PLASTICS AND THE LIMITS OF U.S. ENVIRONMENTAL LAW

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Plastics are among the most ubiquitous materials on the planet, used for functions ranging from single-use cups to medical syringes to industrial equipment. The properties that make plastics useful, however, also make them highly persistent in the environment when improperly disposed of. Moreover, although plastic polymers are inert, they break down in the environment into harmful microplastics and nanoplastics, and plastics are often made using toxic chemicals or include toxic additives. These properties have caused a plastic pollution crisis. Massive amounts of plastics and breakdown chemicals contaminate the oceans and other ecosystems throughout the globe. The United States continues to contribute to this crisis despite extensive regulation at all phases of the plastics life cycle. Two key limitations in U.S. environmental law help explain this paradox. First, the U.S. environmental regulatory process is so granular and complex that EPA and other agencies cannot keep up with massive growth and evolution in plastic materials and production. Second, the core philosophy of U.S. environmental law is to regulate production externalities without infringing on producer and consumer choice. We rarely question a product's societal utility relative to its environmental impacts. U.S. contribution to the plastic pollution crisis is not likely to abate unless these limitations are addressed. Moreover, the limitations highlighted by this analysis apply to other applications of U.S. environmental law, resulting in continued releases of "forever chemicals" and other intractable forms of pollution.

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Introduction

In the acclaimed 1967 film *The Graduate*, Benjamin Braddock, a recent college graduate and the story's protagonist, receives this unsolicited career advice: "There is a great future in plastics. Think about it. Will you think about it?" Braddock replies: "Yes. I will."[1]

This Article modifies Maguire's question. Is there *still* a great future in plastics? Have we thought about plastics correctly? Will we think about plastics more carefully, or will we allow regulatory inertia to perpetuate a global envi-

1. The Graduate (Lawrence Truman Productions 1967). Others have referenced the same quote in evaluating environmental regulation of plastics. *See* Jehan El-Jourbagy et al., *Creating an Industrial Regulatory Framework to Reduce Plastics*, 18 Berkeley Bus. L.J. 94, 95 (2021).

ronmental catastrophe? These questions are important to the specific but critical issue of environmental harm caused by manufacturing, use, recycling, and disposal of plastics. Those inquiries also suggest more fundamental questions about the utility and effectiveness of U.S. environmental law, which was in its formative stages as fictional Braddock pondered career options.[2]

In the 1960s, plastics represented the future for a growing middle class that craved convenience. In addition to creating new careers, plastics offered many economic and social benefits.[3] Some may seem trivial, such as the expedience of fast food in disposable containers. As the COVID-19 pandemic highlighted, however, plastics have medical and other important uses as well.[4] True to the prediction in *The Graduate*, plastics boomed in ensuing decades.[5]

These new synthetic materials, however, created huge environmental problems.[6] Adverse environmental impacts derive from all phases of the plastics life cycle,[7] including extraction and transportation of raw materials, such as petroleum and natural gas, and pollution and waste disposal during plastics manufacturing (hereinafter referred to as "front end" problems). Intractable problems also result from the ubiquitous use of plastics and a leaky and inadequate reuse, recycling, and disposal regime (hereinafter referred to as "back-end" problems).[8] These impacts fall disproportionately on some segments of the United States and global population, while benefits of plastics are distributed widely.[9]

Congress passed federal environmental statutes to address pollution from industrial activity associated with commercial and industrial products, including plastics. Those laws included the 1970 Clean Air Act ("CAA"),[10] and the 1972 Federal Water Pollution Control Act (more commonly known as the Clean

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2. *See* RICHARD J. LAZARUS, THE MAKING OF ENVIRONMENTAL LAW 43–93 (2004) (describing development of environmental law in the 1960s and proliferation of federal environmental statutes in the 1970s).
3. *See infra* Part I.A.
4. *See, e.g.*, Joana C. Prata et al., *Covid-19 Pandemic Repercussions on the Use and Management of Plastics,* 54 ENV'T SCI. & TECH. 7760, 7760–62 (2020) (citing increased need for plastics in masks, gloves, goggles, and other equipment and their impacts).
5. *See infra* Part I.A.
6. *See infra* Part I.B.
7. A product's "life cycle" is "the compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle." Int'l Standards Org., *ISO 14040, Environmental Management – Life Cycle Assessment – Principles and Framework* 3.2 (2nd ed. 2006). It includes environmental impacts from resource extraction, production, product use, and waste management via reuse, recycling, or disposal. *See* HANS DE BRUIJN ET AL., HANDBOOK ON LIFE CYCLE ASSESSMENT 5–6 (2002).
8. *See* U.N. ENV'T PROGRAMME, DROWNING IN PLASTICS, MARINE LITTER AND PLASTIC WASTE VITAL GRAPHICS 13 (2021); C.A. Bernardo et al., *Environmental and Economic Life Cycle Analysis of Plastic Waste Management Options. A Review*, 1779 AIP CONFERENCE PROCEEDINGS 140001-1, 140001-1 (2016), https://perma.cc/3W2T-PXES.
9. *See infra* Part I.
10. 42 U.S.C. §§ 7401–7671q.

Water Act ("CWA")).[11] Congress added the 1976 Resource Conservation and Recovery Act ("RCRA")[12] and the 1980 Comprehensive Environmental Response, Compensation, and Liability Act ("CERCLA," commonly known as "Superfund")[13] to ensure proper recycling, reuse, or disposal of waste from manufacturing and use of plastics and other products. In statutes such as the 1976 Toxic Substances Control Act ("TSCA"),[14] Congress authorized the Environmental Protection Agency ("EPA") to restrict, condition, or ban manufacturing or use of chemical substances when environmental harm exceeded societal benefit.

These and other laws,[15] in addition to toxic tort liability,[16] should allow us to use plastics while avoiding serious environmental consequences. Instead, plastics have created a global environmental crisis.[17] This Article poses two theories as to why. Both suggest broader weaknesses in our approach to environmental law.

First, U.S. environmental law is phenomenally complex and granular. It requires regulatory agencies to analyze what is being manufactured, using what methods, and creating what pollutants and other environmental harms. Then, they must evaluate available control methods and the feasibility and cost of those controls. Regulation of the front end of the plastics life cycle is as complicated and as varied as the colossal activity it targets, confronting regulators with the staggering task of keeping up with an industry that evolves continuously.

Second, U.S. environmental law largely reflects our predominantly free market economic model. The goal of U.S. environmental regulation has never been to tell industry what to produce or consumers what to buy and for what purposes. With a few notable exceptions, the primary focus of environmental law is to reduce or eliminate environmental externalities caused by that production and use. That philosophy has succeeded to some degree for the front end of the plastics life cycle but failed miserably at the back end.

Although plastics present a forceful example of these deficiencies in environmental law, the same problems apply to other substances. Our inability to control toxic, persistent, and bio-accumulative chemicals has reached crisis proportions.[18] Several scientists recently argued that humans have exceeded the

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11. 33 U.S.C. §§ 1251–1387.

12. 42 U.S.C. §§ 6901–6992k.

13. 42 U.S.C. §§ 9601–9675.

14. 15 U.S.C. §§ 2601–2629.

15. *See infra* notes 146–158 and accompanying text for a partial summary.

16. *See* Andrew J. Scholtz et al., *Microplastics: The Looming Challenges, Pitfalls, and Uncertainties Facing the Regulated Community and Beyond*, For Defense, June 2021, at 36, 39 (evaluating challenges of microplastics tort litigation for plaintiffs and defendants).

17. See *infra* Part I.B.

18. *See Persistent Organic Pollutants: A Global Issue, a Global Response,* EPA, https://perma.cc/YPW9-DBM4 (noting global scope of the problem and summarizing widespread health and

"safe operating space of the planetary boundary for novel entities," meaning artificial substances not found in the natural world, because the scale of production and release of those chemicals exceeds our ability to assess and monitor their impacts on global ecosystems.[19] Lessons suggested by the plastics analysis likely apply to similar substances and their associated health and environmental problems.

Part I.A outlines the societal uses and benefits of plastics. Part I.B describes the scope of known environmental harm caused throughout the plastics life cycle. Part II discusses ways in which two core limitations of U.S. environmental law led to gaps and inadequacies in plastics regulation specifically, and highlights flaws in the U.S. environmental regulatory regime generally. Part III evaluates potential solutions to those limitations.

I. The Plastics Dilemma: Societal Benefits and Environmental Impacts

Plastics pose a classic modern dilemma. They benefit society in many ways, from simple convenience to critical improvements in medical care, sanitation, and public health. They provide inexpensive, durable materials in diverse forms for a wide range of uses. This same proliferation of plastics uses, however, along with the durability and persistence that makes plastic so useful, results in an equally diverse and significant range of environmental harms.

A. Uses, Benefits, and Types of Plastic

The first synthetic plastic was invented in 1907, and polyethylene—the most commonly used plastic in the world—was synthesized in 1933.[20] Plastic production in the United States began in earnest during World War II and increased from 0.5 million tons annually in the 1950s[21] to over 300 million tons

environmental impacts); *see also Persistent Organic Pollutants (POPs) and Pesticides*, U.N. Env't Programme, https://perma.cc/SGJ2-KR4H; *Comments from Academics, Scientists and Clinicians on the Regulation of Persistent, Bioaccumulative, and Toxic Chemicals under Section 6(h) of the Toxic Substances Control Act* 1–3 (May 17, 2021), https://perma.cc/W7G4-HBH3. We have known about the dangers of previously unstudied synthetic chemicals for decades. *See, e.g.*, Theo Colborn et al., *Developmental Effects of Endocrine-Disrupting Chemicals in Wildlife and Humans*, 101 Env't Health Persps. 378, 379 (1993). Recently, EPA has increased its efforts to address such chemicals. *See, e.g.*, EPA, PFAS Strategic Roadmap: EPA's Commitments to Action 2021–2024, at 6–8 (2021).

19. Linn Persson et al., *Outside the Safe Operating Space of the Planetary Boundary for Novel Entities*, 56 Env't Sci. Tech. 1510, 1510 (2022).

20. Philippe Chalmin, *The History of Plastics: From the Capitol to the Tarpeian Rock*, 19 Field Actions Sci. Rep. (Special Issue) 6, 8 (2019).

21. Richard C. Thompson et al., *Plastics, the Environment and Human Health: Current Consensus and Future Trends*, 364 Phil. Transactions Royal Soc'y Biol. Sci. 2153, 2154 (2009).

by 2018.[22] To date, humans have produced an estimated 8,300 million metric tons of virgin plastic.[23]

Plastics are light yet durable, and different varieties of polymers can be formulated into a wide range of shapes and qualities.[24] They are airtight and waterproof, making them useful for packaging food, drinks, pharmaceuticals, cosmetics, and other products.[25] They are light yet strong compared to alternative materials, making them useful for storing and transporting goods with lower monetary and energy costs.[26] Perhaps most importantly, most plastics are remarkably inexpensive relative to their alternatives.[27] As a result, although many plastics are used to make durable products (such as toys, housewares, and parts for commercial and industrial materials), a large percentage of plastics are manufactured for single use products ("SUPs"), such as shopping bags; fast food packaging; disposable bottles and other food containers; and disposable cups, straws, plates, and cutlery.[28]

The COVID-19 pandemic illustrates the beneficial uses of plastic. Plastics in masks and surgical equipment have been crucial in administering tests and vaccines. For example, about 129 billion face masks and 65 billion gloves were used every month in 2020.[29] As people switched from restaurant dining to take-out food, single-use plastic packaging use surged.[30] In response, many states and municipalities suspended or delayed implementing policies limiting single-use plastics.[31]

Most plastics are made from petroleum or natural gas,[32] which are combined with other materials in chemical reactions to form synthetic organic polymers. Although systems of categorization vary, there are hundreds of different kinds of plastic materials.[33] Plastic products usually contain a resin iden-

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22. *We Made Plastic. We Depend on It. Now, We're Drowning in It.*, NAT'L GEOGRAPHIC (June 2018), https://perma.cc/474R-GEVX.

23. Roland Geyer et al., *Production, Use, and Fate of All Plastics Ever Made*, 3 SCI. ADVANCES, July 19, 2017, at 1, 1.

24. Anthony L. Andrady & Mike A. Neal, *Applications and Societal Benefits of Plastics*, 364 PHIL. TRANSACTIONS ROYAL SOC'Y BIOL. SCI. 1977, 1977 (2009).

25. *See id.*

26. *Id.* at 1980–81.

27. *Id.*

28. *See id.* at 1981–82.

29. Prata et al., *supra* note 4, at 7760.

30. Emma Newburger & Amelia Lucas, *Plastic Waste Surges as Coronavirus Prompts Restaurants to Use More Disposable Packaging,* CNBC (Jun. 28, 2020), https://perma.cc/7JB3-FB88.

31. El-Jourbagy et al., *supra* note 1, at 122–23.

32. Increasingly, plastics are created from fracked natural gas. To reduce end-of-life environmental impacts by making plastics more biodegradable or recyclable, scientists have begun to develop plant-based plastic polymers. *See* Maja Rujniæ-Sokele & Ana Pilipovic, *Challenges and Opportunities of Biodegradable Plastics: A Mini Review*, 35 WASTE MGMT. & RSCH. 132, 132–33 (2017).

33. Andrady & Neal, *supra* note 24, at 1977.

tification code identifying the type of plastic: polyethylene terephthalate, high-density polyethylene, polyvinyl chloride, low-density polyethylene, polypropylene, and polystyrene make up codes 1–6, respectively.[34] Number 7 plastic simply refers to "other" plastic types.[35]

The proliferation of plastic types significantly increased the complexity of environmental regulation because different pollutants are generated in different production processes, and because different polymers pose different toxicity concerns. For example, polycarbonate and polytetrafluorethylene polymers pose significant toxic risks: the former leaches bisphenol chemicals and the latter can release per- and polyfluoroalkyl substances (or "PFAS"), both of which have adverse effects on human health.[36] As a further complication, most plastic contains additive chemicals, which can be added in different combinations and concentrations depending on product type.[37] Nearly all plastic, for example, contains polymer stabilizers allowing them to be melted and molded without degrading the polymer.[38] Other additives, such as phthalates, help to make the polymer more malleable.[39] Because additive chemicals are not bonded to the polymer, they can leach out during product use.[40]

In just a century, the variety and functionality of plastic types and functions have made plastics one of the most pervasive materials in the world, used in nearly every consumer product or its packaging. It is difficult to find any room—or any complex manufactured product—that contains no plastic. The United States, Europe, and other advanced economies use up to 20 times as much plastic as developing economies such as India and Indonesia on a per capita basis, illustrating the huge potential for growth in plastic production worldwide.[41] Indeed, plastic production is expected to triple by 2050.[42]

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34. ASTM INT'L, ASTM D7611/D7611M, STANDARD PRACTICE FOR CODING PLASTIC MANUFACTURED ARTICLES FOR RESIN IDENTIFICATION 2 (2022), https://perma.cc/SEZ5-V73X; Resford Rouzer, *What do the Numbers Mean? Recycling Codes Explained*, RECYCLE NATION (Mar. 31, 2015), https://perma.cc/9VH9-8XCT.
35. Rouzer, *supra* note 34.
36. *See infra* notes 113–121 and accompanying text.
37. Andrady & Neal, *supra* note 24, at 1979–80.
38. *Id.* at 1979.
39. *Id.* at 1980.
40. John N. Hahladakis et al., *An Overview of Chemical Additives Present in Plastics: Migration, Release, Fate and Environmental Impact During Their Use, Disposal and Recycling*, 344 J. HAZARDOUS MATERIALS 179, 179 (2018).
41. INT'L ENERGY AGENCY, THE FUTURE OF PETROCHEMICALS MOVES TOWARD MORE SUSTAINABLE PLASTICS AND FERTILIZERS 34 (2018).
42. Geyer et al., *supra* note 23, at 3.

B. *Environmental and Human Health Impacts of Plastics*

The domestic and global environmental impacts of plastics have been recounted elsewhere, but most descriptions focus on environmental problems at the "back end" of the plastics life cycle.[43] To understand the full environmental impacts of plastics, and the degree to which they are addressed by existing environmental laws and regulations, it is important to consider the full plastics life cycle. This includes collection and production of raw materials from which plastics are synthesized; manufacturing, formulation, and incorporation of plastics into manufactured products; and various ways in which plastics are used, reused, recycled, or disposed of at the end of a product's initial use.

1. *Life Cycle Analysis*

a. *Raw Materials*

Most plastic is produced from petrochemicals,[44] which are sourced from petroleum or fracked natural gas. Plastics are said to be the oil industry's "Plan B" as the supply of alternative energy grows.[45] Plastic has quickly become the fastest-growing source of oil consumption, and petrochemicals are expected to account for nearly half of the growth in oil demand by 2050.[46]

The environmental harms associated with petroleum and natural gas production are too extensive to be recounted here.[47] The United States has become the world's top producer and exporter of natural gas, however, and hydraulic fracking supplies an increasing percentage of the raw materials for plastic production.[48] As fracking has become more prevalent, associated risks have grown more apparent, from methane emissions to groundwater contamination.[49]

Moreover, petroleum is only one of thousands of input materials used to produce and formulate various types of plastics and plastic products.[50] Although

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43. *See, e.g.*, E. G. Shershneva, *Plastic Waste: Global Impact and Ways to Reduce Environmental Harm*, 1079 INT'L SCI. & TECH. CONF. 1, 1 (2021).

44. *See* Rujniæ-Sokele & Pilipovic, *supra* note 32, at 132. As of 2017, however, bio-based plastics accounted for just 1% of plastic produced annually. *Id.*

45. BEYOND PLASTICS AT BENNINGTON COLLEGE, THE NEW COAL: PLASTICS & CLIMATE CHANGE 4 (2021).

46. INT'L ENERGY AGENCY, THE FUTURE OF PETROCHEMICALS: TOWARDS MORE SUSTAINABLE PLASTICS AND FERTILIZERS 11 (2018).

47. *But see, e.g.*, Diane M. Sicotte, *From Cheap Ethane to a Plastic Planet: Regulating an Industrial Global Production Network*, 66 ENERGY RSCH. & SOC. SCI. 101479, 101479 (2020).

48. *Id.*; Charles Riley, *U.S. Becomes World's Top Exporter of Liquefied Natural Gas*, CNN BUS. (Jan. 5, 2022), https://perma.cc/X54G-RFEZ.

49. Sicotte, *supra* note 47, at 2.

50. *See* Helene Wiesinger et al., *Deep Dive into Plastic Monomers, Additives, and Processing Aids*, 55 ENV'T SCI. TECH. 9939, 9939 (2021). Petroleum is a mixture of various hydrocarbons

used in smaller volumes than petroleum, each causes environmental impacts that need to be considered in assessing the overall environmental burden of plastics.[51]

b. Production

Petrochemical facilities, which convert petroleum and natural gas into plastic precursor chemicals, generate significant air and water pollution.[52] Most petrochemical plants and refineries in the United States are located along the Mississippi River in Louisiana, an area known as "Cancer Alley."[53] Barring significant change, petrochemical industry pollution may increase given the enormous growth in plastics. The magnitude of this growth is illustrated by the fact that since 2019, at least 42 U.S. plastics facilities have opened, are under construction, or are in the permitting process, compared to 130 existing plastic facilities and related power plants.[54] By 2030, the plastic industry's contribution to climate change is expected to exceed that of the coal industry.[55]

Production of plastic products from precursor chemicals also generates significant chemical waste. Over 1,200 facilities manufacture plastic and rubber products in the United States; in 2020, these facilities produced 195 million pounds of waste.[56] For example, fluoropolymer production results in the release of toxic PFAS chemicals, which are used for their oil- and grease-resistant properties. PFAS have been found in the environment, in drinking water, and in human blood of those living near production facilities.[57] A DuPont fluorochemical plant in Parkersburg, West Virginia, released these unregulated

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and other chemicals, the composition of which varies with source. *See Petroleum*, NAT'L GEOGRAPHIC, https://perma.cc/7DGA-LP3C.

51. Wiesinger et al., *supra* note 50, at 9939.

52. Daniel Brockett, *How Plastic Is Made from Natural Gas*, PENN STATE EXTENSION, (Jan. 17, 2017), https://perma.cc/PA3Q-NXJX; Courtney J. Keehan, *Lessons from Cancer Alley: How the Clean Air Act Has Failed to Protect Public Health in Southern Louisiana*, 29 COLO. NAT. RES. ENERGY & ENV'T L. REV. 341, 348–49 (2018).

53. Idna G. Castellón, *Cancer Alley and the Fight Against Environmental Racism*, 32 VILL. ENV'T L.J. 15, 15 (2021).

54. BEYOND PLASTICS, *supra* note 45, at 6.

55. *Id.* at 7; *see also* Denins Wamstead & Seth Feaster, *The Coal-to-Renewables Transition Takes Off. Pre-Biden Changes Underscore Coming 10-Year Wave of Coal Plant Retirements*, INST. ENERGY ECON. & FIN. ANALYSIS (May 5, 2021), https://perma.cc/N4S2-D27Q.

