative_reports/draft_2016_cost_benefit_report_12_14_2016_2.pdf.

[13] *See id.* at 12.

[14] *See id.* at 12.

[15] *See* Brief for the Federal Respondents at 55, Michigan v. EPA, 135 S. Ct. 2699 (2015) (No. 14-46), 2015 WL 797454.

[16] *See id.* ("[V]irtually all of the direct benefits from reducing emissions of hazardous air pollutants are unquantifiable.).

[17] *See id.* at 54; Environmental Protection Agency, *Regulatory Impact Analysis for the Final Mercury and Air Toxics Standards*, EPA-452/R-11-011, at 5-1 (Dec. 2011), https://www3.epa.gov/ttnecas1/regdata/RIAs/matsriafinal.pdf [hereinafter MATS RIA]. These numbers were calculated using a 3% discount rate. *See id*.

[18] *See* Environmental Protection Agency, *Regulatory Impact Analysis for the Clean Power Plan Final Rule*, EPA-452/R-15-003, at 4-27 (Aug. 2015), https://www3.epa.gov/ttnecas1/docs/ria/utilities_ria_final-clean-power-plan-existing-units_2015-08.pdf. This estimate includes reductions in SO_2, which is both a precursor to the formation of $PM_{2.5}$ as well as a component of $PM_{2.5}$ (since SO_2 itself is often present as a fine particle). *See id.* at 4-11. EPA, surveying the scientific literature, also noted that "scientific differences existed only with respect to the magnitude of the effect of $PM_{2.5}$ on mortality, not whether such an effect existed." *Id.* at 4-17. Notably, the Clean Power Plan rule is cost-benefit justified without these additional health benefits; EPA estimated that the regulation would cost between $5.1 and $8.4 billion in 2030, a range dwarfed by the total estimate benefits of between $34 and $54 billion. *See id.* at ES-22, ES-23. Moreover, recent analyses of Clean Power Plan compliance costs suggest that the cost of complying with the Plan has fallen since 2015, when EPA's analysis was released. These compliance costs fell due to declines in the cost of renewable energy, declines in the forecast price of natural gas, extensions of federal tax credits for renewable energy, and expansions of state programs supporting the adoption of clean energy. *See generally* Denise A. Grab & Jack Lienke, *The Falling Cost of Clean Power Plan Compliance*, INSTITUTE FOR POLICY INTEGRITY (Oct. 2017), http://policyintegrity.org/files/publications/Falling_Cost_of_CPP_Compliance.pdf (collecting and analyzing reports of independent groups calculating the updated costs of compliance with the Clean Power Plan).

of the co-benefits come from reductions in particulate matter above the NAAQS, as the regulation would help to bring out of compliance areas into compliance, but that "a large fraction of the . . . related benefits . . . occur below the level of the National Ambient Air Quality Standard (NAAQS)."[19]

The preceding analysis reveals how much is at stake in the controversy over the permissibility of relying on the co-benefits of particulate reductions below the NAAQS. Ignoring these benefits will threaten significant regulatory initiatives and adversely affect populations such as the elderly and asthmatic children, who are particularly sensitive to the adverse health effects particulate matter at levels below the NAAQS.[20]

Opponents of these regulations employ a few key arguments to suggest that these benefits should not be cognizable in evaluating of EPA regulations. In this Article, we address each of these argument in turn. Relying on scientific evidence, EPA practice, and judicial decisions, we show that these arguments are unfounded.

Critics argue first that the benefits from particulate matter reduction do not exist.[21] They do so by assuming that particulate matter is a threshold pollutant. By implication, these critics make the same assumption for all "criteria pollutants," which are pollutants regulated by NAAQS standards pursuant to Section 108 of the Clean Air Act: ground level ozone, particulate matter, carbon monoxide, lead, sulfur dioxide, and nitrogen dioxide.[22] A threshold is the level below which there are no quantifiable health effects from pollutant exposure,[23] and threshold pollutants are those pollutants for which a threshold can be identified. The Clean Air Act

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[19] MATS RIA, *supra* note 17, at ES-4.

[20] In a 2017 study of Medicare recipients, discussed further *infra* in Part III, researchers observed a rising risk of death from any cause in association with $PM_{2.5}$ exposure beginning at levels significantly below the NAAQS for $PM_{2.5}$. *See* Quan Di, et al., *Air Pollution and Mortality in the Medicare Population*, 376 NEW ENG. J. MED. 2513, 2513 (2017). In a study of inner-city children with asthma, short-term increases in $PM_{2.5}$ concentrations below the NAAQS were associated with adverse respiratory health effects. *See* George T. O'Connor et al., *Acute Respiratory Health Effects of Air Pollution on Children with Asthma in US Inner Cities*, 121 J. ALLERGY & CLINICAL IMMUNOLOGY 1133, 1135 (2008).

[21] *See infra* notes 258-263 and accompanying text; *see also* C. Boyden Gray, *EPA's Use of Co-Benefits*, FEDERALIST SOCIETY (Sept. 24, 2015), https://fedsoc.org/commentary/publications/epa-s-use-of-co-benefits ("As a former Chairman of the Texas Commission on Environmental Quality has explained, '[i]f reducing particulate matter had the enormous benefits that EPA's analysis claims, it has a legal responsibility to lower the national ambient standard to a level that is actually protective of human health. The fact that it has not done so suggests that EPA does not really believe its own numbers.' . . . [Agencies should not] be allowed to count reductions of pollutants in areas where they appear below the national standard EPA has already set for those pollutants."); Jonathan A. Lesser, *Missing Benefits, Hidden Costs: The Cloudy Numbers in the EPA's Proposed Clean Power Plan*, MANHATTAN INSTITUTE at 5 (June 16, 2016), https://www.manhattan-institute.org/download/8988/article.pdf ("The EPA's estimates of co-benefits from future air-pollution reductions also suffer from significant uncertainty and modeling errors, [including the] use of epidemiological models that assume that there are no threshold air-pollution concentration levels below which additional health benefits cannot be obtained, even though under the Clean Air Act, the EPA is required to establish exposure levels that are supposed to incorporate an adequate margin of safety to protect the public health."); *id.* at 18-19 ("But because the magnitude of CO_2 reductions under the [Clean Power Plan] is below the threshold level (assumed to be the level where there are measurable climate impacts), the [Plan]'s actual CO_2 reduction benefits are effectively zero.").

[22] *See* Clean Air Act, 42 U.S.C. § 7408 (2012).

[23] *See* Al McGartland et al., *Estimating the Health Benefits of Environmental Regulations*, 357 SCIENCE 457, 458 (2017).

requires that NAAQS levels allow an "adequate margin of safety . . . requisite to protect the public health."[24] The logic of critics who claim criteria pollutants have a threshold is that NAAQS standards are set with reference to the threshold, plus an adequate margin of safety. Thus, they argue, there should be no adverse health effects below the threshold, and therefore no benefits from lowering pollution levels below the NAAQS.

The Trump Administration has embraced these criticisms despite their lack of empirical foundation. In its proposed rule to repeal the Clean Power Plan, announced in October 2017, the Trump EPA presents radically different estimates of the costs and benefits than those presented in the original Plan.[25] The proposed rule includes three estimates of health benefits, the first of which closely mirrors the estimates in the original rule promulgated during the Obama Administration and includes the full range of particulate matter benefits.[26] The middle estimate assumes – without scientific basis – that the benefits of particulate matter reductions fall to zero below the "lowest measured level" or LML, which is the lowest level of exposure studied.[27] There is no scientific support for the proposition that risks are nonexistent below this level, though there is greater uncertainty about the magnitude of risk below this level.[28] Finally, the lowest estimate of benefits incorporates the assumption that NAAQS have a threshold for particulate matter.[29] This estimate completely eliminates all particulate matter benefits below the NAAQS,[30] essentially ignoring a bulk of the benefits of the rule in order to more easily justify the repeal.[31] Even with the significant changes made to other cost and benefits estimates throughout the proposed rule, only this last estimate makes the repeal cost-benefit justified.[32] The issue of how particulate matter benefits are calculated will thus be of central importance in the inevitable slew of litigation challenging the repeal.[33]

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[24] Clean Air Act, 42 U.S.C. § 7409(b)(1) (2012). According to EPA, the margin of safety component is "intended to address uncertainties associated with inconclusive scientific and technical information available at the time of standard setting . . . [and] to prevent lower pollutant levels that [the Administrator] finds pose an unacceptable risk of harm, even if that risk is not precisely identified as to nature or degree." Revisions to the National Ambient Air Quality Standards for Particulate Matter, 52 Fed. Reg. 24,635 (July 1, 1987) (to be codified at 40 C.F.R. pt. 50).

[25] *Compare* Clean Power Plan Proposed Repeal, *supra* note 7, at 48,044-47, *with* Clean Power Plan, *supra* note 6, at 64,928-29, 64,934-35.

[26] *See* Clean Power Plan Proposed Repeal, *supra* note 7, at 48,045-47.

[27] *Id*. at 48,044.

[28] *See infra* notes 355-370 and accompanying text.

[29] *See* Clean Power Plan Proposed Repeal, *supra* note 7, at 48,044.

[30] *See id.* at 48,045-46.

[31] *See* Clean Power Plan Proposed Repeal, *supra* note 7, at 48,043 ("[T]his analysis increases transparency of the 2015 [Clean Power Plan] analysis by presenting the energy efficiency cost savings as a benefit rather than a cost reduction and provides a bridge to future analyses that the agency is committed to performing. The current analysis also provides alternative approaches for examining the forgone benefits, including more clearly distinguishing the direct benefits from the co-benefits and exploring alternative ways to illustrate the impacts on the total net benefits of the uncertainty in health co-benefits at various $PM_{2.5}$ cutpoints. This approach shifts the focus to the domestic (rather than global) social cost of carbon, and employs both 3 percent and 7 percent discount rates. Finally, we consider how changing market conditions and technologies may have affected future actions that may have been undertaken by states to comply with the [Clean Power Plan] and how these changes may affect the potential benefits and costs of the [Plan's] repeal.").

[32] *See supra* note 8.

[33] *See* Caroline Cecot & W. Kip Viscusi, *Judicial Review of Agency Benefit-Cost Analysis*, 22 GEO. MASON L. REV. 575, 578 (2015) (noting that "[a]s agencies rely more on [cost-benefit analyses] in their decision making, challenges

EPA's own early treatment of criteria pollutants potentially contributed to confusion over whether these pollutants have a threshold, as some early analyses arguably implied that criteria pollutants had thresholds. However, EPA has subsequently adjusted its practices in ways that make clear the agency views particulate matter and most criteria pollutants as non-threshold.

As a general matter, EPA currently assumes that carcinogenic pollutants do not have a threshold, and that non-criteria non-carcinogenic pollutants do have a threshold.[34] In its earliest analyses in the late 1970s, EPA treated criteria pollutants similarly to other non-carcinogens. For example, the agency used language that suggested thresholds when setting allowable pollutant levels, such as the "critical populations, critical effects" model.[35] However, as scientific research accumulated showing adverse health effects at lower concentrations, EPA quickly departed from this approach and the agency has not treated criteria pollutants as threshold pollutants for several decades under administrations of both parties. First, EPA has explicitly acknowledged in many NAAQS rulemakings that there is no evidence to support the view that specific criteria pollutants have a threshold.[36] Further, EPA has stopped using the "critical effects" language when setting NAAQS standards.[37] Additionally, EPA has calculated benefits for reducing criteria pollutants below NAAQS levels—a practice that is inconsistent with the notion of a threshold.[38] EPA's modern treatment of the NAAQS moved the agency in line with current science on this question, which supports a non-threshold model.[39]

Critics next argue that EPA "double counts" benefits by claiming benefits already implemented through other regulations.[40] For example, Senator John Barrasso asserted in an Environmental and Public Works Committee hearing in 2015 that multiple EPA rules were using

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to [cost-benefit analyses] will rise, and judicial review of [cost-benefit analyses] will become increasingly important").

[34] *See* NATIONAL RESEARCH COUNCIL, SCIENCE AND DECISIONS: ADVANCING RISK ASSESSMENT 8 (2009) [hereinafter SCIENCE AND DECISIONS].

[35] *See infra* notes 160-169 and accompanying text. The "critical populations, critical effects" model refers to a way of setting the NAAQS with reference to a sensitive population and key early health effects of the pollutant. *Id.*

[36] *See infra* Part II.C.

[37] *See infra* notes 180-181 and accompanying text.

[38] *See infra* Part II.C.

[39] *See id.*

[40] *See* Michael Bastach, *Critics Accuse EPA of Fudging the Math on Its Global Warming Rule*, DAILY CALLER (Oct. 1, 2015), http://dailycaller.com/2015/10/01/critics-accuse-epa-of-fudging-the-math-on-its-global-warming-rule ("Former Sen. John Kyl, an Arizona Republican, also criticized the EPA over double-counting $PM_{2.5}$ reduction benefits in its [Mercury and Air Toxics Standards] rule. In 2012, Kyl took to the Senate floor to lambast the EPA for double-counting the benefits of reducing particulates."); Jude Clemente, *The Clean Power Plan Is Irrelevant*, FORBES.COM (Oct. 29, 2017), https://www.forbes.com/sites/judeclemente/2017/10/29/the-clean-power-plan-is-irrelevant/#38a9a8892732 ("And there seems to be some serious 'double counting' going on under the promoted [Clean Power Plan] benefits. That's mostly because the emissions of criteria pollutants NOx, SO_2, and PM have been regulated for decades, but they are erroneously counted in the claimed benefits of the [Plan]."); Diana Furchtgott-Roth, *Ten Problems with EPA's Clean Power Plan Analysis*, MANHATTAN INSTITUTE (March 20, 2017), https://economics21.org/html/ten-problems-epa%E2%80%99s-clean-power-plan-analysis-2275.html ("If reductions in particulates can be counted as a health benefit of reducing mercury, the first of three major rules put in place by EPA, the agency cannot then count these same reductions as a benefit from reducing ozone and carbon dioxide."); C. Boyden Gray, *EPA's Use of Co-Benefits*, FEDERALIST SOCIETY (Sept. 24, 2015), https://fedsoc.org/commentary/publications/epa-s-use-of-co-benefits ("[W]henever EPA counts $PM_{2.5}$ or ozone reductions in its cost-benefit analysis for other rules, it is double-counting reductions already mandated by the NAAQS.").

"the same reductions in particulate matter [to] claim the same health benefits," including the Clean Power Plan.[41] Other opponents of the Clean Power Plan likewise contend that "not only are [the agency's] estimates of co-benefits highly subjective and uncertain, but the EPA has almost surely double-counted some of those estimates."[42] These critics also allege that the agency achieves the same end by failing to properly calibrate its baseline levels from which to measure costs and benefits.[43] In fact, however, EPA's longstanding guidelines on baselines state that it is the agency's practice "to assume full compliance with regulatory requirements," including newly enacted regulations that are not yet implemented.[44] Moreover, EPA expressly discusses the methods by which it accounts for benefits previously achieved under the NAAQS regime and other rules, which include an explanation of how the agency accounted for existing regulations of particulate matter.[45]

Finally, critics suggest that, even if these benefits are real and not "double-counted," they should not be considered in cost-benefit analyses because they are "co-benefits" instead of direct benefits.[46] For example, while the Mercury and Air Toxics Standards primarily target mercury pollution[47] and the Clean Power Plan directly regulates carbon dioxide emissions,[48] both rules would reduce particulate matter as well.[49] Opponents claim that accounting for co-benefits skews cost-benefit analyses in favor of regulation[50] and exceeds the statutory bounds of EPA's power to regulate these pollutants under the Clean Air Act.[51] The Trump Administration, a key critic of

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[41] *Barrasso Questions EPA Air Official on Ozone Rule, Clean Power Plan*, (Sept. 29, 2015), https://www.barrasso.senate.gov/public/index.cfm/2015/9/barrasso-questions-epa-air-official-on-ozone-rule-clean-power-plan ("Yet when you take a look at the EPA's own documents, you state that you are counting co-benefits of reducing the same PM 2.5 in other rules before [the] 111(d) rule for existing power plants was even released.").

[42] *See* Lesser, *supra* note 21, at 5.

[43] *See id.*

[44] Environmental Protection Agency, *Chapter 5: Baseline* (Dec. 2010) *in* GUIDELINES FOR PREPARING ECONOMIC ANALYSES (updated May 2014), https://yosemite.epa.gov/ee/epa/eerm.nsf/vwAN/EE-0568-05.pdf/$file/EE-0568-05.pdf at 5-3.

[45] *See infra* notes 376-384.

[46] *See* Michael Bastach, *Trump's Executive Order To Repeal Regulations Puts EPA in the Crosshairs*, DAILY CALLER (Jan. 13, 2017), http://dailycaller.com/2017/01/31/trumps-executive-order-to-repeal-regulations-puts-epa-in-the-crosshairs ("Republicans have long criticized EPA for counting "co-benefits" of regulation towards its cost effectiveness."); Diana Furchtgott-Roth, *supra* note 40 ("If EPA believes that their levels of other substances should be reduced, it should issue rules to lower them, with their own comment periods and cost-benefit analysis."); *infra* notes 399-409 and accompanying text.

[47] *See* MATS Rule, *supra* note 5, at 9,305.

[48] *See* Clean Power Plan, *supra* note 6, at 64,663, 64,710.

[49] *See id.* at 64,670, 64,679; MATS Rule, *supra* note 5, at 9,305. Some of these rules would also have the co-benefit of reducing other criteria pollutants. *See* MATS Rule, *supra* note 5, at 9,305, 9,380, 9,418 (noting incidental reductions in sulfur dioxide pollution). While this article focuses primarily on particulate matter because of the scope of those benefits and the clarity of the scientific evidence that particulate matter lacks a threshold, there is likewise no reason to exclude co-benefits of reductions of other NAAQS pollutants where sufficient evidence shows that such pollutants also lack a threshold.

[50] *See* Kyle Feldscher, *Senate Republicans Take Aim at Cost of EPA Regs*, Wash. Examiner, (Oct. 21, 2015), http://www.washingtonexaminer.com/senate-republicans-take-aim-at-cost-of-epa-regs/article/2574605 (quoting Senator Mike Rounds' statement that "[b]ecause of [its] exorbitant regulations, the EPA attempts to justify . . . the costs by identifying ancillary benefits, which the EPA refers to as co-benefits, to help outweigh the cost of regulations.").

[51] *See* C. Boyden Gray, *EPA's Use of Co-Benefits*, FEDERALIST SOCIETY (Sept. 24, 2015), https://fedsoc.org/commentary/publications/epa-s-use-of-co-benefits ("EPA is treating the Clean Air Act as a completely open-ended grant of power, precisely as the Supreme Court forbids. . . . The costs of complying with a

these rules, decries these benefits and asserts that their inclusion "essentially hid[es] the true net cost" of rules like the Clean Power Plan.[52]

This view, however, conflicts with four decades of EPA practice under administrations of both parties: EPA during that time has taken co-benefits under consideration when evaluating air pollution regulations.[53] Further, Office of Management and Budget (OMB) Circular A-4, issued during the George W. Bush Administration, instructs agencies like EPA to look at and consider co-benefits and their mirror image: indirect costs.[54] Indirect costs are consistently calculated for Clean Air Act and other EPA regulations,[55] and it would be incoherent to consider the negative indirect effects of regulations without similarly considering the positive indirect effects.[56] The benefits from reducing particulate matter below the levels of the NAAQS in terms of avoided health harms and premature mortality are scientifically well established and have been acknowledged by EPA for decades.[57] As well-documented co-benefits, there is no reason these benefits should be excluded from analyses of air pollution regulations.

Courts likewise have long held that when a rule's justification includes economic analyses, agencies may not ignore important costs or benefits, whether the effect is direct or ancillary. For example, the D.C. Circuit, the most important appellate court for federal regulation of environmental law,[58] has held that EPA must consider indirect effects in its rulemakings. In 1999, the court remanded a revision to the NAAQS standards for ozone and particulate matter because, in the court's view, the agency failed to consider the potential indirect health costs from lowering pollution.[59] Likewise, in *American Trucking Association v. EPA*,[60] the court held that

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given regulation should be compared against the social goods that that regulation is authorized to achieve—not incidental co-benefits."); *infra* notes 389-398 and accompanying text.

[52] Environmental Protection Agency, *News Releases: EPA Takes Another Step To Advance President Trump's America First Strategy, Proposes Repeal Of "Clean Power Plan"* (Oct. 10, 2017), https://www.epa.gov/newsreleases/epa-takes-another-step-advance-president-trumps-america-first-strategy-proposes-repeal.

[53] *See infra* Part IV.B.

[54] *See* Circular A-4: Regulatory Analysis, OFF. MGMT. & BUDGET 26 (2003) https://obamawhitehouse.archives.gov/sites/default/files/omb/assets/omb/circulars/a004/a-4.pdf (Agencies should "look beyond the direct benefits and direct costs and consider any important ancillary benefits and countervailing risks."). Just as there are various terms for "co-benefits," there are likewise multiple names for "indirect costs," including countervailing risks. This article primarily uses the term "indirect costs," but occasionally employs "countervailing risks" as well.

[55] *See* Samuel J. Rascoff & Richard L. Revesz, *The Biases of Risk Tradeoff Analysis: Towards Parity in Environmental and Health-and-Safety Regulation*, 69 U. CHI. L. REV. 1963, 1980-90 (2002) (chronicling the rise of risk-risk analysis in the regulatory state); *infra* Part IV.B.

[56] *See generally id*. (making the argument that ancillary benefits should be considered, given the rise in consideration of risk tradeoffs).

[57] *See infra* Part III.

[58] *See* Richard J. Lazarus, *Senator Edmund Muskie's Enduring Legacy in the Courts*, 67 ME. L. REV. 239, 242 (2015) ("[T]he D.C. Circuit of course is the nation's most important court for federal environmental law because it has original jurisdiction to hear challenges to EPA rules promulgated under a host of federal environmental laws, including the Clean Air and Clean Water Acts, and exclusive jurisdiction to consider some of those challenges.").

[59] *See* Am. Trucking Ass'ns v. EPA, 175 F.3d 1027, 1036-37 (D.C. Cir. 1999*), rev'd on other grounds sub nom.* Whitman v. Am. Trucking Ass'ns, 531 U.S. 457 (2001).

[60] 175 F.3d 1027 (D.C. Cir. 1999), *rev'd on other grounds sub nom.* Whitman v. Am. Trucking Ass'ns, 531 U.S. 457 (2001).

the agency must consider incidental countervailing risks.[61] More recently, in *Sugar Corp v. EPA* the court upheld an EPA regulation that relied on co-benefits in its analysis of the effects of reducing hazardous air pollutants from boilers, process heaters, and incinerators.[62] The labels "benefit" and "cost" merely serve as useful shorthand for positive effects versus negative effects. In the context of cost-benefit analysis, neither possesses any inherent quality warranting different weight or analytical treatment from the other.[63]

Because the frontal attack on the co-benefits of particulate reductions below the NAAQS arose so recently, there is no existing academic literature in this area. Neither is there sustained discussion on the evolution in the understanding of thresholds for criteria pollutants following the enactment of the Clean Air Act in 1970, or on how this understanding developed alongside different approaches used for carcinogens and non-carcinogens other than criteria pollutants. Neither is there a historical, scientific, and practical analysis of the question of how the competing arguments on thresholds interact with cost-benefit analysis.

This Article fills these voids. Part I discusses EPA's approaches for assessing the risks of carcinogenic and non-carcinogenic pollutants other than criteria pollutants. EPA has consistently treated carcinogens as non-threshold pollutants, whereas for non-carcinogen, non-criteria pollutants, EPA's approach has lagged behind the scientific evidence and assumes that there is a no-harm threshold. Part II turns to criteria pollutants. It examines Congress's growing doubts about the existance of NAAQS thresholds, which resulted in a significant conceptual change in the understanding of criteria pollutant reflected in the 1977 amendments to the Clean Air Act and shows how EPA's approach has evolved, from embracing threshold models in the 1970s to consistently rejecting them since the 1980s. Part III addresses the critics' first two arguments: that benefits from particulate matter reductions below the NAAQS do not exist, and that EPA erroneously "double counts" benefits by failing to adjust its estimation baselines to account for prior regulation of particulate matter. We explain the scientific basis for calculating particulate matter benefits below the NAAQS, as well as EPA's longstanding practice of measuring and quantifying these benefits. We also examine how the agency deals with uncertainty and sets its baselines when revising the NAAQS. Part IV assesses the final assertion of the critics: that even if real, these benefits should not be included in cost-benefit analyses when they are co-benefits as opposed to direct benefits. We discuss the treatment of co-benefits in a range of contexts over the past four decades by academics, EPA, and the judiciary.

I
TRADITIONAL RISK ASSESSMENT MODELS

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[61] *See id.* at 1051-53; *cf.* Michael Livermore & Richard Revesz, *Rethinking Health-Based Environmental Standards*, 89 N.Y.U. L. REV. 1184, 1250 (2014) (quoting Am. Trucking Ass'ns v. EPA, 175 F.3d at 1051-52) ("In a portion of its *American Trucking* opinion not reviewed by the Supreme Court, the D.C. Circuit stated that at least certain types of secondary effects must be considered by the agency when setting the NAAQS. . . . The court noted that it 'seems bizarre that a statute intended to improve human health would . . . lock the agency into looking at only one half of a substance's health effects in determining the maximum level for that substance.' Thus, the D.C. Circuit required the agency to account for the negative secondary consequences of regulation—the countervailing risks.").

