

Climate Change and the Clean Air Act of 1970 Part I: the Scientific Basis

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In Massachusetts v. EPA, the Supreme Court held that the 1970 Clean Air Act granted the Environmental Protection Agency (EPA) the authority to regulate greenhouse gases as air pollution. But, while the Court found the Act to “confer the flexibility necessary” to respond to “changing circumstances,” the Justices expressed skepticism that legislators in 1970 would have been familiar with the climate-altering effects of CO₂ and other heat-trapping gases. At the time of the Clean Air Act’s passage, the Court wrote, “the study of climate change was in its infancy.” That statement was misleading. By the late 1960s, scientists knew that greenhouse gases, derived from fossil fuel combustion, could alter the global climate with potentially serious and deleterious ensuing effects. They also recognized that addressing the problem could have broad economic implications, including on energy production and the automobile industry. These insights led to a wide-ranging conversation between leading scientists, high-level administrators at federal agencies, members of Congress, White House staff under Presidents Lyndon Johnson and Richard Nixon, the Council on

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Environmental Quality, and the President's Science Advisory Committee. It specifically included architects of the Clean Air Act, including Maine Senator Edmund Muskie, Tennessee Senator Howard Baker, Jr., and West Virginia Senator Jennings Randolph. Existing literature understates the breadth and depth of relevant discussions, as well as the specific connection between 1950s and 1960s-era climate science and air pollution research and regulation.

This Article reviews this history and its role in the passage of the Clean Air Act of 1970. We demonstrate (1) that scientists had by 1970 established the concern that greenhouse gases emitted into the atmosphere as a waste product of burning fossil fuel—in other words, as a pollutant—could alter the global climate with potentially destructive effects; (2) that this concern was extensively communicated to both the executive and legislative branches of the U.S. federal government.

*This history has important implications for the scope of EPA's authority under the Clean Air Act in light of the Court's articulation of the major questions doctrine in *West Virginia v. EPA*. By requiring a threshold determination of clear congressional authorization for administrative actions of "vast economic and political significance," the new major questions doctrine begets a novel type of legal-historical methodology that is distinct from both that of the era of strong purposivism and its textualist successor. We advance a template for the kind of historical analysis that may need to become standard in a post-*West Virginia* world.*

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INTRODUCTION

On July 16, 1970, Nixon aide John C. Whitaker received a set of documents from the newly created Council on Environmental Quality. One item specifically caught his attention. “Man’s Inadvertent Modification of Weather and Climate” presented what Whitaker called a “particularly hairy” problem: the capacity for humans to alter the long-term trajectory of the earth’s climate.¹ By trapping heat in the atmosphere, the report warned, “carbon dioxide pollution” would alter the balance of the “atmosphere’s energy which determines weather and climate.”² Pollution from a gas produced by daily activities—burning coal in power plants to produce electricity, burning gasoline to run cars—could raise the surface temperature of the planet and reshape the world’s geography.

1. Correspondence from John C. Whitaker to William M. Magruder, (July 20, 1970) (on file at the Richard Nixon Presidential Library [*hereinafter* RNPL], John C. Whitaker papers (White House Central Files: Staff Member & Office Files [*hereinafter* WHCF:SMOF]), b. 43, f. Annual Report-CEQ 1 of 2).

2. DRAFT FIRST ANNUAL REPORT, COUNCIL ON ENV'T QUALITY (1970) (on file at b.12, f. 2 of 6 RNPL, John C. Whitaker papers (WHCF:SMOF)) .

Three and a half decades later, in *Massachusetts v. EPA*,³ the Supreme Court held that the 1970 Clean Air Act granted EPA the authority to regulate carbon dioxide (CO₂) as air pollution.⁴ The Court found the Act's definition of air pollution to be "capacious," and the Act as a whole to "confer the flexibility necessary" to respond to "changing circumstances" in the rapidly evolving scientific study of air pollution and its control.⁵ Nevertheless, the Justices expressed skepticism that legislators in 1970 would have been familiar with the climate-altering effects of CO₂. At the time of the Clean Air Act's passage, the Court wrote, "the study of climate change was in its infancy."⁶

That statement was misleading. The archival record shows that, as early as the 1950s, scientists referred to CO₂ as "industrial pollution" and compared it with other industrial pollutants including particulate matter and sulfur dioxide.⁷ Many members of the federal government, including legislators involved in the passage of the Clean Air Act, were aware of the potential for CO₂ to adversely alter both local weather and global climate.⁸ While they would learn much more in the decades to come, already by the late 1960s scientists knew that greenhouse gases, derived from fossil fuel combustion, could alter the global climate with potentially serious and deleterious ensuing effects. They also recognized that addressing the problem could have far-reaching economic implications, including on energy production and automobiles.