56. EPA, 2020 TOXIC RELEASE INVENTORY FACTSHEET: INDUSTRY SECTOR: PLASTICS AND RUBBER 326 (2022). EPA includes plastic and rubber facilities in the same industry sector analysis; however, the top five establishments responsible for total releases all manufacture plastic products. *Id.*

57. Rainer Lohmann et al., *Are Fluoropolymers Really of Low Concern for Human and Environmental Health and Separate from Other PFAS?*, 54 ENV'T SCI. TECH. 12820, 12822–23 (2020).

chemicals in such large amounts that many people in the town fell sick, ultimately resulting in a $670 million settlement in a class action suit.[58]

c. Use and End-of-Life

Although environmental impacts of plastics are acute during production and disposal, most people encounter plastics during the use stage of its life cycle. Subsection 3(b) below explores human health impacts from exposure to plastic products. All those materials, however, are discarded either quickly or eventually, resulting in significant back-end environmental challenges. Of all plastics produced to 2017, several experts estimated that only about 9% have been recycled, nearly 12% have been incinerated, and the remaining 79% have accumulated in landfills or the natural environment.[59] Each means of disposal has environmental impacts, explored below.

i. Recycling

Although recycling is hailed by some as a possible solution to the plastics crisis, it is far from a panacea. Given that many plastic products contain toxic chemicals, recycling plastic products also transfers those chemicals into new products. For example, the popular puzzle toy known as the Rubik's Cube has been found to contain toxic flame retardants left over from recycled electronics products.[60]

Moreover, because recycling is not a lucrative business, most plastic recyclables from Western nations have historically been shipped to developing countries, most notably China.[61] In 2017, however, China announced that it no longer wanted to be the "world's garbage dump" and stopped accepting the world's plastic recyclables, resulting in buildups of plastic waste in many Western countries.[62] But the United States has continued sending its plastic to a host of other countries with poor labor and environmental regulations that mismanage most of their own plastic waste.[63] Malaysia, Thailand, and Vietnam have more recently taken steps to stem the tide of plastic imports, and now U.S. plastic is increasingly being sent to Cambodia, Laos, and countries in Africa

58. Roy Shapira & Luigi Zingales, *Is Pollution Value-Maximizing? The DuPont Case* 2 (Nat'l Bureau of Econ. Rsch., Working Paper No. 23866, 2017), https://perma.cc/GJ25-H7PE.

59. Geyer et al., *supra* note 23, at 1.

60. Joseph DiGangi et al., POPS Recycling Contaminates Children's Toys with Toxic Flame Retardants 8 (2007), https://perma.cc/TY7X-GNXV.

61. Erin McCormick et al., *Where Does Your Plastic Go? Global Investigation Reveals America's Dirty Secret*, Guardian (June 17, 2019), https://perma.cc/UX99-DGAK.

62. Kimiko de Freytas-Tamura, *Plastics Pile Up as China Refuses to Take the West's Recycling*, N.Y. Times (Jan. 11, 2018), https://perma.cc/9HL3-MDPL.

63. McCormick et al., *supra* note 61.

that had previously not handled U.S. plastic.[64] Since China's 2017 ban, however, only about half of the plastic waste the United States once exported is still being accepted by foreign markets.[65] U.S. public works facilities are now forced to deal with the waste, which has revealed an uncomfortable truth: it was never possible to recycle most plastic exported for that purpose.[66] An estimated 20 to 70 percent of plastic exported for recycling is ultimately discarded because it is unusable.[67] In developing countries, this has caused buildups of plastic waste with resulting environmental and human health concerns.[68] In the United States, it has resulted in more plastic waste being sent to incinerators and landfills.[69] Indeed, the U.S. plastic recycling rate peaked at just 9.5% in 2014 (including exported plastics) and decreased to a dismal 5–6% in 2021.[70] These figures suggest strongly that plastics recycling is not a viable solution to plastic waste and pollution.[71]

ii. Incineration

Approximately 11–14% of plastics are incinerated, releasing greenhouse gases as well as pollutants such as toxic dioxins and heavy metals.[72] Recent research suggests incineration does not eliminate plastic polymers: significant amounts of microplastics and heavy metals have been detected in residual incineration.[73]

iii. Disposal

Plastic waste can be discarded in landfills that comply with applicable design and operation standards.[74] Nearly half of discarded plastics are mismanaged,[75] however, resulting in littering or leaking from landfills into waterways

64. *Id.*
65. Erin McCormick et al., *Americans' Plastic Recycling Is Dumped in Landfills, Investigation Shows,* GUARDIAN (June 21, 2019), https://perma.cc/ZQN8-9ZQX.
66. *Id.*
67. McCormick et al., *supra* note 61.
68. *Id.*
69. McCormick et al., *supra* note 65.
70. BEYOND PLASTICS, THE REAL TRUTH ABOUT THE U.S. PLASTICS RECYCLING RATE 2–3 (2022).
71. *See id.* at 2. The report ridicules the notion that plastic recycling is a panacea as a "myth" furthered by the plastics industry.
72. *Id.* at 7; *see also* Geyer et al., *supra* note 23, at 2–3.
73. Zhan Yang et al., *Is Incineration the Terminator of Plastics and Microplastics?*, J. HAZARDOUS MATERIALS, July 8, 2020, at 1, 2.
74. *See infra* note 293 and accompanying text.
75. Laurent Lebreton & Anthony Andrady, *Future Scenarios of Global Plastic Waste Generation and Disposal*, 5 PALGRAVE COMM., 2019, at 5.

and the ocean.[76] Indeed, most plastic in the ocean comes from land-based sources, including plastic that was littered or improperly landfilled (due to coastal operations and litter carried from streams and rivers).[77]

At least eight million tons of plastics enter the ocean annually, the equivalent of dumping the contents of one garbage truck into the ocean every minute.[78] A major ocean plastic accumulation zone known as the Great Pacific Garbage Patch (between California and Hawaii) is now approximately 1.6 million square kilometers, roughly three times the size of France and twice the size of Texas.[79] The World Economic Forum estimates that by 2050, the ocean may contain more plastic than fish by weight.[80] Plastic on the ocean surface releases the greenhouse gases methane and ethylene when exposed to sunlight (a process called "photo-degradation"), with polyethylene, the most produced and discarded plastic globally, as the most prolific emitter of the gases.[81] Researchers found that this gas production "may continue indefinitely throughout the lifetime of plastics."[82]

Even proper containment in landfills, however, does not alleviate problems associated with plastic disposal. Municipal landfills generated an estimated 17% of methane emissions in the United States in 2018[83] and are major threats to groundwater.[84] The 2,000 active landfills in the United States are rapidly reaching capacity, with some estimates suggesting that room will run out by 2036.[85] Plastics are a large part of this problem: in 2018, U.S. landfills received 27 million tons of plastic, comprising 18.5% of municipal solid waste landfilled.[86]

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76. Jenna R. Jambeck et al., *Plastic Waste Inputs from Land into the Ocean*, 347 SCI. 768, 768 (2015).

77. Kumar A. Ganesh et al., *Review on Plastic Wastes in Marine Environment—Biodegradation and Biotechnological Solutions*, 150 MARINE POLLUTION BULL., Nov. 2019, at 1, 1.

78. WORLD ECON. F., THE NEW PLASTICS ECONOMY: RETHINKING THE FUTURE OF PLASTICS 7 (2016).

79. *The Great Pacific Garbage Patch,* OCEAN CLEANUP (Oct. 21, 2022), https://perma.cc/4D53-7HEW (citing L. Lebreton et al., *Evidence that the Great Pacific Garbage Patch Is Rapidly Accumulating Plastic*, 8 SCI. REPS., Mar. 2018, at 1, 5).

80. WORLD ECON. F., *supra* note 78, at 7.

81. Sarah-Jeanne Royer et al., *Production of Methane and Ethylene from Plastic in the Environment*, PLOS ONE, Aug. 1, 2018, at 1, 10.

82. *Id.* at 10.

83. Pradeep Jain et al., *Greenhouse Gas Reporting Data Improves Understanding of Regional Climate Impact on Landfill Methane Production and Collection*, PLOS ONE, Feb. 26, 2021, at 1, 1–2.

84. Yue Wang et al., *Site Selection for Municipal Solid Waste Landfill Considering Environmental Health Risks*, 138 RES. CONSERVATION & RECYCLING 40, 40 (2018).

85. Joe McCarthy, *Where Will the Trash Go When All the US Landfills Are Full?*, GLOB. CITIZEN (May 14, 2018), https://perma.cc/63LD-SMF4.

86. *Plastics: Material-Specific Data*, EPA (Sept. 19, 2022) https://perma.cc/2BR9-ARGH.

2. *Ubiquity of Plastics and Routes of Exposure*

Plastics' durability is a double-edged sword: it is one reason the material is so useful in product form, and it is also one cause of its most pressing environmental concerns. The toothbrushes we used as children, the polyester sweater we discarded last year, and the plastic cup containing our iced tea from earlier this week are not "gone;" they persist in the environment.[87] Unlike paper products, plastics do not decompose into benign natural materials; they break down into smaller pieces.[88] When plastics break down into pieces smaller than 5 millimeters, they are called microplastics.[89] Few parts of the world are untouched by microplastics. Airborne microplastics, for example, are nearly ubiquitous and can even be found in remote corners of the world, including the Arctic.[90] Researchers hypothesize that increasing concentrations of microplastics in sea ice may accelerate melting and thus cause faster sea level rise.[91] Microplastics are also abundant in soil, where they greatly influence the soil environment, though effects are just beginning to be researched.[92] Nanoplastics (microplastics broken into even smaller fragments) may be taken up by plants, thus entering our food supply.[93] Microplastics have also been found in the human placenta.[94]

Given the ubiquity of plastic products, people are exposed to microplastic particles persistently. Inhalation of airborne microplastics from polyester clothing fibers and other textiles is a major route of human exposure.[95] A study found microplastics in 81% of 159 globally sourced tap water samples.[96] Microplastics are also present in seafood and other food, in part due to chemi-

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87. *See* Geyer et al., *supra* note 23, at 1.
88. *Id.*
89. Hahladakis et al., *supra* note 40, at 183.
90. Melanie Bergmann et al., *White and Wonderful? Microplastics Prevail in Snow from the Alps to the Arctic*, SCI. ADVANCES, Aug. 14, 2019, at 1, 1.
91. N.-X. Geilfus et al., *Distribution and Impacts of Microplastic Incorporation Within Sea Ice*, 145 MARINE POLLUTION BULL. 463, 463 (2019).
92. Matthias C. Rillig et al., *Microplastic Effects on Carbon Cycling Processes in Soils*, PLOS BIOL., Mar. 2021, at 1, 1–2.
93. Lianzhen Li et al., *Effective Uptake of Submicrometre Plastics by Crop Plants Via a Crack-Entry Mode*, 3 NATURE SUSTAINABILITY 929, 929 (2020).
94. Antonio Ragusa et al., *Plasticenta: First Evidence of Microplastics in Human Placenta*, ENV'T INT'L, Dec. 2, 2020, at 1, 5 (finding microplastics in four out of the six placentas studied).
95. Christos Symeonides et al., *Buy-Now-Pay-Later: Hazards to Human and Planetary Health from Plastics Production, Use and Waste*, 57 J. PAEDIATRICS & CHILD HEALTH 1795, 1800 (2021).
96. Mary Kosuth et al., *Anthropogenic Contamination of Tap Water, Beer, and Sea Salt*, PLOS ONE, Apr. 2018, at 1, 1. "Tap water samples (n = 159 total; Table 1) were collected between January and April of 2017 from the following 14 countries: Cuba (n = 1), Ecuador (n = 24), England (n = 3), France (n = 1), Germany (n = 2), India (n = 17), Indonesia (n = 21), Ireland (n = 1), Italy (n = 1), Lebanon (n = 16), Slovakia (n = 8), Switzerland (n = 2), Uganda (n = 26), and the United States (n = 36)." *Id.* at 3.

cal transfer from food packaging or food-processing equipment.[97] For example, plastic food containers shed huge numbers of microplastics into hot water.[98] Babies whose formula is prepared in a plastic bottle with hot water may be swallowing more than one million microplastic particles each day.[99] Some researchers estimate that humans ingest between 0.1 grams and 5 grams of microplastics every week (for comparison, the average credit card weighs 5 grams).[100] Microplastics were detected in human blood for the first time recently, and were present in varying amounts in about three-quarters of subjects.[101] Nanoplastics are particularly worrisome as they may be able to cross cell membranes, the blood-brain barrier, and the human placenta.[102]

3. *Nature of Impacts*

Research suggests that this ubiquitous presence of plastics may cause serious adverse effects on the health of aquatic and terrestrial organisms, including people.

a. *Fish and Wildlife Impacts*

Plastic harms fish and wildlife through physical effects (entanglement, ingestion causing digestive blockages) and toxicological impacts from microplastics. The media has documented heart-wrenching pictures and videos of whales, birds, and seals entangled in plastic or killed by ingesting plastic.[103] A total of 557 different species of wildlife are known to have been affected by either entanglement or ingestion of plastic debris.[104]

Microplastics have been found to cause toxicological effects on marine animals, adversely affecting their health, feeding, growth, and survival.[105] Labora-

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97. Jane Muncke, *Tackling the Toxics in Plastics Packaging*, PLOS BIOL., Mar. 2021, at 1, 1.
98. Dunzhu Li et al., *Microplastic Release from the Degradation of Polypropylene Feeding Bottles During Infant Formula Preparation*, 1 NATURE FOOD 746, 746 (2020).
99. *Id.* at 747–48.
100. Kala Senathiraja et al., *Estimation of the Mass of Microplastics Ingested – A Pivotal First Step Towards Human Health Risk Assessment*, 404 J. HAZARDOUS MATERIALS, Oct. 2020 at 1, 11.
101. Heather A. Leslie et al., *Discovery and Quantification of Plastic Particle Pollution in Human Blood*, 163 ENV'T INT'L, Mar. 24, 2022, at 1, 5.
102. A. Dick Vethaak & Heather A. Leslie, *Plastic Debris Is a Human Health Issue,* 50 ENV'T SCI. TECH. 6825, 6825 (2016).
103. *See, e.g.*, Aristos Georgiou, *Heartbreaking Images that Show the Impact of Plastic on Animals in the Oceans*, NEWSWEEK (Sept. 18, 2019), https://perma.cc/GFF5-MWDH.
104. Suzanne Kühn et al., *Deleterious Effects of Litter on Marine Life*, *in* MARINE ANTHROPOGENIC LITTER 75–116 (Melanie Bergmann, Lars Gutow & Michael Klages eds., 2015).
105. JOINT GRP. EXPERTS SCI. ASPECTS MARINE ENV'T PROT., SOURCES, FATE AND EFFECTS OF MICROPLASTICS IN THE MARINE ENVIRONMENT: PART 2 OF A GLOBAL ASSESSMENT 44 (2016).

tory studies demonstrate that microplastics induce a strong inflammatory response in mollusks, with worsening response over a longer exposure time.[106] In fish, microplastics were found to cause changes in feeding behavior[107] and gene expression related to endocrine disruption and liver toxicity.[108] Concentration of chemicals associated with plastics—such as PCBs—increase up the food chain (bio-magnify) as predators eat prey containing microplastics and associated chemicals.[109] Humans are predators at the top of the food chain: currently, 89 species of fish have been reported to ingest microplastics, and 49 of these species are targeted commercially for human consumption.[110]

b. Human Health Impacts

Research into the health effects of plastic particles is still in its infancy, but studies of animals and human cells suggest that plastic particles can cause lung and gut injury by causing inflammation and cell damage.[111] A recent study found that microplastics can adhere to and destabilize red blood cells, impairing their proper functioning such as their ability to transport oxygen throughout the body.[112] The most concerning human health impacts posed by plastics relate to toxic chemicals present either in the plastic polymer structure or as additives. Bisphenols, for example, are used in the polymer structure to make polycarbonate plastics.[113] Polycarbonate plastics are not inert. Bisphenol chemicals leach out during the plastics' use into the product; plastic water bottles are one common example of where such leaching occurs.[114] Bisphenols are associated with a wide range of adverse health effects, including reproductive, cardiovascu-

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106. Nadia von Moos et al., *Uptake and Effects of Microplastics on Cells and Tissue of the Blue Mussel* Mytilus Edulis L. *After an Experimental Exposure*, 46 ENV'T SCI. TECH. 11327, 11330 (2012).

107. Tommy Cedervall et al., *Food Chain Transport of Nanoparticles Affects Behaviour and Fat Metabolism in Fish*, PLOS ONE, Feb. 2012, at 1, 1.

108. Chelsea M. Rochman et al., *Ingested Plastic Transfers Hazardous Chemicals to Fish and Induces Hepatic Stress,* 3 SCI. REPS., Nov. 2013, at 1, 1; Chelsea M. Rochman et al., *Early Warning Signs of Endocrine Disruption in Adult Fish From the Ingestion of Polyethylene With and Without Sorbed Chemical Pollutants From the Marine Environment,* 493 SCI. TOTAL ENV'T 656, 660 (2014).

109. Sarah E. Nelms et al., *Investigating Microplastic Trophic Transfer in Marine Top Predators*, 238 ENV'T POLLUTION 999, 1005 (2018).

110. JOINT GRP. EXPERTS SCI. ASPECTS MARINE ENV'T PROT., *supra* note 105 at 70.

111. Vethaak Leslie, *supra* note 102, at 6825.

112. Jean-Baptiste Fleury & Vladimir A. Baulin, *Microplastics Destabilize Lipid Membranes by Mechanical Stretching*, PROC. NAT'L ACAD. SCIS., July 2021, at 1, 1.

113. *See* Hoa H. Le et al., *Bisphenol A Is Released from Polycarbonate Drinking Bottles and Mimics the Neurotoxic Actions of Estrogen in Developing Cerebellar Neurons*, 176 TOXICOLOGY LETTERS 149, 149 (2007).

114. *Id.* at 150.

lar, and immune system harm.[115] Bisphenol A ("BPA") is now nearly ubiquitous in the environment, and although its use is increasingly being phased out due to its well-known toxic effects, the chemical and plastic industries have substituted related bisphenol chemicals such as Bisphenol S ("BPS"), which appear to have similar health concerns.[116]

Fluoropolymers belong to the PFAS class of chemicals, which pose unique concerns to human health.[117] Polytetrafluorethylene, for example, is a type of fluoropolymer used in products such as Teflon nonstick cookware.[118] Under certain conditions such as high temperatures, fluoropolymers can break down, releasing PFAS, which are associated with immune system dysregulation, thyroid disease, and cancer.[119] PFAS are popularly called "forever chemicals" because they persist indefinitely in the environment and for many years in the human body.[120]

Additive chemicals with flame retardant, waterproofing, or plasticizing qualities (which can be distinguished from chemicals in the polymer structure) are mixed with the polymer to enhance the plastic product.[121] Over 8,000 additives are used in combination with polymers to create plastic products.[122] Additive chemicals are typically not bonded to the plastic and may leach out of plastic products over time.[123] In fact, researchers hypothesize that nanoplastics act as a sort of "Trojan horse" in introducing toxic additive chemicals to our bodies because very small plastic particles can cross cell membranes and may enhance absorption of additive chemicals.[124] For example, virtually all pregnant women studied in the United States have the plastic additives polybrominated diphenyl ethers ("PBDEs") and phthalates in their blood.[125] PBDEs, which are associated with adverse neurobiological outcomes, are flame retardant chemicals

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115. Da Chen et al., *Bisphenol Analogues Other Than BPA: Environmental Occurrence, Human Exposure, and Toxicity—A Review*, 50 ENV'T SCI. & TECH. 5438, 5438 (2016).

116. *Id.*

117. Lohmann et al., *supra* note 57, at 12820.

118. *Id.* at 12821.

119. *Id.* at 12823–24.

120. Ying Li et al., *Half-Lives of PFOS, PFHxS and PFOA After End of Exposure to Contaminated Drinking Water*, 75 OCCUPATIONAL & ENV'T MED. 46, 47 tbl.1 (2017). EPA proposed designating certain PFAS as hazardous substances under Superfund in August 2022. Press Release, EPA, EPA Proposes Designating Certain PFAS Chemicals as Hazardous Substances Under Superfund to Protect People's Health (Aug. 26, 2022), https://perma.cc/VQG2-R5BD.

121. MARK S. ROSSI & ANN BLAKE, CLEAN PROD. ACTION, PLASTICS SCORECARD 29 (2014).

122. Wiesinger et al., *supra* note 50, at 9344.

123. Hahladakis et al., *supra* note 40, at 184, 190.

124. Vethaak, *supra* note 111, at 6825.

125. Tracey J. Woodruff et al., *Environmental Chemicals in Pregnant Women in the United States: NHANES 2003–2004,* 199 ENV'T HEALTH PERSPS. 878, 881 (2011).

often put in plastic enclosures encasing electronics.[126] Phthalates make plastic products more malleable and are known hormone disruptors.[127] One study reported that sperm counts among men in Western countries have declined nearly 60% in the last forty years, which those scientists attribute in part to endocrine-disrupting chemicals such as phthalates.[128] Phthalates are also strongly associated with pregnancy loss; in one study, women with the highest levels of phthalates had a 17% chance of early pregnancy loss compared to 4% among the women with the lowest levels.[129] Phthalates may also impact children's IQ: one study found that children whose mothers had the highest levels of phthalates during pregnancy had IQs on average seven points below those whose mothers had the lowest levels.[130]

The reality is that we do not fully know the health concerns posed by our near-constant exposure to plastic and its additive chemicals. Unlike pharmaceuticals and pesticides, there currently is no systematic process for pre-market testing or post-market surveillance for chemicals added to consumer products.[131] Of approximately 10,500 known plastic monomers, additives, and processing aids, about 4,100 lack any reported hazard classifications, and 2,400 are classified as medium to high concern.[132] Global chemical production has increased 50-fold since 1950,[133] with an estimated 350,000 chemicals on the global market.[134] Existing information about microplastics and plastic additives, including flame retardants, phthalates, bisphenols, and PFAS, however, suggest that an increasingly plastic world may pose enormous risks to public health.