[62] *See* U.S. Sugar Corp. v. EPA, 830 F.3d 579, 591, 625 (D.C. Cir. 2016).

[63] *See* Institute for Policy Integrity, *The Importance of Evaluating Regulatory "Co-Benefits,"* at 2 (Feb. 2017), http://policyintegrity.org/files/media/Co-Benefits_Factsheet.pdf.

EPA currently uses different risk assessment approaches for carcinogens, non-carcinogens, and NAAQS criteria pollutants, respectively. This Part analyzes the agency's current models for evaluating the health and environmental risks posed by carcinogens and by noncarcinogens other than criteria pollutants.

A. Carcinogens

EPA assumes that carcinogens have no thresholds unless sufficient pollutant-specific data leads the agency to conclude that a particular carcinogen has a threshold.[64] Under this approach, EPA first attempts to discern a "mode of action" for carcinogens,[65] which describes the sequence of key events and processes resulting in cancer formation.[66] When EPA can determine the mode of action, it will model the risk-exposure relationship based on that mode of action. If that mode suggested a linear, non-threshold relationship, EPA will so model the relationship; if, in contrast, the mode suggests a threshold, EPA will model the threshold. Where EPA does not have sufficient data to determine the mode of action, the agency assumes that pollutants that cause tumors in animals are harmful to humans,[67] that cancer risks of these pollutants do not have a threshold,[68] and that the effects can be modeled by low dose linearity,[69] which describes a relationship between exposure and risk under which additional exposure will result in additional risk at a constant rate.[70]

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[64] *See* SCIENCE AND DECISIONS, *supra* note 34, at 127-28. Note that EPA will adjust its model to include a threshold where there is such evidence. For example, EPA treats chloroform as a threshold carcinogen. *See* Environmental Protection Agency, *Integrated Risk Information System: Chloroform Chemical Assessment Summary*, at 1 (Oct. 19, 2001) https://cfpub.epa.gov/ncea/iris/iris_documents/documents/subst/0025_summary.pdf. However, EPA has not identified many exceptions to its general rule that carcinogens should be treated as non-threshold and non-carcinogens should be treated as having a threshold. *See* Wendy Wagner et al., *Misunderstanding Models in Environmental and Public Health Regulation*, 18 N.Y.U. ENVTL. L.J. 293, 335 (2010) (discussing EPA's assumption that carcinogens have no threshold of effect and noting that EPA has identified threshold carcinogens, including chloroform, and has struggled with accommodating such exceptions). In 2000, the D.C. Circuit spurred the Agency to action on chloroform, finding that EPA's use of an assumption of linearity for chloroform violated the Safe Drinking Water Act because it "openly overrode the best available scientific evidence which suggested that chloroform is a threshold carcinogen." *Chlorine Chemistry Council v. EPA*, 206 F.3d 1286, 1290 (D.C. Cir. 2000).

[65] Environmental Protection Agency, *Guidelines for Carcinogen Risk Assessment*, EPA/630/P-03/001F, at 1-10 (Mar. 2005), https://www.epa.gov/sites/production/files/2013-09/documents/cancer_guidelines_final_3-25-05.pdf.

[66] *See id.* at 1-10 n.2.

[67] *See id.* at 1-10, 1-11.

[68] *See id.* at 1-11; SCIENCE AND DECISIONS, *supra* note 34, at 8.

[69] *See* Environmental Protection Agency, *Guidelines for Carcinogen Risk Assessment*, *supra* note 65, at 1-11.

[70] *See id.* This approach comports with cancer policies of other federal agencies. For example, EPA, FDA, and OSHA "all . . . employ a linear mathematical model for low-dose extrapolation" of carcinogenic risk assessment. Government Accountability Office, *Chemical Risk Assessment: Selected Federal Agencies' Procedures, Assumptions, and Policies*, GAO-01-810, at 40, 173, 197 (Aug. 2001), https://books.google.com/books?id=MfWUWX0L814C&lpg=PP1&pg=PP1#v=onepage&q&f=false (noting FDA's assumption of a "linear, no-threshold approach" for low dose cancer estimation, as well as OSHA's acceptance of the "overwhelming scientific consensus . . . that genotoxins follow low-dose linear functions"); Centers for Disease Control and Prevention, *Current Intelligence Bulletin 68: NIOSH Chemical Carcinogen Policy* (July 2017), https://www.cdc.gov/niosh/docs/2017-100/pdf/2017-100.pdf?id=10.26616/NIOSHPUB2017100revised ("For carcinogen risk assessment, NIOSH generally treats exposure-response as low-dose linear unless a non-linear mode of action has been clearly established, in which case NIOSH will adopt a modeling approach defined by the data

Next, the agency reviews the evidence available from scientific studies and produces a "weight of the evidence narrative," which is intended to assess the health impacts of a pollutant and the strength of the evidence of those effects.[71] EPA considers factors such as whether tumors were found in humans or animals, the agent's chemical and physical properties, and studies addressing its mode of action.[72] The agency uses standard descriptors to express the weight of the evidence: "carcinogenic to humans," "likely carcinogenic to humans," "suggestive evidence of carcinogenic potential," "inadequate information to assess carcinogenic potential," and "not likely to be carcinogenic."[73]

Dose response assessments, the next phase of EPA's analysis of risk from carcinogens, are generally completed for pollutants labeled "carcinogenic to humans" and "likely to be carcinogenic to humans."[74] Dose-response assessments aim to measure health effects at different exposure levels.[75] These assessments are performed by first assessing data to determine a "point of departure" (POD),[76] which marks the beginning of extrapolation to lower doses based on experimental data.[77] Above the point of departure, EPA attempts to develop a tailored model of dose-response pattern, and where it lacks sufficient data to develop one, the agency states that "an appropriate policy choice" is to use a standard curve-fitting model, which is a standardized mathematical function for drawing a trend line among data points.[78] Below the point of departure, EPA assumes that risk is related to exposure in a linear pattern.[79]

EPA's cancer guidelines emphasize that "a critical analysis of all of the [relevant] available information . . . [is] the starting point from which a default option *may* be invoked *if needed* to address uncertainty or the absence of critical information."[80] Thus, if evidence emerges that a particular carcinogenic pollutant does in fact have a threshold, or is non-linear at low levels or all levels (for example if data instead suggests a logarithmic relationship), EPA may depart from the default no-threshold, linear model.[81]

Other agencies have taken similar approaches to regulating carcinogens. The Occupational Safety and Health Administration (OSHA), under its guidance for regulating potential carcinogens,[82] has not standardized its classification and regulation of carcinogens to the degree that EPA has. Rather than identifying default models that will be used when data is

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(including non-linear approaches when appropriate). In general, whether the model forms are linear or non-linear, any nonzero exposure to a carcinogen is expected to yield some excess risk of cancer.").

[71] *Id.*

[72] *See id*.

[73] *Id*. at 1-12.

[74] *Id*. at 3-2.

[75] *See id*. at 1-12.

[76] *Id*. at 1-13.

[77] *See id*. at 1-13 n.4.

[78] *Id*. at 1-9, 1-10.

[79] *See* SCIENCE AND DECISIONS, *supra* note 34, at 127.

[80] Environmental Protection Agency, *Guidelines for Carcinogen Risk Assessment, supra* note 65, at 1-7 (emphasis added).

[81] A linear model is not synonymous with a non-threshold model. A non-threshold model may be non-linear, so long as it includes health effects even at very low levels. However, a linear model is necessarily a non-threshold model as a linear model does display health effects at every positive level of exposure.

[82] *See* 29 C.F.R. § 1990.101 et seq. (2017) (providing guidance for the identification, classification, and regulation of carcinogens).

insufficient to tailor a model, as EPA has done, OSHA has identified the type of data it will consider,[83] criteria used to evaluated arguments for certain carcinogen regulations,[84] and specific issues to be assessed when in the rulemaking including what data is available.[85] Further, OSHA guidance has been affected by the landmark *Benzene* case, in which the Supreme Court struck down OSHA's standard for benzene of 1 part per million (ppm) after the Labor Secretary concluded that there was no safe level of benzene because it was a carcinogen, but did not specifically quantify the risks from benzene exposure at levels below 10 ppm.[86] In order to satisfy the requirements of the *Benzene* case, OSHA now estimates the risk to workers subject to a lifetime of exposure at various potential exposure levels.[87] It is more difficult to discern what OSHA's specific models are for evaluating risks posed by carcinogens and managing those risks. However, OSHA carcinogen guidance makes clear that the agency treats carcinogens as non-threshold pollutants.[88] The agency develops models for risk that "best fit existing data and are consistent with available information on mode of action," but also notes that there is "a reasonable body of scientific evidence that genotoxic carcinogens, and perhaps other carcinogenic modes of action, display linear, non-threshold behavior at very low dose levels."[89]

The National Institute for Occupational Safety and Heath (NIOSH), established under the same legislation as OSHA[90] and empowered to "develop and establish recommended occupational safety and health standards,"[91] recently released a revised chemical carcinogen policy.[92] NIOSH, like EPA, generally treats the exposure response relationship as linear at low

[83] *See* 29 C.F.R. § 1990.145 (2017).
[84] *See* 29 C.F.R. § 1990.144 (2017).
[85] *See* 29 C.F.R. § 1990.146 (2017).
[86] *See Industrial Union Department, AFL-CIO v Amer. Petroleum Institute (The Benzene Case),* 448 U.S. 607, 613-15 (1980).
[87] *See* Proposed Rule on Chemical Management and Permissible Exposure Limits (PELs), 79 Fed. Reg. 61,384, 61,387 (Oct. 10, 2014) (to be codified at 29 C.F.R. Parts 1910, 1915, 1917, 1918, and 1926), https://www.gpo.gov/fdsys/pkg/FR-2014-10-10/pdf/2014-24009.pdf.
[88] *See* 29 C.F.R. § 1990.143(h) ("No determination will be made that a 'threshold' or 'no-effect' level of exposure can be established for a human population exposed to carcinogens in general, or to any specific substance.").
[89] Proposed Rule on Chemical Management and Permissible Exposure Limits (PELs), *supra* note 87, at 61,391.
[90] Occupational Safety and Health Act of 1970, 29 U.S.C. § 671 (2012).
[91] *Id*. at § 671(c)(1). NIOSH was originally conceived as the research arm of a coordinated federal effort to regulate workplace safety, and OSHA was to be the standard-setting agency. *See* Occupational Safety and Health Administration, *All About OSHA: The Standards-Setting Process*, (2006), https://www.osha.gov/Publications/about-osha/3302-06N-2006-English.html ("The OSH Act established the National Institute for Occupational Safety and Health in the Department of HHS as the research agency for occupational safety and health. NIOSH conducts research on various safety and health problems, provides technical assistance to OSHA, and recommends standards for OSHA's consideration."); Centers for Disease Control and Prevention, *About NIOSH* (June 15, 2016), https://www.cdc.gov/niosh/about/default.html. The agencies, however, have not always worked collaboratively. *See* Kyle W. Morrison, *Partners in Safety*, SAFETY & HEALTH (Mar. 1, 2012), http://www.safetyandhealthmagazine.com/articles/partners-in-safety-2. NIOSH's 2017 guidance on carcinogens post-dates OSHA's guidance, which was published in 1980. *Compare* Centers for Disease Control and Prevention, *Current Intelligence Bulletin 68: NIOSH Chemical Carcinogen Policy* (July 2017), https://www.cdc.gov/niosh/docs/2017-100/pdf/2017-100.pdf?id=10.26616/NIOSHPUB2017100revised *with* 29 C.F.R. § 1990. As such, it is not entirely clear how extensively OSHA relies on NIOSH data to set regulations on carcinogens in the workplace. OSHA guidance does, however, reference consulting with the Director of NIOSH. *See* 29 C.F.R. §§ 1990.106, 1990.104 (2017).
[92] *See* Centers for Disease Control and Prevention, *Current Intelligence Bulletin 68: NIOSH Chemical Carcinogen Policy*, *supra* note 91.

doses, which implies a non-threshold model.[93] Also like EPA, NIOSH will depart from this model where a non-linear mode of action has been clearly established.[94] Further, NIOSH explicitly notes that even where there is evidence of a non-linear relationship between risk and exposure at low doses, "it is highly unlikely that one can demonstrate empirically that a threshold exists."[95]

Based on the relevant scientific evidence, EPA, OSHA, and NIOSH all treat carcinogens as non-threshold contaminants. Further, EPA and NIOSH both assume linearity at low doses, unless the data strongly suggests a different relationship between exposure and risk to health. The assumption of non-threshold low dose linearity presumes health impacts even at very low levels of exposure.[96] Because health effects can be estimated at low doses under this model, the agencies can include those health benefits in cost-benefit analyses used to support allowable standards for carcinogenic pollutants. Considering these benefits of pollution regulation allows agencies to more accurately weigh the effects of regulations at different stringencies, facilitating more informed decision-making.

Accounting for adverse health impacts from very low levels of pollution does not mean that EPA or other agencies must or will require the elimination of that pollutant.[97] For example, under the Safe Drinking Water Act (SDWA),[98] EPA is required to set maximum contaminant

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[93] *See id.* at 19.
[94] *See id*.
[95] *Id*.
[96] *See id.*
[97] Commentators have suggested that the non-threshold approach to carcinogens was responsible for EPA's reluctance to list carcinogenic pollutants during the 1970s and much of the 1980s. *See* Matthew D. Adler, *Against "Individual Risk": A Sympathetic Critique of Risk Assessment*, 153 U. PA. L. REV. 1121, 1150 (2005); John P. Dwyer, *The Pathology of Symbolic Legislation*, 17 ECOLOGY L.Q. 233, 251–52 (1990); Bradford C. Mank, *What Comes After Technology: Using an "Exceptions Process" To Improve Residual Risk Regulation of Hazardous Air Pollutants*, 13 STAN. ENVTL. L.J. 263, 268 (1994); Deanna Schmitt, Note, *North Carolina Air Toxics Regulations*, 69 N.C.L. REV. 1579, 1581–82 (1991). Originally, section 112 of the Clean Air Act required an "ample margin of safety" for "hazardous air pollutants." 42 U.S.C. § 7412(b)(1)(B) (1988), amended by Pub. L. No. 101-549, 301, 104 Stat. 2399, 2531 (1990). Because carcinogens have no threshold below which they are safe, EPA officials feared listing a pollutant as a carcinogen might forbid emitting the pollutant at all, shuttering entire industries. *See* Adler, *supra*; Dwyer, *supra*, at 251; Mank, *supra*; Schmitt, *supra*, at 1581. However, the U.S. Supreme Court determined that zero tolerance for carcinogens was not an appropriate approach, at least with regard to Occupational Safety and Health Administration regulations. In *The Benzene Case*, Justice Stevens relied heavily on statutory language mandating that OSHA only regulate standards for toxic materials "to the extent feasible," and determined that before the agency enact more stringent standards, OSHA had to determine the regulated chemical exposure posed a "significant risk." *See* Indus. Union Dep't, AFL-CIO v. API, 448 U.S. 607, 612, 641 (1980). Eventually EPA linked safety to "best available technology" standards: After identifying the lowest level of emissions possible with the best available technology, EPA would decide whether to set emissions at an even lower level by weighing the reduction in health risks against costs of setting the lower standard. *See* NRDC v. EPA, 824 F.2d 1146, 1163–64 (D.C. Cir. 1987). In 1987, the D.C. Circuit rejected this approach, favoring instead a two-step process in which EPA first determined what would be an "acceptable" risk to health without any consideration of cost or technological capability, and in a second step, determined the ample margin of safety, incorporating feasibility considerations. *Id.* at 1164–65. EPA then settled on this approach for regulating carcinogenic air pollutants: EPA would set standards so that the maximally exposed individual had a risk of 1 in 10,000 or less, and if economically feasible, further regulate the pollutant to minimize the number of people with a risk greater than 1 in 1 million. *See* National Emission Standards for Hazardous Air Pollutants, 54 Fed. Reg. 38,044, 38,044-45 (40 C.F.R. pt. 61) (Sept. 14, 1989); Adler, *supa*, at 1151.
[98] *See* 42 U.S.C. § 300f et seq. (2012).

level goals (MCLG), which is the maximum level of a contaminant in drinking water at which no known or anticipated health effects would occur.[99] When EPA regulates carcinogens under the SDWA, the agency sets the MCLG at zero where there is evidence that the chemical may cause cancer, and there is no dose below which the chemical is considered safe.[100] However, the MCLG is *not* an enforceable standard. Rather, the enforceable standard, known as the maximum contaminant level (MCL), is set as close to the MCLG as feasible, taking into consideration costs and available technology.[101] In short, even where EPA recognizes that a carcinogen is unsafe at every level, the agency can, and does, set standards above zero. Including health costs from low level exposure to carcinogenic pollutants does not force EPA to ban the pollutant; it merely facilitates more informed decisions about how to regulate these pollutants.

B. Non-Carcinogens Other than Criteria Pollutants

In contrast to carcinogens, EPA treats non-carcinogens other than criteria pollutants as threshold pollutants. EPA assumes that there is a threshold below which such pollutants do not have adverse health impacts.[102] EPA does so even though the threshold assumption for non-carcinogens is inconsistent with modern scientific understanding.[103] This Section analyzes EPA's current practice and then criticizes its continued use of this assumption.

EPA assessments for non-carcinogens focus on finding a "reference dose," which is the quantity "likely to be without an appreciable risk of deleterious effects."[104] The reference dose is derived from the point of departure, which is the point from which EPA extrapolates the risk-exposure relationship.[105] For non-cancer pollutants, this point of departure is generally the no-observed-adverse-effect level (NOAEL),[106] which is "the highest exposure level at which no statistically or biologically significant increases are seen in the frequency or severity of adverse effect[s],"[107] or the lowest-observed-adverse-effect level (LOAEL), which is "[t]he lowest dose in a study in which there was an observed toxic or adverse effect."[108] The reference dose might also be derived based on the "benchmark dose," which is calculated using "a predetermined

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[99] *See* 42 U.S.C. § 300g-1(b)(4)(A) (2012) ("Each maximum contaminant level goal established under this subsection shall be set at the level at which no known or anticipated adverse effects on the health of persons occur and which allows an adequate margin of safety.").
[100] *See* Environmental Protection Agency, *How EPA Regulates Drinking Water Contaminants*, https://www.epa.gov/dwregdev/how-epa-regulates-drinking-water-contaminants#develop (last visited Dec. 22, 2017) ("For chemical contaminants that are carcinogens, EPA sets the MCLG at zero if . . . there is evidence that a chemical may cause cancer [and] there is no dose below which the chemical is considered safe.").
[101] *See* 42 U.S.C. § 300g-1(b)(4)(B)-(D) (2012).
[102] *See* SCIENCE AND DECISIONS, *supra* note 34, at 128; LOUIS THEODORE & R. RYAN DUPONT, ENVIRONMENTAL HEALTH AND HAZARD RISK ASSESSMENT: PRINCIPLES AND CALCULATIONS 289 (2017).
[103] *See id.* at 8.
[104] SCIENCE AND DECISIONS, *supra* note 34, at 128 (quoting EPA pesticide risk-assessment guidance from 2002).
[105] *See id.*
[106] *See id*.
[107] Environmental Protection Agency, *Conducting a Human Health Risk Assessment: Dose-Response*, https://www.epa.gov/risk/conducting-human-health-risk-assessment#tab-3 (last visited Dec. 23, 2017).
[108] National Institutes of Health, *ToxTutor: Risk Assessment*, https://toxtutor.nlm.nih.gov/06-003.html (last visited Feb. 13, 2018); *see id.* (stating that EPA uses LOAEL "in cases in which a NOAEL has not been demonstrated experimentally").

change in the response rate of an adverse effect."[109] Once EPA determines the NOAEL, LOAEL, or benchmark dose, the agency divides that dose by the "uncertainty factor," a margin of safety intended in part to reflect the possible differences between human and animal responses.[110] The resulting number is the reference dose.[111] This model presumes a threshold at the reference dose: below this exposure level, the health risk from exposure to non-carcinogenic pollutants is considered to be effectively zero.[112]

Modern scientific challenges the accuracy of EPA's threshold approach for non-carcinogens, and suggests that many of these pollutants do not have a population threshold.[113] Epidemiological studies now provide information about the health impacts of pollutants across a range of human exposures, including a very low levels.[114] Most significantly, a 2009 report of the National Research Council of the National Academy of Sciences[115]—an independent organization of distinguished scholars in science and engineering, dedicated to the use of science and technology to improve the general welfare, and created by an act of Congress with a mandate to provide independent and objective advice to the federal government[116]—explained that EPA's current threshold assumption model for non-carcinogens is based on outdated approaches developed in the 1950s to 1980s.[117] The report observed that non-carcinogenic pollutants do not necessarily have a threshold,[118] and recommended that EPA evaluate all non-carcinogens without assuming that they have a threshold.[119] According to the report, the current model yields end products "inadequate for benefit-cost analyses or for comparative risk analyses,"[120] and instead "creates an inconsistent approach for bringing toxicology and risk science into the decision-making process."[121] EPA has largely ignored this particular

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[109] Environmental Protection Agency, *Conducting a Human Health Risk Assessment: Dose-Response*, *supra* note 107.
[110] *See id.*
[111] *See id.*
[112] *See* SCIENCE AND DECISIONS, *supra* note 34, at 128.
[113] *See id.* at 8.
[114] *See* McGartland et al., *Estimating the Health Benefits of Environmental Regulations*, *supra* note 23, at 458.
[115] NAS was chartered by the Senate in 1863 with the purpose to, "whenever called upon by any department of the Government, investigate, examine, experiment, and report upon any subject of science or art." Steve Olson, *The National Academy of Sciences at 150*, PNAS ONLINE (June 24, 2014), http://www.pnas.org/content/111/Supplement_2/9327.full. The organization is "a private agency with the public role of advising the government on policy-related technical issues." *Id.* The National Research Council is the "principal operating agency" of the National Academies. National Academies of Sciences, Engineering, and Medicine, Articles of Organization of the National Research Council, (June 1, 2015), http://www.nationalacademies.org/nasem/na_070358.html. It was established in 1916 at the request of President Wilson to recruit specialists to participate in the National Academy of Sciences' advisory work for the government. *See* National Academies of Sciences, *About NAS: History*, http://www.nasonline.org/about-nas/history (last visited Dec. 23, 2017).
[116] *See* National Academies of Sciences, *About NAS: Mission*, http://www.nasonline.org/about-nas/mission (last visited Dec. 23, 2017).
[117] *See* McGartland et al., *Estimating the Health Benefits of Environmental Regulations*, *supra* note 23, at 458. The report concluded that EPA's approach is no longer scientifically supportable, as it "does not make the best possible use of available scientific evidence." SCIENCE AND DECISIONS, *supra* note 34, at 177.
[118] *See* SCIENCE AND DECISIONS, *supra* note34, at 8.
[119] *See id*. at 132.
[120] *Id*. at 133.
[121] *Id.*

recommendation from the 2009 report, and has not changed its model for assessing non-carcinogens.[122]

Even if there were a threshold for an averagely sensitive individual, that level would, by definition, be lower for more sensitive individuals. Especially sensitive individuals would have an even lower threshold. And for the most sensitive individuals in a population, there might be no threshold at all.[123] While there might be individual thresholds for average people, there would be no population threshold—the level at which a population experiences no negative health effects.[124] Thus, deciding to treat one individual's threshold as a population threshold necessarily is a decision to leave some individuals—those with lower thresholds—unprotected. For example, very young children, pregnant women, or the elderly might have harm thresholds for certain pollutants that are much lower than the average population threshold.[125] By assuming a threshold for a typical person, EPA overlooks sensitive individuals who may experience negative health impacts at exposure levels lower than the regulatory standard. The question of how many people to leave unprotected is ultimately a policy question. An accurate accounting of the effects of these pollutants on sensitive people does not necessitate draconian regulations to completely eliminate all risks; rather this information facilitates more informed decision-making that accurately accounts for the impacts on all members of the population.

The current threshold model also ignores all scientific evidence of health effects that lacks a high level of confidence. This problem is built in to EPA's process for determining the limits for these pollutants: when EPA determines standards, it performs a benefits analysis that includes evidence of different health impacts of the pollutant.[126] It classifies evidence as "likely" or "known" if there is a high degree of confidence in the association between exposure and a health outcome, or as "suggestive" where there is lesser confidence in the link.[127] "Suggestive" evidence is generally excluded from the potential health risks assessed by EPA in its primary

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[122] It is interesting to note that Dr. Thomas Burke, who chaired that NAS committee that wrote *Science and Decisions*, served as the Deputy Assistant Administrator of EPA's Office of Research and Development during the Obama Administration and did not, during that time, usher in implementation of the *Science and Decisions* recommendation to eschew the threshold assumption for non-carcinogens. *See* Environmental Protection Agency, *About the Deputy Assistant Administrator of EPA's Office of Research and Development, and EPA's Science Advisor*, https://19january2017snapshot.epa.gov/aboutepa/about-deputy-assistant-administrator-epas-office-research-and-development-and-epas-science_.html (last updated Jan. 19, 2017).

[123] *See* Lorenz R Rhomberg et al., *Linear Low-Dose Extrapolation for Noncancer Health Effects Is the Exception, Not the Rule*, 41 CRITICAL REV. TOXICOLOGY 4 (2011) ("[L]ow-dose linearity asserts that there is no population threshold, meaning that there will always be some individuals having personal thresholds of zero, and so they will respond to any increment of dose no matter how small.").

[124] *See* Environmental Protection Agency, *Summary of Expert Opinions on the Existence of a Threshold in the Concentration-Response Function for $PM_{2.5}$-related Mortality*, (June 2010), https://www3.epa.gov/ttnecas1/regdata/Benefits/thresholdstsd.pdf (defining a population threshold as "the concentration below which no member of the study population would experience an increased risk of death").

[125] *See, e.g.*, Bingheng Chen & Haidong Kan, *Air Pollution and Population Health: A Global Challenge*, 13 ENVTL. HEALTH PREV. MED. 94, 96 (2008) (noting that for "[a]dverse health effects associated with exposure to air pollution . . . . [h]igh-risk subgroups include young children, the elderly, persons with predisposed diseases, and persons with low socioeconomic status."); National Ambient Air Quality Standards for Particulate Matter, 78 Fed. Reg. 3,086, 3,104 (Jan. 15, 2013) (to be codified at 40 C.F.R. pts. 50, 51, 52, 53 and 58) ("There is emerging, though still limited, evidence for additional potentially at-risk populations, such as those with diabetes, people who are obese, pregnant women, and the developing fetus.").

[126] McGartland et al., *Estimating the Health Benefits of Environmental Regulations*, *supra* note 23, at 457.

[127] *See id.*

benefits analysis for non-carcinogenic effects.[128] As a result, EPA essentially gives health effects that have not been conclusively demonstrated no weight when determining the benefits of a regulation. In effect, EPA imposes a sharp discontinuity in the level of risk depending on how the agency classifies the evidence: the agency assumes there is a risk associated with "known" and "likely" evidence, the specific level of which is based on data, but assumes a 0% probability of risk when evidence is "suggestive." But the probability of an adverse impact is not zero. "Suggestive" evidence, instead, presents some other positive level of risk which is arbitrarily ignored.

Economics has a way of addressing uncertainty without ignoring it completely. Using the concept of expected value, economists can incorporate the level of uncertainty into the calculation of overall risk.[129] In the example of non-carcinogenic pollutants, if EPA employed this concept, the expected value of the health risk posed by exposure to these pollutants would incorporate both the best estimates for overall harm from exposure and the level of uncertainty. The fact of uncertainty would lower the estimated potential risk, but some level of risk would still be calculated from exposure at low levels.

Another way to better account for this risk would be to look at the willingness of individuals to pay to avoid risks from low level exposures. The "willingness to pay" measure can be calculated by directly asking people what they would hypothetically pay to avoid a risk, or by comparing wages from similar jobs that are more or less risky.[130] Workers who take riskier jobs get higher wages to compensate for that risk. By measuring this difference, it is possible to calculate the "risk premium," or willingness to pay for the additional risk posed by the job.[131] By assuming there is zero risk below the threshold, EPA has presumed that there is zero willingness to pay to avoid low level exposure. There is evidence to suggest, however, that individuals actually display a greater willingness to pay when risk is ambiguous than they do for unambiguous risks with the same expected value.[132] A willingness to pay or expected value model would better account for the magnitude and the certainty of these risks.

EPA's failure to update its non-carcinogen model to account for more recent scientific evidence, sensitive populations, and scientific uncertainties has important policy implications. Because EPA ignores risks below the threshold, the agency is unable to fully incorporate data on health effects at low levels of exposure. EPA cannot calculate what percentage of the population or how many additional people would be protected by reductions in pollution below the reference dose. Further, when EPA regulates these pollutants it does not include any health benefits from reducing pollution below the reference dose, thus undercounting potential benefits of regulation. The resulting standards therefore do not reflect any potential harm from lower-

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[128] *See id.*

[129] *See* INSTITUTE OF MEDICINE OF THE NATIONAL ACADEMIES, ENVIRONMENTAL DECISIONS IN THE FACE OF UNCERTAINTY 167-69 (2013).

[130] *See* John Bronsteen et al., *Well-Being Analysis vs. Cost-Benefit Analysis*, 62 DUKE L.J. 1603, 1645-46 (2013).

[131] *See id.* at 1646.

[132] *See* Paul A. Kivi & Jason F. Shogren, *Second-Order Ambiguity in Very Low Probability Risks: Food Safety Valuation*, 35 J. AGRIC. RES. ECON. 443, 446 (2010) (finding in the context of food safety that "people prefer unambiguous food safety choices over ambiguous ones with the same expected value," asserting that "[a]mbiguity premiums—how much more people are willing to pay to avoid an ambiguous situation than an equivalent unambiguous one—are positive" for scenerios the authors tested, and noting that the findings are consistent with previous studies.)

level exposure. If EPA instead modeled the marginal risk of reductions or increases in dose exposure at every level using a tool like willingness to pay or expected value, the agency would be able to calculate with greater accuracy the overall costs and benefits of different levels of regulation, which would facilitate more informed decision-making.

II
TREATMENT OF CRITERIA POLLUTANTS

The previous Part analyzed EPA's risk assessment models of carcinogens and noncarcinogens other than criteria pollutants. That discussion provides a useful foundation upon which to examine NAAQS criteria pollutants. EPA's understanding of criteria pollutants has evolved over five decades of implementing the Clean Air Act, shifting from a model that resembled the current treatment of other noncarcinogens, which are treated as threshold contaminants, to an analysis that more closely approximates its handling of carcinogens, which are treated as no threshold contaminants. Under multiple presidential administrations of both parties, the agency has calculated benefits from reducing criteria pollutants below the NAAQS, acting inconsistently with the existence of thresholds. Further, EPA has explicitly stated in recent rules when there is no evidence of thresholds for certain criteria pollutants.

This Part first explores Congress's understanding of criteria pollutants, and describes how even by the mid-1970s, Congress had already recognized that criteria pollutants likely do not have a threshold. It then presents EPA's revision of lead NAAQS standards in 1978 and 2008 as a case study demonstrating EPA's shift away from threshold language in its promulgation of criteria pollutant standards. The Part concludes with a survey of EPA's rejection of thresholds, both in its rulemaking language and in its calculation of benefits, for the remaining criteria pollutants excepting particulate matter, which receives an in-depth examination in Part III.

A. Clean Air Act Amendments of 1977

The NAAQS criteria pollutants are six air pollutants for which there are clearly established public health concerns at historic ambient levels.[133] The Clean Air Act governs the establishment, review, and revision of the NAAQS to provide for the protection of public health and the environment.[134] Health-based standards have been developed for each pollutant, and the standards are periodically reviewed based on human exposure assessments, health risk assessments, and ecological risk assessments.[135]

Critics of clean air regulations have asserted that the NAAQS levels are adequate to fully address criteria pollutant risks, and that reductions in these pollutants below the level of the standard are not beneficial.[136] Even though the statute does not refer to thresholds, some of these

[133] *See* SCIENCE AND DECISIONS, *supra* note 34, at 368.
[134] *See* Clean Air Act, 42 U.S.C. § 7401 et seq. (2012); Environmental Protection Agency, *Criteria Air Pollutants: Process of Reviewing the National Ambient Air Quality Standards*, https://www.epa.gov/criteria-air-pollutants/process-reviewing-national-ambient-air-quality-standards (last visited Dec. 24, 2017).
[135] *See* Clean Air Act, 42 U.S.C. § 7409(d)(1) (2012) (mandating periodic review of NAAQS every five years); SCIENCE AND DECISIONS, *supra* note 34, at 369 ("Human exposure and/or health risk assessments and ecological risk assessments are performed during the periodic reviews of these standards.").
[136] *See supra* note 21.

critics argue that thresholds are implied by the statutory requirement commanding EPA to set the NAAQS at levels that "allowing an adequate margin of safety, are requisite to protect the public health."[137] This argument requires the significant leap of equating "requisite to protect the public health" with a no-risk standard.

An examination of the legislative history for the 1977 Clean Air Act Amendments reveals that, in the years following the 1970 Act, Congress developed a more nuanced understanding of the relationship between air pollution at low concentrations and adverse health effects[138]—so much so that by the mid-1970s, Congress expressly rejected the view that criteria pollutants have thresholds.

Congress's understanding of thresholds by the time of the 1977 amendments was influenced by an evaluation by the National Academy of Sciences (NAS), [139] which was contracted in 1973 by the Senate Public Works Committee to evaluate and study the implementation of the 1970 Clean Air.[140] Among other questions, the Committee asked NAS to determine whether "there [are] assumed to be 'threshold' effects levels" for various criteria pollutants.[141] The NAS conducted a review of existing studies on air pollutants, including several it had undertaken for both the Committee and for EPA.[142] The result of that effort, the NAS's

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[137] *See* Clean Air Act of 1970, § 109(b)(1), Pub. L. No. 91–604, 84 Stat. 1679, 1680.

[138] Congress's early acknowledgement of the threshold concept's inapplicability to air pollutants has been discussed extensively in literature about the Clean Air Act. *See, e.g.*, Cary Coglianese & Gary E. Marchant, *Shifting Sands: The Limits of Science in Setting Risk Standards*, 152 U. PA. L. REV. 1255, 1288–90, 1360 (2004) ("The absence of clear thresholds for these pollutants was a well-known fact to members of Congress during deliberations over the 1977 amendments to the Clean Air Act, if not earlier."); Christopher T. Giovinazzo, *Defending Overstatement: The Symbolic Clean Air Act and Carbon Dioxide*, 30 HARV. ENVTL. L. REV. 99, 112 (2006) ("By 1977, when Congress undertook major revisions to the [Clean Air Act], it was perfectly clear that most pollutants had no clear thresholds, and that it would therefore be impossible to set NAAQS 'requisite to protect the public health' without considering cost. Yet Congress chose to maintain the fiction that thresholds exist."); Craig N. Oren, *Prevention of Significant Deterioration: Control-Compelling Versus Site-Shifting*, 74 IOWA L. REV. 1, 71 (1988) ("Judging from its frequency of citation, the apparent lack of thresholds was considered by PSD supporters to be a powerful argument for the program.").

[139] *See* Cary Coglianese & Gary E. Marchant, *Shifting Sands: The Limits of Science in Setting Risk Standards*, 152 U. PA. L. REV. 1255, 1288–90, 1360 (2004) ("Congress was strongly influenced by a 1974 report prepared for the Senate by the National Academy of Sciences and National Academy of Engineering which concluded that, contrary to the assumption underlying the 1970 Act, there were no thresholds for criteria pollutants.").

[140] NAS was explicitly contracted under section 202(d) of the 1970 Clean Air Act to examine "the health effects of air pollutants, the relation of automobile emissions to ambient air quality, and the costs and benefits of automobile emission control." National Research Council, *Report of the Conference on Air Quality and Automobile Emissions*, at 4 (May 5, 1975), https://books.google.com/books?id=DUMrAAAAYAAJ&lpg=PP1&pg=PP1#v=onepage&q&f=false. According to the Committee, "[t]he Academy was chosen as the body most likely to provide an independent and objective study of issues relating to health effects of air pollution at a time when the Committee found it increasingly difficult to obtain sufficient independent and objective information through its own limited staff investigative capacity." National Academy of Sciences, *Air Quality and Automobile Emission Control: A Report*, at 22 (Aug. 31, 1974), https://books.google.com/books?id=rlgrAAAAYAAJ&lpg=PP2&pg=PR8#v=onepage&q&f=false.

[141] *Id.* at 23. The Public Works Committee asked NAS to specifically examine "the health effects of air pollutants, the relation of automobile emissions to ambient air quality, and the costs and benefits of automobile emission control." National Research Council, *Report of the Conference on Air Quality and Automobile Emissions*, at 4 (May 5, 1975), https://books.google.com/books?id=DUMrAAAAYAAJ&lpg=PP1&pg=PP1#v=onepage&q&f=false.

[142] *See id.* at 4.

1974 "Air Quality and Automobile Emission Control" report, embraced a non-threshold view of NAAQS pollutants:

> "The present standards were derived on the assumption that such thresholds do exist. . . . However, in no case is there evidence that the threshold levels have a clear physiological meaning, in the sense that there are genuine adverse health effects at and above some level of pollution, but no effects at all below that level. On the contrary, evidence indicates that the amount of health damage varies with the upward and downward variations in the concentration of the pollutant, with no sharp lower limit.[143]

The NAS's guidance for the Committee was clear: "Thus, at any concentration, no matter how small, health effects may occur, the importance of which depends on the gravity of the effect."[144]

Similarly, the House Committee report for the amendments emphasized that there was "neither empirical evidence nor a theoretical basis for a threshold phenomenon" for any of the NAAQS pollutants.[145] The report, analyzing the limitations of NAAQS standards in 1976, also stated as one of its key findings: "The national primary standards are based on the assumption that a no-effects threshold level exists and can be proved; in fact, this assumption of a safe threshold appears to be false."[146] The report likewise discounted the utility of a threshold's "margin of safety": "From the fact that the 'safe threshold' concept is, at best, a necessary myth to permit the setting of some standards, it necessarily follows that the margin of safety concept is also an illusion. . . . [T]he supposed existence of even a modest (two or threefold) margin of safety is hardly reassuring."[147] The House Committee report endorsed verbatim NAS's assertion that "it is impossible at this time to establish an ambient air concentration for any pollutant—other than zero—below which it is certain that no human beings will be adversely affected."[148] Even by 1976, "[t]he idea that the national primary standards are adequate to protect the health of the public ha[d] been belied."[149]

In the floor debates leading up to 1977 Clean Air Act Amendments, various members of both chambers endorsed a nonthreshold view of NAAQS contaminants.[150] The bill's chief

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[143] *Id.* at 17.

[144] *Id.* at 18. The report further noted that "other considerations also argue against accepting a threshold model for health effects literally. Even if there were sharp threshold levels for individual persons, the levels would certainly not be the same for different persons, or even for the same person in different states of health." *Id.* at 17. Moreover, thresholds fail to account for "synergistic effects" of combining several pollutants, both in the human body and in the atmosphere. *See id.* at 18-19. The D.C. Circuit cited NAS's discussion of NAAQS thresholds in its *Lead Industries Ass'n v. EPA* decision, one of the early legal challenges to the 1977 amendments. *See* 647 F.2d 1130, 1152 n.43 (D.C. Cir.), *cert. denied*, 442 U.S. 1042 (1980) (quoting the NAS report as countering "the assumption that there is a discoverable no-effects threshold").

[145] Clean Air Act Amendments of 1977: Report by the Committee on Interstate and Foreign Commerce, H.R. Rep No. 95-294 (May 12, 1977).

[146] Clean Air Act Amendments of 1976: Report by the Committee on Interstate and Foreign Commerce, H.R. Rep. No. 94-1175, at 89 (May 15, 1976).

[147] *Id.* at 91.

[148] Clean Air Act Amendments of 1976: Report by the Committee on Interstate and Foreign Commerce, H.R. Rep. No. 94-1175, at 91 (May 15, 1976) (citing National Academy of Sciences, *Summary of Proceedings: Conference on Health Effects of Air Pollution*, at 7 (Nov. 1973)).

[149] *Id.*

[150] Senators Muskie and Brooke, as well as Representatives Waxman, Rogers, Preyer, Maguire, and Staggers, all contested the assumption of a "safe" threshold. *See* Senate Committee on Environment and Public Works, *A*

author, Senator Edmund Muskie, emphasized a consistent theme throughout the deliberations: "There is no threshold health effect which can be used to say that above this threshold there is danger to health and below it there is not. The testimony before the committee is replete over 14 years to that effect."[151] Only seven years into the Clean Air Act regime, Senator Muskie was unequivocal, stating that "there is no such thing as a threshold for health effects. Even at the national primary standard level, which is the health standard, there are health effects that are not protected against."[152] There was evidence suggesting these pollutants were non-threshold before the 1970 Clean Air Act was passed, and at least some members of Congress were aware of that issue.[153] But whatever Congress believed in 1970, by 1977 Congress was well aware of the threshold model's inaccuracy.

Most importantly, the core element of the PSD program is inconsistent with the notion that criteria pollutants have thresholds. The PSD program constrains the degradation of ambient air quality in areas that have air quality that is better than the NAAQS.[154] If criteria pollutants had thresholds and if the NAAQS were set at these thresholds, then there would be no reason for Congress to attempt to provide such protection. A program of this sort would have costs but no benefits. Quite to the contrary, in establishing the PSD program, Congress rejected the argument

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Legislative History of the Clean Air Act Amendments of 1977: A Continuation of the Clean Air Act Amendments of 1970, CONG. RES. SERV. (1979), https://catalog.hathitrust.org/Record/002947778 (collecting six volumes of congressional reports, floor debates, and testimony for the 1977 amendments).

[151] 123 CONG. REC. S9162 (daily ed. June 8,1977) (statement of Sen. Muskie). Senator Muskie was emphatic on this point, stressing that "[l]ong-term, low-level exposure to pollutants produce health effects which are not guarded against by national primary standards. We would have to get down to zero pollution in order to eliminate all health effects. At any level between zero pollution and the pollution permitted by national primary standards, there are health effects. Let us not disabuse ourselves on that score." 123 CONG. REC. S18460 (daily ed. June 10, 1977) (statement of Sen. Muskie). Senator Muskie's views on environmental legislation have held particularly strong sway in the federal courts. As Professor Richard Lazarus concluded:

> Congressional intent in the context of federal environmental law may be fairly equated with the intent of Senator Ed Muskie of Maine. Federal courts in their opinions have cited to the views of Senator Muskie in the enactment of federal environmental statutes in at least 293 separate cases. That is an enormous number of cases. The United States Court of Appeals for the District of Columbia has itself cited to Muskie's views in fifty-four cases. . . . Looking just to the United States Supreme Court, the statistics are even more striking. The Justices have cited to Muskie in twenty-two different cases. They include eight Clean Air Act cases, and eleven Clean Water Act cases. For each of those laws, that number constitutes a large percentage of Clean Air and Clean Water Act cases decided by the Court. The Senator, moreover, was cited most often by the Court majority in those cases, meaning that his views literally influenced the reasoning underlying the Court's ruling. Seventeen different majority opinions cited to Muskie. . . . The Justices referred to the Senator as "the principal Senate sponsor" and the "primary author" of federal environmental legislation.

Richard J. Lazarus, *Senator Edmund Muskie's Enduring Legacy in the Courts*, 67 ME. L. REV. 239, 242–43 (2015).

[152] 123 Cong. Rec. S9423 (daily ed. June 10, 1977).

[153] In fact, Muskie asserted that Congress was aware of this issue when it passed the original Act: "The [1970] Clean Air Act is based on the assumption, although we knew at the time it was inaccurate, that there is a threshold." Hearing Before the Subcommittee on Environmental Pollution of the Senate Committee on Environment and Public Works, (pt. 3), 95th Cong., 1st Sess. 8 (1977); *see* Cary Coglianese & Gary E. Marchant, *Shifting Sands: The Limits of Science in Setting Risk Standards*, 152 U. PA. L. REV. 1255, 1288–90, 1360 (2004) ("The absence of clear thresholds for these pollutants was a well-known fact to members of Congress during deliberations over the 1977 amendments to the Clean Air Act, if not earlier.").

[154] *See* Clean Air Act, 42 U.S.C. § 7473(b), 7476 (2012).

now being made by opponents of the Obama Administration's environmental regulations: that there can be no benefits from particulate reductions below the NAAQS.[155]

In sum, a broad collection of evidence—advisory group reports, committee reports, floor debates, and the structure of the legislation itself—all indicate that by 1977 Congress had rejected the view the threshold model for criteria pollutants. Only a few years after the setting of the first standards for criteria pollutants, Congress equated "[t]he concept of a 'no-effect' concentration" with "a chimera."[156]

B. Shift in EPA's Approach: A Case Study of Lead

Some early EPA practices, before the 1977 amendments, were consistent with a threshold model. This approach, however, did not persist, as a result of advances in scientific understanding. In this Section, we illustrate EPA's shift through a comparison of how EPA set the NAAQS levels for one pollutant—lead—for the first time in 1978 and how it revised it in 2008.

When EPA first developed standards for criteria pollutants, the agency treated these contaminants similarly to the way in which it treats other non-carcinogens, using language suggesting criteria pollutants had thresholds.[157] The first model developed by EPA was used during the promulgation of the 1978 lead standard,[158] which focused on finding the "safe level of total lead exposure."[159] To find this level, EPA employed the "critical population, critical effects" model: identify a "critical population" and "critical effect," analyze the relationship between environmental exposure and the critical effect, and determine an averaging period.[160] The first step of this model was to identify the critical population, a particularly vulnerable segment of the population that differed depending on the pollutant and the type of harm posed.[161] EPA chose young children ages one to five as the critical population for lead, both because young children are more susceptible to adverse health effects at lower exposure levels than adults

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[155] *See supra* notes 21-24 and accompanying text; *infra* notes 257-273 and accompanying text.

[156] Clean Air Act Amendments of 1977, H.R. Rep No. 95-294, at 111 (May 12, 1977). The report further quotes NAS's findings that it had "been unable to . . . prove that a threshold for nitrogen dioxide-induced injury exists" and that "ozone is a compound like carbon monoxide for which no safe threshold exists." *Id.*

[157] *See* Livermore & Revesz, *Rethinking Health-Based Environmental Standards*, *supra* note 61, at 1202, 1203 n.111, 1206, 1227-28 (discussing EPA's use of threshold language for its earliest NAAQS). It is worth noting that even by the 1978 Lead Rule, which as discussed in this section included language suggestive of a threshold of health effects for lead, EPA acknowledged that a threshold may not, in fact, exist. "It is also true that the absence of statistical correlation of EP levels with blood lead levels below15 pg Pb/d does not necessarily mean that these lower blood lead levels are known to be without risk." National Primary and Secondary Ambient Air Quality Standards for Lead (Proposed Rule), 42 Fed. Reg. 63,076, 63,279 (Dec. 14, 1977) (to be codified at 40 C.F.R. pt. 50).

[158] *See* Livermore & Revesz, *Rethinking Health-Based Environmental Standards*, *supra* note 61, at 1211.

[159] Lead: Proposed National Ambient Air Quality Standard, 42 Fed. Reg. 63,076, 63,079 (proposed Dec. 14, 1977) (to be codified at 40 C.F.R. pt. 50) [hereinafter Lead 1977 Proposed Rule]. A "safe level" assumes there is a threshold; by definition, a threshold is a level below which there are no health effects. For a more detailed discussion of how EPA set the 1978 lead standard, see Livermore & Revesz, *Rethinking Health-Based Environmental Standards*, *supra* note 61, at 1202-06.

[160] *See* Livermore & Revesz, *Rethinking Health-Based Environmental Standards*, *supra* note 61, at 1211.