126. Julie B. Herbstman et al., *Prenatal Exposure to PBDEs and Neurodevelopment*, 118 ENV'T HEALTH PERSPS. 712, 716 (2010).

127. *See, e.g.*, Shanna H. Swan et al., *Decrease in Anogenital Distance Among Male Infants with Prenatal Phthalate Exposure*, 113 ENV'T HEALTH PERSPS. 1056, 1056 (2005) (discussing adverse effects on reproductive system).

128. Hagai Levine et al., *Temporal Trends in Sperm Count: A Systemic Review and Meta-Regression Analysis*, 23 HUM. REPROD. UPDATE 646, 652 (2017); *see also* Susan M. Duty et al., *The Relationship Between Environmental Exposures to Phthalates and DNA Damage in Human Sperm Using the Neutral Comet Assay*, 111 ENV'T HEALTH PERSPS. 1164, 1166–67 (2003). *But see* Marion Boulicault et al., *The Future of Sperm: A Bioavailability Framework for Understanding Global Sperm Count Trends*, HUM. FERTILITY, May 2021 (questioning earlier methodologies and interpretations of reasons for variability in human sperm counts).

129. Carmen Messerlian et al., *Urinary Concentration of Phthalate Metabolites in Relation to Pregnancy Loss Among Women Conceiving with Medically Assisted Reproduction*, 27 EPIDEMIOLOGY 879, 882 (2016).

130. Pam Factor-Litvak et al., *Persistent Associations Between Maternal Prenatal Exposure to Phthalates on Child IQ at Age 7 Years,* PLOS ONE, Dec. 2014, at 1, 10–12.

131. Symeonoides et al., *supra* note 95.

132. Wiesinger et al., *supra* note 50, at 9343–45.

133. EUROPEAN ENV'T AGENCY, CHEMICALS FOR A SUSTAINABLE FUTURE 10 (2017).

134. Zhanyun Wang et al., *Toward a Global Understanding of Chemical Pollution: A First Comprehensive Analysis of National and Regional Chemical Inventories*, 54 ENV'T SCI. & TECH. 2575, 2575 (2020).

Chronic human disease has increased dramatically in the last several decades—mirroring the increase in plastics production.[135] Though a confluence of factors undoubtedly contribute to this increase, the demonstrated toxicological effects of many chemicals used in plastic products parallel many of the diseases increasingly plaguing society.

i. Disproportionate Impacts

Plastics pose considerable risks to human health, but not all people are equally at risk. Pregnant women, developing fetuses, and children, for example, are among the populations most susceptible to the hormone-disrupting properties of some plastics and additive chemicals.[136] Certain populations are also more exposed to pollution from plastic manufacturing and disposal by virtue of their geography. For example, residents of Cancer Alley in Louisiana have a 50% greater likelihood of developing cancer than the national average.[137] Louisiana has the highest concentration of petrochemical facilities in the entire Western Hemisphere.[138] People living within three miles of these petrochemical facilities earn 28% less than the average U.S. household and are 67% more likely to be people of color.[139] Cancer Alley has had one of the highest death rates from COVID-19, prompting studies which found a strong association between air pollution from the nearby petrochemical facilities and COVID-19 severity.[140]

Disposed plastics also lead to inequitable distributions of exposure. Approximately 4.4 million people in the United States are exposed to pollution from the 73 waste incinerators across the country, with 79% located within three miles of low-income and minority neighborhoods.[141] U.S. plastic recycling also poses significant environmental and human health hazards in foreign countries. The United States exports more than one million tons of its plastic

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135. *See, e.g.*, Aaron Lerner et al., *The World Incidence and Prevalence of Autoimmune Diseases Is Increasing*, 3 INT'L J. CELIAC DISEASE 151, 152–54 (2015).

136. *See, e.g.,* Marya G. Zlatnik, *Endocrine-Disrupting Chemicals and Reproductive Health*, 61 J. MIDWIFERY & HEALTH 442, 442–43 (2016).

137. Wesley James et al., *Uneven Magnitude of Disparities in Cancer Risk from Air Toxics*, 9 INT'L J. ENV'T RSCH. & PUB. HEALTH 4365, 4369 (2012) (comparing average rates of cancer risk in Cancer Alley, Louisiana, and rest of United States).

138. Keehan, *supra* note 52, at 345. Cancer Alley spans "an eighty-five mile stretch of land" along the Louisiana portion of the Mississippi River. *Id.*

139. JIM VALLETTE, BEYOND PLASTICS, THE NEW COAL: PLASTICS & CLIMATE CHANGE 6 (2021).

140. Kimberly A. Terrell & Wesley James, *Racial Disparities in Air Pollution Burden and COVID-19 Deaths in Louisiana, USA, in the Context of Long-Term Changes in Fine Particulate Pollution*, ENV'T JUST. 1, 5–10 (2020).

141. Oliver Milman, *Revealed: 1.6m Americans Live Near the Most Polluting Incinerators in the US,* GUARDIAN (May 21, 2019), https://perma.cc/4SRD-W5HS.

waste annually.[142] Exporting plastic waste leads to an "out of sight and out of mind" mentality for consumers in high-income countries, leading to sustained consumption.[143] But for developing countries that import plastic waste, the ramifications of continued plastic consumption are far more apparent. In Cambodia, for example, some villages are so swamped with plastic that residents have raised their homes on stilts to keep them afloat above a sea of plastic.[144] People living closer to landfill sites suffer from higher rates of medical conditions including asthma, reoccurring flu, and stomach problems, with participants in one study indicating fear for their health.[145]

II. The Limits of Environmental Law

A. Introduction and Guiding Principles

To address the environmental impacts of plastics summarized in Part I, the federal and state governments extensively regulate manufacturing, use, and disposal of plastics. For example, EPA and states regulate water pollution discharges under the CWA via permits that apply best technology ("technology-based") treatment requirements augmented by stricter limits to protect ambient water quality ("water quality-based" regulations).[146] EPA and states control air emissions under the CAA through a similar system, through best technology and residual risk requirements.[147] EPA establishes requirements for treatment, storage, and disposal of hazardous wastes generated during plastics manufacturing and when plastics are reused or recycled through incineration or other industrial processes.[148] EPA and states regulate disposal of plastics in municipal landfills.[149] The Occupational Safety and Health Administration regulates worker exposure to chemicals and other hazards during plastics manufacturing.[150] In CERCLA, Congress established removal and remediation requirements and liability for cleanup of hazardous substances released during plastics

142. McCormick et al., *supra* note 61.

143. Stuart J. Barnes, *Out of Sight, Out of Mind: Plastic Waste Exports, Psychological Distance and Consumer Plastic Purchasing*, Glob. Env't Change, July 2019, at 1, 1.

144. McCormick et al., *supra* note 61.

145. Prince O. Njoku et al., *Health and Environmental Risks of Residents Living Close to a Landfill: A Case Study of Thohoyandou Landfill, Limpopo Province, South Africa*, 16 Int'l J. Env't Res. & Pub. Health, June 15, 2019, at 1, 3, 14.

146. *See infra* Part II.B.

147. *See id.*

148. *See* 42 U.S.C. §§ 6921–25 (requiring EPA regulations governing generation, treatment, storage, and disposal of hazardous waste).

149. *See id.* § 6944 (requiring EPA regulations governing sanitary landfills).

150. *See* Occupational Safety and Health Act of 1970, 29 U.S.C. §§ 651–75, 677–78; 42 U.S.C. § 3142-1.

manufacturing, processing, and use or disposal.[151] Also pursuant to CERCLA, EPA establishes detailed requirements for hazardous substance removal and remediation.[152] The Food and Drug Administration ("FDA") has authority to regulate plastics in food packaging.[153] Other laws and regulations apply to particular plastics disposal problems, such as ocean pollution and product and waste exports to other countries.[154] Some state and local governments have adopted laws or regulations governing single-use plastics, with varying levels of success.[155]

Despite this massive regulatory process, the health and environmental effects of plastics continue to grow. This raises two fundamental questions. First, why has this extensive regulatory scheme failed so badly to control the adverse effects of plastics? Second, if those impacts cannot be controlled, why can we not ban or curtail production and use of dangerous plastics?

In most respects, U.S. environmental law reflects a liberal approach to political economy. In a free market, producers decide what to manufacture and consumers decide what to purchase and use, and for what purposes. Under this view, aggregate production and consumption decisions promote economic efficiency.[156] If consumers do not value a product, they purchase less of it, and vice versa. Profit-maximizing manufacturers reduce or increase production accordingly. Everyone is better off, without government intervention.

One problem with this rosy picture is that externalities distort free market efficiency. Externalities are costs imposed on others and thus not considered in free market decisions.[157] Manufacturing externalities include pollution, the costs of which are borne by others, such as residents who live near a factory and breathe air pollution or drink contaminated water. Because manufacturers do

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151. *See* 42 U.S.C. §§ 9604, 9606, 9607 (establishing hazardous substance removal, remediation, and liability requirements).

152. *See id.* § 9605 (requiring adoption of National Contingency Plan including cleanup requirements).

153. *See infra* Part II.C.2(b).

154. *See, e.g.*, Joan M. Bondareff et al., *Plastics in the Ocean: The Environmental Plague of Our Time*, 22 Roger Williams U. L. Rev. 360, 367–76 (2017) (evaluating effectiveness of U.S. laws governing marine disposal of plastics); Jessica R. Coulter, Note, *A Sea Change to Change the Sea: Stopping the Spread of the Pacific Garbage Patch with Small-Scale Environmental Legislation*, 51 Wm. & Mary L. Rev. 1959, 1965–73 (2010) (evaluating efforts to address ocean disposal of plastics); Ying Xia, *China's Environmental Campaign: How China's "War on Pollution" Is Transforming the International Trade in Waste*, 51 N.Y.U. J. Int'l L. & Pol. 1101, 1122–25 (2019) (evaluating regulation of U.S. export of plastics).

155. *See* Sarah J. Morath, *Our Plastic Problem*, 33 Nat. Res. & Env't 45, 46–47 (2019); Qiying Zhu, *The California Plastic Bag Ban: Where Do We Go from Here?*, 5 Ariz. J. Env't L. & Pol'y 1053, 1055–57 (2015); Coulter, *supra* note 154, at 1972–73.

156. *See* David M. Driesen, The Economic Dynamics of Environmental Law 20–21 (2003) (describing efficiency as "a summation of private preferences" as part of a critique of this view of efficiency).

157. *See id.* at 18 (referring to externalities as "effects costs").

not incur those costs directly, absent altruism, they lack incentive to consider pollution in production decisions. Altruism is limited in corporate decisions because corporate managers and directors have a fiduciary duty to shareholders to maximize profits.[158] Now, not everyone is better off absent intervention to correct the market distortion.

The predominant response to pollution externalities in U.S. environmental law is government regulation.[159] Regulations require producers to control pollution, thus "internalizing" the costs otherwise imposed. This protects third parties from harm and forces producers to consider control costs in production decisions. One main limitation of this approach, however, is the cost, expense, and time necessary to adopt and enforce effective regulations. Part II.B shows that our environmental regulatory system has stagnated due to the granularity of the process and the massive complexity involved in regulating plastics.

Even if regulation adequately controlled pollution from plastics production, the volume of plastics produced and used and ineffective waste disposal requirements have left a massive waste disposal problem.[160] A potential free market response is that adequately informed consumers might consider pollution impacts of plastics in purchasing decisions. To modify the canon stated above: If consumers do not value a particular product sufficiently, *or if they believe it causes more harm than good*, they will purchase less. Rational manufacturers will reduce or increase production accordingly. Everyone is again better off, without government intervention.

Absent altruism, however, consumers are not likely to sacrifice to generate "public goods," the benefits of which are spread widely.[161] Some programs assume adequately informed consumers will make environmentally beneficial choices.[162] Because consumers are not constrained by fiduciary duty, they are freer to base decisions on factors external to their welfare. The efficacy of this

158. *See In re* Trados Inc. S'holder Litig., 73 A.3d 17, 37 (Del. Ch. 2013) (holding "the duty of loyalty therefore mandates that directors maximize the value of the corporation over the long-term for the benefit of the providers of equity capital").

159. *See* J. Clarence Davies & Jan Mazurek, Pollution Control in the United States, Evaluating the System 15 (1998).

160. *See supra* Part I.B.

161. *See* Driesen, *supra* note 156, at 99.

162. Labeling can inform consumers about harm they might incur from products. *See, e.g.*, Clifford Rechtschaffen, *The Warning Game: Evaluating Warnings Under California's Proposition 65*, 23 Ecology L.Q. 303, 306–07 (1996). Examples such as "dolphin-safe" labeling requirements assume consumers consider external environmental impacts. *See* Brett Grosko & Andrew Long, *The World Trade Organization's Tuna Dolphin Decision*, 44 Trends 29, 32 (2012).

approach, however, depends on the availability and accuracy of information and its use.[163]

One potential solution to this problem would be to require producers to internalize the back-end costs of plastics as well as production externalities, that is, to bear the costs of proper product disposal or to manufacture products that can more readily be reused or recycled. Although such extended producer responsibility ("EPR") and circular economy ("CE") requirements have been adopted in Europe and in several U.S. states,[164] they have not been adopted at a national scale in the United States despite calls to do so.[165] A second potential regulatory solution would be regulations or taxes to ban or curtail production and use of plastics, or of some kinds of plastics or plastics uses. Part II.C argues that the predominantly free market philosophy of U.S. environmental law has precluded that strategy on a large scale, explaining our inability to control the most serious environmental harms caused by plastics.

B. Complexity, Stagnation, and Scale: Overwhelming the Regulatory Process

Environmental law has failed to effectively curtail harm associated with plastics in part due to rapid development of new materials relative to our ability to adopt new or amended regulations. Because it is impossible to catalog this fully here, we use as a principal example the water pollution rules for the plastics industry. Part II.B.1 applies this analysis to EPA's technology-based rules for plastics. Part II.B.2 does so for water quality-based controls.

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163. *See* Peter S. Menell, *Environmental Federalism: Structuring a Market-Oriented Federal Eco-Information Policy*, 54 Md. L. Rev. 1435, 1436 (1995) (discussing challenges of consumer education approaches).

164. California, Maine, and Oregon have passed EPR laws for plastic packaging. *See* S. B. 54, 2021–22 Reg. Sess. (Cal. 2022); Me. Rev. Stat. tit. 38, § 2146 (2019); S. B. 582, 81st Legis. Assemb., Reg. Sess. (Or. 2021). *See also* Mary Ellen Ternes, *Plastics: Global Outlook for Multinational Environmental Lawyers*, 35 Nat. Res. & Env't 36, 39–40 (2020) (describing efforts by the European Union, United Nations, and individual nations); Madeline June Kass, *Fishing for Plastic: EU Targets Marine Pollution*, 34 Nat. Res. & Env't 58, 58–59 (2019) (describing EU's Circular Economy Action Plan). *But see* Erin Eastwood et al., *Marine Plastic Pollution: How Global Extended Producer Responsibility Can Help*, 50 Env't L. Rep. 10976, 10978 (2020) (noting 119 EPR laws regarding fourteen non-plastics product categories in thirty-three U.S. states).

165. *See* Rachel Hart, *Shifting the Burden of Plastic Bags: A Proposal for a Federal Extended Producer Responsibility* Law, 9 LSU J. Energy L. & Res. 531, 533 (2021); Hannah M. Diaz, *Plastic: Breaking Down the Unbreakable*, 19 Fla. Coastal L. Rev. 85, 110–12 (2018) (arguing for U.S. EPR requirements); Marcus Eriksen, *The Plastisphere—The Making of a Plasticized World*, 27 Tul. Env't L.J. 153, 162–63 (2014) (advocating shift from consumer to producer responsibility).

1. Complexity and Stagnation in Best Technology Controls

In the CAA and the CWA, EPA determines the "best" technology available to reduce air and water pollution from industrial production.[166] Likewise, EPA promulgates best technology standards to minimize harm from transportation and disposal of hazardous industrial wastes[167] and landfill design and operation standards to minimize environmental harm from industrial and municipal waste disposal.[168] EPA adopted technology-based water pollution controls for the plastics industry in 1987.[169]

Although technology-based regulation is a logical and effective system to control industrial pollution,[170] it is extremely complex. "Best" pollution control technology varies with product and manufacturing process,[171] and factors such as plant location and size.[172] Therefore, EPA first must determine how to classify industry categories to assess available control methods and equipment.[173] Then it must evaluate that technology's effectiveness and affordability to control pollutants. EPA subdivided the organic chemical, plastics, and synthetic fibers ("OCPSF") industry into seven subcategories based on product.[174] It further distinguished between dischargers who do or do not use end-of-pipe biological treatment and between plants that discharge directly into surface waters versus plants that discharge into public sewage treatment plants.[175] EPA's emis-

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166. *See* 33 U.S.C. §§ 1311(a), 1314(b), 1316 (requiring technology-based controls for water pollution); 42 U.S.C. §§ 7411(a), 7502(c), 7501(3), 7503(a)(2), 7479 (requiring technology-based controls for air pollution).

167. *See* 42 U.S.C. §§ 6923 (requiring hazardous waste transportation standards), 6924 (requiring hazardous waste disposal standards).

168. *See id.* § 6925 (requiring permits and standards for hazardous waste treatment, storage, or disposal facilities).

169. 40 C.F.R. § 414 (2022) (effluent limitations guidelines for the organic chemicals, plastics, and synthetic fibers industry category) [hereinafter OCPSF effluent limitations guidelines].

170. *See* Wendy E. Wagner, *The Triumph of Technology-Based* Standards, 2000 U. ILL. L. REV. 83, 84 (2000).

171. *See, e.g.*, Weyerhaeuser Co. v. Costle, 590 F.2d 1011, 1020–24 (D.C. Cir. 1978) (illustrating variability in paper making processes and impact on pollution control).

172. *See, e.g.*, Ass'n Pac. Fisheries v. EPA, 615 F.2d 794, 802 (9th Cir. 1980) (illustrating effect of location and production capacity on pollution controls).

173. EPA has promulgated effluent limitations for sixty-seven industry categories. *See* 40 C.F.R. §§ 405–71 (2022).

174. *See* 40 C.F.R. § 414, Subparts B–H (2022) (rayon fibers, other fibers, thermoplastic resins, thermosetting resins, commodity organic chemicals, bulk organic chemicals, and specialty organic chemicals).

175. *See id.* Subparts I–K. Indirect dischargers must pretreat industrial waste to protect public sewage treatment plants from toxic chemicals and to prevent pass-through of pollutants into receiving waters. *See* 33 U.S.C. § 1317(b).

sions standards for air pollutants are similarly granular by industry subcategory.[176]

Each statute also includes multiple definitions of "best" technology. Thus, for each subcategory of OCPSF effluent guidelines,[177] EPA adopted separate limitations reflecting the "best practicable technology currently available" ("BPT") for conventional pollutants governed by the first round of CWA pollution controls,[178] the "best available technology economically achievable" ("BAT") for toxic pollutants under the second round of controls,[179] new source performance standards ("NSPS") for new plants,[180] and pretreatment standards for existing and new sources discharging to public treatment plants.[181] The CAA has an even more complex array of technology-based standards.[182]

The process through which EPA ascertains the degree of pollution reduction attainable using each definition of best technology is complex and laborious, as described in EPA's lengthy "development document" for the OCPSF effluent limitations.[183] After subcategorizing the industry,[184] EPA characterized the waste streams and decided which pollutants to regulate for each subcategory

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176. EPA adopted hazardous air pollutant emissions standards for plastics industry sectors. *See, e.g.*, 40 C.F.R. § 63, Subparts F, G (2022) (synthetical organic chemicals), U (Group I polymers and resins), JJJ (Group IV polymers and resins), OOO (ammo-phenolic resins), PPPP (surface coating of plastic parts and products), WWWW (reinforced plastic composites production).

177. *See, e.g.*, 40 C.F.R. § 414, Subpart D (2022) (establishing standards of "best" technology pursuant to different definitions for thermoplastic resins subcategory).

178. *See* 33 U.S.C. § 1311(b)(1)(A) (requiring BPT by July 1, 1977).

179. *See id.* § 1311(b)(2)(A) (requiring supplemental effluent limitations for identified toxic pollutants).

180. *See id.* § 1316 (requiring new source standards for plastics and synthetic materials manufacturing).