[161] *See id.*

and because children are at higher risk of exposure to lead through dirt and soil.[162] EPA noted that children are at greater risk because of higher intake of lead per unit of body weight, greater absorption and retention of ingested lead, physiologic stresses due to rapid growth and dietary habits, incomplete development of metabolic defense mechanisms, and greater sensitivity of developing systems.[163] EPA acknowledged that there were other potential critical populations, notably pregnant women and fetuses, but stated that there was no available evidence to indicate that this population would require more stringent standards than small children.[164]

The critical effect is defined by EPA as the first adverse effect or known precursor which occurs to the critical population.[165] EPA identified as the critical effect lead-induced elevation of erythrocyte protoporphyrin (EP elevation), which is limited iron absorption in red blood cells that can be caused by exposure to lead.[166] EPA noted that EP elevation indicates impairment of cell functions which should not, in the agency's view, be permitted to persist as a chronic condition.[167]

In 1978, EPA reasoned that if the most sensitive population was protected, everyone else would be protected as well.[168] Moreover, if the critical population is protected against the critical effect, then everyone would be protected against every effect of the pollutant.[169] After making these two determinations, EPA established a relationship between environmental exposure and the critical effect of EP elevation. The agency first determined the blood lead level at which children ages one to five would experience EP elevation. EPA selected 30 μg/dL as the "maximum safe blood level for an individual child."[170] This was the individual threshold of risk for children established by the Center for Disease Control at that time.[171] EPA then selected 15 μg/dL as the average blood level target, reasoning that at that level 99.5% of the population of children would have blood levels below the 30 μg/dL level.[172]

EPA then attempted to account for non-air sources of lead, which are much more significant than airborne lead pollution and include lead paint, which may be ingested by small children.[173] Studies examined by EPA suggested nonair pollution to be from from 10.2 μg/dL to

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[162] *See* Lead 1977 Proposed Rule, *supra* note 159, at 63,077-78.
[163] *See id*. at 63,078.
[164] *See id*.
[165] *See* Environmental Protection Agency, *Fate, Exposure, and Risk Analysis: Risk Assessment for Other Effects*, https://www.epa.gov/fera/risk-assessment-other-effects (last visited Dec. 25, 2017).
[166] *See* Lead 1977 Proposed Rule, *supra* note 159, at 63,077-78.
[167] *See id*.
[168] *See* National Primary and Secondary Ambient Air Quality Standards for Lead, 43 Fed. Reg. 46,246, 46,250, 46,252, 46,254 (Oct. 5, 1978) (to be codified at 40 C.F.R. pt. 50) [hereinafter 1978 Lead Final Rule]; *see also* Livermore & Revesz, *Rethinking Health-Based Environmental Standards*, *supra* note 61, at 1203.
[169] *See* Livermore & Revesz, *Rethinking Health-Based Environmental Standards*, *supra* note 61, at 1203.
[170] 1978 Lead Final Rule, *supra* note 168, at 46,253.
[171] *See* Lead 1977 Proposed Rule, *supra* note 159, at 63,079.
[172] *See id*. Despite its use of a threshold model, EPA effectively opted to leave more than 20,000 children unprotected and likely subjected to levels of blood above 30 μg/dL. *See* Livermore & Revesz, *Rethinking Health-Based Environmental Standards*, *supra* note 61, at 1207 (citing to 1978 Lead Final Rule, *supra* note 168, at 46,255). Thus, even when the agency tried to set a threshold standard, it knowingly failed to set that standard at a level below which no adverse health effects occurred.
[173] *See* 1978 Lead Final Rule, *supra* note 168, at 46,253-54.

as much as 14.4 μg/dL,[174] from which the agency estimated a contribution of 12 μg/dL.[175] EPA then subtracted the nonair contributions from its target average blood level of 15 μg/dL, leading to a permissible air contribution of 3 μg/dL.[176]

EPA then needed to translate the target level of lead in blood into a limitation on lead in air, which is what the NAAQS regulate. To do so, EPA estimated the ratio of lead in air to lead in blood. Finally the agency divided by 2, the air-to-blood ratio it had selected.[177] The final standard set was a maximum allowable concentration of lead in the air of 1.5 $\mu g/m^3$.[178]

In 2008, EPA under President George W. Bush revisited its 1978 lead NAAQS determination and revised from 1.5 $\mu g/m^3$ to one tenth that amount; 0.15 $\mu g/m^3$.[179] EPA maintained its focus on young children, but shifted its focus from EP elevation to loss of IQ points. EPA did so because of a "general consensus" that these effects were among the most sensitive of lead's harms and of the greatest public concern.[180] Though EPA focused on loss of IQ points, EPA eliminated the "critical effect" language.[181]

In evaluating potential lead limits, EPA focused on measurements of lead in urban areas[182] where lead pollution and lead exposure is generally higher.[183] EPA chose three urban case studies: Cleveland, Chicago, and Los Angeles to measure ambient air quality.[184] EPA also included a "general urban case study," not based on a specific geographic area, but using simplifications to represent exposure of children in small residential areas near the current NAAQS.[185] Finally, EPA included a "primary smelter case study," based on a specific area not currently in compliance with NAAQS.[186] The agency analyzed each of these cases under alternative NAAQS, including the current standard, and calculated the median blood level associated with each scenario.[187] To convert each ambient air standard into a distribution of blood levels in children, EPA used two models that incorporated air, soil, and indoor dust estimations for each case study and separated sources of blood level into non-air related, "recent air," including ingesting ambient air and dust recently carried into the home, and "past air," air, including sources less immediately affected by a standard change, like ingesting outdoor soil and

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[174] *See id*.
[175] *See id*. at 46,254. One consequence of selecting the 12 μg/dL estimate for contribution was that individuals living in areas of the country in which non-air contribution exceeded 12 μg/dL were left unprotected by the threshold that EPA ultimately chose.
[176] *See id.*; Lead 1977 Proposed Rule, *supra* note 159, at 63,081.
[177] *See* 1978 Lead Final Rule, *supra* note 168, at 46,252, 46,254; Lead 1977 Proposed Rule, *supra* note 159, at 63,081.
[178] *See* 1978 Lead Final Rule, *supra* note 168, at 46,246.
[179] *See* 2008 Final Rule National Ambient Air Quality Standards for Lead, 73 Fed. Reg. at 66,964, 66,966 (Nov. 12, 2008) (to be codified at 40 C.F.R. pts. 50, 51, 53, 58) (hereinafter 2008 Lead Final Rule).
[180] *See* National Ambient Air Quality Standards for Lead, 73 Fed. Reg. 29,184, 29,198 (proposed May 20, 2008) (to be codified at 40 C.F.R. pts. 50, 51, 53, 58) (hereinafter 2008 Lead Proposed Rule).
[181] *See id.* at 29,198-29,207.
[182] *See id.* at 29,208.
[183] *See* Ronnie Levin et al., *Lead Exposures in U.S. Children, 2008: Implications for Prevention*, 116 ENVTL. HEALTH PERSP. 1285, 1289 (2008), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2569084/pdf/ehp-116-1285.pdf.
[184] *See* 2008 Lead Proposed Rule, supra note 179, at 29,210.
[185] *Id.* at 29,209.
[186] *Id.* at 29,209-10.
[187] *See id.* at 29,216.

dust.[188] For each blood level estimated as a result of a particular NAAQS scenario, EPA attempted to estimate what percentage of the blood level was attributable to air sources, with the lower bound of the estimate including only recent air sources and the upper bound including recent and past air sources.[189]

EPA then needed to translate blood levels into lost IQ points. EPA noted that the slope for effects on IQ is steeper at lower blood lead levels,[190] meaning that one additional unit of exposure at low levels has a greater health effect than one additional unit at higher levels. EPA suggested that one possible reason for this is that lead at low exposures might interfere with different biological mechanisms than lead at higher exposures, and the mechanisms affected at lower levels might be more easily saturated.[191]

Across the case study locations, at the then-current standard of 1.5 $\mu g/m^3$, the model showed a median loss of more than two IQ points, and an upper bound of four or more IQ points lost.[192] This is not a small risk: because this figure measures a *median* loss, the actual loss for certain individuals at the high end of the distribution could be much greater.[193] EPA also estimated the number of children in Cleveland, Chicago, and Los Angeles likely to lose between one and seven IQ points under the 1978 NAAQS regime, still in place at the time.[194] One model[195] predicted 395,528 children in Chicago, 13,857 in Cleveland, and 284,945 in Los Angeles would lose more than one IQ point.[196] In Chicago, 100,159 children were estimated to lose more than seven IQ points; in Cleveland, 1,858 children would suffer such losses; as would 57,834 children in Los Angeles.[197] As a result of the existing studies and risk assessment, the Administrator determined the current standard did not protect public health with an adequate margin of safety.[198]

Reviewing this data, a panel of the Clean Air Scientific Advisory Committee (CASAC), a

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[188] *See id*. at 29,210-11.
[189] *See id.* at 29,215.
[190] *See id.* at 29,201.
[191] *See* Environmental Protection Agency, *Air Quality Criteria for Lead*, EPA/600/R-5/144aF, at 8-66 (Oct. 2006), http://ofmpub.epa.gov/eims/eimscomm.getfile?p_download_id=459555.
[192] *See* 2008 Lead Proposed Rule, *supra* note 179, at 29,217.
[193] *See id.* at 29, 195 ("While levels in the U.S. general population, including geometric mean levels in children aged 1–5, have declined significantly, levels have been found to vary among children of different socioeconomic status . . . and other demographic characteristics . . For example, while the 2001–2004 median blood level for children aged 1–5 of all races and ethnic groups is 1.6 µg/dL, the median for the subset living below the poverty level is 2.3 µg/dL and 90th percentile values for these two groups are 4.0 µg/dL and 5.4 µg/dL, respectively. Similarly, the 2001–2004 median blood level for black, non-Hispanic children aged 1–5 is 2.5 µg/dL, while the median level for the subset of that group living below the poverty level is 2.9 µg/dL and the median level for the subset living in more well-off households (i.e., with income more than 200% of the poverty level) is 1.9 µg/dL. Associated 90th percentile values for 2001–2004 are 6.4 µg/dL (for black, non- Hispanic children aged 1–5), 7.7 µg/dL (for the subset of that group living below the poverty level) and 4.1 µg/dL (for the subset living in a household with income more than 200% of the poverty level).")
[194] *See id.* at 29,219.
[195] *See id.* (employing a log-linear model).
[196] *See id.* at 29,219-20.
[197] *See id.* at 29,220.
[198] *See id.* at 29,229.

non-partisan entity tasked with providing independent scientific advice to EPA,[199] advised EPA that a population IQ loss of 1-2 points represented a "highly significant" public health loss[200] and advised a standard "no higher than 0.2 μg/m^3."[201] Using the air-to-blood ratio and the concentration-response function, the Administrator determined in the final rule that 0.15 μg/m^3 would result in a mean IQ loss within the subset population below two points.[202]

Between 1978 and 2008, EPA's analysis shifted significantly with regard to the issue of thresholds.[203] In 1978, EPA adopted the CDC's threshold of 30 μg/dL as the "maximum safe blood lead level."[204] The agency's next steps were all premised on the assumption that so long as a child's blood level remained below this limit, adverse health effects would be avoided. In EPA's 2008 revision for lead, this premise was gone. The proposed rule explicitly stated that "the Administrator recognizes that [lead] can be considered a non-threshold pollutant."[205] Moreover, EPA noted in 2008 that the Center for Disease Control and Prevention recognized that no "safe" threshold for blood lead has been identified,[206] and stated that "[t]hreshold levels, in terms of blood [lead] levels in individual children, for neurological effects cannot be discerned from the currently available studies."[207] The agency acknowledged that there are effects from lead at very low levels,[208] and even asserted that the slope for effects on IQ is actually steeper at lower blood lead levels.[209] Further, though EPA based the final steps of its analysis around the "significant health effect" of loss of 1-2 IQ points, the agency did not claim that this was a level below which there are no health risks. The Administrator even acknowledged that standards would ideally be set so that no children would lose IQ points due to lead pollution.[210] The rule's Regulatory Impact Analysis (RIA), which examines the "the potential social benefits and social costs of a regulation,"[211] effectively reaffirmed these conclusions about risks below thresholds:

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[199] CASAC was established as part of the 1977 amendments "to review the criteria and standards promulgated [by EPA] and provide other related scientific and technical advice." Environmental Protection Agency, *EPA Clean Air Scientific Advisory Committee (CASAC): Charter*, https://yosemite.epa.gov/sab/sabproduct.nsf/WebCASAC/currentcharter?OpenDocument (last updated Sept. 21, 2015). By statute, CASAC is composed of seven members appointed by the EPA Administrator, "including at least one member of the National Academy of Sciences, one physician, and one person representing State air pollution control agencies." Clean Air Act, 42 U.S.C. § 7409(d)(2) (2012).

[200] 2008 Lead Proposed Rule, *supra* note 179, at 29,226.

[201] *Id.* at 29,241.

[202] *See* 2008 Lead Final Rule, *supra* note 179, at 67,005-06. Note that the proposed rule modeled the median loss of IQ points, whereas the final rule modeled the mean loss of IQ points.

[203] Though the 2008 method represents a significant shift, there are still concerns about this analysis. For a brief overview, see Livermore & Revesz, *Rethinking Health-Based Environmental Standards*, *supra* note 61, at 1214. The most significant issue is that the population IQ loss of 1-2 points is rather arbitrary. *Id.*

[204] 1978 Lead Final Rule, *supra* note 168, at 46,253.

[205] 2008 Lead Proposed Rule, *supra* note 179, at 29,244. This claim is reiterated in the final rule, albeit qualified by the possibility that thresholds may still exist at levels "at levels distinctly lower than the lowest exposures examined in these epidemiological studies." 2008 Lead Final Rule, *supra* note 179, at 66,999.

[206] *See* 2008 Lead Final Rule, *supra* note 179, at 66,972.

[207] *Id*. at 66,975.

[208] EPA "recognizes today that there is no level of [lead] exposure that can yet be identified, with confidence, as clearly not being associated with some risk of deleterious health effects.'' *Id.* at 66,992.

[209] *See id.* at 66,987.

[210] *See* 2008 Lead Proposed Rule, *supra* note 179, at 29,242.

[211] Environmental Protection Agency, *Regulatory Impact Analyses for Air Pollution Regulations*, https://www.epa.gov/economic-and-cost-analysis-air-pollution-regulations/regulatory-impact-analyses-air-pollution (last visited Dec. 18, 2017). The agency's RIAs include descriptions of social costs and benefits "that cannot be

While EPA ultimately adopted an updated standard of 0.15 μg/m^3, it had also analyzed the costs and benefits of a more stringent standard of 0.10 μg/m^3 [212] and found additional total benefits from moving to a 0.15 μg/m^3 level to a 0.10 μg/m^3 level to be between $1.1 billion and $1.7 billion.[213] These are benefits that would not exist below a true threshold. EPA acknowledged that the decision was ultimately a "public health policy judgment" because there is no "evidence- or risk-based bright line that indicates a single appropriate level."[214] Overall, this 2008 rulemaking reflected an important shift in how EPA regulates NAAQS pollutants: from assuming that there is a threshold below which no health effects will occur to acknowledging that the decision is ultimately a policy judgment because there is no exposure level where all risks can be avoided.[215]

C. Rejecting Thresholds and Calculating Benefits Below the NAAQS

EPA's rejection of thresholds for lead is not atypical. Across the range of criteria pollutants, EPA has moved toward a nonthreshold model. For many criteria pollutants, EPA has explicitly acknowledged—in some cases for decades—where it has evidence to suggest that NAAQS pollutants lack a threshold. Futher, for all but one of the criteria pollutants,[216] the

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quantified in monetary terms and a determination of the potential net benefits of the rule[,] including an evaluation of the effects that are not monetarily quantified." *Id.*

[212] *See* Environmental Protection Agency, *Regulatory Impact Analysis of the Proposed Revisions to the National Ambient Air Quality Standards for Lead*, at 1-7 (Oct. 2008), https://www3.epa.gov/ttn/ecas/docs/ria/naaqs-lead_ria_final_2008-10.pdf.

[213] *See id.* at ES-11. This number is the difference between the low estimate for the 0.10 μg/m^3 level and the 0.15 μg/m^3 level and the difference between the high estimates at those levels. Both estimates are calculated using a 3% discount rate, though EPA also calculates benefits and costs using a 7% discount rate. *Id.* However, economists generally find the 7% rate to be unrealistically high for air pollution estimates. *See* Newell, *Unpacking the Administration's Revised Social Cost of Carbon*, *supra* note 8. The benefits discussed in this section were all calculated using the 3% discount rate unless otherwise noted.

[214] 2008 Lead Final Rule, *supra* note 179, at 67,006.

[215] In 2016, EPA again reviewed the lead NAAQS and declined to adjust the standard, leaving in place the 0.15 μg/m^3 level. The agency noted that newly available evidence "reaffirms conclusions" from the 2008 NAAQS, and stated that the "currently available evidence is generally consistent with the evidence available in the last review." Review of the National Ambient Air Quality Standards for Lead, 81 Fed. Reg. 71,906, 71,907 (Oct. 18, 2016) (to be codified at 40 C.F.R. pt. 50). The agency also reiterated that the NAAQS were not a no-risk threshold. In reviewing the 2008 standard, EPA "recognize[ed] the continued lack of a discernible threshold of exposure associated with neurocognitive effects." *Id.* at 71,929. Moreover, the Administrator, responding to comments that there is no safe level of lead exposure, instead noted that she was not required by the Clean Air Act to establish a NAAQS with zero risk. *Id.* at 71,928. *See also* Joseph M. Feller, *Non-Threshold Pollutants and Air Quality Standards*, 24 ENVTL. L. 821, 824-25, 837 (1994) ("The absence of health or welfare thresholds is well-known not only to scientists but also to Congress, EPA, and the courts, which are often called on to oversee EPA's implementation of the Act. Nonetheless, attempts to deal rationally with the problems of air pollution are frustrated because the threshold assumption is built into the structure of the Act. . . . While recognizing that health-effects thresholds may not exist for some pollutants, EPA has nonetheless generally structured its NAAQS rulemakings as if they do.").

[216] EPA found benefits for every criteria pollutant for which has it performed an RIA in recent times. The sole exception is carbon monoxide: the agency reviewed the carbon monoxide NAAQS in 2011, but did not conduct an RIA. *See* Review of National Ambient Air Quality Standards for Carbon Monoxide, 78 Fed. Reg. 54,294 (Aug. 31, 2011) (to be codified at 40 C.F.R. pts. 50, 53 and 58). The most recent RIA for carbon monoxide was conducted in 1985. *See* Environmental Protection Agency, *Regulatory Impact Analysis of the National Ambient Air Quality Standards for Carbon Monoxide*, EPA-450/5-85-007, (July 1985), http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=2000NK80.TXT.

agency has calculated benefits from alternatives more stringent than what EPA ultimately selected as its standard, and it has done so under presidents from both parties.[217] That EPA finds additional benefits for levels more stringent than the NAAQS is inconsistent with the existence of a threshold for these pollutants: below a threshold there should be no additional benefits from reductions. This section surveys EPA's historical practices for ozone, carbon monoxide, nitrogen dioxide, and sulfur dioxide,[218] revealing the agency's consistent calculations of benefits below NAAQS levels and its more explicit finding on the lack of evidence of thresholds. A similar analysis for particulates follows in Part III.

As early as 1979, EPA began to acknowledge the difficulty of identifying thresholds for criteria pollutants. In its revision for ozone, President Jimmy Carter's EPA noted that the rule's "criteria document supports the contention that a clear threshold of adverse health effects cannot be identified with certainty for ozone."[219] In revising that standard, EPA under President George H.W. Bush concluded that "[t]here appears to be no threshold level below which materials damage will not occur, exposure of sensitive materials to any non-zero concentration of O_3 (including natural background levels) can produce effects if the exposure duration is sufficiently long."[220] In its 1997 review for ozone, President Bill Clinton's EPA went even further. The agency recognized "O_3 may elicit a continuum of biological responses down to background concentrations."[221] In stark terms, the agency noted that, "in the absence of any discernible threshold, it is not possible to select a level below which absolutely no effects are likely to occur. . . [or] to identify a level at which it can be concluded with confidence that no 'adverse' effects are likely to occur."[222] In 2008, the George W. Bush EPA's final rule for ozone repeatedly confirmed that "the underlying scientific evidence is [not] certain enough to support a focus on any single bright line benchmark level."[223] The rule's Regulatory Impact Analysis explicitly

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[217] These calculations are part of EPA's efforts to comply with Executive Order 12,866, issued during the Clinton Administration, and OMB Circular A-4, issued during the George W. Bush Administration. *See* Environmental Protection Agency, *Final Regulatory Impact Analysis (RIA) for the NO_2 National Ambient Air Quality Standards (NAAQS)*, at ES-2 (Jan. 2010), https://www3.epa.gov/ttn/ecas/docs/ria/naaqs-no2_ria_final_2010-01.pdf (discussing these documents as presenting "guidelines for EPA to assess the benefits and costs of the selected regulatory option, as well as one less stringent and one more stringent option.").

[218] The additional benefits for more stringent lead standards were discussed as part of the case study in Part II.B, while the benefits for additional particulate matter reductions are discussed in depth *infra* Part III.

[219] Revisions to the National Ambient Air Quality Standards for Photochemical Oxidants, 44 Fed. Reg. 8,202, 8,213 (Feb. 8, 1979) ("Rather, there is a continuum consisting of ozone levels at which health effects are certain, through levels at which scientists can generally agree that health effects have been clearly demonstrated, and down to levels at which the indications of health effects are less certain and harder to identify.").

[220] Proposed Rule for National Ambient Air Quality Standards for Ozone, 57 Fed. Reg. 35,542, 35,553 (Aug. 10, 1992) (to be codified at 40 C.F.R. pt. 50).

[221] National Ambient Air Quality Standards for Ozone, 62 Fed. Reg. 38,856, 38,863 (July 18, 1997) (to be codified at 40 C.F.R. pt. 50).

[222] *Id.*

[223] National Ambient Air Quality Standards for Ozone, 73 Fed. Reg. 16, 436, 16,465, 16,747, 16,476-77, 16,481-82 (Mar. 27, 2008) (to be codified at 40 C.F.R. pts. 50 and 58). Moreover, the rule noted that, in light of the continuum of effects associated with varying levels of exposure to ozone, adverse health effects are "related to the actual magnitude of the O_3 concentration, not just whether the concentration is above a specified level." *Id.* at 16, 475. The Administrator recognized "that exposures of concern must be considered in the context of a continuum of the potential for health effects of concern, and their severity, with increasing uncertainty associated with the likelihood of such effects at lower O_3 exposure levels." *Id.* at 16,465, 16,466.

noted that "ozone is a non-threshold pollutant."[224] In 2015, EPA under President Obama noted in its final rule for ozone that "[f]rom the inception of the NAAQS standard-setting process, EPA and the courts have acknowledged that scientific uncertainties in general, and the lack of clear thresholds in pollutant effects in particular, preclude any [] definitive determinations."[225] Similarly, the rule's Integrated Science Assessment stated more explicitly the agency's "overall conclusion[] that the epidemiologic studies . . . indicated a generally linear [concentration-response] function with no indication of a threshold. . . ."[226]

EPA in 2008 also included benefits calculations for levels below the standard set by the regulation. While EPA selected a standard of 75 ppb,[227] the agency also analyzed a more stringent standard of 70 ppb—the level later selected by the Obama Administration in 2015—as well as an even more stringent 65 ppb standard.[228] The agency provided third-party estimates of benefits for its chosen standard of 75 ppb which ranged from $2 billion to $19 billion in 2020.[229] For a more stringent standard of 70 ppb, the agency estimated benefits of $3.5 billion to $37 billion.[230] For the most stringent standard of 65 ppb, EPA included estimates of benefits ranging from $5.5 billion to $58 billion in 2020.[231]

In its 2015 RIA, EPA again calculated benefits for reductions in ozone below its chosen NAAQS level. In the RIA analyszing a revision of the secondary standard for ozone from 75 to 70 ppb,[232] EPA provided an analysis of the benefits of a 70ppb standard and an alternative of 65 ppb.[233] The agency estimated the benefits of the 70 ppb level to be between $2.9 and $5.9 billion in 2025, and the benefits of a 65ppb level to be between $15 and $30 billion over the same period.[234] Further, the agency found that in 2025, the 70 ppb standard would prevent between 96 and 160 ozone-related premature deaths and 220 to 500 particulate matter-related premature deaths. However, the 65 ppb level would prevent between 490 and 820 ozone-related deaths and between 1,100 and 2,500 particulate matter-related deaths.[235]

In its 1985 revision for nitrogen dioxide, the Reagan EPA asserted a qualified rejection of NO_2 thresholds, stating that "none of the evidence presented in the Criteria Document shows a

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[224] Environmental Protection Agency, *Final Ozone NAAQS Regulatory Impact Analysis*, at 6-30 (Mar. 2008), https://www3.epa.gov/ttn/ecas/docs/ria/naaqs-o3_ria_final_2008-03.pdf.
[225] National Ambient Air Quality Standards for Ozone, 80 FR 65,292, 65,355 (to be codified at 40 C.F.R. Parts 50, 51, 52, 53, and 58) (Oct. 26, 2015).
[226] *Id.* at 65,309.
[227] *See* Environmental Protection Agency, *Final Ozone NAAQS Regulatory Impact Analysis*, *supra* note 224, at ES-1.
[228] *See id*.
[229] *See id*. at 7-3, Table 7.1a.
[230] *See id*. at 7-3, Table 7.1c.
[231] *See id*. at 7-4, Table 7.1d.
[232] *See* Environmental Protection Agency, *Regulatory Impact Analysis of the Final Revisions to the National Ambient Air Quality Standards for Ground-Level Ozone*, EPA-452/R-15-007, at 1-1 (Sept. 2015), https://www3.epa.gov/ttn/ecas/docs/ria/naaqs-o3_ria_final_2015-09.pdf. The standard was set with an averaging time of 8 hours and the form of annual fourth-highest daily maximum averaged over three years. *See id*.
[233] *See id*. at ES-2.
[234] *See id*. at ES-15, Table ES-5. These figures were calculated at a 7% discount rate as EPA only summarized benefits at the 7% discount rate. *Id*.
[235] *See id.* at ES-16, Table ES-6.

clear threshold of adverse health effects for NO_2."[236] As it had done six years earlier with ozone, the agency described adverse health effects from nitrogen dioxide exposure as occupying "a continuum, ranging from NO_2 levels at which health effects are undisputed, through levels at which many, but not all scientists generally agree that health effects have been convincingly shown, down to levels at which the indications of health effects are less certain and more difficult to identify."[237] In the 2010 update to that standard, the Obama EPA noted that "[t]he meta-analysis does not provide any evidence of a threshold below which effects do not occur."[238] The revision's Integrated Science Assessment also "concluded that NO_2 epidemiologic studies provide 'little evidence of any effect threshold'" and that "concentration-response relationships… appear linear."[239] That 2010 review prompted EPA to set at new short-term NO_2 standard of 100 parts per billion (ppb), based on the 3-year average of the 98th percentile of 1-hour daily maximum concentrations.[240]

The agency in 2010 also found additional benefits for reductions in nitrogen dioxide below NAAQS levels. In addition to its 100 ppb standard, EPA also analyzed a lower, more stringent level of 80ppb.[241] At and above 100 ppb, according to the controlled human exposure studies, increased airway responsiveness was observed in "a large percentage of asthmatics."[242] However, EPA acknowledged that people with more severe asthma would be expected to experience symptoms at concentrations below the 100 ppb standard.[243] The agency calculated that there would be an additional $3.2 to $8.6 million in benefits in 2020 for an 80 ppb standard than there are under the 100 ppb standard EPA chose.[244]

The primary sulfur dioxide NAAQS standard was most recently revised under the Obama Administration in 2010. The final rule recognized that "the available health effects evidence reflects a continuum consisting of ambient levels of SO_2 at which scientists generally agree that health effects are likely to occur, through lower levels at which the likelihood and magnitude of the response become increasingly uncertain."[245]

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[236] Retention of the National Ambient Air Quality Standards for Nitrogen Dioxide, 50 Fed. Reg. 25,532, 25,537 (June 19, 1985) (to be codified at 40 C.F.R. pt. 50).
[237] *Id.* The agency went on to note that there was uncertainty, acknowledinging that based on evidence available at the time, "[t]his does not necessarily mean that there is no threshold, other than zero, for NO_2 related health effects; it simply means no precise threshold can be identified with certainty based on existing medical evidence." *Id.*
[238] Primary National Ambient Air Quality Standards for Nitrogen Dioxide, 75 Fed. Reg. 6,474, 6,500 (Feb. 9, 2010) (to be codified at 40 C.F.R. pts. 50 and 58).
[239] *Id.* at 6,480; *see also id.* at 6,500 (stating that ISA's "meta-analysis does not provide any evidence of a threshold below which effects do not occur"). For further discussion of EPA's acknowledgment of scienfitic "uncertainty" of thresholds, see *infra* Part III.C.
[240] *See* Environmental Protection Agency, *Final Regulatory Impact Analysis (RIA) for the NO_2 National Ambient Air Quality Standards (NAAQS)*, at ES-1 (Jan. 2010), https://www3.epa.gov/ttn/ecas/docs/ria/naaqs-no2_ria_final_2010-01.pdf.
[241] *See id*.
[242] Livermore & Revesz, *Rethinking Health-Based Environmental Standards*, *supra* note 61, at 1218.
[243] *See id.* at 1218.
[244] *See* Environmental Protection Agency, *Final Regulatory Impact Analysis (RIA) for the NO_2 National Ambient Air Quality Standards (NAAQS)*, *supra* note 240, at ES-6, ES-7. This is at the 65% gradient, which was the level EPA chose in its final regulation. *See id*.
[245] Primary National Ambient Air Quality Standard for Sulfur Dioxide, 75 Fed. Reg. 35,520, 35,529 (June 22, 2010) (to be codified at 40 C.F.R. pts. 50, 53, and 58).

As part of these regulations, EPA set a new standard of 75 ppb, based on the 3-year average of the 99th percentile of 1-hour daily maximum concentrations,[246] but also analyzed alternative primary standards of 50 ppb.[247] At the 75 ppb level, EPA found $2.2 million in benefits, including 260 fewer emergency room visits for respiratory symptoms.[248] At the lower 50 ppb level, EPA calculated $8.5 million in benefits, including 930 fewer such emergency room visits.[249] The agency also calculated that a 50ppb standard could have yielded as much as $46 billion in additional $PM_{2.5}$ co-benefits compared to the 75 ppb standard.[250]

In its 2011 revision for carbon monoxide, the Obama EPA recognized carbon monoxide pollution as similarly exhibiting a "continuum" of adverse health effects with varying degrees of certainty.[251] The agency highlighted two studies that were unable to discern a threshold for cardiovascular effects from carbon monoxide exposure.[252] The rule's Integrated Science Assessment concluded that "[e]pidemiologic analyses investigating the exposure-response relationship for mortality and cardiovascular morbidity did not find evidence for a departure from linearity or a threshold for CO effects."[253]

In short, EPA has moved away from the "critical effect" language it originally developed for NAAQS pollutants in 1978 and which might have suggested a threshold,[254] and since the late 1970s has openly rejected the threshold assumption for criteria pollutants on the basis of advances in the scientific understanding of these pollutants. EPA also calculates benefits for criteria pollutant reductions below the levels at which the agency chose for each of the most

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[246] *See id.* at 35,524.

[247] *See* Environmental Protection Agency, *Final Regulatory Impact Analysis (RIA) for the SO_2 National Ambient Air Quality Standards (NAAQS)*, at ES-1 (June 2010), https://www3.epa.gov/ttn/ecas/docs/ria/naaqs-so2_ria_final_2010-06.pdf.

[248] *See id*. at 5-21, Table 5.5. These figures represent "the incidences of health effects and monetized benefits of attaining the alternative standard levels by health endpoint. Because all health effects from SO_2 exposure are expected to occur within the analysis year, the monetized benefits for SO_2 [for these figures] do not need to be discounted. Please note that these benefits do not include any of the benefits listed as 'unquantified' . . . nor do they include the PM co-benefits . . ." *Id.* at 5-20.

[249] *See id*.

[250] *See id.* at 5-31 (comparing estimates in particulate matter co-benefits calculated in the Laden study, using a 3% discount rate).

[251] *See* National Ambient Air Quality Standards for Carbon Monoxide, 76 Fed. Reg. 54,294, 54,308 (Aug. 31, 2011) (to be codified at 40 C.F.R. pts. 50, 53, and 58) ("These judgments are informed by the recognition that the available health effects evidence generally reflects a continuum, consisting of ambient levels at which scientists generally agree that health effects are likely to occur, through lower levels at which the likelihood and magnitude of the response become increasingly uncertain.").

[252] *See id.* at 54,300 ("Among the controlled human exposure studies, the ISA places principal emphasis on the study of CAD patients by Allred et al. (1989a, 1989b, 1991) (which was also considered in the previous review) for the following reasons: (1) Dose-response relationships were observed; (2) effects were observed at the lowest COHb levels tested (mean of 2–2.4% COHb following experimental CO exposure), with no evidence of a threshold."). EPA later in the same section on "Cardiovascular Effects" notes that "an important finding of the multilaboratory study was the dose-response relationship observed between COHb and the markers of myocardial ischemia, with effects observed at the lowest increases in COHb tested, without evidence of a measurable threshold effect." *Id*.

[253] Environmental Protection Agency, *Integrated Science Assessment for Carbon Monoxide*, EPA/600/R-09/019F, at 2-16 (Jan. 2010), http://ofmpub.epa.gov/eims/eimscomm.getfile?p_download_id=494432.

[254] *See supra* notes 160-169 and accompanying text; *supra* notes 180-181 and accompanying text.

recent NAAQS.[255] All of this is flatly inconsistent with the notion, advanced by the Trump Administration and by other opponents to Obama era regulations in litigation,[256] that the NAAQS standards represent a no-harm threshold for criteria pollutants, and that Obama-era rules inflated benefits in ways inconsistent with historical EPA practices by quantifying the benefits of reductions in NAAQS pollutants below the NAAQS.

III
CALCULATING HEALTH BENEFITS FROM PARTICULATE REDUCTIONS BELOW THE NAAQS

Critics of climate change regulations argue that particulate reduction benefits do not exist below the NAAQS standards, which they characterize as a no-harm threshold.[257] According to adherents of this view, "[b]oth theory and data suggest that thresholds exist below which further reductions in exposure to $PM_{2.5}$ do not yield changes in mortality response and that one should expect diminishing returns as exposures are reduced to lower and lower levels."[258] Similarly, the Heartland Institute, which bills itself as "the world's most prominent think tank promoting skepticism about man-made climate change,"[259] advocates "the widely held belief among scientists and health experts, supported by ample research, that some threshold must exist below which pollution has no health impact. That belief is often summarized as '[t]he dose makes the poison.'"[260] More recently, it has deemed $PM_{2.5}$ "a favorite new bogeyman"[261] of EPA, and thresholds the result of "a fabricate[d] disease entity [of] post-modern pseudo-science."[262] The National Mining Association advanced the same line of reasoning in *Michigan v. EPA* in its challenge to the Mercury and Air Toxics Standards: "EPA concedes that most of these benefits supposedly result from reducing [particulate matter] concentrations to below the level that EPA set in its $PM_{2.5}$ NAAQS. . . . But EPA set the [particulate matter] NAAQS, as it set all of the

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[255] Note that EPA did not calculate benefits for carbon monoxide, the lone exception to this pattern, as EPA did not produce a new RIA. *See supra* note 117.
[256] *See supra* notes 24-30. Moreover, this argument is not supported by science. *See infra* notes 355-370and accompanying text.
[257] *See supra* note 21.
[258] Susan E. Dudley, *OMB's Reported Benefits of Regulation: Too Good to Be True?*, REGULATION, July 8, 2013, at 28, http://www.cato.org/sites/cato.org/files/serials/files/regulation/2013/6/regulation-v36n2-4.pdf.
[259] *Arthur B. Robinson Center on Climate and Environmental Policy: About*, Heartland Inst., https://www.heartland.org/Center-Climate-Environment/About/index.html (last visited Jan. 1, 2018).
[260] Jay Lehr, *Warning: New HEI Report on PM10 Easy to Misinterpret*, HEARTLAND INST. (June 17, 2004), https://www.heartland.org/news-opinion/news/warning-new-hei-report-on-pm10-easy-to-misinterpret?source=policybot; *see also* Paul Driessen, *EPA's Dangerous Regulatory Pollution*, HEARTLAND INST. (Sept. 6, 2016), https://www.heartland.org/news-opinion/news/epas-dangerous-regulatory-pollution ("How can it be that $PM_{2.5}$ particulates are dangerous or lethal for Americans in general, every time they step outside—but harmless to human guinea pigs [in EPA experiments] who were intentionally administered pollution dozens of times worse than what they would encounter outdoors? How can it be, as EPA-funded researchers now assert, that 'acute, transient responses seen in clinical studies cannot necessarily be used to predict health effects of chronic or repeated exposure'—when that is precisely what EPA claims they can and do show?"). The Heartland Institute now asserts that EPA's $PM_{2.5}$ science constitutes "an attempted takeover of absolutely all industry in the United States," despite "[t]he best scientific research show[ing] these particles are ubiquitous and, contrary to EPA's claims, . . . harmless." H. Sterling Burnett, *EPA Air Quality Research, Regulations Flawed, Study Finds*, HEARTLAND INST. (Aug. 23, 2017), https://www.heartland.org/news-opinion/news/epa-air-quality-research-regulations-flawed-study-finds.
[261] Charles Battig, *Driving Policies Through Fraud and Fear-Mongering*, HEARTLAND INST. (July 10, 2015), https://www.heartland.org/news-opinion/news/driving-policies-through-fraud-and-fear-mongering?source=policybot.
[262] *Id.*

NAAQS, at a level that is 'requisite to protect the public health' with a margin of safety and without considering compliance costs."[263] In other words, the National Mining Association asserts, if EPA followed its mandate to regulate particulate matter to the extent required under the NAAQS regime, then there would be no benefits below the NAAQS standard because the NAAQS standard would be set at the point at which benefits would not accrue below it. Either, they assert, EPA has not appropriately set the particulate matter NAAQS standard with the requisite margin of safety or the asserted co-benefits of particulate matter reduction are nonexistent.

Opponents also challenge the science underlying EPA's calculation of additional benefits from pollution reduction below the NAAQS. EPA's use of a linear, non-threshold approach for low-level PM concentrations[264] has been criticized as "highly imprecise" and guilty of "cherrypicking" epidemiology studies en route to a "biased assessment of the available data."[265] Moreover, EPA's assertion of benefits from particulate matter have been deemed "illusory";[266] based on "empty generalities and speculative claims";[267] "based on questionable assumptions and . . . likely overstated";[268] "specious";[269] and "employ[ing] a methodology that places a thumb on the scale at every step of its benefit calculations and that regularly eschews real data in place of unrealistic assumptions and wild speculations."[270] These purported benefits are allegedly "vague[,] un-monetized,"[271] and "too speculative,"[272] with the implication that if they are too uncertain to be quantified, they are too uncertain to be contemplated at all. The agency simply "cannot quantify them [because] they are not supported by the scientific literature."[273]

Benefits from particulate matter reductions are thus a key battleground in the fight over major Obama era Clean Air Act rules, and will almost certainly be a point of contention over future climate change regulations. Because of the size of these benefits, both in absolute terms and in comparison with other regulatory effects, there is a substantial incentive for both sides to misrepresent them, and a critical need to get these estimates right. The following section describes the robust scientific basis for EPA's determination that particulate matter lacks a threshold below which adverse health effects occur.

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[263] Opening Brief of Petitioner the National Mining Association at 41 n.19, Michigan v. EPA, 135 S. Ct. 2699 (2015) (No. 14-46), 2015 WL 294672 (internal citations omitted).
[264] *See* National Ambient Air Quality Standards for Particulate Matter, 78 Fed. Reg. 3,086, 3,119 (Jan. 13, 2013) (to be codified at 40 C.F.R. pts. 50, 51, 52, 53 and 58); *infra* notes 347-348 and accompanying text.
[265] Brief for the Cato Institute as Amicus Curiae in Support of Petitioners at 25, Michigan v. EPA, 135 S. Ct. 2699 (2015) (No. 14-46), 2015 WL 412058.
[266] Opening Brief of State and Industry Petitioners at 51, Murray Energy Corp. v. EPA, No. 16-1127 (D.C. Cir. filed Nov. 18, 2016).
[267] *Id.* at 56.
[268] Brief of the Chamber of Commerce of the United States of America, the National Association of Manufacturers, the National Federation of Independent Business, and the National Association of Home Builders as Amici Curiae in Support of Petitioners at 22 n.15, Michigan v. EPA, 135 S. Ct. 2699 (2015) (Nos. 14-46, 14-47, 14-49), 2015 WL 428995.
[269] Brief of Amicus Curiae Cato Institute in Support of Petitioners at 4, Murray Energy Corp. v. EPA, No. 16-1127 (D.C. Cir. filed Nov. 18, 2016).
[270] *Id.*
[271] Opening Brief of State and Industry Petitioners at 55, Murray Energy Corp. v. EPA, No. 16-1127 (D.C. Cir. filed Nov. 18, 2016).
[272] *Id.* at 56.
[273] *Id.*

A. Scientific Basis

Particulate matter (PM) is a mixture of very small particles and liquid droplets that are found in the air. Some particles including dust, dirt, soot, and smoke are large enough to be visible, while others are too small to be seen with the naked eye.[274] Exposure to particulate matter can have negative effects on lung and heart health, including coughing or difficulty breathing, aggravating asthma and decreased lung function, as well as heart attacks and irregular heartbeat. Exposure can be deadly, particularly for people with heart or lung disease.[275]

EPA regulates particulate matter under two standards, which are based on the size of the particulate matter particles. Extremely small particles, those measuring 2.5 micrometers or less, are regulated under the $PM_{2.5}$ standards, while larger particles measuring between 2.5 and 10 micrometers are regulated under the PM_{10} standards. The current standards for particulate matter set limits on $PM_{2.5}$ of 35 $\mu g/m^3$ averaged over 24 hours and of 12 $\mu g/m^3$ averaged annually.[276] The PM_{10} standard is a 24-hour average of 150 $\mu g/m^3$, and there is no annual standard.[277]

These standards do not represent the level at which there are no health effects from particulate matter exposure. The science on benefits from reductions in particulate matter below the NAAQS, some of which is summarized in this section, is robust. In general, the evidence suggests there is no threshold for particulate matter, which means that risk from particulate matter exists at every level of exposure.[278]

For example, in 2006, EPA solicited a report of judgments from experts on the concentration response relationship between small particulate matter particles ($PM_{2.5}$) and mortality.[279] The twelve experts who participated were selected through a peer-nomination process and included experts in epidemiology, toxicology, and medicine.[280] As part of this study, the experts were asked about their views on the concentration-response function, which measures health effects at different levels of exposure.[281] While all experts believed that individuals may exhibit thresholds for PM-related mortality, eleven of the twelve rejected the idea of a population

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[274] *See* Environmental Protection Agency, *Particulate Matter (PM) Basics: What Is PM, and How Does It Get into the Air?*, https://www.epa.gov/pm-pollution/particulate-matter-pm-basics#PM (last updated Sept. 12, 2016).
[275] *See* Environmental Protection Agency, *Health and Environmental Effects of Particulate Matter (PM)*, https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm (last updated July 1, 2016).
[276] *See* National Ambient Air Quality Standards for Particulate Matter, 78 Fed. Reg. 3086, 3086 (Jan. 13, 2013) (to be codified at 40 C.F.R. pts. 50, 51, 52, 53 and 58).
[277] *See id.* at 3,089.
[278] It is well beyond the scope of this article to comprehensively review and independently evaluate all of the scientific research on the relationship between particulate matter exposure and negative health outcomes. The research presented here thus focuses primarily on aggregated reports written by scientists, doctors, and other experts on the effects of particulate matter on human health. In doing so, the authors defer to the expertise of these writers and their judgments in aggregating and analyzing evidence on the health effects of particulate matter.
[279] *See* Industrial Economics, Inc., *Expanded Expert Judgment Assessment of the Concentration-Response Relationship Between $PM_{2.5}$ Exposure and Mortality*, at i-ii (Sept. 21, 2006), https://www3.epa.gov/ttnecas1/regdata/Uncertainty/pm_ee_report.pdf (documenting "expert judgments concerning the impact of a one $\mu g/m^3$ change in ambient, annual average $PM_{2.5}$ on annual, adult, all-cause mortality in the U.S.")
[280] *See id*. at ii.
[281] *See id*. at iv.

threshold, stating that was is insufficient evidence to support such a threshold.[282] Seven experts noted that a population threshold was unlikely due to variations in susceptibility as a result of genetic, environmental, and socioeconomic factors.[283] The single expert who believed it was possible to make a conceptual argument for a population threshold noted that he did not believe such a threshold was detectable in currently available epidemiologic studies.[284] This expert also stated that he was 50 percent certain a population threshold existed, and that if there were a threshold, he thought there was an 80 percent chance the threshold would be less than 5 $\mu g/m^3$, and a 20 percent chance that it would fall between 5 and 10 $\mu g/m^3$.[285] Both levels cited by the expert are lower than the current NAAQS levels for $PM_{2.5}$ of 12 $\mu g/m^3$.[286]

A 2010 scientific report from the American Heart Association reached similar conclusions.[287] The authors of that report included specialists in a wide range of disciplines including cardiovascular and environmental epidemiology and statistics, atmospheric sciences, cardiovascular and pulmonary medicine, basic science research, and public policy.[288] The report comprehensively reviewed studies, published between 2004 to 2009, on the relationship between particulate matter and heart health.[289] The report concluded that there "appeared to be no lower-limit threshold below which PM_{10} was not associated with excess [cardiovascular] mortality."[290] With regard to $PM_{2.5}$, the report stated that there appeared to be a linear concentration-response relationship between the small particles and mortality risk without a discernible safe threshold.[291] The report suggested that an area for future research was determining whether there is any safe PM threshold that protects both healthy and susceptible individuals,[292] but noted that current evidence reviewed supports the conclusion that there is overall no safe threshold.[293]

The American Thoracic Society (ATS) in a 2016 article likewise reported adverse health effects below NAAQS standards.[294] ATS recommended an annual standard for $PM_{2.5}$ of 11 $\mu g/m^3$, which is lower than the current NAAQS requirements. The report estimated the health impacts from PM exposure in places that violated the ATS annual standard, including places in compliance with EPA's requirements. The report found that relative to current particulate matter

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[282] *See id*. at 3-25. For the discussion of the difference between individual and population thresholds, see *supra* notes 123-125 and accompanying text.
[283] *See id*.
[284] *See id*. at 3-25, 3-26.
[285] *See id*. at 3-26.
[286] *See* National Ambient Air Quality Standards for Particulate Matter, 78 Fed. Reg. 3,086, 3,157 (Jan. 15, 2013) (to be codified at 40 C.F.R. pts. 50, 51, 52, 53 and 58).
[287] *See* Robert D. Brook, et al., *Particulate Matter Air Pollution and Cardiovascular Disease: An Update to the Scientific Statement from the American Heart Association*, 121 CIRCULATION 2331, 2338 (2010).
[288] *See id*. at 2332.
[289] *See id*.
[290] *Id*. at 2338.
[291] *See id*. at 2350-51.
[292] *See id*. at 2366.
[293] *See id*. at 2365.
[294] *See* Kevin R. Cromer et al., *American Thoracic Society and Marron Institute Report Estimated Excess Morbidity and Mortality Caused by Air Pollution Above American Thoracic Society-Recommended Standards, 2011–2013*, 13 ANNALS AM. THORACIC SOC. 1195, 1201 (2016).

levels across the country,[295] an estimated 2913 deaths and 5543 instances of morbidity would be avoided if the 11 $\mu g/m^3$ were met.[296] The report also noted that "this does not imply that further health benefits would not be achieved by still further reductions to pollution levels," relying in part on EPA's own statement that there is no epidemiological evidence of a threshold for PM.[297]

The Harvard School of Public Health "Six Cities Study"[298] and an American Cancer Society Study[299] are two key studies in the evaluation of particulate matter exposure health impacts, and both have been extensively relied upon by EPA in its particulate matter NAAQS rulemakings. Both studies include follow up research; the Six Cities study was originally published in 1993, with follow up research released in 2006 and again in 2012; the ACS study was released in 1995 and updated in 2002 and 2004.[300] These studies were cited by the Bush EPA in the 2006 particulate matter NAAQS,[301] by all experts solicited in the 2006 EPA expert solicitation,[302] and were also relied upon by the Obama Administration in the 2016 particulate matter NAAQS,[303] the Mercury and Air Toxics Standards,[304] the Clean Power Plan,[305] and the Cross Border Air Pollution Rule.[306] The Bush EPA noted that "these studies have found consistent relationships between fine particle indicators and premature mortality across multiple locations in the United States."[307] EPA summarized in the Cross Border rule that the authors of

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[295] Note that many parts of the United States violate the current NAAQS levels. *Id.* at 1196-97. As such these estimates reflect cumulative effects of current violations of NAAQS standards plus the benefits of lowering the $PM_{2.5}$ from the current 12 $\mu g/m^3$ to 11 $\mu g/m^3$, as recommended by the American Thoracic Society. *See id*.
[296] *See id*. at 1198.
[297] *Id*. at 1201
[298] Douglas W. Dockery et al., *An Association Between Air Pollution and Mortality in Six U.S. Cities*, 329 NEW ENG. J. MED. 1753 (1993).
[299] C. Arden Pope III et al., *Particulate Air Pollution as a Predictor of Mortality in a Prospective Study of U.S. Adults*, 151 AM. J RESPIRATORY & CRITICAL CARE MED. 669 (1995).
[300] *See* Environmental Protection Agency, *Regulatory Impact Analyses for the Final Revisions to the National Ambient Air Quality Standards for Particulate Matter*, EPA-452/R-12-005, at 1-12 (Dec. 2012), https://www3.epa.gov/ttn/ecas/docs/ria/naaqs-pm_ria_final_2012-12.pdf [hereinafter 2012 PM RIA] ("Since the proposed rule, the EPA has incorporated an array of policy and technical updates to the benefits analysis approach applied in this RIA, including incorporation of the most recent follow-up to the Harvard Six Cities cohort study (Lepeule et al., 2012)."); Environmental Protection Agency, *Regulatory Impact Analyses for the Review of Particulate Matter National Ambient Air Quality Standards*, at 5-27 (Oct. 6, 2006), https://www3.epa.gov/ttn/ecas/docs/ria/naaqs-pm_ria_final_2006-10.pdf [hereinafter 2006 PM RIA] ("The most extensive analyses have been based on data from two prospective cohort groups, often referred to as the Harvard "Six-Cities Study" (Dockery et al., 1993; Laden et al, 2006) and the "American Cancer Society or ACS study" (Pope et al., 1995; Pope et al, 2002; Pope et al, 2004)…").
[301] *See* 2006 PM RIA, *supra* note 300, at 5-27.
[302] *See* Industrial Economics, Inc., *Expanded Expert Judgment Assessment of the Concentration-Response Relationship Between $PM_{2.5}$ Exposure and Mortality*, *supra* note 279, at viii.
[303] *See* 2012 PM RIA, *supra* note 300, at 1-12.
[304] *See* MATS RIA, *supra* note 17, at 5-27.
[305] *See* Environmental Protection Agency, *Regulatory Impact Analysis for the Clean Power Plan Final Rule*, *supra* note 18, at 4-16, 4-17.
[306] *See* Environmental Protection Agency, *Regulatory Impact Analysis for the Federal Implementation Plans to Reduce Interstate Transport of Fine Particulate Matter and Ozone in 27 States; Correction of SIP Approvals for 22 States*, at 98-100 (June 2011), https://www3.epa.gov/ttn/ecas/docs/ria/transport_ria_final-csapr_2011-06.pdf; Environmental Protection Agency, *Regulatory Impact Analysis of the Cross-State Air Pollution Rule (CSAPR) Update for the 2008 National Ambient Air Quality Standards for Ground-Level Ozone*, EPA-452/R-16-004, at 5-11 to 5-13, https://www3.epa.gov/ttn/ecas/docs/ria/transport_ria_final-csapr-update_2016-09.pdf.
[307] 2006 PM RIA, *supra* note 300, at 5-27.

the 2012 Six Cities follow-up "found significant associations between $PM_{2.5}$ exposure and increased risk of premature all-cause, cardiovascular and lung cancer mortality" and concluded that "the [concentration-response] relationship was linear down to $PM_{2.5}$ concentrations of 8 $\mu g/m^3$."[308] This level is substantially lower than 12 $\mu g/m^3$, the current NAAQS annual standard for particulate matter.[309]