181. *See id.* § 1317(b), (c) (requiring pretreatment standards for existing and new sources). EPA must also develop effluent limitations reflecting the "best conventional pollutant control technology" for listed conventional pollutants. *See id.* § 1311(b)(2)(E). EPA "reserved" this category for the OCPSF industry. *See* 40 C.F.R. § 414, Subparts B–H (2022).

182. *See, e.g.*, 42 U.S.C. §§ 7411 (requiring and defining new source performance standards as reflecting the "best system of emissions reductions"), 7412 (requiring and defining National Emission Standards for Hazardous Air Pollutants ("NESHAPs") as "maximum achievable control technology" or more stringent requirements to reduce residual risk from hazardous air pollutants), 7502 (requiring "reasonably available control technology" for major existing sources), 7479 (requiring "best available control technology" for major new or modified major sources in areas attaining ambient air quality standards (attainment areas)), 7501(3) (requiring the "lowest achievable emission rate" for new and modified major sources in areas not attaining ambient air quality standards (nonattainment areas)).

183. EPA, 440/1-87/009, Development Document for Effluent Limitations Guidelines and Standards for the Organic Chemicals, Plastics, and Synthetic Fibers Point Source Category, Vols. I, II (1987) [hereinafter 1987 OCPSF Development Document].

184. *See id.* Sections III–IV.

through sampling and industry surveys.[185] Next, EPA analyzed available and affordable technologies to treat pollutants, and to what degree, before proposing numeric effluent limitations.[186] Given variability in production processes, products, waste streams, and control technologies, this required complex sampling and statistical analysis.[187] EPA then proposed and promulgated the rule pursuant to the Administrative Procedure Act[188] and additional regulatory review processes imposed by the President and Congress.[189]

Final rules are subject to judicial challenge, with potential vacatur or remand and another regulatory cycle in response.[190] Industry challenged EPA's initial OCPSF effluent limitations adopted in 1974–1976,[191] causing those rules to be remanded or withdrawn.[192] It took over a decade for EPA to replace those regulations in 1987, whereupon they were challenged again by one environ-

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185. *See id.* Sections V–VI.

186. *See id.* Sections VI–VIII.

187. *See id.* Sections IX–XIII.

188. 5 U.S.C. §§ 701–706.

189. President Reagan first required cost-benefit analysis of agency rules. *See* Exec. Order No. 12,291, 46 Fed. Reg. 13193 (Feb. 17, 1981). Some criticized these extra-statutory rulemaking requirements, *see* Thomas O. McGarity, *Regulatory Analysis and Regulatory Reform*, 65 TEX. L. REV. 1243, 1246 (1987); Erik Olson, *The Quiet Shift of Power: Office of Management and Budget Supervision of Environmental Agency Rulemaking Under Executive Order 12,291*, 4 VA. J. NAT. RES. L. 1, 51 (1984), but Democratic presidents continued the practice. *See, e.g.*, Exec. Order No. 12,866, 58 Fed. Reg. 51735 (Sept. 30, 1993) (issued by President Clinton). Congress added requirements in the Unfunded Mandates Reform Act, Pub. L. No. 104-4, § 202, 109 Stat. 48 (1995) (codified at 2 U.S.C. § 1532). Other new requirements include Exec. Order No. 12,866, 58 Fed. Reg. 51735 (Sept. 30, 1993) (Regulatory Planning and Review); Exec. Order No. 13,563, 76 Fed. Reg. 3821 (Jan. 18, 2011) (Improving Regulation and Regulatory Review); Exec. Order No. 13,771, 82 Fed. Reg. 9339 (Jan. 30, 2017) (Reducing Regulations and Controlling Regulatory Costs); Paperwork Reduction Act, 44 U.S.C. §§ 3501–3521; Regulatory Flexibility Act, 5 U.S.C. §§ 601–612; Exec. Order No. 13,132, 64 Fed. Reg. 43255 (Aug. 4, 1999) (Federalism); Exec. Order No. 13,175, 65 Fed. Reg. 67249 (Nov. 6, 2000) (Consultation and Coordination with Indian Tribal Governments); Exec. Order No. 13,045, 62 Fed. Reg. 19885 (Apr. 21, 1997) (Protection of Children from Environmental Health Risks and Safety Risks); Exec. Order No. 13,211, 66 Fed. Reg. 28355 (May 18, 2001) (Actions Concerning Regulations that Significantly Affect Energy Supply, Distribution, or Use); National Technology Transfer and Advancement Act, 15 U.S.C. §§ 3701–3714; Exec. Order No. 12,898, 59 Fed. Reg. 7629 (Feb. 11, 1994) (Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations); and Congressional Review Act, 5 U.S.C. §§ 801–808.

190. 33 U.S.C. § 1369(b) (providing for judicial review of EPA effluent limitations guidelines in the U.S. Courts of Appeals).

191. *See* 1987 OCPSF DEVELOPMENT DOCUMENT, *supra* note 183, at I-5.

192. *See id.*; Union Carbide v. Train, 541 F.2d 1171 (4th Cir. 1976) (approving remand pursuant to joint motion and stipulation of the parties); FMC Corp. v. Train, 539 F.2d 973, 980–83 (4th Cir. 1976) (remanding regulations for failure to address variability in hydraulic flows within the industry and improper use of control parameter absent record evidence of control technology).

mental organization and by chemical companies and trade associations.[193] The Fifth Circuit largely upheld the regulations this time,[194] after noting the immense complexity of the challenges.[195] It remanded portions of the rule, however, leading to another rulemaking.[196]

Since that time, the speed with which the plastics industry has evolved, changes in plastic types and uses, and the massive increase in plastics production, use, and disposal, has overwhelmed the regulatory process.[197] The OCPSF rules have not been significantly updated in decades,[198] although EPA recently began a limited review for some chemicals and some producers.[199] This leaves significant unregulated pollution despite statutory requirements to review and revise applicable regulations to address those gaps.

Congress intended water pollution control to become increasingly stringent, with the goal of *eliminating* the discharge of point source pollutants by 1985,[200] two years before EPA adopted OCPSF effluent limitations. Thus, best technology requirements proceeded from immediately available controls (BPT) to stricter controls (BAT) to reduce or eliminate discharges using improved technology. As explained in the 1972 Report of the Senate Committee on Public Works, to which the 1972 legislation was referred:

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193. *See* Chem. Mfrs. Ass'n v. EPA, 870 F.2d 177 (5th Cir. 1989).

194. *See id.* at 184–88 ("summarizing" the court's holdings in four pages).

195. *See id.* at 184 (noting the "case is of such complexity that the parties have submitted briefs totalling [sic] more than 3,000 pages and a joint appendix 9,000 pages long distilled from a 600,000-page administrative record").

196. *See id.* at 235–36, 262–67.

197. Others have described the "ossification" of regulatory processes. *See, e.g.*, Thomas O. McGarity, *Some Thoughts on "Deossifying" the Rulemaking Process*, 41 Duke L.J. 1385 (1992) (critiquing the cumbersome nature of federal rulemaking process generally); David Schoenbrod, *Goals Statutes or Rules Statutes: The Case of the Clean Air Act*, 30 UCLA L. Rev. 740 (1983) (lamenting the complexity of CAA regulatory process); Davies & Mazurek, *supra* note 159, at 2 (decrying "byzantine" provisions of federal environmental statutes).

198. The CFR identifies the sources of the OCPSF regulation as 52 Fed. Reg. 42568 (Nov. 5, 1987), "unless otherwise noted." 40 C.F.R. § 414 (2022). The rule has been amended only twice, in 1992 and 1993. The 1992 amendment weakened the guidelines by allowing flexibility for individual facilities discharging cyanide-bearing wastes to settle litigation with the chemical industry. *See* 57 Fed. Reg. 41836, 41836 (Sept. 11, 1992). The 1993 amendments responded to the Fifth Circuit's remand of aspects of the original rule in *Chemical Manufacturers Association*, 870 F.2d 177, *modified*, 885 F.2d 253 (5th Cir. 1989), *cert. denied*, PPG Indus. Inc. v. EPA, 495 U.S. 910 (1990), but did not substantially change the rule. *See* 58 Fed. Reg. 36872, 36873 (July 9, 1993). One author was a counsel of record for petitioner Natural Resources Defense Council in this litigation. *See Chem. Mfrs. Ass'n*, 870 F.2d at 183.

199. Advance Notice of Proposed Rulemaking Clean Water Act Effluent Limitations Guidelines and Standards for the Organic Chemicals, Plastics and Synthetic Fibers Point Source Category, 86 Fed. Reg. 14560 (Mar. 17, 2021) [hereinafter CWA Proposed Rulemaking].

200. 33 U.S.C. § 1251(a)(1) (establishing the zero-discharge goal); *see also id.* § 1314(b)(3) (requiring EPA to adopt zero discharge effluent limitations wherever attainable).

> The distinction between best practicable and best available is intended to reflect the Committee's intent [to] press toward increasingly higher levels of control, applied over five year periods. Through research and development of new processes, and other improvements in technology, the Committee anticipates that it should be possible, taking into account the cost of controls, to achieve, by 1981 levels of control approaching 95-99 percent reduction of pollutants discharged in most cases and complete recycling in the remainder.[201]

Congress demanded even stricter controls for new sources, which do not face the same design and operational constraints as older facilities.[202] Congress also directed EPA to review and revise effluent limitations frequently to reflect new control and production methods.[203]

Despite the requirement that BAT require stricter pollution control than BPT,[204] EPA determined BAT was identical to BPT for OCPSF plants producing up to five million pounds of products annually.[205] The BPT rules control only three conventional pollutants, with no limits on toxic pollutants for smaller OCPSF plants.[206] For larger facilities, the rules establish effluent limitations for sixty-two toxic pollutants[207] based on EPA's waste stream characterizations

201. S. Rep. No. 92-414 (1972).

202. 33 U.S.C. § 1316(a) (requiring new source standards reflecting "the greatest degree of effluent reduction which [EPA] determines to be achievable through application of the best available demonstrated control technology, processes, operating methods, or other alternatives, including, where practicable, a standard permitting no discharge of pollutants."). *See* S. Conf. Rep. 92-1236 (1972).

203. Under one provision, EPA must revise its effluent limitations guidelines regulations annually. 33 U.S.C. § 1314(b). Under another, reviews must occur at least every five years. *Id.* § 1311(d). The 1987 amendments required EPA to publish a biennial plan establishing "a schedule for the annual review and revision of promulgated effluent guidelines. . ." *Id.* § 1314(m). Given EPA's failure to revise the OCPSF guidelines during the past three decades (*see supra* note 198 and accompanying text), these differences are inconsequential.

204. The compliance deadline for BPT was 1977. 33 U.S.C. § 1311(b)(1)(A). The compliance deadline for stricter BAT controls was 1989. *Id.* § 1311(b)(2)(C)–(F).

205. 40 C.F.R. §§ 414.23(a), 414.33(a), 414.43(a), 414.53(a), 414.63(a), 414.73(a), 414.83(a) (reaching identical conclusion for each industry subcategory). *See* 1987 OCPSF Development Document, *supra* note 183, Section II-11 (explaining rationale).

206. 40 C.F.R. §§ 414.21, 414.31, 414.41, 414.51, 414.61, 414.71, 414.81 (2022) (establishing effluent limitations for biological oxygen demand (BOD5), total suspended solids (TSS), and acidity (pH)). Individual plants may have water quality-based effluent limits for toxic pollutants based on state water quality standards. *See* 33 U.S.C. § 1311(b)(1)(C).

207. Limitations differ for plants that did not require end-of-pipe biological treatment to comply with the BPT limits for BOD5, TSS and pH. 40 C.F.R. §§ 414.91, 414.101 (2022). Indirect dischargers to public sewage treatment plants are subject to similar controls, but for only 45 toxic pollutants. *Id.* § 414.111.

conducted at the time.[208] That analysis focused only on sixty-five priority pollutants included in a 1976 Consent Decree between EPA and environmental groups[209] and incorporated into the 1977 CWA amendments.[210] Despite the statutory command to subject new sources to stricter controls, and evidence that closed cycle technologies could eliminate discharges from new sources,[211] EPA subjected new OCPSF sources to the same limits as existing OCPSF sources.[212]

Because EPA has not revised the OCPSF rules, plastics manufacturers are subject to the same limits EPA found acceptable in 1987. For smaller facilities, this remains the first, weakest round of BPT controls adopted by Congress. Even for larger plants, the stricter 1987 controls reflect no ensuing technological improvements. EPA still requires OCPSF plants to use the pollution control equivalent of push button telephones that were contemporaneously replacing rotary dial phones[213] rather than a pollution control smart phone.

Moreover, water pollution from plastics may be worse today than in 1987. The OCPSF rules limit discharges based on total mass, calculated by multiplying waste flow by daily and monthly concentrations for each pollutant.[214] Yet total plastics production has skyrocketed since 1987.[215] Assuming a roughly proportionate increase in waste stream volume, the mass of pollutants the rules allow could increase as well.[216] Second, industry has developed many new plastics and additives since 1987.[217] This suggests additional pollutants relative to EPA's mid-1980s analysis. Yet the OCPSF rules have not been reviewed and updated to reflect those changes. In March 2021, EPA published an advanced notice of proposed rulemaking ("ANPR") soliciting comments on an effort to

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208. *See* 1987 OCPSF Development Document, *supra* note 183, at Section V (describing origins of priority pollutant list).

209. *See* Nat. Res. Def. Council v. Train, 8 E.R.C. 2120 (D.D.C. 1976), *modified*, 12 E.R.C. 1833 (D.D.C. 1979).

210. *See* 33 U.S.C. § 1317(a) (incorporating list of toxic pollutants in table 1 of Committee Print 95-30 of the House Committee on Public Works and Transportation). EPA denominates these "priority pollutants," listed at 40 C.F.R. § 423 app. A (2022).

211. The Fifth Circuit remanded the new source issue for further consideration. *See* Chem. Mfrs. Ass'n v. EPA, 870 F.2d 177, 264 (5th Cir. 1989).

212. Organic Chemicals, Plastics, and Synthetic Fibers, 40 C.F.R. §§ 414.24, 414.34, 414.44, 414.54, 414.64, 414.74, 414.84 (2022) (same decision for each subcategory).

213. *See* Anthony Dean, *When Seven Pieces of Technology Were Deemed Obsolete*, Diverse Tech Geek (Apr. 27, 2015), https://perma.cc/4UGJ-AZAL.

214. For the three conventional pollutants, this formula is specified by industry subcategory. EPA Organic Chemicals, Plastics, and Synthetic Fibers, 40 C.F.R. §§ 414.21, 414.31, 414.41, 414.51, 414.61, 414.71, 414.81 (2022). For toxic pollutants subject to BAT and NSPS, formulae are specified in 40 C.F.R. §§ 414.101, 414.91 (2022).

215. *See* Geyer et al., *supra* note 23, at 3.

216. *See supra* Part I.B.1.b. EPA's Toxic Release Inventory data suggest otherwise, *see* EPA, *supra* note 56, although some suggest that toxics releases from petrochemical plants are significantly underreported. *See* Keehan, *supra* note 52, at 366–68.

217. *See* Persson et al., *supra* note 19, at 1512.

initiate "further data collection and analysis to support potential further rulemaking"[218] to address PFAS pollution that has received recent attention.[219] Yet this is only one of the many new plastics chemicals and additives discharged by the OCPSF industry.[220] Moreover, the same factors that delayed EPA's 1987 rulemaking remain. The ANPR is based on EPA's PFAS Action Plan and Preliminary Effluent Guidelines Program Plan published in 2019.[221] It took more than two years to get to the ANPR stage for one subset of the gap in plastics water pollution control, based on an extensive data collection process and meetings with numerous stakeholders.[222] The ANPR announced plans for additional data collection before EPA even decides whether to initiate further rulemaking,[223] and EPA indicated no schedule for those decisions. EPA received nearly 30,000 comments on the ANPR and EPA's docket for the ANPR includes 118 supporting documents,[224] suggesting any rulemaking will be complex and controversial. This level of complexity illustrates the difficulty EPA faces—under the existing statutory and regulatory process—to keep pace with such a quickly evolving and expanding industry as plastics.

2. Complexity and Stagnation in Effects-Based Controls

The CAA and the CWA also use effects-based standards to protect ambient air and water quality if best technology controls are insufficient to do so.[225] Water-quality based effluent limitations to control pollutants from plastics plants rely on state water quality standards ("WQS").[226] State WQS are based on EPA's water quality criteria ("WQC") guidance[227] and are subject to EPA review and approval or EPA adoption if state standards are inadequate.[228] The current WQC process for toxic water pollutants, however, focuses mainly on

218. *See* CWA Proposed Rulemaking *supra* note 199.

219. *See, e.g.*, Tom Perkins, *PFAS "Forever Chemicals" Constantly Cycle Through Ground, Air and Water, Study Finds*, GUARDIAN (Dec. 18, 2021) https://perma.cc/AC5F-GM6U.

220. *See supra* notes 131–134 and accompanying text.

221. *See* CWA Proposed Rulemaking, *supra* note 199 at 14563.

222. *See id.* at 14563–65.

223. *See id.* at 14565–66.

224. *See* EPA, Rulemaking Docket, Effluent Limitations Guidelines and Standards for the Organic Chemicals, Plastics and Synthetic Fibers Point Source Category, EPA-HQ-OW-2020-0582 (proposed Mar. 17, 2021), https://perma.cc/Z3UH-9MYH.

225. *See* 33 U.S.C. §§ 1313(c)–(d), 1314(a) (requiring water quality standards for all surface waters); 42 U.S.C. §§ 7407–7410 (establishing national ambient air quality standards and implementing programs).

226. Water quality standards include designated uses for each water body and water quality criteria to protect those uses. 33 U.S.C. § 1313(a)–(c); 40 C.F.R. §§ 130–131 (2022).

227. *See* 33 U.S.C. § 1314(a); 40 C.F.R. §131 (2022).

228. *See* 33 U.S.C. § 1313(c).

the same 65 priority pollutants discussed above.[229] Even for those pollutants, EPA must evaluate a large body of scientific evidence regarding the impacts of each pollutant on human health and environmental quality,[230] and translate that information to recommended WQC.

For example, phthalates are chemicals known as "plasticizers" that make plastics more durable.[231] EPA adopted its WQC document for phthalate esters in October 1980.[232] The 110-page criteria document includes extensive analysis of the literature available as of the late 1970s regarding aquatic toxicity[233] and mammalian toxicity and human health effects.[234] EPA explained the detailed processes used to derive WQC for aquatic life and human health when it published proposed criteria in three groups addressing the 65 toxic priority pollutants.[235] Presumably because of the complexity of the process, EPA has not reviewed or updated WQC for phthalates since 1980,[236] despite considerable new information about human exposure,[237] human health effects,[238] and aquatic environment exposure and toxicity.[239]

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229. *See supra* notes 206–207 and accompanying text. In the CAA, EPA adopts National Ambient Air Quality Standards ("NAAQS") for only six pollutants, none of which are hazardous air pollutants of concern from plastics manufacturing. *See* NAAQS CHART, EPA (Apr. 5, 2022), https://perma.cc/83V9-78ZZ (identifying carbon monoxide, lead, nitrogen dioxide, ozone, particle pollution, and sulfur dioxide as pollutants for which EPA adopts NAAQS).

230. *See* CHARLES E. STEPHEN ET AL., EPA, GUIDELINES FOR DERIVING NUMERICAL WATER QUALITY CRITERIA FOR THE PROTECTION OF AQUATIC ORGANISMS AND THEIR USES iv–v (1985) (acknowledging the complexity of the WQC development process).

231. *See* NATIONAL BIOMONITORING PROGRAM, PHTHALATES FACTSHEET, CTR. FOR DISEASE CONTROL & PREVENTION (Apr. 5, 2021), https://perma.cc/L72S-FB7U [hereinafter CDC Phthalates Factsheet].

232. *See* EPA, AMBIENT WATER QUALITY CRITERIA FOR PHTHALATE ESTERS (1980) [hereinafter Phthalate Esters WQ Criteria Document]; *see also supra* Part I.B.3.b.

233. *See* Phthalate Esters WQ Criteria Document, *supra* note 232, at B-1–B-20.

234. *See id.* at C-1–C-62.

235. *See* EPA, Notice of Availability, Water Quality Criteria, 44 Fed. Reg. 15926 (1979); EPA, Notice of Availability, Water Quality Criteria, 44 Fed. Reg. 43660 (1979); EPA, Notice of Availability, Water Quality Criteria, 44 Fed. Reg. 56628 (1979).

236. *See* EPA, Quality Criteria for Water 1986, at Water Quality Criteria Summary (1986) (table depicting dates of adoption).

237. *See* CDC Phthalates Factsheet, *supra* note 231; CTR. FOR DISEASE CONTROL & PREVENTION, FOURTH NATIONAL REPORT ON HUMAN EXPOSURE TO ENVIRONMENTAL CHEMICALS: UPDATED TABLES, MARCH 2021 (2021), https://perma.cc/6EV2-SWDS.

238. *See, e.g.*, Sailas Benjamin et al., *Phthalates Impact Human Health: Epidemiological Evidences and Plausible Mechanism of Action*, 340 J. HAZARDOUS MATERIALS 360, 361 (2017); *see also supra* Part I.B.3.b.

239. *See, e.g.*, Ying Zhang et al., *Hazards of Phthalates (PAEs) Exposure: A Review of Aquatic Animal Toxicology Studies*, 771 SCI. TOTAL ENV'T 145418, 145418 (2021).

Finally, WQC only reduce pollution once translated into enforceable permit limits.[240] This requires time-consuming proceedings for each facility, also subject to public notice and comment and judicial review under either federal or state law.[241] For example, several additional steps are needed to adopt water quality-based permit limits for the proliferation of chemicals used to manufacture plastics. States must monitor water bodies to detect an increasing array of toxic pollutants,[242] but due to inadequacies in state and federal monitoring programs[243] many pollutants likely evade detection. When pollutants are identified at levels exceeding WQC, the state must calculate the pollutant loads from one or more sources that will cause WQC violations,[244] and translate them into permit limits.[245]

State WQC only fill gaps in the OCPSF effluent limitations guidelines if the WQC are current and complete. EPA has been adopting WQC guidance since 1968.[246] After the 1968 version (the "Green Book"), EPA published updated and expanded versions in 1973 (the "Blue Book"), 1976 (the "Red Book"), and 1986 (the current version, known as the "Gold Book").[247] The document has not been updated since then. Most of EPA's WQC thus predate 1986,[248] although EPA has published updated guidelines regarding some pollutants.[249]

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240. *See* 33 U.S.C. § 1342 (requiring National Pollutant Discharge Elimination System ("NPDES") permits for water pollutant discharges from point sources); 42 U.S.C. §§ 7503, 7661–7661f (providing for Clean Air Act permits for various pollution sources).

241. *See, e.g.*, 33 U.S.C. § 1342 (providing for discharge permits from EPA or delegated states); 40 C.F.R. §§ 122–124 (2022) (specifying detailed permit requirements and decision process for EPA and state-issued permits).

242. *See* EPA, ELEMENTS OF A STATE WATER QUALITY MONITORING PROGRAM (2003), https://perma.cc/BN6A-SJ3J.

243. *See generally* U.S. GOV'T ACCOUNTABILITY OFF., GAO-04-382, WATERSHED MANAGEMENT: BETTER COORDINATION OF DATA COLLECTION EFFORTS NEEDED TO SUPPORT KEY DECISIONS 5–6 (2004) (identifying problems in data collection, consistency, and coordination); EPA, EVALUATION OF STATE AND REGIONAL WATER QUALITY MONITORING COUNCILS 1 (2003) (noting EPA's priority to improve state water quality monitoring); U.S. GOV'T ACCOUNTABILITY OFF., GAO-02-186, WATER QUALITY: INCONSISTENT STATE APPROACHES COMPLICATE NATION'S EFFORTS TO IDENTIFY ITS MOST POLLUTED WATERS 2–3 (2002) (identifying inconsistencies in state monitoring).

244. *See* 33 U.S.C. §§ 1313(d) (requiring total maximum daily load calculations for all pollutants); 1314(l) (requiring individual control strategies for toxic pollutants).

245. *Id.* §§ 1311(b)(1)(C), 1342(a)(1), (b)(1).

246. *See* QUALITY CRITERIA FOR WATER 1986, *supra* note 236, at "To Interested Parties.".

247. *See id.*

248. *See id.*

249. *See* NATIONAL RECOMMENDED WATER QUALITY CRITERIA—AQUATIC LIFE CRITERIA TABLE, EPA (Sept. 15, 2022), https://perma.cc/Q5CF-YXA7 (documenting recent updates to existing criteria).

Since identification of the 65 toxic priority pollutants, many other toxic or potentially toxic chemicals have been manufactured and used, including new plastics and plastics additives.[250] EPA recognizes the existence of additional "pollutants of concern" for which new WQC are or may be warranted.[251] EPA identified endocrine disruption, reproductive effects on aquatic organisms, and other adverse effects, suggesting the need for more evaluation and potential criteria adoption.[252] EPA highlighted pharmaceuticals and personal care products but also identified persistent organic pollutants in plastics.[253] EPA's working group characterized the problem and developed recommendations, but apparently the draft has not been finalized in the past 14 years.[254] EPA planned to develop a new technical support document on this issue for public dissemination in 2009,[255] but its website reflects no further action on this issue.[256]

EPA understands that the science used to develop existing WQC is outdated:

> The existing *Guidelines for Deriving Water Quality Criteria for the Protection of Aquatic Life and Their Uses* have not been updated since 1985. Although based on science of that time, the past 30 years have witnessed substantial scientific advancement in aquatic toxicology, aquatic biology, fate, transport, and effects modeling, and ecological risk assessment. Such advancements, coupled with increasing complexity of water quality impairment issues requires criteria derivation approaches beyond the existing *Guidelines* methods.[257]

To address these factors, EPA initiated a process to update its methods for developing aquatic life WQC.[258] Again, however, the website reflects no further action on this issue. By contrast, EPA updated its WQC guidance for human

250. *See supra* Part I.B.3.b.

251. *See* Contaminants of Emerging Concern including Pharmaceuticals and Personal Care Products, EPA (Mar. 10, 2022), https://perma.cc/U3PX-ZQ8L.

252. *See id.*

253. EPA, OW/ORD Emerging Contaminants Workgroup, Aquatic Life Criteria for Contaminants of Emerging Concern 2 (2008), https://perma.cc/LV6J-WP5H.

254. EPA's Science Advisory Board reviewed the issue in 2008. *See* Letter from Dr. Deborah L. Swackhamer, Sci. Advisory Bd. Chair, and Dr. Judith L. Meyer, SAB Ecological Processes and Effects Comm. Chair, to Stephen L. Johnson, EPA Adm'r (Dec. 18, 2008), https://perma.cc/FYN5-6KX7 (forwarding SAB report).

255. *See* Letters from Lisa Jackson, EPA Adm'r to Drs. Swackhamer and Meyer (May 1, 2009), https://perma.cc/8A3R-V44J.

256. *See* Contaminants of Emerging Concern including Pharmaceuticals and Personal Care Products, *supra* note 251.

257. *Aquatic Life Criteria and Methods for Toxics*, EPA (July 11, 2022), https://perma.cc/T9KG-PL73.

258. EPA hosted a meeting of scientific experts in 2015. *See id.*; *see also* 81 Fed Reg. 59621 (Aug. 30, 2016).

health in 2015 to recommend more conservative human exposure factors.[259] It did not, however, promulgate human-health-based WQC for additional pollutants, including newer plastics or plastics additives.

The CAA includes a similarly complex provision to regulate hazardous air pollutants.[260] EPA must identify major industries that emit any hazardous air pollutants from a lengthy list, and first adopt technology-based regulations to control those emissions.[261] Those rulemakings are also extremely complex.[262] The hazardous air pollutants provision, however, adds a second step—a risk assessment and potentially a supplemental risk-based regulation for any technology-based standard deemed insufficient to "provide an ample margin of safety to protect public health" or "an adverse environmental effect."[263] The supplemental risk assessment and rulemaking is similar in complexity to that used to develop WQC.[264] Thus, the National Emissions Standards for Hazardous Air Pollutants ("NESHAPs") provision combines the complexity of technology-based rulemaking with the complexity of risk-based rulemaking.

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259. *See* Final Updated Ambient Water Quality Criteria for the Protection of Human Health, 80 Fed. Reg. 36986, 36987–89 (June 29, 2015); *National Recommended Water Quality Criteria—Human Health Criteria Table*, EPA (Sept. 15, 2022), https://perma.cc/D628-5V9J; UPDATE OF HUMAN HEALTH WATER QUALITY CRITERIA: ACENAPHTHENE 83-32-9, at 2–9 (July 2015) (updating WQC based on revised assumptions regarding body weight, drinking water intake, fish consumption, bioaccumulation, and toxicity).

260. 42 U.S.C. § 7412.

261. *See* 42 U.S.C. §§ 7412(b) (adopting list of hazardous air pollutants), 7412(c) (requiring EPA to identify source categories emitting hazardous air pollutants), 7412(d) (requiring EPA to adopt technology-based emissions standards for source categories).

262. EPA proposed NESHAPs for reinforced plastic composites production in a 47-page Federal Register notice published 11 years after the 1990 amendments, *see* National Emission Standards for Hazardous Air Pollutants: Reinforced Plastic Composites Production, 66 Fed. Reg. 40324 (Aug. 2, 2001) (to be codified at 40 C.F.R. pt. 63); promulgated the final rule nearly two years later, 68 Fed. Reg. 19375 (Apr. 21, 2003) (to be codified at 40 C.F.R. pt. 63), with 10 extra-statutory review steps, *see id.* at 19397–19402; and adopted minor amendments two years later. *See* 70 Fed. Reg. 50118 (Aug. 25, 2005) (to be codified at 40 C.F.R. pt. 63). Extensive documentation in EPA's rulemaking docket shows the complexity of CAA technology-based rules. *See generally* EPA, NATIONAL EMISSIONS STANDARDS FOR HAZARDOUS AIR POLLUTANTS: REINFORCED PLASTIC COMPOSITES PRODUCTION—PROPOSED DOCKET INDEX, https://perma.cc/W74Z-3AQQ.

263. 42 U.S.C. § 7412(f)(2).

264. For reinforced plastic components, *see supra* note 262. EPA published a proposed residual risk assessment more than a decade and a half after the final technology-based rule, *see* National Emission Standards for Hazardous Air Pollutants: Boat Manufacturing and Reinforced Plastic Composites Production Residual Risk and Technology Review, 84 Fed. Reg. 22642 (May 17, 2019) (to be codified at 40 C.F.R. pt. 63), and a rule based on that assessment a year later. *See* 85 Fed. Reg. 15960 (Mar. 20, 2020) (to be codified at 40 C.F.R. pt. 63). EPA's docket lists the extensive documentation for this analysis. *See* EPA, Rulemaking Docket, National Emission Standards for Hazardous Air Pollutants for the Reinforced Plastics Composites Production Industry, Risk and Technology Review, EPA-HQ-OAR-2016-0449 (proposed July 21, 2017), https://perma.cc/4JZR-LX3F.

C. *Free Markets and Full Life Cycle Impacts*

Even if "front-end" pollution from plastics production can be addressed adequately, U.S. environmental law does not effectively confront an even larger problem—use of plastics in such massive quantities that the domestic and global plastics disposal problem is overwhelming. Production and use of plastics continues to grow dramatically,[265] causing a massive problem of scale. Clearly, RCRA's aspirational policy to reduce solid waste[266] has given way to incentives for industry profits and consumer convenience. Although federal and state solid waste laws and regulations require plastics to be disposed of in environmentally sound ways, much plastic waste ends up in the environment.[267] Unfortunately, the promise of plastics recycling has not been realized.[268] The United States exports much of that material to developing nations, and some reaches the oceans and causes other harm.[269] Finally, U.S. plastic is exported in products and packaging, where it is beyond the control of U.S. solid waste law.

Given these realities, the larger question is why we do not—or cannot—ban, curtail production, or limit plastics uses where their harm exceeds their benefits? Other nations curtail use of plastics, most notably SUPs, through taxes, bans, or other regulation.[270] Aside from efforts by some localities,[271] some of which have been stricken by courts or state legislatures,[272] the United States has not done so. Part II.C.1 suggests that this failure results from the predominantly regulated free market philosophy of U.S. environmental law. Part II.C.2

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265. *See* Geyer et al., *supra* note 23, at 1.

266. *See infra* notes 292–293.

267. *See* Geyer et al., *supra* note 23, at 1.

268. *See supra* Part I.B.1.c.i. In 2020, however, EPA announced a goal to increase the national recycling rate to 50 percent by 2030. *Administrator Wheeler Announces National Goal to Increase Recycling Rate at 3rd Annual Recycling Summit,* EPA (Nov. 17, 2020), https://perma.cc/TU9K-GE59. In November 2021, EPA announced its "National Recycling Strategy" to support the implementation of this goal. *See* EPA, NATIONAL RECYCLING STRATEGY: PART ONE OF A SERIES ON BUILDING A CIRCULAR ECONOMY FOR ALL (2021).

269. *See id.*

270. *See* Ternes, *supra* note 164, at 39–40; Marcela Romero Mosquera, *Banning Plastic Straws: The Beginning of the War Against Plastics*, 9 ENV'T & EARTH L.J. 5, 13–14 (2019); Morath, *supra* note 155, at 47; Kass, *supra* note 164, at 58–59.

271. *See* El-Jourbagy, *supra* note 1, at 118–19; Morath, *supra* note 155, at 46–47; Stephanie F. Wood, *Comment, Move Over Diamonds—Plastics Are Forever: How the Rise of Plastic Pollution in Water Can Be Regulated*, 29 VILL. ENV'T L.J. 155, 160 (2018). As of February 2021, ten states had plastic bag legislation, and two taxed or allowed localities to tax plastic bags. *State Plastic Bag Legislation*, NAT'L CONF. STATE LEGISLATORS (Feb. 8, 2021), https://perma.cc/YA7T-NM4G.

272. *See, e.g.,* City of Laredo v. Laredo Merchs. Ass'n, 550 S.W.3d 586 (Tex. 2018); MO. REV. STAT. § 260.283(2); MINN. STAT. ANN. § 471.9998. As of February 2021, 18 states had legislation preempting local measures. *See State Plastic Bag Legislation*, *supra* note 271. No state that did so adopted statewide measures. *See id.*

describes the ineffectiveness of even those statutes that confer authority to EPA and other agencies to ban or curtail extremely harmful product uses.

1. Producer and Consumer Choice and U.S. Environmental Law

In most U.S. environmental statutes, Congress addressed pollution-related externalities in ways that are as unintrusive as possible on free market decisions. Instead, Congress adopted statutes designed to reduce or eliminate pollution from those choices.

a. Pollution Control Statutes

In the CAA and the CWA, Congress sought to reduce air and water pollution impacts of industrial operations, but not to dictate what is produced or used. As explained above, for each category of industrial activity, *taking as a given what they produce and how*, EPA determines the "best" technology to reduce the ensuing pollution.[273]

The legislative history of the 1972 CWA confirms that Congress purposefully elected not to interfere with free market production and consumption decisions, but instead to mitigate adverse environmental impacts from those choices. The 1972 Report of the House Committee on Public Works specifies that, in the BPT round of industrial effluent limitations, EPA must consider controls at the discharge point without interfering with production or process decisions.[274] For stricter BAT and NSPS controls, Congress allowed EPA to base effluent limitations on internal process changes that might affect water pollution.[275] However, under none of the technology-based standards may EPA mandate an industrial process or pollution control technology.[276] It may only establish end-of-pipe effluent limitations based on what the agency determines is the "best" technology under the respective statutory definitions.[277] The 1972 CWA Conference Report confirms that both houses of Congress embraced this philosophy:

> This does not mean that the Administrator is to determine the kind of production processes or the technology to be used by a new source. It does mean that the Administrator is required to establish standards of performance which reflect the levels of control achievable through improved production processes, and of process technique, etc., leav-

273. *See supra* Part II.B.

274. *See* H.R. Rep. No. 92-911, at 101, 107 (1972).

275. *See id.* at 102–03, 111.

276. *See id.* at 107–08.

277. *See* 33 U.S.C. § 1311(b) (requiring industrial effluent limitations guidelines based on the degree of effluent reduction attainable through various levels of best technology).

ing to the individual new source the responsibility to achieve the level of performance by the application of whatever technique determined available and desirable to that individual owner or operator.[278]

If the CWA does not allow EPA to dictate manufacturing process choices in establishing pollution controls, *a fortiori*, it does not authorize EPA to ban production of plastics because their manufacturing, use, or disposal cause too much harm. EPA can only require industry to reduce or eliminate water pollution from production under the statutory standards.[279] Congress may have embraced this less intrusive regulatory philosophy because it expected industries to achieve zero discharge by 1985.[280] We have not achieved anything close to zero discharge of industrial water pollutants generally,[281] and the plastics industry continues to discharge large volumes of water pollutants.[282]

The CAA similarly relies on technology-based standards. For new major stationary air pollution sources, CAA Section 111 requires EPA to determine "the degree of emission limitation achievable through the best system of emission reduction" the agency finds "has been adequately demonstrated."[283] For emitters of hazardous air pollutants, EPA must require "the maximum degree" of emissions reductions achievable.[284] As was true for stricter CWA provisions, hazardous air pollutant controls may consider "process changes, substitution of materials" and other control strategies that go beyond end-of-process pollution controls.[285] Those controls address production process decisions, however, not what to produce.[286]

The effects-based provisions of the CWA and the CAA focus more directly on health and environmental impacts of pollutants but do little to mitigate impacts from later phases of the plastics life cycle. Air and water pollution

278. S. Rep. No. 92-1236, at 128 (1972); *see also* S. Rep. No. 92-414, at 58–59 (1971).

279. Congress accepted that pollution control costs might require some industrial facilities to close. *See* Weyerhaeuser Co. v. Costle, 590 F.2d 1011, 1036 (D.C. Cir. 1978) (concluding Congress understood that some facilities might not be able to afford BPT controls and therefore close).

280. 33 U.S.C. § 1251(a)(1); *see* S. Rep. No. 92-414, (1971); Robert W. Adler, *The Decline and (Possible) Renewal of Aspiration in the Clean Water Act*, 88 Wash. L. Rev. 759, 765 (2013).

281. For example, plastic and rubber producers discharged about 200 million pounds of toxic pollutants into water in 2020. *See* EPA, *supra* note 56.

282. *See id.*

283. 42 U.S.C § 7411(a)(1).

284. *Id.* § 7412(d)(2).

285. *See id.* § 7412(d)(2)(A)–(B).

286. *See, e.g., id.* §§ 7475(a) (requiring best available control technology for major sources in areas that attain the NAAQS), 7503(2) (requiring lowest achievable emissions for new sources in nonattainment areas), 7502(c)(1) (requiring reasonably available control measures for existing sources in nonattainment areas). EPA may prescribe "design, equipment, work practice, or operational" standards where it is not feasible to set performance standards based on best technology, but it still may not dictate what to produce. *See id.* §§ 7411(h), 7412(h).

controls often concentrate waste material into industrial sludges, shifting the problem from surface waters to landfills and other areas.[287] Stricter effects-based limits might require plastics manufacturers to spend more on pollution control, but they do not proscribe or limit production of materials which cause harm from disposal. Those issues are potentially subject to the waste disposal statutes discussed next.

b. Waste Disposal Statutes

The two major federal statutes governing solid and hazardous waste management, RCRA and CERCLA, reinforce the regulatory philosophy of addressing externalities rather than intruding into producer and consumer choices. In the opening findings of the Solid Waste Disposal Act (as amended by RCRA), Congress recognized that technological progress, improved manufacturing methods, increased packaging, and consumer marketing "resulted in an ever-mounting increase, and in a change in the characteristics, of the mass material discarded by the purchaser of such products."[288] Likewise, Congress found that economic and population growth "have *required increased industrial production* to meet our needs . . . [and] have resulted in a rising tide of scrap, discarded and waste material;"[289] and that urbanization had caused "problems in the disposal of solid waste resulting from . . . industrial, commercial, domestic, and other activities. . . ."[290] Adverse impacts included improper solid and hazardous waste[291] management and disposal, and Congress identified a need for alternative waste disposal methods.[292]

As in the pollution control statutes, Congress did not intrude on producer and consumer decisions to manufacture and purchase products, including plastics. If this caused a solid waste crisis,[293] the solution was to reduce accompanying adverse impacts, not to question product need or benefits. That would affect producer and consumer freedom and impede economic growth.[294] Thus, RCRA includes strategies and controls such as solid waste management plans,

287. *See* 42 U.S.C. § 6901(b)(3) (congressional finding in Solid Waste Disposal Act that CAA and CWA controls resulted in more solid waste to be disposed on land).

288. 42 U.S.C. § 6901(a)(1).

289. *Id.* § 6901(a)(2) (emphasis added).

290. *Id.* § 6901(a)(3).

291. Congress distinguished "solid waste" from more dangerous "hazardous waste." *See id.* §§ 6903(27) (defining solid waste), 6903(5) (defining hazardous waste).

292. *See id.* § 6901(b), (c).

293. *See, e.g.*, David Byrd, *Problem of Ridding City of Garbage Eludes a Solution*, N.Y. TIMES, Mar. 24, 1970, at 49. Regarding the rapid growth of U.S. solid waste generation, *see National Overview: Facts and Figures on Materials, Wastes and Recycling*, EPA (July 31, 2022), https://perma.cc/6B2A-HWE5.

294. Some economists question that assumption. *See* HERMAN E. DALY, BEYOND GROWTH: THE ECONOMICS OF SUSTAINABLE DEVELOPMENT (1997).

prohibition of open waste dumping, better management and disposal methods for hazardous waste, and regulations governing solid and hazardous waste disposal.[295]

RCRA also focuses on waste minimization and solid and hazardous waste reuse and recycling.[296] However, the statute seeks to reduce hazardous waste generation through changes in product manufacturing processes;[297] it does not implicate choices about what to produce. Material must be "discarded" to be considered "solid waste," hence excluding consumer products before they are discarded.[298] Congress established as a national policy that ". . . wherever feasible, the generation of hazardous waste is to be reduced or eliminated as expeditiously as possible. Waste that is nevertheless generated should be treated, stored, or disposed of so as to minimize the present and future threat to human health and the environment."[299] Plastics production generates hazardous waste, but plastics products are not solid or hazardous waste until discarded.[300] Therefore, the choice to produce them is not regulated by the statute even if products contribute disproportionately to waste disposal problems.