Experts outside of the EPA have also relied on the findings of the "Six Cities Study" and the American Cancer Society Study to support their holdings that particulate matter is a no threshold pollutant. In 2002, relying on the American Cancer Society Study, the National Research Council's Committee on estimating the Health-Risk-Reduction Benefits of Proposed Air Pollution Regulations[310] concluded that "there is no evidence . . . for any indication of a threshold" for particulate matter.[311] Additionally, the Health Effects Subcommittee of the Advisory Council on Clean Air Compliance Analysis relied on both the Six Cities Study and the American Cancer Society Study to conclude that it "fully supports EPA's use of a no-threshold model to estimate the mortality reductions associated with reduced PM exposure." [312] It reasoned that EPA's decision "is supported by the data, which are quite consistent in showing effects down to the lowest measured levels."[313] And, a 2008 follow-up to the Harvard Six Cities study, found that there was an eighty six percent probability that $PM_{2.5}$ followed a linear no-threshold model.[314] This report explained that a "key finding of this study is that there is little evidence for a threshold in the association between exposure to fine particles and the risk of death on follow-up."[315] Instead of reducing PM concentration by relying on "an arbitrary standard," such as a threshold model, the study recommended "reduc[ing] particle concentration everywhere, at all times, to the extent feasible and affordable."[316]

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[308] Environmental Protection Agency, *Regulatory Impact Analysis of the Cross-State Air Pollution Rule (CSAPR) Update for the 2008 National Ambient Air Quality Standards for Ground-Level Ozone*, *supra* note 306, at 5-13.
[309] National Ambient Air Quality Standards for Particulate Matter, 78 Fed. Reg. 3,086, 3,086 (Jan. 13, 2013) (to be codified at 40 C.F.R. pts. 50, 51, 52, 53 and 58).
[310] In 2000, due to Congressional concerns about EPA's method of estimating health benefits from air pollution reduction, the Senate appropriated funds to EPA and directed the agency to request a study from National Academy of Sciences on the EPA's methodologies. *See* National Academy of Science arranged from the National Research Council's Committee on Estimating the Heath-Risk-Reduction Benefits of Proposed Air Pollution Regulations to prepare a report in 2002 which reviewed and critiqued the EPA's benefit analysis. *See* COMMITTEE ON ESTIMATING THE HEALTH-RISK-REDUCTION BENEFITS OF PROPOSED AIR POLLUTION REGULATIONS, NATIONAL RESOURCE COUNCIL, ESTIMATING THE PUBLIC HEALTH BENEFITS OF PROPOSED AIR POLLUTION REGULATIONS 1-2 (2002).
[311] *Id.* at 109. The committee went on to recommend that if the EPA plans to base its benefit analysis on the assumption that a threshold exists, which is not proven in any scientific study, it should make its assumptions and reasoning clear. *See id.* at 111.
[312] Similarly to the National Research Council's Committee on Estimating the Heath-Risk-Reduction Benefits of Proposed Air Pollution Regulations call, *see supra* note 310, HES was tasked with drafting a report in order to provide the EPA with guidance on how it estimates benefits and uncertainties for particulate matter and ozone. *See* U.S. Environmental Protection Agency Advisory Council on Clean Air Compliance Analysis Health Effects Subcommittee, *Review of EPA's Draft Health Benefits of the Second Section 812 Prospective Study of the Clean Air Act*, at 2 (2010), https://yosemite.epa.gov/sab/sabproduct.nsf/0/72D4EFA39E48CDB28525774500738776/$File/EPA-COUNCIL-10-001-unsigned.pdf.
[313] *Id.* at 13.
[314] *See* Joel Schwartz et al., *The Effect of Dose and Timing of Dose on the Association between Airborne Particles and Survival*, 116 ENVTL. HEALTH PERSP. 64, 67 (2008).
[315] *Id.*
[316] *Id.*

The World Health Organization (WHO), a specialized agency of the United Nations,[317] in a report cataloguing the global impact of particulate matter pollution, noted that this pollution represents one of world's the biggest environmental health risks, killing around 3 million people annually worldwide.[318] The report explains that this pollution "has health impacts even at very low concentrations – indeed no threshold has been identified below which no damage to health is observed."[319] WHO recommends that countries set standards at the lowest concentrations possible, and has set guideline values for $PM_{2.5}$ at 10 $\mu g/m^3$ annual mean and 25 $\mu g/m^3$ 24-hour mean,[320] well below the current NAAQS of 12 $\mu g/m^3$ annual mean and 35 $\mu g/m^3$ 24-hour mean.

A recent study from the Harvard School of Public Health confirms these findings and strengthens the evidence of health effects from particulate matter exposure below the current NAAQS. The 2017 study, which included a cohort of all Medicare beneficiaries (approximately 60 million people) throughout the United States, focused specifically on measuring health effects below the current particulate matter and ozone NAAQS.[321] The researchers measured health effects for people residing in places where $PM_{2.5}$ concentrations ranged from 6.21 to 15.64 $\mu g/m^3$.[322] The study reported a relationship between $PM_{2.5}$, ozone, and all-cause mortality that was almost linear, with no sign of a threshold down to 5 $\mu g/m^3$ in annual exposure.[323] Moreover, the authors found that there was a "significant association between $PM_{2.5}$ exposure and mortality when the analysis was restricted to concentrations below 12 μg per cubic meter [the current NAAQS], with a steeper slope below that level."[324] This study, which contains a very large sample size representing a geographically and socioeconomically diverse cross section of the country, concludes that in the entire population studied "there was significant evidence of adverse effects related to exposure to $PM_{2.5}$ . . . concentrations below current national standards."[325] The study "found no evidence of a threshold value—the concentration at which $PM_{2.5}$ exposure does not affect mortality—at concentrations as low as approximately 5 μg per cubic meter,"[326] confirming a finding similar to those of other studies.[327]

B. Regulatory Treatment

EPA has consistently found over three decades, and under administrations of both parties, that there are health effects from particulate matter exposure at low levels, below the NAAQS. The agency has done so at different times by explicitly stating that there is no evidence of a threshold; by calculating benefits for reductions in particulate matter below the level of the

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[317] *See* WHO CONST. pmbl., July 22, 1946.
[318] *See* World Health Organization, *Ambient Air Pollution: A Global Assessment of Exposure and Burden of Disease*, at 11 (2016), http://apps.who.int/iris/bitstream/10665/250141/1/9789241511353-eng.pdf?ua=1.
[319] *Id*. at 20.
[320] *See id*.
[321] *See* Quan Di, et al., *Air Pollution and Mortality in the Medicare Population*, 376 NEW ENG. J. MED. 2513, 2514 (2017).
[322] *See id*. at 2515.
[323] *See id*. at 2518.
[324] *Id*. at 2520. A steeper slope at low levels indicates that the marginal health risk from additional exposure at low levels is actually higher than the marginal risk at higher levels of exposure.
[325] *Id*. at 2513.
[326] *Id.* at 2520.
[327] *See id.*

NAAQs; or both.

As early as 1984, EPA under President Reagan explicitly stated that there is no evidence of a threshold for particulate matter.[328] Specifically, the agency's 1984 Regulatory Impact Analysis stated that "the data do not . . . show evidence of a clear threshold in exposed populations. Instead they suggest a continuum of response with both the likelihood (risk) of effects occurring and the magnitude of any potential effect decreasing with concentration."[329] This language was reiterated verbatim in the 1987 final rule.[330]

In 1997, the Clinton EPA determined that "the available epidemiological studies provide strong evidence suggesting that PM causes or contributes to health effects at levels below the current standards"[331] and that "the level or even existence of population thresholds below which no effects occur cannot be reliably determined."[332] The agency also calculated benefits for reducing particulate matter below the level it ultimately selected. In the 1997 NAAQS revision, EPA set the annual average standard for $PM_{2.5}$ at 15μg/m^3, and the 24-hour limit at 65 μg/m^3.[333] In the accompanying RIA, EPA analyzed the costs and benefits of the level it chose along with a more stringent standard. The more stringent standard EPA reviewed was an annual standard set at 15μg/m^3, in combination with a lower 24-hour standard set at 50 μg/m^3.[334] At the level EPA eventually selected for the NAAQS standard, the agency found annual benefits from partial attainment[335] to be between $19 billion (low estimate) and $104 billion (high estimate).[336]

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[328] *See* Environmental Protection Agency, *Regulatory Impact Analysis on the National Ambient Air Quality Standards for Particulate Matter*, at VI-15 to VI-17, (Feb. 21, 1984), http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=9101HEPX.TXT

[329] *Id*. at VI-15. The 1984 RIA was also the first time EPA calculated the economic benefits for ambient air standards, and the agency also analyzed benefits from particulate matter at different levels. *See id*. at VI-1. While the agency did not analyze an alternative that was equally or more stringent for both the annual average and 24-hour standard, it did analyze an annual standard lower than the one it ultimately selected, paired with a 24-hour limit higher than what it chose. In the 1987 NAAQS, EPA selected a PM_{10} annual average limit of 50 μg/m^3 and a 24-hour limit of 150 μg/m^3. *See* Revisions to the National Ambient Air Quality Standards for Particulate Matter, *supra* note 300, at 24,634. However, in its RIA, EPA reviewed benefits from a PM_{10} annual limit of 48 μg/m^3 paired with a 24-hour limit of 183 μg/m^3. *See* Environmental Protection Agency, *Regulatory Impact Analysis on The National Ambient Air Quality Standards for Particulate Matter*, *supra* note 328, at VI-38. While EPA did not conduct an analysis of benefits at the level it ultimately selected, making it impossible to directly compare the two options, EPA did find benefits at the 48 μg/m^3 annual limit scenario. *See id*. at VI-37, VI-38.

[330] *See* Revisions to the National Ambient Air Quality Standards for Particulate Matter, 52 Fed. Reg. 24,634, 24,642 (July 1, 1987) (to be codified at 40 C.F.R. pt 50).

[331] National Ambient Air Quality Standards for Particulate Matter, 62 Fed. Reg. 38,652, 38,670 (July 18, 1997) (to be codified at 40 C.F.R. pt. 50).

[332] *Id.*

[333] *See id.* at 38,652.

[334] *See* Environmental Protection Agency, *Regulatory Impact Analyses for the Particulate Matter and Ozone National Ambient Air Quality Standards and Proposed Regional Haze Rule*, at EΣ−23, Table ES-3 (July 16, 1997), https://www3.epa.gov/ttn/ecas/docs/ria/naaqs-o3-pm_ria_proposal_1997-07.pdf (comparing annual costs and benefits of PM alternatives for 2010).

[335] The RIA refers to "partial attainment" rather than full attainment because the analysis "does not attempt to force its models to project full attainment of the new standard in areas not predicted to achieve attainment by 2010," the year selected for the baseline. *Id.* at EΣ−13. Instead, the RIA attempts to account for the probability that "counties with $PM_{2.5}$ levels above the standard will likely need more time beyond 2010; new control strategies (e.g., regional controls or economic incentive programs); and/or new technologies in order to attain the standard." *Id.* at EΣ−12. ("For the PM analysis, a $1 billion/μg/m^3 cut-off is used to limit the adoption of control measures. Control measures

However, EPA found greater benefits, a high estimate of $107 billion, under this more stringent level.[337]

In 2006, EPA under George W. Bush found that "effect thresholds can neither be discerned nor determined not to exist."[338] The agency also noted that "several new studies available in [its] review have used different methods to examine [particulate matter concentration-response relationships], and most have been unable to detect threshold levels in time-series mortality studies."[339] EPA again calculated benefits at a particulate matter standard more stringent than the one it ultimate chose for the NAAQS. The 2006 final rule established a $PM_{2.5}$ 24-hour standard of 35 $\mu g/m^3$ and retained the annual standard of 15 $\mu g/m^3$. The RIA also included an analysis of benefits from a more stringent annual standard of 14 $\mu g/m^3$ paired with the same 35 $\mu g/m^3$ 24-hour limit.[340] Again, EPA found higher benefits for the more stringent standard. Using a 3% discount rate,[341] EPA found $17 billion in benefits at the 15 $\mu g/m^3$ standard, but $30 billion in benefits under more stringent the 14 $\mu g/m^3$ standard.[342] Again using a 3% discount rate, EPA also calculated benefits using a different methodology and found between $9 billion and $76 billion in benefits from the 15 $\mu g/m^3$ standard, but $17 billion to $140 billion in benefits for the 14 $\mu g/m^3$ standard.[343]

Further, the Bush EPA calculated additional health and welfare benefits under the more stringent standard. Under multiple valuation methods, EPA found that approximately twice as many deaths would be avoided under the 14 $\mu g/m^3$ standard compared with the 15 $\mu g/m^3$ standard it ultimately selected.[344] EPA found that chronic bronchitis effects would be reduced be reduced by 8700 cases under a more stringent standard but by 5000 under the standard it selected.[345] Hospital admissions for respiratory events would be reduced by 980 under the stricter level but by 530 under EPA's standard, and hospital admissions for cardiovascular events for people over 17 would decrease by 2100 under the stricter level but by 1100 under the standard selected.

In the most recent revision of particulate matter NAAQS standards under the Obama Administration, EPA expressed its clearest rejection of thresholds for particulate matter. The agency noted in the Final Rule updating NAAQS standards in 2013 that, because "there is no

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providing air quality improvements are less than $1 billion/$\mu g/m^3$ are adopted where the air quality model and cost analysis identify control measures as being necessary.").

[336] *See id*. These are annual gross benefits. *See id.*

[337] *See id*. The RIA does not provide a low estimate of annual benefits or annual costs for the more stringent 15$\mu g/m^3$ standard. *See id*.

[338] National Ambient Air Quality Standards for Particulate Matter, 71 Fed. Reg. 61,144, 61,152 (Oct. 17, 2006) (to be codified at 40 C.F.R. pt. 50, 51, 52, 53 and 58).

[339] *Id.* at 61,158.

[340] *See* 2006 PM RIA, *supra* note 300, at ES-1.

[341] As noted above, the 3% discount rate presents a more realistic figure for calculating the present value of benefits from reduction of future air pollution. *See* Newell, *Unpacking the Administration's Revised Social Cost of Carbon*, *supra* note 8.

[342] *See id*. at ES-7, Table ES-1 (comparing full attainment benefits with social costs through incremental attainment of the 1997 standards).

[343] *See id*.

[344] *See id*. at ES-8, Table ES-2 (estimating the reduction of adverse health and welfare effects associated with incremental attainment of alternative standards).

[345] *See id*.

discernible population-level threshold below which effects would not occur, . . . it is reasonable to consider that health effects may occur over the full range of concentrations observed in the epidemiological studies, including the lower concentrations in the latter years."[346] EPA also explicitly addressed comments from the American Petroleum Institute and the American Chemistry Council asserting that "there is a threshold in the PM-health effect relationship and that the log-linear model is not biologically plausible."[347] The agency countered that:

> "The EPA disagrees with this assertion due to the number of studies evaluated in the Integrated Science Assessment that continue to support the use of a no-threshold, log-linear model to most appropriately represent the PM concentration-response relationship. . . . [EPA's Clean Air Science Advisory Committee] likewise advised that '[a]lthough there is increasing uncertainty at lower levels, there is no evidence of a threshold.'"[348]

As in previous administrations, EPA again found additional benefits from a standard more stringent than the NAAQS. The 2012 RIA presents the benefits for the NAAQS levels EPA chose, a $PM_{2.5}$ 24-hour standard of 12 $\mu g/m^3$ and an annual average standard of 35 $\mu g/m^3$.[349] The agency also calculated benefits from an 11$\mu g/m^3$ standard, also paired with the 35$\mu g/m^3$ annual standard.[350] At a 3% discount rate, EPA found between $4 and $9.1 billion in benefits for the 12 $\mu g/m^3$ standard, but $13 to $29 billion in benefits at the more stringent 11 $\mu g/m^3$ level.[351]

C. Addressing Uncertainty

The preceding discussion should not be read to suggest that there is no uncertainty about the health effects of particulate matter at low levels of exposure. Exposure studies generally do not examine populations exposed to ambient levels down to zero. Rather, studies generally have a "lowest measured level" (LML), which is the lowest level of exposure studied.[352] EPA is

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[346] National Ambient Air Quality Standards for Particulate Matter, 78 Fed. Reg. 3,086, 3,148 (Jan. 15, 2013) (to be codified at 40 C.F.R. pts. 50, 51, 52, 53 and 58).

[347] *Id.* at 3,119.

[348] *Id.* Further, when EPA acknowledged in its Intregrated Review Plan for the 2016 PM NAAQS rulemaking that particulate matter lacks a threshold of effects, the Clean Air Science Advisory Committee affirmed that conclusion. Memo from Dr. Ana Diez Roux, Chair, Clean Air Scientific Advisory Committee, to Gina McCarthy, Administrator, Environmental Protection Agency, *CASAC Review of the EPA's* Integrated Review Plan for the National Ambient Air Quality Standards for Particulate Matter (External Review Draft), (Aug. 31, 2016), https://yosemite.epa.gov/sab/sabproduct.nsf/0/9920C7E70022CCF98525802000702022/$File/EPA-CASAC+2016-003+unsigned.pdf (noting that "[t]he approach in the last review to setting an annual standard when there is 'no discernible population level threshold' for health effects is clearly explained" and appropriate).

[349] *See* 2012 PM RIA, *supra* note 300, at ES-1.

[350] *See id*.

[351] *See id*. at ES-14, Table ES-2 (showing total monetized benefits, costs, and net benefits for full attainment by 2020).

[352] For example, the RIA for the proposed repeal of the Clean Power Plan states that "[e]stimates were calculated assuming that the number of $PM_{2.5}$-attributable premature deaths falls to zero at $PM_{2.5}$ levels at or below the Lowest Measured Level of each of two [long-term] epidemiological studies used to quantify $PM_{2.5}$-related risk of death (Krewski et al. 2009, LML = 5.8 $\mu g/m^3$; Lepeule et al. 2012; LML = 8 $\mu g/m^3$)." Environmental Protection Agency, *Regulatory Impact Analysis for the Review of the Clean Power Plan: Proposal*, at 10 (Oct. 2017), https://www.epa.gov/sites/production/files/2017-10/documents/ria_proposed-cpp-repeal_2017-10_0.pdf. EPA routinely deals with this issue for carcinogens as well. *See* Environmental Protection Agency, *Guidelines for Carcinogen Risk Assessment*, EPA/630/P-03/001F, at 1-14, 3-16, 3-17 (March 2005)

tasked with the difficult job of extrapolating a dose-response relationship below these levels, and it has acknowledged that uncertainty remains about the shape of that relationship.

One tactic of regulatory critics is to conflate this uncertainty with the existence of a threshold. For example, state and industry challengers to the Clean Power Plan emphasized EPA's admission that there is uncertainty about the scale of particulate matter health effects at very low exposure levels. These challengers asserted that NAAQS are "'precautionary and preventative' in nature . . . and intended to protect the most sensitive subgroups in the population, [yet] EPA did not have confidence that a level below 12 $\mu g/m^3$ was needed to provide the rigorous protections the Act requires."[353] The group further asserted that if EPA, in its 2013 NAAQS review of particulate matter, determined that the health benefits of reductions were "so uncertain that it [was] not appropriate to include exposures below 12 $\mu g/m^3$ within the 'adequate margin of safety' provided by the NAAQS," EPA should not later be able to claim that reductions below that same level will yield billions of dollars in benefits.[354]

However, over the course of several decades, EPA has consistently considered and incorporated uncertainty into its assessments of NAAQS standards on the basis of the relevant scientific research. In its 1997 Regulatory Impact Analysis for particulate matter, EPA noted that "one significant source of uncertainty is the possible existence of a threshold concentration below which no adverse health effects occur."[355] EPA addressed this uncertainty in its benefits calculations, providing a "high end" estimate, which assumed that health benefits from reductions in particulate matter occur "all the way down to background levels" for certain health effects.[356] EPA also provided a "low end" estimate which assumed that health benefits from particulate matter reductions occur only down to the level of the standard.[357]

In 2006, EPA acknowledged that there was a debate as to whether a threshold exists for particulate matter,[358] and addressed the uncertainty by assuming that the particulate matter concentration-response function was linear within the concentrations "under consideration," which EPA defined to be above an assumed threshold of 10 $\mu g/m^3$.[359] The agency also noted that

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https://www.epa.gov/sites/production/files/2013-09/documents/cancer_guidelines_final_3-25-05.pdf (describing the use of the "point of departure" method).

[353] Opening Brief of State and Industry Petitioners at 53, Murray Energy Corp. v. EPA, No. 16-1127 (D.C. Cir. filed Nov. 18, 2016). "Indeed, EPA explained any health benefits that may occur at $PM_{2.5}$ concentrations below 12 $\mu g/m^3$ are not merely 'less certain'—they are so uncertain that it is not appropriate to include exposures below 12 $\mu g/m^3$ within the 'adequate margin of safety' provided by the NAAQS. . . . EPA's lack of confidence in any such benefits was so low that a standard below 12 $\mu g/m^3$ 'would not be warranted.'" *Id.* at 54.

[354] *See* Opening Brief of State and Industry Petitioners at 53, Murray Energy Corp. v. EPA, No. 16-1127 (D.C. Cir. filed Nov. 18, 2016). "EPA cannot justify its decision to regulate EGU HAPs under § 112 based on asserted public health benefits it only recently concluded did not justify regulation of those non-HAPs." *Id.* at 51.

[355] Environmental Protection Agency, *Regulatory Impact Analyses for the Particulate Matter and Ozone National Ambient Air Quality Standards and Proposed Regional Haze Rule*, *supra* note 334, at 12-14.

[356] *Id*.

[357] *See id*.

[358] *See* 2006 PM RIA, *supra* note 30, at 5-20.

[359] *See id.* at 5-7 ("The C-R function for fine particles is approximately linear within the range of ambient concentrations under consideration (above the assumed threshold of 10 $\mu g/m^3$). Thus, we assume that the [C-R] functions are applicable to estimates of health benefits associated with reducing fine particles in areas with varied concentrations of PM, including both regions that are in attainment with $PM_{2.5}$ standards and those that do not meet the standards."). However, EPA also examined several alternative thresholds in a sensitivity analysis. *See id.* at 5-44

its Science Advisory Board, which provides advice to EPA on benefits analysis methods, "model[ed] premature mortality associated with PM exposure as a non-threshold effect, that is, with harmful effects to exposed populations regardless of the absolute level of ambient PM concentrations."[360]

By 2012, a much larger number of studies had produced evidence of the health effects of particulate matter exposure. EPA still acknowledged uncertainty in the 2012 RIA, but both the language used by the agency and the assumptions it makes reflect the growing body of evidence that particulate matter has health effects at low levels. Specifically, EPA stated that it was "more confident in the magnitude of the risk [estimated] from simulated $PM_{2.5}$ concentrations that coincide with the bulk of observed PM concentrations."[361] EPA further acknowledged that it was "less confident in the risk we estimate from simulated $PM_{2.5}$ concentrations that fall below the bulk of the observed data in these studies."[362]

EPA likewise discussed uncertainties in developing the Mercury and Air Toxics Standards. EPA calculated particulate matter reduction benefits for the Mercury and Air Toxics Standards using studies measuring health impacts below the NAAQS levels, but above the zero exposure level. The LML of these studies helped inform EPA's analysis.[363] EPA calculated the benefits at LMLs of major PM studies and found that 11% of the estimated benefits from avoided premature deaths occur at or above an annual mean $PM_{2.5}$ level of 10 $\mu g/m^3$,[364] and 73% of the benefits at or above 7.5 $\mu g/m^3$.[365] EPA modeled benefits below the LML, in line with the agency's acknowledgement that particulate matter is not a threshold pollutant, but noted that the agency has lower confidence in the exact value of those estimates.[366] EPA also noted that it addressed uncertainties in the magnitude of effects by following the same approached used by

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("Five cutpoints (including the base case assumption) were included in this sensitivity analysis: (a) 14 $\mu g/m^3$ (assumes no impacts below the alternative annual NAAQS), (b) 12 $\mu g/m^3$ (c) 10 $\mu g/m^3$ (reflects comments from CASAC - 2005), (d) 7.5 $\mu g/m^3$ (reflects recommendations from SAB-HES to consider estimating mortality benefits down to the lowest exposure levels considered in the Pope 2002 study used as the basis for modeling chronic mortality) and (e) background or 3 $\mu g/m^3$ (reflects NRC recommendation to consider effects all the way to background).") For the more stringent 7.5 $\mu g/m^3$ and 3 $\mu g/m^3$ threshold cutpoints, the sensitivity analyses estimated increased benefits relative to the assumed 10 $\mu g/m^3$ threshold, albeit with increasing uncertainty at lower concentrations. *See id.* at 5-81, 5-82, 5-83, 5-84 (estimating greater reductions in mortality incidence and greater monetized benefits from reduced mortality risk for lower threshold cutpoints).

The 2008 RIA for PM reiterated the Science Advisory Board's discussion of PM exposure as a non-threshold effect and endorsed the use of a non-threshold model at low concentrations. *See* Environmental Protection Agency, *Final Ozone NAAQS Regulatory Impact Analysis*, at 6c-5 (Mar. 2008), https://www3.epa.gov/ttn/ecas/docs/ria/naaqs-o3_ria_final_2008-03.pdf ("For the studies of long-term exposure, . . . the most careful work on this issue . . . report[s] that the associations between $PM_{2.5}$ and both all-cause and cardiopulmonary mortality were near linear within the relevant ranges, with no apparent threshold. Graphical analyses of these studies . . . also suggest a continuum of effects down to lower levels. Therefore, it is reasonable for EPA to assume a no threshold model down to, at least, the low end of the concentrations reported in the studies.").

[360] *See* 2006 PM RIA, *supra* note 300, at 5-20.

[361] 2012 PM RIA, *supra* note 300, at 5-81.

[362] *Id*.