RCRA Subchapter III includes a rigorous system of identifying, classifying, and regulating hazardous waste during generation; transportation; and treatment, storage, and disposal.[301] Because consumer products cannot be hazardous waste—regardless of how much harm they cause—they are not subject to those regulations. Even to the extent that RCRA regulates hazardous pollution from burning waste to produce energy, which Congress encourages in RCRA,[302] plastics and other wastes from households, hotels, and motels are exempt from regulation.[303] Municipal solid waste, by contrast, including consumer plastic waste, is subject to flexible federal guidelines for waste management planning and landfill operation.[304]

Because RCRA does little to influence product manufacturing choices, except if producers modify input chemicals and processes to reduce regulatory compliance costs,[305] it influences consumer decisions even less. Indeed, produc-

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295. *See* 42 U.S.C. § 6902(a) (articulating statutory objectives).

296. *See id.* § 6902(a)(6), (b).

297. *See id.* § 6902(a)(6) (calling for "process substitution, materials recovery, properly conducted recycling and reuse, and treatment").

298. *See, e.g.*, Am. Mining Cong. v. EPA, 824 F.2d 1177, 1183 (D.C. Cir. 1987).

299. *See* 42 U.S.C. § 6902(b).

300. *See id.* § 6903(27) (defining solid waste, *inter alia*, as "garbage, refuse . . . and *other discarded material*") (emphasis added); *see also Am. Mining Cong.*, 824 F.2d at 1183 (holding that material cannot be solid waste until discarded).

301. *See* 42 U.S.C. §§ 6921–6925.

302. *See* 42 U.S.C. § 6941a.

303. *Id.* § 6921(i).

304. *See id.* §§ 6941–6947.

305. *See* DRIESEN, *supra* note 156, at 149 (suggesting firms may avoid costs through pollution prevention).

tion and consumer use of plastics has increased dramatically since RCRA was enacted, as has the ensuing disposal crisis.[306]

CERCLA is the second federal statute designed to address residual chemical waste.[307] Unlike RCRA, which regulates hazardous wastes associated with product manufacturing, CERCLA addresses "back end" issues resulting from releases of "hazardous substances."[308] It includes release reporting and other public information requirements,[309] cleanup and remediation standards,[310] mandatory hazardous substance removal and remediation by government and private parties,[311] and cleanup costs and responsibilities.[312] As such, CERCLA does not regulate what products are made, or how. Rather, CERCLA addresses the failure of other regulatory statutes to prevent the release of hazardous substances from those activities. Retroactive liability can affect production decisions, but only if the amount and frequency of liability is significant enough to render those decisions unprofitable.[313] Moreover, CERCLA exemptions might limit its tendency to change manufacturing decisions for plastics.[314] CERCLA liability and other environmental compliance costs have incentivized some manufacturers to reduce toxic input chemicals.[315] Based on the massive increase in the volume and kinds of plastics produced since CERCLA was enacted,[316] however, apparently it has not significantly affected industry decisions about plastics production.

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306. *See supra* Part I.

307. RCRA identifies chemicals regulated under Subchapter III as "hazardous wastes." *See* 42 U.S.C. § 6903(5) (defining "hazardous waste"). CERCLA establishes cleanup liability for release of "hazardous substances." *See id.* § 9601(14) (defining "hazardous substance" as any hazardous waste identified under RCRA and chemicals identified under other statutes).

308. *See* 42 U.S.C. § 9601(14).

309. *See* 42 U.S.C. § 9603. *See also* Emergency Planning and Community Right-to-Know Act of 1986 ("EPCRA"), 42 U.S.C. §§ 11001–11005, 11021–11023, 11041–11050 (adding reporting requirements).

310. *See* 42 U.S.C. §§ 9605, 9621.

311. *See id.* §§ 9604, 9606.

312. *See id.* §§ 9607, 9613.

313. *See* DRIESEN, *supra* note 156, at 156 (noting the effect of CERCLA liability on waste generation).

314. *See, e.g.*, 42 U.S.C. §§ 9607(j), 9601(10) (subjecting broadly defined "federally permitted releases" to existing law rather than CERCLA liability), 9601(22) (exempting certain categories of releases), 9607(b) (creating defenses for acts of God, acts of war, and acts or omissions by certain third parties), 9601(14) (exempting petroleum, natural gas, and related products).

315. *See supra* note 299; Michele Ochsner, *Pollution Prevention: An Overview of Regulatory Incentives and Barriers*, 6 N.Y.U. ENV'T L.J. 586 (1998); Mary Raivel, *CERCLA as a Pollution Prevention Strategy*, 4 MD. J. CONTEMP. LEGAL ISSUES 131 (1993); MARK H. DORFMAN ET AL., ENVIRONMENTAL DIVIDENDS: CUTTING MORE CHEMICAL WASTES 14 (1992).

316. *See supra* notes 131–134 and accompanying text.

CERCLA is also even less relevant than RCRA to consumer decisions about plastics products use and disposal choices. CERCLA exempts from its liability provisions household waste and other municipal solid waste.[317] Thus, individual consumers bear no responsibility for the downstream impacts of their product choices and uses, for example to purchase water in plastic bottles, or even decisions about whether to discard or recycle the plastics they use.

2. *Exceptions to the Free Market Approach: Toxic Substances and Product Bans*

Several federal environmental and other regulatory statutes, at least facially, do not entirely follow the free market regulatory philosophy. These laws confer authority on agencies to change producer and consumer decisions by prohibiting or restricting the manufacture and use of end products. Of these, two are particularly relevant to plastics: TSCA[318] and the Food, Drug, and Cosmetic Act ("FDCA").[319]

a. *TSCA*

TSCA is the federal statute best designed to allow the federal government to ban or restrict the manufacture and use of substances deemed so harmful that they should not be made at all or should only be made for certain uses and in certain ways. TSCA Section 6 is unusual but not unique[320] in authorizing EPA to prohibit, limit, or regulate "manufacturing, processing, or distribution in commerce" of "chemical substances or chemical mixtures" if the agency finds they present "an unreasonable risk of injury to health or the environment."[321] Indeed, TSCA was adopted to fill gaps in laws that regulate production externalities rather than the substance itself.[322] TSCA Section 4 supports this effort by authorizing EPA to require producers to test substances for which insufficient information exists to ascertain risk.[323]

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317. *See* 42 U.S.C. § 9607(p).

318. 15 U.S.C. §§ 2601–2629.

319. Federal Food, Drug, and Cosmetic Act, Pub. Law No. 75-717, 52 Stat. 1040 (1938) (codified as amended in scattered sections of 21 U.S.C.).

320. Federal Insecticide, Fungicide, and Rodenticide Act, 7 U.S.C. §§ 136–136y, authorizes EPA to ban products, but only pest control chemicals.

321. 15 U.S.C. § 2605(a). Section 6 lists regulatory options including bans, quantity or use limits, recordkeeping, labeling, and notice requirements. *See id*.

322. *See* Safer Chems., Healthy Fams. v. EPA, 943 F.3d 397, 406 (9th Cir. 2017) (citing S. REP. NO. 94-698, at 1 (1976)).

323. 15 U.S.C. § 2603(f) (providing information submitted pursuant to section 4 triggers EPA regulatory decisions under sections 5–7); *see* Chem. Mfrs. Assn. v. EPA, 859 F.2d 977, 979 (D.C. Cir. 1988) (explaining that information acquired pursuant to section 4 triggers regulatory decisions under section 6).

EPA could use TSCA to ban, limit, or regulate production and use of the chemical substances or mixtures used in plastics. That would require greater intrusion into private production and consumption decisions, based on a judgment that external harms caused by some plastics, or some plastics applications, are too great to justify their production and use. For at least two reasons, however, TSCA has not been used to curtail the environmental effects of plastics.

i. Limitations in TSCA

The text of TSCA as initially enacted, combined with restrictive judicial interpretations and EPA interpretations of those decisions, has limited it from being used effectively to address harms from chemical substances generally.[324] Judicial decisions in particular imposed such significant analytical burdens on EPA that effective use of the statute was precluded.[325] In *Corrosion Proof Fittings v. EPA*,[326] the Fifth Circuit held that before imposing product bans or bans for certain uses, the agency must evaluate all "less burdensome regulatory alternatives," beginning from the least and moving up, to determine whether they would produce "the least burdensome yet still adequate solution."[327] In practice, this suggested a full cost-benefit analysis for all listed regulatory options. That imposed such a steep analytical burden that EPA effectively abandoned its efforts to ban harmful chemicals under TSCA.[328] As a result, EPA has only banned or regulated a handful of the more than 80,000 chemical substances, mixtures, or categories of substances currently in use, many of which have not been characterized for toxicity or have been identified as medium to high concern.[329] Moreover, it only required testing of approximately 200 chemicals in the first forty years after Congress enacted TSCA.[330]

324. *See* S. Rep. No. 114-67, at 2 (2015) (explaining reasons for corrective amendments); H.R. Rep. No. 114-176, at 23 (2015) (identifying as problems the lack of mandatory regulatory action and application of cost-benefit analysis to risk analysis phase of the decision as well as choice of regulatory options).

325. *See* S. Rep. No. 114-67, at 2 (2015); H.R. Rep. No. 114-176, at 23 (2015).

326. 947 F.2d 1201 (5th Cir. 1991).

327. *Id.* at 1215.

328. *See* S. Rep. No. 114-67, at 3 (2015). *See also* Physicians Comm. for Responsible Med. v. Johnson, 436 F.3d 326, 331 (2d Cir. 2006) (declining to require EPA to promulgate TSCA test rule for high production volume chemicals). Even the more limited analysis EPA conducted to support the asbestos rule vacated by the Fifth Circuit took ten years and cost between five to ten million dollars in consultants alone. *See* Economic Analysis at EPA: Assessing Regulatory Impact 173 (Richard Morgenstern, ed., 1997).

329. *See* S. Rep. No. 114-67, at 3 (2015) (indicating EPA addressed only six chemicals in four rulemakings from 1978–1990); *supra* note 132 and accompanying text.

330. *See* S. Rep. No. 114-67, at 3 (2015).

In 2016, Congress amended TSCA[331] to remedy some of the regulatory stagnation resulting from the *Corrosion Proof Fittings* decision and flaws in the original text. Among other reforms, Congress facilitated more chemical testing by eliminating the requirement that EPA ascertain potentially unreasonable risk before it has the information needed to make such a preliminary finding.[332] It also mandated that EPA prioritize chemicals for testing and analysis and required EPA to conduct a minimum number of chemical risk assessments and regulatory decisions.[333] Finally, the amendments eliminated the problematic "least burdensome requirement" provision construed in *Corrosion Proof Fittings* and decoupled the cost-benefit requirement from the risk assessment decision.[334]

Even with these amendments, it appears unlikely that TSCA will suffice to address the health and environmental threats posed by plastics. The 2016 amendments required EPA to initiate ten risk assessments within 180 days of enactment,[335] and to initiate at least twenty assessments within three and a half years of enactment.[336] This will restart EPA's aborted toxic substance regulatory process, and EPA indeed has renewed efforts to control toxic chemicals.[337] This level of action, however, pales by comparison to the tens of thousands of chemicals currently in use.[338] At this pace, it will take decades to make a dent in the backlog of existing untested and unanalyzed chemical substances and mixtures, in addition to potentially new chemicals. Moreover, TSCA directs EPA to prioritize chemicals with high persistence and bioaccumulation, and those that are known human carcinogens and that have high acute and chronic toxicity.[339] Although entirely logical, these preferences may further delay assessment of plastics that may have lower toxicity or unknown toxicity,[340] but are produced

331. Frank R. Lautenberg Chemical Safety for the 21st Century Act, Pub. L. No. 114-182, 130 Stat. 448 (2016) (codified in scattered sections of 15, 42, and 47 U.S.C.).

332. Pub. L. No. 114-182, § 4, 130 Stat. 449–454; *see* S. Rep. No. 114-67, at 8 (2015).

333. Pub. L. No. 114-182, § 6(3), 130 Stat. 461–465; *see* S. Rep. No. 114-67, at 9 (2015).

334. Pub. L. No. 114-182, § 6(4), 130 Stat. 465–68; *see* S. Rep. No. 114-67, at 13–15 (2015). EPA still considers costs and benefits to choose regulatory options once it finds a chemical poses unreasonable health or environmental risk.

335. 15 U.S.C. § 2605(b)(2)(A). The initial ten assessments must be drawn from EPA's 2014 Work Plan for TSCA Risk Assessments, *see* EPA, TSCA Work Plan for Chemical Assessments: 2014 Update (2014).

336. 15 U.S.C. § 2605(b)(2)(B).

337. *See* Lab. Council for Latin Am. Advancement v. EPA, 12 F.4th 234, 239 (2d Cir. 2021) (upholding EPA's methylene chloride rule).

338. *See supra* notes 131–134 and accompanying text.

339. 15 U.S.C. § 2605(b)(2)(D); *see* Procedures for Prioritization of Chemicals for Risk Evaluation Under the Toxic Substances Control Act, 82 Fed. Reg. 33753 (July 20, 2017) (to be codified at 40 C.F.R. pt. 702).

340. The absence of such information prompted adoption of TSCA. *See supra* note 322; S. Rep. No. 94-698, at 5–6, 15–17 (1976) (explaining testing requirements).

and disposed in extremely large quantities and cause significant environmental harm.

EPA currently identifies thirty-three existing chemicals undergoing TSCA risk evaluation, all initiated between 2016 and 2020.[341] Although none of the chemicals under review are plastics polymers, at least 20 out of 33 are associated in some way with plastic manufacturing.[342] At this pace, EPA's TSCA risk evaluation process cannot possibly keep pace with the approximately 10,500 known plastic monomers, additives, and processing aids in existence,[343] even with the unlikely assumption that industry does not continue to develop new chemicals.

These reviews underscore the complexity and length of the TSCA process even under the amended statute. EPA initiated a risk assessment for a violet pigment used to color plastics in December 2016, shortly after the TSCA amendments.[344] It published a scope document in June 2017, a draft risk assessment in November 2018, a test order for manufacturers in November 2018, a revised draft risk assessment in October 2020, and a final risk assessment finding unreasonable risks to workers in January 2021, slightly more than four years after initiating the process.[345] The rulemaking docket demonstrates the mindboggling complexity of the process.[346] For example, as part of the scoping, EPA published a 118-page bibliography listing potentially relevant literature.[347] The final risk assessment, however, is just the first phase of TSCA's regulatory process. EPA still must decide what risk management strategies are appropriate for the pigment, and then undergo a complete rulemaking proceeding, a process it began in mid-2021.[348] It is reasonable to predict that the complete process will take nearly a decade for each chemical, not including subsequent litigation and potential remands.

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341. *See Chemicals Undergoing Risk Evaluation Under TSCA*, EPA (Aug. 19, 2022), https://perma.cc/6D7H-BKGT.

342. We reviewed risk evaluation pages for each chemical in the list cited *supra* note 341. Each page includes information on chemical use and associated products. *See, e.g.*, *Risk Evaluation for p-Dichlorobenzene*, EPA (Mar. 25, 2022), https://perma.cc/2B69-5DLB (indicating primary use as reactant in plastic and resin manufacturing).

343. Wiesinger et al., *supra* note 50, at 9339.

344. *See* Memorandum from Joel Wolf, Chief, Existing Chems. Branch, to Maria J. Doe, Dir., Chem. Control Div. (Dec. 12, 2016) (authorizing posting of assessments for ten chemicals).

345. *See Risk Evaluation for C.I. Pigment Violet 29*, EPA (Sept. 7, 2022), https://perma.cc/9ZMP-CYZ6.

346. *See Pigment Violet 29 (Anthra[2,1,9-def:6,5,10-d'e'f'] diisoquinoline-1,3,8,10(2H,9H)-tetrone); TSCA Review and Risk Evaluation*, REGULATIONS.GOV, https://perma.cc/CU37-7LUE.

347. EPA, PIGMENT VIOLET 29 (CASRN:81-33-4) BIBLIOGRAPHY: SUPPLEMENTAL FILE FOR THE TSCA SCOPE DOCUMENT (July 11, 2017), https://perma.cc/72B7-5A6C.

348. *See Risk Management for C.I. Pigment Violet 29*, EPA (Sept. 6, 2022), https://perma.cc/P79F-RVAU.

Thus, the 2016 TSCA amendments, while a welcome development, likely portend little progress in addressing the plastics crisis in the near-to-midterm future. Moreover, other limitations in design and implementation of TSCA discussed below may preclude complete or effective use of TSCA to regulate plastics.

ii. The Scope of TSCA and the Polymer Exemption

Even if EPA uses TSCA successfully to regulate some chemicals used to manufacture plastics, many severe environmental effects of plastics may be beyond the statute's reach as it has been construed and implemented. The focus of TSCA, underscored by the statutory name as governing *toxic* substances, has been toxicity of chemical substances to humans and other species.[349] Statutory testing protocols support this focus: "carcinogenesis, mutagenesis, teratogenesis, behavioral disorders [and] cumulative or synergistic effects."[350] Likewise, chemical characteristics for which testing may be required include "persistence, acute toxicity, subacute toxicity, chronic toxicity, and any other characteristics which may present such a risk."[351] If limited in this way, TSCA does not address the full range of plastics impacts outlined above,[352] such as strangulation of birds and aquatic organisms.[353]

Moreover, plastics are inert chemically—one property that makes them useful for their intended purposes.[354] That typically makes them nontoxic in manufactured product condition.[355] As a result, pursuant to TSCA section 5(h)(4),[356] EPA promulgated a rule in 1984 exempting most new polymers from statutory testing and reporting requirements that allows EPA to ascertain whether a new chemical poses undue risk to human health or the environment.[357] The original exemption entailed an abbreviated application twenty-one days before initiation of production of the polymer,[358] and included most polyester polymers.[359] EPA expanded the exemption in 1995[360] and replaced the

349. *See, e.g.*, 15 U.S.C. §§ 2601(a)(2) (focusing on human exposure to chemicals), 2602(8) (defining "health and safety study" to include "epidemiological studies, studies of occupational exposure . . . toxicological, clinical, and ecological studies of a chemical substance or mixture . . .").

350. *Id.* § 2603(b)(2)(A).

351. *Id.*

352. *See supra* Part I.B.3.

353. *See supra* notes 103–110 and accompanying text.

354. *See* Geyer et al., *supra* note 23, at 3.

355. *Id.*

356. 15 U.S.C. § 2604(h)(4).

357. 40 C.F.R. § 723.250 (2022); 49 Fed. Reg. 46086 (Nov. 21, 1984).

358. *See* 40 C.F.R. § 723.250(f), (g) (2022).

359. *See* 40 C.F.R. § 723.250(e)(3) (2022).

expedited application with an annual report.[361] In the 2016 amendments, Congress retained EPA's exemption authority, including the polymer exemption, to help EPA focus activity on high-priority potential risks.[362]

All plastics are polymers, although not all polymers are plastics.[363] Effectively, then, the polymer exemption precludes EPA from using TSCA to ban, restrict, or regulate many chemical substances used to manufacture and process plastics. As of the 1995 regulation, EPA had reviewed 2,000 applications to qualify new polymers for the exemption, and by then it had already reviewed 10,000 polymers under the initial notification process.[364]

EPA's primary justification for the polymer exemption was that, based on toxicological science available at the time, most polymers above a certain molecular size and weight are not absorbed by humans or other organisms at levels that cause toxicological effects.[365] Based on this and other information and assumptions, EPA concluded that exempted polymers "will not present an unreasonable risk to human health or the environment."[366] This explanation confirms that EPA's focus in implementing TSCA is on toxicological effects of chemical substances at cellular and genetic levels.[367] Although EPA recognized several exceptions to its assumption that polymers are unlikely to cause toxicological effects, based on the chemical reactivity and other properties of certain

360. 60 Fed. Reg. 16316 (Mar. 29, 1995) (to to be codifed at 40 C.F.R. pt. 723). EPA broadened the exemption to include all polymers with less than 32% carbon, biopolymers or their synthetic equivalent, and polymers with halogen molecules or cyano groups. *See id.* at 16317.

361. *See* Final Rule, Premanufacture Notification Exemptions; Revisions of Exemptions for Polymers, 60 Fed. Reg. 16316, 16317 (to be codified at 40 C.F.R. pt. 723).

362. *See* S. REP. NO. 114-67, at 12–13 (2015).

363. *See Science of Plastics*, SCI. HIST. INST., https://perma.cc/74CP-K87X. Polymers are materials comprised of long, repeating chains of smaller molecules, and may be either synthetic (like plastics) or natural (like wood, rubber, or DNA). *See* Alina Bradford, *What Is a Polymer?*, LIVESCIENCE (Oct. 13, 2017), https://perma.cc/CPU4-F5DR. *See also supra* Part I.A for a discussion of how plastics are made from polymers.