[363] *See* MATS RIA, *supra* note 17, at 5-98, 5-100.

[364] 10 $\mu g/m^3$ was the LML for a major 2006 study. *See id*. at 5-100.

[365] 7.5 $/m^{3,}$ was the LML for a prominent 2002 study. *See id*.

[366] *See id*.

the Bush EPA in the 2006 particulate matter NAAQS RIA.[367]

The fact that uncertainty remains does not mean there is evidence to conclude that particulate matter causes no health effects below a certain level. As EPA noted in the 2012 RIA, "[i]t is important to emphasize that 'less confidence' does not mean 'no confidence'. . . . [W]e still have high confidence that $PM_{2.5}$ is causally associated with risk at those lower air quality concentrations."[368] EPA went on to note that although it uses benchmarks as part of its analysis, including the LML, this does not mean that EPA views "these concentration benchmarks as a concentration threshold below which we would not quantify health benefits of air quality improvements."[369] In short, EPA has consistently acknowledged scientific uncertainty. Though EPA accounted for this uncertainty differently at various times, the agency has repeatedly noted the existence of and modeled health effects from particulate matter exposure at low levels.[370] And, EPA has found adverse health effects below the NAAQS nearly every time the agency has studied exposure effects below those levels.[371]

D. Adjusting Baselines

In addition to asserting that particulate matter reductions below the NAAQS yield no health benefits, critics of regulations also attack the methods EPA uses to measure these effects. Specifically, critics claim that EPA has not adjusted the baseline to account for prior regulation of particulate matter, effectively "double counting" particulate matter benefits.[372] This section addresses those criticisms, showing that, in fact, EPA practice has consistently accounted for emission reductions resulting from prior regulations in setting its basis of comparison.

A baseline is the status quo that would exist without a new regulation, and it is necessary to measure the benefits of the regulation. OMB Circular A-4 instructs agencies to "[i]dentify a baseline" so as to "evaluate properly the benefits and costs of regulations and their alternatives."[373] Baselines are straightforward in theory but quite complex in practice. For example, think of a rule that has already been promulgated but is not scheduled to go into effect immediately and will be rolled out over many years—or consider that the earlier rule may never be fully implemented if a later administration decides to repeal it. How should EPA measure that

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[367] *See id*. at 5-17.
[368] *Id*. at 5-81 to 5-82.
[369] *Id*. at 5-82.
[370] *See*, *e.g.*, Environmental Protection Agency, *Regulatory Impact Analyses for the Final Revisions to the National Ambient Air Quality Standards for Particulate Matter*, EPA-452/R-12-005, at ES-1 (Dec. 2012), https://www3.epa.gov/ttn/ecas/docs/ria/naaqs-pm_ria_final_2012-12.pdf; Environmental Protection Agency, *Regulatory Impact Analyses for the Review of Particulate Matter National Ambient Air Quality Standards*, at ES-1 (Oct. 6, 2006), https://www3.epa.gov/ttn/ecas/docs/ria/naaqs-pm_ria_final_2006-10.pdf; Environmental Protection Agency, *Regulatory Impact Analyses for the Particulate Matter and Ozone National Ambient Air Quality Standards and Proposed Regional Haze Rule*, at EΣ−23, Table ES-3 (July 16, 1997), https://www3.epa.gov/ttn/ecas/docs/ria/naaqs-o3-pm_ria_proposal_1997-07.pdf; Environmental Protection Agency, *Regulatory Impact Analysis on the National Ambient Air Quality Standards for Particulate Matter*, at VI-15 (Feb. 21, 1984), http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=9101HEPX.TXT.
[371] *See supra* Part III.B (cataloging EPA's consistent finding over three decades of adverse health effects from particulate matter below NAAQS levels).
[372] *See* Lesser, *supra* note 21, at 5.
[373] Circular A-4: Regulatory Analysis, *supra* note 54, at 2.

earlier rule? Should the agency include it in the baseline for a new regulation? EPA has developed standard methods for handling such questions to promote uniformity across regulations, which are discussed in this section.

Opponents argue that EPA is "double counting;" that is, inflating a regulation's purported benefits by failing to account for existing regulations that will achieve the same reduction of the pollutant. According to one critic, the agency "regularly flouts [a] basic principle of sound regulation by ignoring the $PM_{2.5}$ and ozone reductions it has already mandated, and counting those reductions again as benefits in new rules. The same ton of pollutant thus serves to justify multiple rules, even though the pollution can only be prevented once."[374] Tellingly, Trump EPA Administrator Scott Pruitt has expressed a commitment to ensuring that his agency will not "double count" benefits from existing regulations; he asserts that EPA "shouldn't take pollutants that we regulate under our [NAAQS] program and then count that as a benefit when we're already achieving that with other regulation and contribute it to . . . the Clean Power Plan cost-benefit analysis. And [the Obama Administration] did that because the costs were so extraordinary."[375]

These claims ignore the reality that EPA has maintained clear standards designed to prevent double counting. EPA's guidelines on baselines state that it is EPA's common practice "to assume full compliance with regulatory requirements"[376] which includes newly enacted but not yet implemented regulations.[377] This means that benefits from rules that are fully promulgated will be counted in the baseline – these benefits are not ignored and then used again for a later regulation. The agency specifically notes that this general rule allows EPA to focus on incremental economic effects of the new rule without double counting benefits and costs captured by analyses performed for earlier rules.[378]

EPA also explicitly discusses the ways in which it accounts for prior benefits achieved under the NAAQS. For the Mercury and Air Toxics Standards, EPA notes that its baseline accounts for "the emissions reductions of SOx, NOx, directly emitted PM, and CO_2 . . . consistent with application of federal rules, state rules and statutes, and other binding, enforceable commitments in place by December 2010,"[379] as well as "the Cross-State Air Pollution Rule (CSAPR) as finalized in July 2011."[380] Likewise, in the Clean Power Plan, EPA states that it included in its baseline all state and federal air regulations either in effect or enacted and clearly delineated at the time.[381]

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[374] C. Boyden Gray, *EPA's Use of Co-Benefits*, FEDERALIST SOCIETY, https://fedsoc.org/commentary/publications/epa-s-use-of-co-benefits (Sept. 24, 2015).
[375] Justin Worland, *EPA Head Scott Pruitt Says Oil and Coal Companies He Met With Aren't 'Polluters'*, TIME.COM, http://time.com/4990060/scott-pruitt-interview-epa-schedule-meetings (Oct. 20, 2017).
[376] Environmental Protection Agency, *Chapter 5: Baseline*, at 5-3 (Dec. 2010) *in* GUIDELINES FOR PREPARING ECONOMIC ANALYSES (updated May 2014), https://yosemite.epa.gov/ee/epa/eerm.nsf/vwAN/EE-0568-05.pdf/$file/EE-0568-05.pdf.
[377] *See id*. at 5-9.
[378] *See id*.
[379] MATS RIA, *supra* note 17, at 1-11.
[380] *Id*.
[381] *See* Environmental Protection Agency, *Regulatory Impact Analysis for the Clean Power Plan Final Rule*, *supra* note 18 at 1-5 ("Base Case v.5.15 includes the Cross-State Air Pollution Rule (CSAPR), the Mercury and Air Toxics Rule (MATS), the proposed Carbon Pollution Standards for New Power Plants, the Cooling Water Intakes (316(b))

EPA also notes in its Base Case, which documents the agency's calculations of the baseline used to measure the benefits and costs of new regulations, that the baseline includes "NAAQS to the extent that state regulations…contain measures to bring non-attainment areas into attainment."[382] EPA further notes that "[a]part from these state regulations, individual permits issued by states in response to NAAQS are captured [to the extent they are reported to EPA]."[383] Thus, EPA includes benefits from NAAQS requirements to the extent they are implemented by states. Such treatment makes sense in light of the regulatory structure created by the Clean Air Act. Under the Act, EPA sets the NAAQS, which are a national standard for allowable air pollution levels. However, the NAAQS are implemented by the states through State Implementation Plans (SIPs). States have a great deal of discretion in determining how to work toward achieving the NAAQS. As a result of this structure, when EPA promulgates the NAAQS and attempts to estimate the costs and benefits of these standards, the agency must make a number of assumptions about how states will ultimately chose to regulate pollution. The SIPs provide a much clearer picture of the actual costs and benefits of the NAAQS. Further, it is the SIPs, and not the NAAQS, which are actually enforceable. EPA used the SIPs as its baseline for the Mercury and Air Toxics Standards and the Clean Power Plan, which were promulgated to bring areas into attainment with the NAAQS.

EPA likewise accounts for rules that have the co-benefit of reducing NAAQS pollutants in its baseline for future NAAQS. Particulate matter is regulated directly under the NAAQS, but is also affected indirectly by rules like the Mercury and Air Toxics Standards and the Clean Power Plan that directly target other pollutants. In a subsequent update of the NAAQS standards for particulate matter, EPA stated that it included the Mercury and Air Toxics Standards in that baseline as well, noting that "[e]mission reductions achieved under rules that require specific actions from sources—such as Mercury and Air Toxics Standards—are in the baseline of this NAAQS analysis, as are emission reductions needed to meet the current NAAQS."[384]

The Trump Administration in its draft repeal of the Clean Power Plan also raises the issue of baselines. However, the agency takes a different approach than other critics of these regulations. Rather than arguing that EPA's 2015 Regulatory Impact Analysis for the Clean Power Plan double counts particulate matter benefits, the proposed rule points out that particulate matter could be regulated in other ways. This is, of course, the case; particulate matter is regulated directly under the National Ambient Air Quality Standards. From this fact, the Trump

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Rule, the Combustion Residuals from Electric Utilities (CCR), and other state and Federal regulations to the extent that they contain measures, permits, or other air-related limitations or requirements.").

[382] Environmental Protection Agency, *EPA Base Case v.5.14 Using IPM: Incremental Documentation*, at 1 (March 25, 2015), https://www.epa.gov/sites/production/files/2015-08/documents/epa_base_case_v514_incremental_documentation.pdf. The Base Case in place when the Mercury and Air Toxics Standards rule was promulgated in 2011 similarly include "ozone and particulate matter standards to the extent that some of the state regulations . . . contain measures to bring non-attainment areas into attainment." Environmental Protection Agency, *Documentation for EPA Base Case v.4.10 Using the Integrated Planning Model*, EPA #430R10010, at 1-1 (August 2010), https://nepis.epa.gov/Exe/ZyPDF.cgi/P100CF8G.PDF?Dockey=P100CF8G.PDF.

[383] *See id*. With regard to which permits are included, EPA specifically notes that permits are included "to the extent that they are reflected in the NOx rates reported to EPA under CSAPR, Title IV and the NOx Budget Program which are incorporated in the base case and . . . to the extent that SO_2 permit limits are used in the base case to define the choice of coal sulfur grades that are available to specific power plants." *Id*.

[384] 2012 PM RIA, *supra* note 300, at ES-18.

EPA presents the following hypothetical: "[H]ad those SO_2 and NOx [particulate matter] reductions been achieved through other means, then they would have been represented in the baseline for this proposed repeal (as well as for the 2015 Final [Clean Power Plan]), which would have affected the estimated costs and benefits of controlling CO_2 emissions alone."[385] The agency then presents calculations of the foregone benefits of repealing the Clean Power Plan, with all of the SO_2 and NO_X benefits removed.[386] The logic seems to be that because these benefits *could* be achieved through other regulations, the agency need not calculate the benefits of reducing the pollution through this regulation; rather, it can just assume the benefits have already been achieved through another regulation. Of course, such a regulation does not exist. EPA cannot wish away benefits by pretending we live in a world where the benefits have already been achieved, and courts tasked with overseeing EPA should not stand idly by while the agency attempts to do so. Not only does the Trump Administration's approach deviate from EPA's longstanding methodology for determining baselines, but its benefits calculations also depart from reality.

IV
CONSIDERING CO-BENEFITS

Particulate matter reductions are often co-benefits, or ancillary benefits, from rules targeting other types of pollution.[387] For example, the Mercury and Air Toxics Standards directly limit mercury emissions from power plants but would likewise have the effect of reducing particulate matter emissions. Similarly, the Clean Power Plan directly regulates carbon dioxide emissions from power plants because these well-known greenhouse gases contribute to global climate change.[388] However because the rule requires energy generators to internalize the cost of emissions, thus raising the cost of polluting, the rule will likely cause a shift in sources of energy production away from sources that produce large quantities of greenhouses gases, notably coal, to cleaner forms of energy. This shift will additionally have the effect of reducing particulate matter because coal-fired power plants are also significant sources of particulate pollution.

Critics of regulations argue that cost-benefit analyses for specific pollutants should not include co-benefits from reductions in non-targeted pollutants. They contend that only direct and quantifiable benefits resulting from the reduction of the specific pollutant at issue should be included in a rule's calculus. In their view, the consideration of co-benefits extends beyond the scope of the problems Congress intended to address, and instead is a "sleight of hand" to

[385] Clean Power Plan Proposed Repeal, *supra* note 7 at 48,044 n.24.
[386] *See id*. at 48,044-45.
[387] Of course, for the NAAQS standards regulating particulate matter, benefits from PM reduction are the target benefits.
[388] *See, e.g.*, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2013–THE PHYSICAL SCIENCE BASIS: WORKING GROUP I CONTRIBUTION TO THE FIFTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE 467 (2014); NATIONAL RESEARCH COUNCIL ET AL., CLIMATE STABILIZATION TARGETS: EMISSIONS, CONCENTRATIONS, AND IMPACTS OVER DECADES TO MILLENNIA 3-4 (2011); Environmental Protection Agency, *Climate Change Science: Causes of Climate Change*, https://19january2017snapshot.epa.gov/climate-change-science/causes-climate-change_.html (last updated Dec. 27, 2016).

"circumvent the[] statutory limitations on [EPA's] authority."[389] According to regulation opponents, "[p]ermitting EPA to use such illusory and statutorily irrelevant co-benefits to justify the Rule would . . . amount to an unconstitutional delegation of legislative power."[390]

This theme arose prominently in *Michigan v. EPA,* where co-benefits were attacked as a means of "impermissibly enabl[ing EPA] to expand its authority to conduct additional $PM_{2.5}$ regulation without following the proper procedures of imposing such restrictions upon the country."[391] Critics argued that the agency "routinely takes credit for reductions of $PM_{2.5}$ caused by rules that address harms from other pollutants" as a "power grab" in order to regulate "outside the specific [statutory] authority under which they are acting"[392] and to obligate "further $PM_{2.5}$ reductions beyond those required under other Clean Air Act programs."[393] Mercury, the pollutant directly regulated by the Mercury and Air Toxics Standards, was deemed "a Trojan horse used to justify regulation under Section 112, when EPA's real focus was particulate-matter emissions by power plants, which the agency has targeted across numerous rulemakings in recent years."[394] Because they are not targeted by the section of the statute upon which the rule is based, critics argue that including co-benefits circumvents the Clean Air Act by additionally reducing pollutants that are directly regulated by other sections of the Act,[395] so as to "indirectly require further reductions in $PM_{2.5}$ emissions from power plants that EPA would be unable to require directly."[396] At oral argument in the *Michigan* case, Chief Justice John Roberts suggested that indirect benefits merely served as "an end run" around statutory restrictions.[397] Chief Justice Roberts also noted that he believed it was "good thing if your regulation also benefits in other ways. But when it's such a disproportion, you begin to wonder whether it's an illegitimate way of avoiding the different—quite different limitations on EPA that apply in the criteria program."[398]

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[389] Brief for the Cato Institute as Amicus Curiae in Support of Petitioners at 4, Michigan v. EPA, 135 S. Ct. 2699 (2015) (No. 14-46), 2015 WL 412058.
[390] Brief of 166 State and Local Business Associations as Amici Curiae in Support of Petitioners at 26, West Virginia v. EPA, Nos. 15-1363 et al. (D.C. Cir. filed Feb. 23, 2016).
[391] Motion For Leave To File Amicus Curiae Brief And Brief Of The Chamber Of Commerce Of The United States Of America As Amicus Curiae In Support Of Petitioners at 25, Michigan v. EPA, 135 S. Ct. 2699 (2015) (Nos. 14-46, 14-47, 14-49), 2014 WL 4075971.
[392] *Id.* at 15.
[393] *Id.* at 23.
[394] Brief for the Cato Institute as Amicus Curiae in Support of Petitioners at 22, Michigan v. EPA, 135 S. Ct. 2699 (2015) (No. 14-46), 2015 WL 412058.
[395] *See* Opening Brief of State and Industry Petitioners at 47, Murray Energy Corp. v. EPA, No. 16-1127 (D.C. Cir. filed Nov. 18, 2016).
[396] Brief of the Chamber of Commerce of the United States of America, the National Association of Manufacturers, the National Federation of Independent Business, and the National Association of Home Builders as Amici Curiae in Support of Petitioners at 16, Michigan v. EPA, 135 S. Ct. 2699 (2015) (Nos. 14-46, 14-47, 14-49), 2015 WL 428995.
[397] *See* Opening Brief of State and Industry Petitioners at 47, Murray Energy Corp. v. EPA, No. 16-1127 (D.C. Cir. filed Nov. 18, 2016). ("At oral argument in *Michigan*, Chief Justice Roberts described relying on co-benefits as 'an end run' around § 109's restrictions" and as an issue that "raises the red flag.") (internal citations omitted).
[398] Clean Power Plan Proposed Repeal, *supra* note 8, at 48,044 (quoting Chief Justice Roberts at oral argument in *Michigan v. EPA*).

Opponents contend that even if a rule yields co-benefits, those effects are essentially "irrelevant"[399] or mere "regulatory externalities"[400] that should play no part in a cost-benefit analysis. Critics of co-benefits have called their use a "well-worn accounting trick"[401] and "a controversial and legally dubious accounting method."[402] Petitioners in *Michigan v. EPA* argued that "ancillary co-benefits from lower $PM_{2.5}$ emissions are not *relevant* benefits for the purpose of deciding whether it is appropriate to regulate HAP emissions from electric utilities. Congress required EPA to determine whether reducing emissions of hazardous air pollutants (not $PM_{2.5}$) is 'appropriate.'"[403] Put differently, "[e]ven if Congress intended that EPA may consider cobenefits—a concept found nowhere in the statute—in setting technology-based standards, Congress certainly did not dictate that the purported cobenefits may force regulation of HAPs under Section 112(n)(1)(A) where the reductions of the HAPs themselves provide no relative benefits in comparison to the substantial costs of regulation."[404] Others have called co-benefits "inflated"[405] and "unlawful[,] . . . obscur[ing] the impact of the rule on the targeted pollutant (CO_2) and creates deliberate confusion regarding the Rule's costs and benefits."[406]

In the case of the Clean Power Plan, critics argue that "[w]ithout the artificial consideration of these purported co-benefits, the Rule's benefits would be seen for what they are: vastly exceeded by its costs."[407] The Trump EPA echoed this claim when, in announcing the repeal of the Clean Power Plan, it decried co-benefits as "essentially hid[ing]" the plan's true cost.[408] The Trump Administration EPA also described the Obama Administration's inclusion of co-benefits in the Plan as an area of "controversy and/or uncertainty,"[409] suggesting that the incorporation of these benefits is outside common EPA practice.

The arguments against considering co-benefits ring hollow, however, when looked at in context. EPA has consistently and over multiple presidential administrations considered both co-

[399] Brief for the Cato Institute as Amicus Curiae in Support of Petitioners at 3, Michigan v. EPA, 135 S. Ct. 2699 (2015) (No. 14-46), 2015 WL 412058; Opening Brief of State and Industry Petitioners at 49, Murray Energy Corp. v. EPA, No. 16-1127 (D.C. Cir. filed Nov. 18, 2016).
[400] Brief of Amicus Curiae Cato Institute in Support of Petitioners at 4, Murray Energy Corp. v. EPA, No. 16-1127 (D.C. Cir. filed Nov. 18, 2016).
[401] Brief of 166 State and Local Business Associations as Amici Curiae in Support of Petitioners at 69, West Virginia v. EPA, Nos. 15-1363 et al. (D.C. Cir. filed Feb. 23, 2016).
[402] Brief of the Chamber of Commerce of the United States of America, the National Association of Manufacturers, the National Federation of Independent Business, and the National Association of Home Builders as Amici Curiae in Support of Petitioners at 3, Michigan v. EPA, 135 S. Ct. 2699 (2015) (Nos. 14-46, 14-47, 14-49), 2015 WL 428995.
[403] Brief for Petitioners Michigan et al. at 48, Michigan v. EPA, 135 S. Ct. 2699 (2015) (No. 14-46), 2015 WL 309090 (emphasis in original).
[404] Brief of the Chamber of Commerce of the United States of America, the National Association of Manufacturers, the National Federation of Independent Business, and the National Association of Home Builders as Amici Curiae in Support of Petitioners at 22, Michigan v. EPA, 135 S. Ct. 2699 (2015) (Nos. 14-46, 14-47, 14-49), 2015 WL 428995.
[405] Gray, *supra* note 21.
[406] Brief of 166 State and Local Business Associations as Amici Curiae in Support of Petitioners at 27, West Virginia v. EPA, Nos. 15-1363 et al. (D.C. Cir. filed Feb. 23, 2016).
[407] *Id.*
[408] *See* Environmental Protection Agency, *EPA Takes Another Step To Advance President Trump's America First Strategy, Proposes Repeal of "Clean Power Plan,"* (Oct. 10, 2017), https://www.epa.gov/newsreleases/epa-takes-another-step-advance-president-trumps-america-first-strategy-proposes-repeal.
[409] *See id.*

benefits and their mirror image, indirect costs, in evaluating the consequences of regulation. Removing co-benefits would mean systematically considering a narrower range of benefits than costs, because it would leave intact EPA's current practice of measuring indirect costs while ignoring co-benefits.[410] Were this not the case, critics would potentially have a valid point. Were it true that EPA only considers indirect effects that are benefits, then EPA arguably would be inflating benefits, as critics accuse.[411] However, because EPA does consider both indirect costs and benefits, what critics really want is to put a thumb on the scale against regulation by forcing EPA to ignore some indirect effects while embracing others. This Part examines the well-established use of co-benefits in cost-benefit analyses by presidential administrations, EPA, and the courts, as well as their endorsement in the academic literature.

A. Co-Benefits and Indirect Costs

The question of how to measure indirect costs and benefits arises in the context of cost-benefit analyses. Federal agencies have been required to perform these analyses since 1981, when President Reagan issued Executive Order 12,291.[412] Previous presidents had required some assessment of the impacts of proposed regulatory actions, but the Reagan Administration was the first to formalize this requirement.[413] EPA's early cost–benefit analyses focused only on the direct costs and benefits of regulations. However, substantial academic, administrative, and judicial attention turned to the consideration of countervailing risks in the 1990s with the publication of *Risk Versus Risk* by John D. Graham and Jonathan Baert Wiener.[414] The book outlined the leading framework for considering indirect costs, also known as countervailing risks: risk-risk analysis. The guiding principal of risk-risk analysis, as conceived by Graham and Wiener, is that regulations intended to minimize or eliminate certain health or environmental risks can have the perverse effect of promoting other risks, and thus a more comprehensive and accurate accounting of regulatory effects would consider these countervailing risks.[415]

Risk-risk analysis picked up traction among academics specializing in administrative law.

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[410] For a more detailed discussion of co-benefits as the "mirror image" of indirect costs, see Samuel J. Rascoff & Richard L. Revesz, *The Biases of Risk Tradeoff Analysis: Towards Parity in Environmental and Health-and-Safety Regulation*, 69 UNIV. CHI. L. REV. 1763, 1780-90 (2002).

[411] *See* Gray, *supra* note 21.

[412] *See* Exec. Order No. 12,291, 46 Fed. Reg. 13,193, 13,193-94 (Feb. 19, 1981).

[413] This order was later modified and expanded by President Clinton under Executive Order 12,866, which remains in effect today. *See* Exec. Order No. 12,866, 58 Fed. Reg. 51,735 (Oct. 4, 1993). President Obama reinforced the continued viability of this order and expanded it modestly under Executive Order 13,563, which modestly expanded the scope of cost benefit analyses to permit consideration of values that are difficult or impossible to quantify including equity, human dignity, fairness, and distributive impacts. *See* Exec. Order No. 13563, 76 Fed. Reg. 3,821 (Jan. 18, 2011).

[414] *See* RISK VERSUS RISK: TRADEOFFS IN PROTECTING HEALTH AND THE ENVIRONMENT (John D. Graham & Jonathan Baert Wiener eds., 1995). Graham and Wiener coined the term "risk tradeoff analysis." *See* John D. Graham & Jonathan Baert Wiener, *Confronting Risk Tradeoffs*, *in* RISK VERSUS RISK 1, 4.

[415] *See* RISK VERSUS RISK, *supra* note 414, at 270. For example, Graham examines Corporate Average Fuel Economy (CAFE) standards, a Department of Transportation regulation intended to improve automobile fuel standards and reduce attendant environmental and health harms, as potentially promoting countervailing risks in the economic, energy, and national security sectors. *See* John D. Graham, *Saving Gasoline and Lives*, *in* RISK VERSUS RISK 87-103. In a separate article, Wiener discusses how risk-risk analysis reveals a "bewildering array of countervailing risks that face efforts to prevent global warming." Jonathan Baert Wiener, *Protecting the Global Environment*, *in* RISK VERSUS RISK 193-225.

In addition to Graham and Wiener, Professor Cass Sunstein, a prominent administrative law scholar and the head of the Office of Information and Regulatory Affairs (OIRA) under President Obama, advocated at that time for broad application of risk-risk analysis.[416] W. Kip Viscusi, an administrative law scholar and leading proponent of cost-benefit analysis, also endorsed risk tradeoff analysis in the regulatory process.[417]

Judges at this time began to embrace risk-risk analysis as well. Justice Breyer, concurring in *American Trucking*,[418] agreed with the Court's unanimous ruling that the Clean Air Act prohibits the consideration of costs in setting the NAAQS but wrote separately to argue that the statute does permit "the Administrator to take account of comparative health risks."[419] Judge Stephen Williams of the D.C. Circuit was also a notable proponent of risk-risk analysis. For example, in a concurrence in *International Union, UAW v. OSHA*,[420] Judge Williams used risk-risk analysis to challenge what he viewed as the "casual assumption that more stringent regulation will always save lives."[421] He argued that the health-wealth connection[422] required consideration of negative economic effects of regulation and their purported effect on health: "More regulation means some combination of reduced value of firms, higher product prices, fewer jobs in the regulated industry, and lower cash wages. All the latter three stretch workers' budgets tighter. . . . And larger incomes enable people to lead safer lives."[423]

The growing focus on examining the broader range of regulatory effects ultimately led to Office of Management and Budget (OMB) Circular A-4, which was promulgated when John Graham served as Administrator of OIRA within OMB.[424] OIRA is responsible for overseeing regulatory efforts of administrative agencies and has the power to issue guidance which they must follow. Circular A-4 guides federal agencies in the cost-benefit regulatory analyses required under Executive Order 12,866,[425] "standardizing the way benefits and costs of Federal regulatory actions are measured and reported."[426] As part of this standardization, Circular A-4 explicitly requires the consideration of countervailing risks, enshrining the analysis of the type of risks Graham and Weiner identified. However, Circular A-4 goes a step further by likewise requiring consideration of ancillary benefits. The Circular instructs agencies to "look beyond direct benefits and direct costs . . ." and "consider any important ancillary benefits and

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[416] *See* Cass R. Sunstein, *Health-Health Tradeoffs*, 63 U. CHI. L. REV. 1533, 1537 (1996); Rascoff & Revesz, *supra* note 410, at 1764.
[417] *See* Rascoff & Revesz, *supra* note 410, at 1792
[418] 531 U.S. 457 (2001).
[419] *Id*. at 495. The D.C. Circuit opinion in that case examined a different countervailing risk: less protection from harmful ultraviolet radiation as a result of reducing ozone pollution. *See infra* notes 477-480.
[420] 938 F.2d 1310 (D.C. Cir. 1991).
[421] *Id.* at 1326.
[422] There is much evidence to suggest that the "health-wealth" effect, which asserts that less wealth causes worse health outcomes, is fallacious. For a detailed discussion of this criticism, see RICHARD L. REVESZ & MICHAEL A. LIVERMORE, RETAKING RATIONALITY: HOW COST-BENEFIT ANALYSIS CAN BETTER PROTECT THE ENVIRONMENT AND OUR HEALTH 67-76 (2008) (questioning the "health-wealth" effect and offering alternative explanations for both health and wealth—notably, education—as well as the potential for reverse causation (i.e., that worse health causes lower wealth)).
[423] 938 F.2d at 1326.
[424] *See* Circular A-4: Regulatory Analysis, *supra* note 54, at 1.
[425] *See id*. at 1.
[426] *Id*.

countervailing risks."[427] Further, it states that "[t]he same standards of information and analysis quality that apply to direct benefits and costs should be applied to ancillary benefits and countervailing risks."[428]

B. EPA's Practice

EPA has long acknowledged the relevance of co-benefits, and specifically has done so for regulations promulgated under the Clean Air Act. First, EPA's current guidelines for cost-benefit analyses, which were adopted in 2010 after extensive peer review, instruct the agency to assess "all identifiable costs and benefits,"[429] and state that an economic analysis of regulations should include both "directly intended effects . . . as well as ancillary (or co-)benefits and costs."[430] The aim of these analyses is to "inform decision making" and allow meaningful comparisons between policy alternatives.[431]

These guidelines build on principles applied in previous administrations. For example, the Bush EPA used similar language in its 2008 draft "Guidelines for Preparing Economic Analyses," declaring that "[a]n economic analysis of regulatory or policy options should present all identifiable costs and benefits that are incremental to the regulation or policy under consideration. These should include directly intended effects and associated costs, as well as ancillary (or co-) benefits and costs."[432] The proposed Bush guidelines also stated that "[f]or a regulation that is expected to have substantial indirect effects beyond the regulated sector, it is important to choose a model that can capture those effects."[433]

Likewise, the Clinton EPA's guidelines for conducting cost-benefit analyses endorsed the importance of considering indirect costs and benefits.[434] Issued in 2000, the Clinton guidelines included indirect costs as a component of its calculations for health and social costs.[435] Emphasizing that "[a] complete benefits analysis is also useful because it makes explicit the assumptions about the value of benefits embedded in different policy choices,"[436] the guidelines determined that indirect benefits are cognizable, focusing on indirect ecological benefits.[437] Moreover, the guidelines noted that "immediately following a net benefit calculation, there should be a presentation and evaluation of all benefits and costs that can only be quantified but not valued, as well as all benefits and costs that can be only qualitatively described."[438] The

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[427] *Id*. at 26.
[428] *Id*.
[429] Environmental Protection Agency, *Guidelines for Preparing Economic Analyses*, at 11-2 (Dec. 2010), https://yosemite.epa.gov/ee/epa/eerm.nsf/vwAN/EE-0568-05.pdf/$file/EE-0568-05.pdf.
[430] *Id.*
[431] *See id*. at 7-1.
[432] Environmental Protection Agency, "Guidelines for Preparing Economic Analyses (External Review Draft)," at 10-4 (Sept. 15, 2008) (on file with author).
[433] *Id.* at 8-17.
[434] *See* Environmental Protection Agency, *Guidelines for Preparing Economic Analyses*, at 67, 70, 81 (Sept. 2000), https://www.epa.gov/sites/production/files/2017-09/documents/ee-0228c-07.pdf.
[435] *Id.* at 82-83, 94, 114-15.
[436] *Id.* at 59.
[437] *Id.* at 70 (noting that "[e]cosystem services that do not directly provide some good or opportunity to individuals may be valued because they support off-site ecological resources or maintain the biological and biochemical processes required for life support").
[438] *Id.* at 177.

implication is that, even for effects that cannot be monetized, informed decisionmaking requires consideration of all benefits and costs, not just direct ones. In short, all three iterations of guidelines authored by EPA—the 2000 guidelines, the 2008 draft guidelines, and the 2010 guidelines—called for the use of co-benefits in cost-benefit analyses.

EPA's cost-benefit analyses for clean air rules have also long included co-benefits.[439] EPA began acknowledging these benefits in Clear Air Act rules all the way back in the 1980s. In 1985, EPA under President Ronald Reagan conducted an extensive analysis of co-benefits from reductions of non-target pollutants in its landmark 1985 regulation reducing lead in gasoline, including an analysis of benefits from reductions in ozone, nitrogen oxides, and hydrocarbons.[440] As part of this analysis, EPA found monetized co-benefits from reducing hydrocarbons, nitrous oxide, and carbon monoxide, benzene, and other non-targeted pollutants to be worth an estimated $222 million over just a one year period.[441] The Reagan-era EPA in also proposed to develop New Source Performance Standards for municipal waste combustors. As part of this proposal, EPA discussed the importance of considering indirect benefits from its regulation of toxic emissions from municipal waste combustors.[442] EPA explained that it would include "indirect benefits accruing from concomitant reductions in other regulated pollutants."[443]

Under President George H.W. Bush, EPA in 1991 justified performance standards in a proposed rule for landfill gases in part on "the ancillary benefit of reducing global loadings of methane."[444] Further, EPA examined countervailing climate change risks. The agency noted that carbon dioxide emissions under the proposed standard would increase, but justified regulation in part because of the climate change benefits from methane emission reductions.[445] EPA took into consideration both the ancillary benefits of methane reductions in reducing greenhouse gas pollution as well as the countervailing risk of increasing carbon dioxide emissions. EPA's judgment on how to regulate was guided by the full scope of effects.

EPA under President Bill Clinton in a 1998 rule establishing standards for hazardous air pollutant emissions from pulp and paper producers analyzed indirect effects, both co-benefits from reductions in emissions, and indirect costs from increases in emissions, for NAAQS criteria pollutants.[446] Though hazardous air pollutants (HAPs) were directly targeted by the rule, EPA

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[439] The Senate Report accompanying the 1990 Clean Air Act amendments indicated that EPA could take co-benefits into account when setting standards for hazardous air pollutants. It states that "[w]hen establishing technology-based standards under this subsection, the Administrator may consider the benefits which result from the control of air pollutants that are not listed but the emissions of which are, nevertheless, reduced by control technologies or practices necessary to meet the prescribed limitation." S. Rep. No 101-228, at 172 (1989).

[440] *See* Environmental Protection Agency, *Regulatory Impact Analysis of the National Ambient Air Quality Standards for Carbon Monoxide*, EPA-450/5-85-007, at VI-1 to VI-74 (July 1985), http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=2000NK80.TXT.

[441] *See id*. at E-8.

[442] *See* Assessment of Municipal Waste Combustor Emissions Under the Clean Air Act, 52 Fed. Reg. 25,399, 25,406 (July 7, 1987) (codified at 40 C.F.R. pt. 60).

[443] *Id*.

[444] Standards of Performance for New Stationary Sources and Guidelines for Control of Existing Sources: Municipal Solid Waste Landfills, 56 Fed. Reg. 24,468, 24,469 (May 30, 1991) (codified at 40 C.F.R. pts. 51, 52, and 60).

[445] *See id*. at 24,472.

[446] *See* National Emission Standards for Hazardous Air Pollutants for Source Category: Pulp and Paper Production; Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards: Pulp, Paper, and

nonetheless analyzed the effects of its regulation on other air pollutants, including the criteria pollutants.[447] For the "Best Available Technology" standards which govern existing plants,[448] EPA estimated small increases in emissions of carbon monoxide, nitrogen oxides, and sulfur dioxides from the rule, but a significant decrease in particulate matter.[449] For the New Source Performance Standards which govern new sources of emissions, EPA concluded that in addition to decreasing HAPs, the rule would also decrease many criteria pollutant emissions including particulate matter.[450] Rather than ignoring some or all of these effects because they did not derive from the target pollutants, EPA estimated these effects and analyzed them as part of its rule-making process.

In 2005, EPA under George W. Bush noted that its Clean Air Interstate Rule, which targeted particulate matter and ozone emissions, would also reduce mercury emissions,[451] and included the benefits from mercury reductions in its cost-benefit analysis for the rule.[452] The Bush EPA also discussed co-benefits as part of a regulation governing hazardous air pollutants from mobile sources (primarily cars).[453] The agency noted that though the rule dealt with control of air toxics and not criteria pollutants including particulate matter and ozone, "this co-benefit . . . is significant."[454] EPA calculated that the standards would reduce exhaust emissions of direct particulate matter by over 19,000 tons in 2030 nationwide.[455] The agency also analyzed the effects of the rule on ozone emissions, concluding that overall ozone emissions reductions would be small, but some areas would have "non-negligible improvements in projected 8-hour ozone . . . ."[456] EPA further noted that it viewed "those improvements as useful in meeting the 8-hour ozone NAAQS."[457]

EPA has consistently examined a full range of effects from regulations. Rather than arbitrarily ignoring certain effects because they are ancillary or indirect, EPA discusses and analyzes indirect costs and co-benefits. The agency has done so through multiple presidential administrations of different parties, and in a wide range of clean air regulations. Indeed, Chris DeMuth and Judge Douglas Ginsburg, both Administrators of OIRA under President Reagan, summarize EPA's consideration of ancillary benefits this way: "EPA and other agencies frequently include ancillary benefits in their benefits estimates."[458] They also note that "OIRA

Paperboard Category, 63 Fed. Reg. 18,504, 18,504, 18,576 (Apr. 15, 1998) (codified at 40 C.F.R. pts. 63, 261, and 430).

[447] *See id*. at 18,576.

[448] *See id*. at 18,508.

[449] *See id*. at 18,576.

[450] *See id*. at 18,579.

[451] *See* Rule To Reduce Interstate Transport of Fine Particulate Matter and Ozone (Clean Air Interstate Rule); Revisions to Acid Rain Program; Revisions to the NOX SIP Call, 70 Fed. Reg. 25,162, 25,170 (May 12, 2005) (codified at 40 C.F.R. pts. 51, 72, 73, 74, 77, 78 and 96).

[452] *See id*. at 25,312.

[453] *See* Control of Hazardous Air Pollutants From Mobile Sources, 72 Fed. Reg. 8,428, 8,430, 8,461 (Feb. 26, 2007) (codified at 40 C.F.R. pts. 59, 80, 85, and 86).

[454] *Id*. at 8,461.

[455] *See id*. at 8,453.

[456] *Id*. at 8,458.

[457] *Id*.

[458] Christopher DeMuth & Douglas H. Ginsburg, *Rationalism in Regulation*, 108 MICH. L. REV. 877, 887 (2010) (reviewing RICHARD L. REVESZ & MICHAEL A. LIVERMORE, RETAKING RATIONALITY: HOW COST-BENEFIT ANALYSIS CAN BETTER PROTECT THE ENVIRONMENT AND OUR HEALTH (2008))

itself recommends that agencies account for ancillary benefits as well as countervailing risks."[459] Similarly, high-profile Obama-era EPA regulations like the Mercury and Air Toxics Standards and the Clean Power Plan reflect the requirement of OMB Circular A-4 that the agency consider co-benefits, and the requirement of EPA's own guidelines to consider "all identifiable costs and benefits."[460] The inclusion of co-benefits in these regulations is well in line with the longstanding practice of EPA to include co-benefits and countervailing risks in its assessment of clean air regulations.

C. Judicial Recognition

Courts are often asked to review the adequacy of an agency's cost-benefit analysis, and in this context they have addressed the issue of indirect benefits and costs.[461] Reviewing courts have frequently required agencies to include ancillary impacts. This section first discusses judicial decisions requiring the consideration of indirect risks, and then turns to the nascent case law on co-benefits.

In 1991, the Fifth Circuit rejected EPA's attempt to ban asbestos-based brakes under the Toxic Substances Control Act.[462] A central part of the court's holding was its finding that EPA needed to consider the indirect safety effects of other potential, non-asbestos options for car breaks.[463] The court determined that under the Toxic Substances Control Act, "EPA was required to consider both alternatives to a ban and the costs of any proposed actions and to 'carry out [the Act] in a reasonable and prudent manner [after considering] the environmental, economic, and social impact of any action.'"[464] The court noted with disapproval that the agency had not evaluated the harm from increased use of substitute products.[465] Because EPA did not account for "the dangers posed by the substitutes, including cancer deaths from the other fibers used and highway deaths occasioned by less effective, non-asbestos brakes," [466] the agency's "failure to examine the likely consequence of the the regulation render[ed] the ban of asbestos friction products unreasonable."[467] In short, EPA's cost-benefit analysis did not, in the court's view, adequately address indirect costs and was therefore unsupported by substantial evidence as required under the statute.[468]

A year later the D.C. Circuit again struck down a regulation, this time promulgated by the National Highway Traffic Safety Administration (NHTSA), for failing to consider indirect costs.[469] NHTSA had attempted to increase fuel efficiency standards for cars.[470] The agency failed to consider the potential increased safety risks because smaller, more fuel efficient cars

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[459] *Id.*
[460] *See* Environmental Protection Agency, *Guidelines for Preparing Economic Analyses*, *supra* note 429, at 11-2.
[461] *See generally* Caroline Cecot & W. Kip Viscusi, *Judicial Review of Agency Benefit-Cost Analysis*, *supra* note 33 (collecting and analyzing cases where courts reviewed agencies' cost-benefit analyses).
[462] *See* Corrosion Proof Fittings v. EPA, 947 F.2d 1201, 1229-30 (5th Cir. 1991).
[463] *See id*. at 1225.
[464] *Id.* at 1215 (quoting 15 U.S.C. § 2601(c)).
[465] *See id*. at 1221.
[466] *Id.* at 1224.
[467] *Id.*
[468] *Id.* at 1207.
[469] *See* Competitive Enterprise Inst. v. Nat'l Highway Traffic Safety Admin., 956 F.2d 321, 323-35 (D.C. Cir. 1992).
[470] *See id*.

might be less protective in a crash.[471] The court admonished the agency and required NHTSA to "reconsider the matter and provide a genuine explanation for whatever choice it ultimately makes."[472] Without calculating these indirect costs, the court found that the agency had not met the requirement of reasoned decisionmaking.[473]

Other circuit court decisions have likewise addressed the issue of indirect costs and have rejected cost-benefit analyses that lacked an estimate of these effects. In 1993, the Seventh Circuit partially vacated an OSHA regulation putting standards in place to limit the transmission of communicable diseases.[474] The agency failed to consider the indirect health effects that might result if the rule increased health care costs and thus limited access to care.[475] OSHA's "consideration of the indirect costs of the rule is thus incomplete."[476] Similarly, the D.C. Circuit also rebuffed an EPA regulation revising the NAAQS standards for ozone and particulate matter in 1999 because in the court's view, the agency failed to consider the potential health detriments from lowering pollution.[477] Specifically, EPA failed to consider whether "ground-level (tropospheric) ozone—the subject of th[e] rule—has [an ultraviolet radiation]-screening function independent of the ozone higher in the atmosphere"[478] with indirect health benefits, such as reducing incidences of cataracts and skin cancers.[479] The court asserted that by ignoring these consequences, EPA looked only at "half of a substance's health effects";[480] as a result, the agency's interpretation of Title VI of the Clean Air Act[481] failed under the reasonableness standard laid out in *Chevron U.S.A. Inc. v. NRDC*.[482] In 2002, the D.C. Circuit also overturned two Federal Communications Commission rules for the agency's failure to consider the rules' indirect costs[483] in contravention of the language and objectives of the Telecommunication

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[471] *See id*. at 326-27.
[472] *Id*. at 327.
[473] *See id*. ("When the government regulates in a way that prices many of its citizens out of access to large-car safety, it owes them reasonable candor. If it provides that, the affected citizens at least know that the government has faced up to the meaning of its choice. The requirement of reasoned decisionmaking ensures this result and prevents officials from cowering behind bureaucratic mumbo-jumbo. Accordingly, we order NHTSA to reconsider the matter and provide a genuine explanation for whatever choice it ultimately makes.").
[474] *See* Am. Dental Ass'n v. Martin, 984 F.2d 823, 823-27, 830-31 (7th Cir. 1993).
[475] *See id.* ("OSHA also exaggerated the number of lives likely to be saved by the rule by ignoring lives likely to be sacrificed by it, since the increased cost of medical care, to the extent passed on to consumers, will reduce the demand for medical care, and some people may lose their lives as a result.").
[476] *See id.* (citing a comparison to *Competitive Enterprise Inst. v. Nat'l Highway Traffic Safety Admin*., 956 F.2d 321 (D.C. Cir. 1992)).
[477] *See* Am. Trucking Ass'ns v. EPA, 175 F.3d 1027, 1036-37 (D.C. Cir. 1999*), rev'd on other grounds sub nom.* Whitman v. Am. Trucking Ass'ns, 531 U.S. 457 (2001).
[478] *Id.* at 1052.
[479] *See id.* at 1051.
[480] *Id*. at 1052.
[481] Clean Air Act, 42 U.S.C. §§ 7671–7671q (2012).
[482] *See* Am. Trucking Ass'ns v. EPA, 175 F.3d at 1052 (citing *Chevron U.S.A. Inc. v. NRD*C, 467 U.S. 837, 843 (1984)).
[483] *See* U.S. Telecom Ass'n v. Fed. Commc'ns Comm'n, 290 F.3d 415, 424-25 (D.C. Cir. 2002). One rule required incumbent local exchange carriers to lease "unbundled network elements" to competitive local exchange carriers ("CLECs"), while the other rule unbundled the spectrum of local copper loops such that the CLECs would be positioned to offer competitive internet access. *See id.* at 417. However, the court found that the Commission "loftily abstracted away all specific markets" and did not take into account indirect cost differentials in different competitive markets. *See id.* at 423. Moreover, the agency "completely failed to consider the relevance of competition in broadband services coming from cable" and satellite companies, another crucial indirect cost. *Id.* at 428.

Act.[484]

The D.C. Circuit has also addressed the "mirror image" of indirect costs: co-benefits.[485] In 2016, the court's decision in *Sugar Corp v. EPA*[486] upheld EPA's consideration of co-benefits in regulating the effects of reducing hazardous air pollutants from boilers, process heaters, and incinerators.[487] Specifically, EPA decided not to adopt more lenient hydrogen chloride emission standards, reasoning that it could weigh additional factors such as the "cumulative adverse health effects due to concurrent exposure to other [hazardous air pollutants] or emissions from other nearby sources" and the "potential impacts of increased emissions on ecosystems." Industry challengers argued that EPA's consideration of these co-benefits in its decision to maintain the more stringent emissions standard rendered the agency's decision arbitrary and capricious under the Administrative Procedure Act.[488] EPA asserted that "its consideration of these co-benefits was not a regulation of other pollutants; rather, it was simply choosing not to ignore the purpose of the [Clean Air Act]—to reduce the negative health and environmental effects of HAP emissions—when exercising its discretionary authority under the Act."[489] The D.C. Circuit held that EPA acted within its legal authority when it considered not only the direct benefits of reducing hydrogen chloride, but also the co-benefits from that reduction—namely, indirect reductions of other hazardous air pollutants.[490] The court agreed that the use of co-benefits conforms with the Clean Air Act's purpose, finding that "EPA was free to consider potential co-benefits that might be achieved" from enforcing the more stringent standard.[491]

Courts that have examined cost-benefit analyses have acknowledged the logic of examining the indirect effects of regulations and using this information to guide the rule-making process. While more cases deal with indirect costs, modern cases address indirect benefits as well, and no court has said there is any reason to treat them differently. Courts are correct to do so; these terms are merely descriptors that helpfully depict whether effects are positive or negative and they provide no justification for focusing on some effects while ignoring others.[492] Further, as Ginsburg and DeMuth note, "[t]here appear to be no legal, political, or intellectual . . . impediments to treating ancillary benefits and countervailing risks equally in cost-benefit analysis and regulatory design."[493] It would therefore be incoherent to consider the negative indirect effects of regulations without also considering the positive indirect effects.

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[484] *See* U.S. Telecom Ass'n v. F.C.C., 290 F.3d at 427-29 (quoting *AT&T Corp. v. Iowa Utilities Board*, 525 U.S. 366, 388-89 (1999)) (The Federal Communications Commission "must 'apply some limiting standard, rationally related to the goals of the Act,' . . . [and] 'cannot, consistent with the statute, blind itself to the availability of elements outside the incumbent's network.'").
[485] *See* Rascoff & Revesz, *supra* note 410, at 1793 (noting that indirect costs and indirect benefits "are simply mirror images of each other").
[486] 830 F.3d 579 (D.C. Cir. 2016).
[487] *See id.* at 591, 625.
[488] *See id.* at 625.
[489] *Id*. at 624-25.
[490] *See id.*
[491] *Id*.
[492] *See* Rascoff & Revesz, *supra* note 410, at 1793 ("Risk tradeoffs and ancillary benefits are simply mirror images of each other. There is no justification for privileging the former and ignoring the latter.").
[493] Ginsburg & DeMuth, *supra* note 458, at 888.

CONCLUSION

Considering co-benefits from reductions in particulate matter and other criteria pollutants below the NAAQS is clearly supported by science and long-standing EPA precedent. It is also necessary in order to give the public an accurate understanding of the effects of regulation and deregulation. Critics of regulation seek to paint benefits below the NAAQS as illusory, and suggest their inclusion in rules targeting other pollutants is overreach by an overzealous regulator. In this Article, we have shown that this narrative rings hollow. EPA through multiple presidential administrations has calculated benefits from criteria pollutant reductions below the NAAQS, following established science. With regard to particulate matter reductions, which account for the bulk of criteria pollutant benefits in the Mercury and Air Toxics Standards and Clean Power Plan, and would likely be substantial for any regulation of greenhouse gases, the health and premature mortality reduction benefits are exceptionally well documented. EPA has acknowledged the lack of evidence of a particulate matter threshold for more than thirty years, and has calculated benefits from reductions below particulate matter NAAQS levels for two decades. The science on these benefits clearly indicates that no threshold can be identified, and shows that reducing this pollution at levels well below the current NAAQS will yield dramatic health benefits.

The Trump Administration has embraced these anti-regulatory stances in its efforts to repeal the Clean Power Plan. The Administration, and other regulation opponents, suggest that theirs a logical way to account for effects, arguing that including these benefits artificially inflates the positive effects of regulating. But what they advocate is a dishonest attempt to obscure the actual effects of regulations from the public.

Ideological differences about the appropriate role for government to play in the control of pollution are a natural part of democratic debate. But public participation is a key attribute of a vibrant democracy, and such participation is meaningful only if the public is given accurate information about the effects of different proposals. Hiding these substantial benefits obscures the real-world effects of deregulation. We encourage policy makers and the courts that oversee them to embrace sound science and economics, and to require transparent and accurate accounting of the benefits of air pollution regulations.