364. *See* Premanufacture Notification Exemptions; Revisions of Exemptions for Polymers; Final Rule, 60 Fed. Reg. 16316 (Mar. 29, 1995) (to be codified at 40 C.F.R. pt. 723).

365. *See* Premanufacture Notification Exemptions; Exemptions for Polymers, 49 Fed. Reg. 46066, 46080–81 (Nov. 21, 1984) (to be codified at 40 C.F.R. pt. 723). "[P]olymers are relatively unreactive and stable compared to other chemical substances and are not readily absorbed. These properties generally limit a polymer's ability to cause adverse effects." *Id.* at 46084.

366. *See id.* at 46083–85.

367. *See also* Chem. Mfrs. Ass'n. v. EPA, 899 F.2d 344, 348 (5th Cir. 1990) (considering EPA's test rule for cumene based on genotoxicity, oncogenicity, teratogenicity, and acute and chronic aquatic toxicity). EPA's environmental effects testing rule is limited to toxicity to four types of aquatic organisms. *See* 40 C.F.R. §§ 797.1050–797.1950 (2022). Human health effects testing pertains entirely to toxicity. *See id.* § 798.

polymers,[368] EPA's rule effectively exempted most plastics from TSCA scrutiny.

The very properties that make plastics useful, however, also make them persistent in the environment. Furthermore, when plastics break down into smaller particles or into breakdown chemicals, they can be toxic to humans and other species.[369] The impacts targeted by TSCA include not only the effects of manufacturing, processing, and use, but also the effects of *disposal* of those substances.[370] Thus, EPA's initial exemption improperly focuses only on the effects of the original chemical substances and products, ignoring significant toxicological effects later in their life cycles. EPA sought to address this concern by excluding from the polymer exemption chemicals that are "designed or . . . reasonably anticipated to substantially degrade, decompose, or depolymerize."[371] EPA has not yet used this generic language, however, to expand its TSCA testing or regulation, perhaps making it too early to assess the efficacy of the regulatory exclusion.

Significant new scientific evidence suggests plastics may have greater toxicological effects than EPA considered when adopting its 1984 and 1995 exemptions. For example, even during consumer use, toxic chemicals from plastics, such as food packaging, can leach into human food and liquids.[372] EPA recognized some of this new information in a 2010 regulatory amendment excluding polymers that contain chemical substances, such as PFAS and perfluoroalkyl carboxylates that demonstrably cause significant domestic human health and environmental problems.[373] Some chemicals currently undergoing risk assessment under the 2016 TSCA amendments are plastics additives,[374] but the limited scope and slow pace of those reviews suggest that many toxic additives are likely going unaddressed.

The polymer exemption also ignores the broader range of environmental impacts arguably included in the statutory text. TSCA authorizes regulation to address "any other effect which may present an unreasonable risk of injury to

368. *See* Premanufacture Notification Exemptions; Exemptions for Polymers, 49 Fed. Reg. at 46081–82; 40 C.F.R. § 723.250(d).

369. *See supra* Part I.B.3.

370. *See supra* note 349, 15 U.S.C. §§ 2603(a)(1), 2605(a).

371. 40 C.F.R. § 723.250(d)(3) (2022).

372. *See* Hahladakis et al., *supra* note 40.

373. *See* Premanufacture Notification Exemption for Polymers; Amendment of Polymer Exemption Rule to Exclude Certain Perfluorinated Polymers, 75 Fed. Reg. 4295 (Jan. 27, 2010) (to be codified at 40 C.F.R. pt. 723).

374. *See supra* notes 360–364 and accompanying text (pigment used to dye plastic). Other examples include phthalates used to plasticize (make more malleable) plastics polymers, *see, e.g.*, *Risk Evaluation for Bibutyl Phthalate (1,2-Benzene-dicarboxylic acid, 1,2-dibutyl ester)*, EPA (Mar. 30, 2022), https://perma.cc/YPU4-2HTA; and flame retardants added to make plastics fire resistant, *see, e.g.*, *Risk Evaluation for Phosphoric Acid, Triphenyl Ester (TPP)*, EPA (Mar. 30, 2022), https://perma.cc/JD9Z-2QBV.

health or the environment."[375] The statute defines "environment" broadly to include "water, air, and land and the relationship which exists among and between water, air, and land and all living things."[376] Although some serious human health and environmental effects of plastics are toxicological,[377] other impacts include physical harm to wildlife.[378]

One potential justification for EPA's decision to limit its TSCA analysis to toxicological harm is the statutory title: the *Toxic* Substances Control Act. Statutory titles can be used to interpret otherwise ambiguous statutory language.[379] A second argument might be that, under the statutory construction principle *ejusdem generis*, general language following a more specific list includes only additional things of a similar nature.[380] Thus, in the context of TSCA the words "any other effect which may present an unreasonable risk of injury to health or the environment" might be construed to mean "any other *toxicological* effect."[381]

Other rules of statutory construction, however, suggest otherwise. Clear statutory text controls over titles or section headings,[382] and the unqualified language "any other effect" is not limited to toxicological effects, especially given the ease with which Congress could have specified such a limitation. Moreover, specific statutory provisions govern over general language,[383] suggesting that this portion of the text should govern over the generic statutory title. Even if the text of TSCA is sufficiently ambiguous in this regard to allow EPA to interpret the statute to either include or exclude non-toxicological impacts, under Step II of the *Chevron* doctrine[384] an EPA regulatory interpretation of TSCA to include non-toxicological health and environmental effects of plastics would likely be upheld.

b. Food, Drug & Cosmetic Act

The federal FDCA tasks the FDA with regulating food contact substances, including plastic food packaging.[385] The FDA must "consider criteria such as the probable consumption of such food contact substance and potential

375. 15 U.S.C. § 2603(b)(2)(A).
376. *Id.* § 2602(6).
377. *See supra* Part I.B.3.
378. *See supra* Part I.B.3.a.
379. *See* ANTONIN SCALIA & BRYAN A. GARNER, READING LAW: THE INTERPRETATION OF LEGAL TEXTS 199 (2012).
380. *See id.* at 199–213.
381. 15 U.S.C. § 2603(b)(2)(A).
382. *See* SCALIA & GARNER, *supra* note 379, at 221–23.
383. *See id.* at 183.
384. Chevron, U.S.A., Inc. v. Nat. Res. Def. Council, 467 U.S. 837, 842–43 (1984).
385. 21 U.S.C. § 348.

toxicity of the food contact substance."[386] In 1958, the Food Additives Amendment authorized the FDA to conduct premarket approval and introduced the Delaney Clause, which required that "no additive shall be deemed to be safe if it is found to induce cancer when ingested by man or animal."[387] In 1979, the D.C. Circuit in *Monsanto Co. v. Kennedy*[388] held that the FDA could decline to regulate chemicals present in food packaging if the chemicals were present in insignificant amounts.[389] Yet in 1987, the same court reached a very different conclusion in *Public Citizen v. Young*[390] in a case about color additives, holding that the Delaney Clause was not subject to a de minimis exception.[391] The Court held that Congress had been "extraordinarily rigid": if a chemical was found to induce cancer in a laboratory animal, the FDA was required to ban its use.[392] Interestingly, however, the Court limited its holding to color additives:

> [W]e deal here only with the color additive Delaney Clause, not the one for food additives. Although the clauses have almost identical wording, the context is clearly different. Without having canvassed the legislative history of the food additive Delaney Clause, we may safely say that its proponents could not have regarded as trivial the social cost of banning those parts of the American diet that . . . are at risk.[393]

Thus, the FDA has continued its negligible risk approach consistent with the holding in *Monsanto* for all chemicals present in food packaging other than food additives, despite the literal reading of the Delaney Clause.[394] Determining what constitutes a negligible risk, however, poses further regulatory hurdles: what amounts of a chemical are insignificant and to what degree does a chemical leach from packaging into food? The FDA has only rarely and inconsistently banned chemicals in food packaging, and generally only after significant public pressure or after industry has already voluntarily phased out the chemicals' use. For example, the FDA banned BPA from sippy cups and baby bottles in 2012, years after manufacturers voluntarily phased out BPA from use in such products.[395] In 2016, the FDA banned three PFAS chemicals linked to cancer from use in food packaging after a petition by several environmental groups,

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386. *Id.* § 348(h)(3)(B).
387. *Id.* § 348(c)(3)(A).
388. 613 F.2d 947 (D.C. Cir. 1979).
389. *Id.* at 955.
390. 831 F.2d 1108 (D.C. Cir. 1987) *cert. denied*, 108 U.S. 1470 (1988).
391. *Id.* at 1122.
392. *Id.*
393. *Id.* at 1120.
394. *See* Catherine A. Picut & George A. Parker, *Interpreting the Delaney Clause in the 21st Century*, 20 Toxicologic Pathology 617, 620–21 (1992).
395. 77 Fed. Reg. 41899 (Jul. 17, 2012) (to be codified at 21 C.F.R. pt. 177).

noting that industry was already phasing the chemicals out.[396] In contrast, the FDA has still not banned phthalates from food packaging despite significant evidence of harm.[397] Environmental groups recently sued the FDA in federal court to compel a response on the petition they filed in 2016 urging the agency to ban phthalates.[398]

Single-use plastics like polystyrene and polypropylene were approved decades ago, and some scholars argue that the FDA has not adhered to its statutory mandate in reevaluating these materials' safety given more recent research.[399] Therefore, like TSCA, the FDCA may also represent a relatively unexplored statutory means of better regulating plastic.

III. Recommendations for Reform

A. Introduction

U.S. environmental law has been ineffective in addressing the full life cycle environmental impacts of plastics. This Part evaluates several categories of existing, proposed, or potential reforms at the national level[400] to address those gaps.

Two recent federal statutes address some, but not all, of those impacts. The 2016 TSCA amendments reduced barriers to EPA regulation of chemicals used in plastics.[401] Those reforms leave gaps in the impacts EPA considers, however, and the pace of TSCA review and regulation remains slow.[402] Moreover, regulating individual chemicals used to make plastics rather than plastics *as a product* cannot meaningfully address the global plastic waste disposal problem.

In 2015, Congress enacted the Microbead-Free Waters Act ("MBFWA"), which banned manufacturing and introduction into interstate commerce of

396. 81 Fed. Reg. 5 (Jan. 4, 2016) (to be codified at 21 C.F.R. pt. 176).

397. *See supra* notes 127–130 and accompanying text.

398. The FDCA requires the FDA to respond to petitions within 180 days. 21 U.S.C. § 348(c)(2). *See* Petition for Writ of Mandamus, *In re* Env't Def. Fund et al., No. 21-1255 (D.C. Cir. 2021).

399. Zoe M. Grant, *The Plastic Pollution Crisis: Combating Single-Use Plastics Through NEPA Challenges to the FDA's Food Contact Substance Regulations*, 35 J. Env't L. & Litig. 371, 393–94 (2020) (arguing that relying on outdated data in reaching a decision may be a violation of the National Environmental Policy Act).

400. Some states and localities and international bodies have adopted laws and resolutions regarding plastics. Most notably, the United Nations adopted a resolution in March 2022 which lays out a plan to develop a legally binding treaty to "end plastic pollution" by the end of 2024. Environment Assembly of the United Nations Environment Programme Res. 5/14 (Mar. 2, 2022). The resolution recognizes that plastic pollution includes microplastics. *Id.* at 2. This article, however, focuses on national regulation in the United States.

401. *See supra* Part II.C.

402. *See id.*

rinse-off cosmetic products with intentionally added microbeads.[403] One analyst speculated this result was possible because the law was tightly focused, narrow in scope, supported by multiple interest groups, and focused on human health as well as environmental impacts.[404] Other possible explanations include significant public concern about the health and environmental impacts of microbeads, and industry's desire to avoid unfair competition and inconsistent state and local regulation.[405] The MBFWA effectively addressed an environmentally significant problem, but for only one set of products. Nevertheless, it overcame one key limit in existing law discussed above by banning products Congress deemed caused more harm than justified by product benefits. This was an unusual legislative encroachment on manufacturer and consumer choice.

Given the precedent set by the MBFWA, what additional reforms can further reduce pollution from plastics? Options evaluated below include improvements to the existing regulatory system, improved consumer information, taxes and other economic incentives, EPR, CE requirements, and product bans and phase-outs. Many, but not all, of these ideas appear in the Break Free from Plastic Pollution Act ("BFPPA"), first introduced in the 116th Congress[406] and reintroduced in the 117th Congress.[407] Below we discuss the extent to which the BFPPA reflects each strategy, and the extent to which those approaches address the limitations identified in Part II.[408]

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403. 23 U.S.C. § 331(ddd)(1). Microbeads are polyethylene microspheres used as exfoliates in cosmetics and toothpastes. *See* David A. Strifling, *The Microbead-Free Waters Act of 2015: Model for Future Environmental Legislation, or Black Swan?*, 32 J. LAND USE & ENV'T L. 151, 154 (2016). They reach aquatic environments when washed down drains because sewage treatment plants are not designed to filter them. *See id.* at 155. Although inert, they absorb and concentrate environmental toxics such as PCBs and pesticides; and because they are similar in size and shape to fish eggs, they are consumed by aquatic species and biomagnify up the food chain. *See id.* at 155–56.

404. *See* Strifling, *supra* note 403, at 161–64.

405. *See id.* at 162–64. The bill preempted non-identical state and local regulation. Microbead-Free Waters Act of 2015, Pub. L. No. 114–114, § 2(c), 129 Stat. 3129.

406. The House and Senate bills were referred to committee but did not reach the floor of either house. *See* H.R. 5845, 116th Cong. (2d Sess. 2020); S. 3263, 116th Cong. (2d Sess. 2020).

407. Break Free From Plastic Pollution Act, S. 984, 117th Cong. (1st Sess. 2021); H.R. 2238, 117th Cong. (1st Sess. 2021). The House and Senate bills are identical. *See All Information (Except Text) for S.984 - Break Free From Plastic Pollution Act of* 2021, CONGRESS.GOV, https://perma.cc/ZD2Y-3AEP (identifying related bills).

408. This is not a complete evaluation of a long (161-page) and complex bill.

B. Pending and Additional Reform Proposals

1. Updating Existing Regulations

The most straightforward approach to control plastics pollution more effectively is through targeted improvements to existing regulations or statutes. Examples include updating the OCPSF effluent limitations guidelines and CAA emissions limitations for plastics manufacturers. The potentially most impactful change, however, might be to EPA's TSCA polymer exemption[409] given that supposedly benign polymers cause more harm than EPA initially assumed. EPA currently excludes certain potentially toxic additives as well as polymers that break down with environmental exposure.[410] EPA should review all polymers with potentially toxic additives and subject them to full TSCA testing and evaluation. Moreover, EPA should evaluate evidence that polymers degrade in the environment and reconsider its initial assumptions underlying the polymer exemption.

EPA should also amend its regulations and TSCA practices to consider the significant non-toxicological effects of plastics in the environment, such as ingestion by birds and marine organisms and entanglement of birds and other wildlife in floating and submerged plastics. The text of TSCA supports this interpretation.[411] If courts disagree, however, Congress should amend the statute to clarify its intent to consider all impacts of chemical substances and mixtures—and the products they are used to make—on human health and the environment.

In addition, EPA could streamline TSCA chemical review by making decisions based on chemical *class* to avoid regrettable substitutions, such as the substitution of BPA with BPS, which has similar toxicological concerns.[412] This would better equip EPA to keep up with the fast pace of chemical production.[413] As a model for such action, Washington State recently passed a law that authorizes its state Department of Ecology to classify and take actions on chemicals on a class-by-class approach.[414]

The BFPPA addresses some of these proposals and could go a long way to further reduce air and water pollution from plastic manufacturing. It would

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409. *See supra* Part II.C.2(a)(ii).

410. *See supra* note 359–361.

411. *See supra* notes 376–378 and accompanying text.

412. *See* Chen et al., *supra* note 115.

413. Over nine thousand different chemicals within the "PFAS" class have been identified to date. *See Perfluoroalkyl and Polyfluoroalkyl Substances*, NAT'L INST. ENV'T HEALTH SCIS. (July 29, 2022), https://perma.cc/N3FG-FMR8; *see also supra* notes 117–120 and accompanying text.

414. Pollution Prevention for Healthy People and Puget Sound Act, Wash. Rev. Code 70.365 (2019).

require EPA to update nationwide controls for air pollution[415] and water pollution[416] from plastic manufacturing, and to add environmental justice requirements for individual facilities.[417] The bill does not, however, address gaps left by EPA's existing TSCA exemption.[418] Moreover, even full compliance with the mandated new and revised regulations may not correct all defects in existing regulation. For example, the bill does not require EPA to revisit its 1987 decision to set BAT equal to BPT, or its decision not to require zero discharge methods for new sources.[419]

In addition to these gaps, this reform strategy remains bound by the problems of complexity, change, and stagnation that plague existing regulatory efforts. The regulatory process will continue to take many years and will remain subject to potential litigation delays. The "temporary pause" provision in the BFPPA preventing new permits until EPA adopts final regulations is an effective approach similar to one Congress adopted in RCRA to speed EPA adoption of hazardous waste treatment standards.[420] It also reflects the "precautionary principle" in international environmental law, which provides that lack of full scientific certainty should not preclude measures to prevent threats of serious or irreversible environmental damage.[421] Existing facilities, however, remain subject to inadequate regulation until EPA issues new rules. Moreover, one additional round of mandated new rules may not capture pollutants generated by new plastics and new additives. EPA will still struggle to keep up with such a dynamic industry.

Even to the extent that revisions to air and water pollution controls for plastics succeed, targeting changes for one industry does not address the systemic problem of complexity, change, and stagnation that limit the efficacy of pollution controls for all industries. Congress could streamline the regulatory

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415. *See* Break Free From Plastic Pollution Act, S. 984, 117th Cong. § 4(d) (1st Sess. 2021) (requiring EPA adoption of new source performance standards, NESHAPs, and other controls for plastic manufacturing).

416. *See id.* § 4(e) (requiring revised OCPSF effluent limitations to limit all pollutants discharged, require zero discharge for plastic pellets and other plastic material, and revise effluent limitations for petroleum refining facilities making plastic precursors).

417. *See id.* § 4(f) (requiring environmental justice assessments and mitigation of disproportionate impacts from new plastics manufacturing facilities).

418. Congress affirmed the polymer exemption in 2016. *See supra* note 362.

419. It does require zero discharge unless EPA finds the best available technology will not achieve that target, with similar provisions for NESHAPs. That merely restates existing law, and EPA once before rejected the use of closed cycle methods available to achieve zero discharge. *See supra* notes 209–210.

420. *See* 42 U.S.C. §§ 6924(b)–(g).

421. *See* U.N. Conference on Environment and Development, *Rio Declaration on Environment and Development*, U.N. Doc. A/CONF.151/26 (Vol. 1), annex I, at 3 (Aug. 12, 1992), https://perma.cc/8CXN-ZS23.

process by amending the Administrative Procedure Act[422] and by reducing the litany of extra-statutory processes that impede expeditious agency action.[423] Congress might also consider broader application of the precautionary principle via statutory zero discharge and emissions requirements for all industrial discharges after prescribed deadlines unless EPA fully reevaluates and revises applicable regulations.

2. *Probing Life Cycle Sustainability of Plastic*

Strategies evaluated in Part III.B.1 would further reduce environmental externalities from plastic manufacturing. They would not, however, address broader global environmental problems posed by plastics use and improper disposal. The regulated free market approach does not consider whether the life-cycle harm from making and using plastic can be reduced sufficiently to justify societal benefits. Further reforms could seek to limit plastics to the most beneficial uses, and to reduce the harm caused by remaining plastics uses. Other goals could be easily recyclable single polymers without toxic additives or production chemicals, non-toxic and biodegradable plant-based plastics, and improved waste disposal and recycling systems. These goals are not mutually exclusive, nor are possible means to attain them. None of the strategies (short of bans) are "silver bullets" capable of addressing plastic pollution alone. Thus, multiple reforms are most likely to provide adequate solutions to the plastic crisis.

a. *Improved Consumer Information*

Providing consumers more and better information on life cycle environmental impacts could influence product selection and use. This strategy is least intrusive on producer and consumer choice and hence potentially the most politically likely option. Information has been used as a strategy to influence consumer choice for other products with varying degrees of success.[424]

Several information gaps impede consumer ability to make informed choices about what plastics they use, for what purposes, and how many times per product. Plastic has easily discerned properties for different uses, such as thickness, rigidity, durability, and color. Nonexperts, however, have no easy way to know whether a product is a single or composite polymer, was manufactured using toxic chemicals, contains toxic additives, or will break down into harmful components.[425] Even the familiar product symbol bearing numeric codes that

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422. 5 U.S.C. §§ 551–706.

423. *See supra* note 189.

424. *See supra* note 162.

425. *See, e.g.*, Kathryn M. Rodgers et al., *How Well Do Product Labels Indicate the Presence of PFAS in Consumer Items Used by Children and Adolescents?* 56 ENV'T SCI. TECH. 6294, 6294 (2022).

purport to inform consumers about recyclability are misleading and confusing.[426] This leads to ineffective consumer waste sorting and impedes effective plastic recycling.[427] Some have argued that efforts to promote plastics recycling and to reduce litter, in addition to being less effective than promised, reflect industry strategy to encourage plastic use and to focus attention on consumer behavior rather than producer responsibility.[428]

The BFPPA would address several consumer information gaps. The bill would require industry Producer Responsibility Organizations ("PROs")[429] to implement consumer outreach and education programs regarding product end-of-life management, waste collection opportunities and locations, and recycling and composting instructions, including understandable and consistent information on the recyclability of various plastics.[430] It also mandates standardized product labeling.[431] These provisions could promote better informed consumer decisions regarding purchases and post-use product handling.

Although better consumer education is desirable and potentially useful, several factors limit its efficacy. It presumes altruistic consumer decisions based on external harm.[432] Factors that fueled the plastics boom, such as low cost and convenience, will likely limit the effectiveness of an information-based approach to market change. Efficacy also depends on accuracy, completeness, understandability, and accessibility of information, but maximizing those factors simultaneously is impossible. For example, more complete information will be longer and more complex, which will likely reduce the degree to which busy consumers comprehend and act on that information.

426. *See* Gail L. Achterman, *Implementing Plastics Recycling Mandates*, 9 Fall Nat. Res. & Env't 13, 13–14 (1994); *see also* John Hocevar, Greenpeace Reports, Circular Claims Fall Flat: Comprehensive U.S. Survey of Plastics Recyclability 4–5 (Ivy Schlegel & Perry Wheeler eds., 2020).

427. *See* Hocevar, *supra* note 426, at 6.

428. *See* Eriksen, *supra* note 165, at 162.

429. *See* Break Free From Plastic Pollution Act, S. 984, 117th Cong. § 2 (1st Sess. 2021) (adding 42 U.S.C. § 12102 providing for PROs).

430. *See id.* (adding 42 U.S.C. § 12106 requiring PRO implementation of consumer outreach and education). The bill also promotes standardization through EPA guidance on plastic recycling and composting. *See id.* (adding 42 U.S.C. § 12301).

431. *See id.* (adding 42 U.S.C. §§ 12304–12306).

432. Consumer behavior varies based on external factors. *See* Thomas L. Powers & Raymond A. Hopkins, *Altruism and Consumer Purchase Behavior*, 19 J. Int'l Consumer Mktg. 107, 122–24 (2006). Empirical surveys suggest consumer altruism depends on personal sacrifice involved, personal reputation, and self-identity. *See* Julian Le Grand et al., *Buying for Good: Altruism, Ethical Consumerism and Social Policy,* 55 Soc. Pol'y & Admin. 1341 (2021).

b. Taxes and Other Economic Incentives

Taxes and other economic incentives employ a somewhat more intrusive strategy by internalizing costs without dictating producer and consumer choices. Making a product more expensive might reduce production or consumption and potentially incentivize development of cheaper and less harmful alternatives. This strategy can be used by changing costs to producers, sellers, or consumers,[433] and it has been effective to reduce SUP use domestically and internationally.[434]

The BFPPA would impose taxes or other economic incentives in several ways. Covered private entities must participate in a PRO and pay fees necessary for the organization to meet its statutory responsibilities.[435] Although the bill does not mandate specific fee structures, entities would internalize harm by funding efforts to reduce, mitigate, and remediate that harm. By requiring PROs to consider factors regarding the disparate harm caused by different products,[436] sufficiently high fees might incentivize producers to change manufacturing choices to reduce their proportionate costs.

The BFPPA would also create a national deposit-refund scheme for plastic beverage containers, requiring manufacturers to impose refundable deposit fees on retailers, and retailers to impose refundable deposit fees on end purchasers.[437] Unrefunded fees would pay for collection and recycling programs and other efforts to mitigate harm from disposal of plastic beverage waste.[438] At a minimum, a deposit-refund scheme would incentivize consumers to return rather than discard empty beverage containers for recycling or proper disposal. They might also incentivize consumers to purchase beverages in other materials or sizes.

Economic incentives in the BFPPA apply to only some phases of the plastics life cycle. Other incentives might include taxes or elimination of subsidies for natural gas and petroleum products used to make plastics precursors, particularly given that fossil fuel subsidies make plastics artificially inexpensive relative to competing materials,[439] or taxes on SUPs and other plastic products to

433. A tax on production will likely be passed to consumers if possible given the price and efficacy of competing products. A tax imposed on consumers will influence purchasing decisions, and thereby product demand and ensuing producer decisions.

434. *See supra* note 270 and accompanying text.

435. *See* Break Free From Plastic Pollution Act, S. 984, 117th Cong. § 2 (1st Sess. 2021) (adding 42 U.S.C. §§ 12101–12102).

436. *See id.*

437. *See id.* (adding 42 U.S.C. § 12104).

438. *See id.*

439. *See* Anastasia M. Telesetsky, *Beyond Existing Legislated Efforts to Control Single-Use Plastics: A Proposal for Ending Fossil-Fuel Subsidies and Standardizing Single-Use Plastic Packaging*, 57 CAL. W.L. REV. 43, 68 (2021) (proposing elimination of fossil fuel subsidies as one solution to plastics pollution).

disincentivize their use and to incentivize alternatives.[440] The BFPPA would do so for one product—single use plastic bags with specified exceptions—by imposing a $0.10 per bag tax made from *any material*[441] to disincentivize use of throwaway bags.[442] Conversely, given the competitive advantage plastics made from subsidized petrochemicals have enjoyed for decades, it is appropriate to offer subsidies, tax breaks, or other incentives for bio-based plastics so long as they are demonstrably compostable or recyclable and are not produced using or containing toxic chemicals.

The biggest impediment to using taxes to address the plastic crisis is not the concept but congressional aversion to new taxes. This is evidenced in a similar context by Congress' reluctance to adopt a carbon tax to fight climate change.[443]

Political feasibility aside, the efficacy of taxes and subsidies to incentivize safer materials depends on the levels of incentives or disincentives relative to market dynamics, such as the cost and competitiveness of alternative products. For example, it is difficult to predict the effectiveness of the proposed ten cent tax on single-use bags, but the tax level could be adjusted if it proves ineffective.

c. Extended Producer Responsibility and Circular Economy

EPR embraces an even broader cost internalization by making businesses, rather than consumers or governments, responsible for the full life cycle impacts of products.[444] The European Union and various U.S. states have applied this strategy to plastics and other goods.[445] California recently passed the most comprehensive EPR law of any U.S. state, requiring manufacturers of plastic packaging to pay for recycling by charging fees depending on the weight of the packaging, the ease of recycling, and whether the products contain toxic substances such as PFAS.[446]

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440. *See* Charles Grosenick, *The Price of Plastic*, 42 ADMIN. & REGUL. L. NEWS 34 (2017) (advocating SUP bag tax).

441. This choice avoids debates over comparative environmental impacts of "paper or plastic." *See* Margaret Kolcon, *Plastic Prohibition: The Case for a National Single-Use Plastic Ban in the United States,* 9 PENN STATE J.L. & INT'L AFFS. 194, 220–21 (2021).

442. *See* Break Free From Plastic Pollution Act, S. 984, 117th Cong. § 3 (1st Sess. 2021) (amending Internal Revenue Code to impose single-use bag tax).

443. *See* Alicia Doniger, *Will U.S. Ever Put a Price on Carbon as Part of Climate Change Policy?*, CNBC (Nov. 15, 2021), https://perma.cc/J8TG-W9CW.

444. *See* Eriksen, *supra* note 165, at 162 (proposing producer responsibility for life cycle plastics impacts).

445. *See* El-Jourbagy et. al., *supra* note 1, at 113–17 (evaluating EPR requirements in the EU and elsewhere); Eastwood et al., *supra* note 164, at 10978 (cataloguing state EPR laws).

446. California's new EPR law also requires that all single-use packaging be recyclable or compostable by 2032, and further mandates a 25% reduction in plastic packaging sold in the state. S.B. 54, 2021–22 Reg. Sess. (Cal. 2022). Maine and Oregon passed the country's first

The related goal of CE is production and use of materials and products that have maximum utility and life cycles, are versatile for multiple-use, and that maximize reuse or safe recycling.[447] In the case of plastics, this could mean elimination of SUPs and production only of multiple use plastics or bioplastics that decompose; are free of toxic materials or breakdown products; and are expressly designed to be sustainable throughout their production, use, and end-of-life phases.

The BFPPA would apply EPR and CE to the plastics industry. PROs would be responsible for functions otherwise borne by governments, such as collection and sorting of products for which they are responsible and prevention of litter or collection and disposal of plastic trash.[448] The BFPPA would promote CE for plastics by requiring PROs to develop product stewardship plans[449] addressing issues such as post-use product collection and "any plans to transition to reusable covered products."[450] The qualifier "any" continues the policy of leaving production choices to the industry. However, the BFPPA would also require producers to "design for the environment" by minimizing the "impacts of extraction, manufacture, use, and end-of-life management" of covered products.[451] It would also set targets or mandate standards regarding percent of products recycled,[452] post-consumer recycled material, and nontoxic content.[453]

These provisions would reflect an evolution in the regulated free market approach to U.S. environmental law by regulating the product itself rather than simply pollution from its manufacturing and disposal. Those changes are not revolutionary, however, from the perspective of U.S. regulatory law generally. We regulate the nature and content—and not merely manufacturing externali-

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EPR laws for plastics in 2021. *See* ME. REV. STAT. ANN. 38, § 2146 (West 2021); S.B. 582, 81st Legis. Assemb., Reg. Sess. (Or. 2021).

447. *See generally*, Erick Hungaro Arruda et al., *Circular Economy: A Brief Literature Review (2015-2020)*, 2 SUSTAINABLE OPERATIONS & COMPUTS. 79, 79 (2021). There is no single accepted definition of CE. *See id.;* Julian Kirchherr et al., *Conceptualizing the Circular Economy: An Analysis of 114 Definitions*, 127 RES., CONSERVATION & RECYCLING 221, 221 (2017).

448. *See* Break Free From Plastic Pollution Act, S. 984, 117th Cong. § 2 (1st Sess. 2021) (adding 42 U.S.C. § 12103).

449. *See id.* (adding 42 U.S.C. § 12105).

450. *See id.* (adding 42 U.S.C. § 12105(b)(3)(J)).

451. *See id.* (adding 42 U.S.C. § 12303). Specifically, producers would be required to eliminate or reduce material used; eliminate toxic substances; eliminate mixed-polymer and mixed material packaging; reduce additives; design for reuse and lifespan expansion; use recycled and sustainably and renewably sourced materials; minimize packaging; reduce degradability in aquatic environments; and improve recyclability and composability. *See id.*

452. *See id.* (adding 42 U.S.C. § 12105) (providing for recycling targets).

453. *See id.* (adding 42 U.S.C. § 12302) (establishing mandatory product standards).

ties—of other products deemed highly dangerous, for example by requiring seatbelts in private vehicles.[454]

Congressional adoption of these provisions would reflect an important shift and potentially more effective approach to historically elusive environmental problems. EPR does not overtly change the regulated free market philosophy of U.S. environmental law because it does not dictate or impede producer and consumer decisions directly. Rather, it ensures those decisions reflect full environmental costs and requires those initially responsible for the problems—rather than consumers[455] or governments—to reduce or eliminate resulting impacts. CE "prods" in the BFPPA's product stewardship plans would encourage, but not require, producers to adopt more sustainable products and practices. The more stringent product design and legislative standards in the BFPPA more intrusively—and likely more effectively—would mandate such changes.

One issue regarding EPR is the degree to which it is appropriate to delegate governmental functions to private businesses with vested and potentially conflicting interests, and the monitoring and oversight needed to prevent self-serving implementation. Activities such as waste collection and recycling can be governed by regulatory requirements, monitoring, and enforcement.[456] Decisions affecting land use and planning, however, such as the location of waste collection and disposal facilities, intrude more significantly on traditional government functions.[457] Given the history of misleading labeling and other information about plastics recycling,[458] it is also potentially troubling—absent careful oversight—to delegate to the plastics industry responsibility to design and disseminate accurate and reliable consumer information.

A second potential issue is the efficiency of delegating functions such as waste collection and recycling beyond a single industry. It may make sense to require the plastics industry to collect and recycle or properly dispose of their discarded products. Although plastics pose a particularly troubling waste disposal problem, they are not the only products with similar issues. Subjecting those producers to independent EPR requirements could result in an inefficient network of commercial and municipal waste disposal. Requiring producers to compensate responsible government entities to operate unified waste collection and

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454. *See* Motor Vehicle Mfrs. Ass'n v. State Farm Mut. Auto Ins. Co., 463 U.S. 29, 31 (1983).

455. Producers will likely pass the resulting costs to consumers, but prices would then reflect the product's environmental costs.

456. This oversight is accomplished governmentally in RCRA and similar statutes and regulations, *see* 42 U.S.C. §§ 6901–6992k, but there is precedent for industry self-regulation through voluntary compliance in the environmental arena. *See, e.g.*, *ISO 14000 family, Environmental Management*, INT'L ORG. FOR STANDARDIZATION, https://perma.cc/PG62-49N2.

457. *See* DOUGLAS A. PORTER, MANAGING GROWTH IN AMERICA'S COMMUNITIES 15–18 (1997) (noting that local governments, and to some extent states and the federal government, typically are responsible for regulating land use and development).

458. *See, e.g.*, HOCEVAR, *supra* note 426, at 4–5.

management could avoid that problem, while still imposing financial responsibility on those responsible for the problems rather than the general taxpayer.

d. Bans and Phase-outs

EPR and CE would reflect a significant shift in the philosophy of U.S. environmental law. If effectively implemented and enforced, they might substantially reduce domestic and global pollution from the manufacturing, use, and disposal of plastics. They are not likely, however, to eliminate them. For example, Given nearly three-quarters of a century of partially effective litter control efforts in the United States,[459] the BFPPA's litter control provisions are not likely to eliminate improper disposal of SUPs and other plastic. Plastic waste and plastic pollution reach all corners of the globe through multiple pathways.[460] Moreover, the United States has shipped plastic products and plastic waste around the globe, much of which has been improperly managed and causes significant harm in other nations or contaminates oceans and other parts of the global environment.[461]

The BFPPA seeks to reduce this global impact from U.S. plastic waste by banning plastic waste exports to non-member nations of the Organization for Economic Cooperation and Development ("OECD"), as well as waste that will then be exported elsewhere from an OECD nation or is contaminated with toxics.[462] This would significantly reduce, but not eliminate, global waste disposal problems from U.S. plastic. Enforcement of further waste exports from OECD nations is uncertain. More importantly, the bill does not regulate U.S. exports of plastic *products*, including plastics beverage containers and other SUPs. The post-use fate of those products depends on laws and regulations in the recipient nations.

The most extreme means to address this problem is to prohibit plastics production. This would reflect maximum government intrusion on producer and consumer choice and therefore may be a hard sell in Congress.[463] Yet product bans, in addition to those imposed by the MBFWA,[464] have precedents in U.S. environmental law. For example, the CAA successfully banned chloro-

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459. The "Keep America Beautiful" campaign launched in 1953. *See Who We Are*, KEEP AMERICA BEAUTIFUL, https://perma.cc/D6CC-FCZW.

460. *See supra* Part I.B.

461. *See id.*

462. The BFPPA also bans exports to OECD nations without their consent, which ensures the ability of those nations to control the exported material adequately pursuant to OECD standards. *See* Break Free From Plastic Pollution Act, S. 984, 117th Cong. § 2 (1st Sess. 2021) (adding 42 U.S.C. § 12307).

463. SUP bans have been proposed for at least a decade. *See, e.g.*, Coulter, *supra* note 154, at 1983.

464. *See supra* note 403.

fluorocarbons, substances that damaged the protective global ozone layer.[465] The CAA also banned production and use of leaded gasoline,[466] and conferred on EPA extensive authority to ban or regulate other automotive fuel additives.[467] Notably, although Congress adopted the leaded gasoline ban to protect catalytic converters designed to reduce automotive air pollution, it had the corollary but important benefit of vastly reducing lead pollution in air, water, and elsewhere.[468]

Although bans would eliminate harm from new plastics,[469] they would also eliminate benefits without considering availability of substitutes and offsetting harms. The wisdom of a ban, however, may differ for swizzle sticks used to mix drinks than for syringes to disseminate vaccines without needing repeated sterilization. Likewise, the answer may differ for single-polymer plastics without toxic additives than for mixed polymers or polymers with toxic additives that cannot be recycled or cause toxic contamination from recycling or reuse.

Despite this characterization, formal, product-specific cost-benefit analysis ("CBA") is not a sound or viable solution to these questions. CBA is fraught with serious methodological problems that can overcount benefits and undercount costs.[470] Moreover, experience with TSCA as interpreted in *Corrosion Proof Fittings* suggests product-specific CBA would further impede regulation by EPA or other agencies.[471] That obstacle would be particularly acute if agencies must use CBA to reach product-specific decisions about product utility versus harm, particularly if subject to existing regulatory complexities.

One potential solution to this problem is to streamline the regulatory process, either for this issue or generally. The 2016 TSCA amendments renewed efforts to evaluate chemicals used to make plastics and other goods, but not with significantly greater speed; and those reforms currently apply only to chemicals used to make plastics, not to plastic products.[472] Despite the current legislative gridlock in Congress, legislative bans have the potential to be adopted more swiftly than regulatory bans and with lower risk of judicial override.

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465. *See* 42 U.S.C. §§ 7671–7671q.

466. *See id.* § 7545(n).

467. *See id.* § 7545.

468. *See* Richard B. Alexander & Richard A. Smith, *Trends in Lead Concentrations in Major U.S. Rivers and Their Relation to Historical Changes in Gasoline-Lead Consumption*, 24 WATER RES. BULL. 557, 568 (1988).

469. Harm from past plastics use and disposal will continue for a long time regardless of future controls.

470. *See* DRIESEN, *supra* note 156, at 20–31.

471. *See* Corrosion Proof Fittings v. EPA, 947 F.2d 1201, 1215–23 (5th Cir. 1991).

472. *See supra* notes 335–340 and accompanying text.

The BFPPA adopts a mixed approach to plastics bans. It would ban or reduce some plastic uses legislatively, including SUP bags[473] and utensils,[474] although with significant exemptions[475] and ironically, one provision creates a massive automatic market for one SUP use.[476] The bill would also authorize EPA to ban other SUPs administratively, if EPA finds that a product is not recyclable or compostable and can be replaced by a reusable or refillable substitute.[477] This adds the potential for EPA to ban or curtail use of many other SUPs, but regulatory and litigation challenges for those actions would remain as impediments relative to direct legislative bans.

Conclusion

In the 1954 film *Sabrina*, a seemingly innocuous romantic comedy starring Humphrey Bogart and Audrey Hepburn,[478] Bogart plays a corporate executive pushing a miraculous new set of materials: plastics. Unlike the real plastics of *The Graduate*'s era a decade later, however, Bogart's fictional company promoted plastics made from sugar cane, remarkably prescient of the current generation of plant-based plastics substitutes.[479] Had the plastics industry followed the lead of *Sabrina* rather than that of *The Graduate*, perhaps the environmental impacts of their products would have been more benign. Because we cannot turn back the clock, however, a more salient question now is what legal changes might help solve the plastics crisis through product substitutes or other means.

As currently formulated, U.S. environmental law includes extensive authority to regulate the health and environmental impacts of plastic. Those efforts, however, have been woefully inadequate both domestically and globally, leaving a sad legacy of plastic pollution. At least two key factors help explain this failure. First, the regulatory process is extremely granular and complex, as is seemingly fitting to address such complicated technical issues. That complexity, however, has led to serious stagnation, particularly for an industry that has grown and changes as dramatically as plastics manufacturing. Environmental regulations simply have not kept up with that change. Second, the basic philos-

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473. *See* Break Free From Plastic Pollution Act, S. 984, 117th Cong. § 2 (1st Sess. 2021) (adding 42 U.S.C. § 12201).

474. *See id.* (adding 42 U.S.C. § 12202).

475. For example, the SUP bag ban excludes bags for in-store use, for example, to package produce and bulk items, or single-use garbage bags. *See id.* (adding 42 U.S.C. § 12201).

476. Restaurants and other beverage servers could not offer SUP straws automatically but would be *required* to stock them and provide them on request. Although designed to address legitimate disability needs, this provision ironically intrudes on business choices in the opposite direction. *See id.*

477. *See id.* (adding 42 U.S.C. § 12202).

478. SABRINA (Paramount Pictures 1954).

479. *See id.*

ophy of U.S. environmental law is to regulate production externalities but not to interfere with producer and consumer choice about what to make and what to purchase and use. That works for many products, but not when the product itself and its disposal has generated such serious and ubiquitous environmental harm.

Effective solutions to the plastic pollution crisis—and to similarly intractable environmental problems—must address these two fundamental problems. Absent expediting reforms to the regulatory process generally, which have been elusive for decades, the best solution to the first problem would be more effective use of the precautionary principle to prohibit new plastics and new plastics uses until proven safe. The soundest resolution to the second problem is to ban the use of SUPs and other plastics whose harm cannot be justified by their benefits, and to require or incentivize development of nontoxic alternative materials with longer life cycles and easier recyclability or biodegradability.