These insights led to a wide-ranging and largely forgotten conversation between leading scientists, high-level administrators at federal agencies, members of Congress, White House staff under Presidents Lyndon Johnson and Richard Nixon, the Council on Environmental Quality, and the President's Science Advisory Committee.⁹ It specifically included architects of the Clean Air Act, including Maine Senator Edmund Muskie, Tennessee Senator Howard Baker, Jr., and West Virginia Senator Jennings Randolph.¹⁰

3. See generally *Massachusetts v. EPA*, 549 U.S. 497 (2007).

4. *Id.* at 532.

5. *Id.*

6. *Id.* at 507. Justice Stevens may have been inspired by the 1970 Council on Environmental Quality (CEQ) Report itself, which stated that the "science and technology of weather modification are only in their infancies." COUNCIL ON ENV'T QUALITY, FIRST ANNUAL REPORT OF THE COUNCIL ON ENVIRONMENTAL QUALITY 93 (1970). But this statement was in reference to the idea of using science for purposes of deliberate weather modification, the efficacy of which was highly contested.

7. See, e.g., E. WENDALL HEWSON, SCI. REP. NO. 1: SOME ASPECTS OF THE DISPERSION OF POLLENS AND INDUSTRIAL CONTAMINANTS IN RELATION TO MICROMETEOROLOGY 39 (1953).

8. See, e.g., 116 CONG. REC. 32,901 (1970) (statement of Sen. Edmund Muskie) (warning that air pollution, if not controlled, would "threaten irreversible atmospheric and climatic changes"); *Report of the Council on Environmental Quality: Hearing Before the Senate Subcomm. on Air and Water Pollution of the S. Comm. On Pub. Works*, 91st Cong. 5 (1970) (statement of Russell Train, Chairman, Council of Env't Quality) (testifying that the "international dimensions of the air pollution problem should not be overlooked . . . [as] discharge of particulates and carbon dioxide to the atmosphere could have dramatic and long-term effects on the world's temperature with many major consequences").

9. See *infra* Parts II.B, III.B, III.G, IV.A, V.C, V.D.

10. See *infra* notes 180–181 and accompanying text, notes 213–217 and accompanying text, notes 220–225 and accompanying text, Part III.B, note 255 and accompanying text, Part IV.A, notes 348–350 and accompanying text, and notes 361–362 and accompanying text.

Discussion of CO₂ and climate appeared in reports and congressional hearings on environmental problems broadly, including in relation to intentional weather modification, nuclear energy, the development of supersonic aviation, and space exploration, and in hearings specifically related to the consideration and drafting of the 1970 Clean Air Act.¹¹ The impact of CO₂ on climate was a major subject in the first report of the Council on Environmental Quality, released in draft form in 1969 and entered into congressional testimony as part of the hearings for the 1970 Act.¹² The topic was the subject of a wide variety of scientific papers and reports, several of which were transmitted to the Executive Branch and communicated to Congress in the 1960s and in 1970, particularly but not only in the context of urban air pollution.¹³ Concern about CO₂ pollution also made its way into film and television, including during an interview with President Nixon's Science Advisor, Lee DuBridge, on *Meet the Press* in 1969.¹⁴

This history has important implications for the scope of EPA's authority under the Clean Air Act. The Supreme Court's new articulation of the major questions doctrine in *West Virginia v. EPA*¹⁵ sets up what is essentially a historical inquiry: in those "extraordinary cases"¹⁶ in which an agency asserts control over issues of "vast economic and political significance,"¹⁷ the Court must closely scrutinize the extent to which Congress authorized the agency action.¹⁸ Significant greenhouse gas regulations pose one such major question, and the answer the Court requires now comes in the form of a clear statement from Congress in the statutory text. What counts as clarity, however, depends on both "context"¹⁹ and "history."²⁰ A major questions doctrine-inflected interpretation of terms in the 1970 Clean Air Act such as "weather [. . .] and climate"²¹ and "best system of emission reduction"²² thus involves recourse to the historical record to glean a "practical understanding of legislative intent."²³

Yet, neither the majority nor the dissent in *West Virginia* seriously engaged with the historical understanding of global climate change at the time of the 1970

11. These hearings will be discussed in a follow up article, Lanier-Christensen et al., *Climate Change and the 1970 Clean Air Act Part II: Congressional Debates* (forthcoming).

12. See generally COUNCIL ON ENV'T QUALITY, *supra* note 6; 91 CONG. REC. 32,908–17 (daily ed. Sept. 21, 1970).

13. See, e.g., ENV'T POLLUTION PANEL OF THE PRESIDENT'S SCI. ADVISORY COMM. [hereinafter *Env't Pollution Panel*], RESTORING THE QUALITY OF OUR ENVIRONMENT 113 (1965); NAT'L SCI. FOUND., WEATHER MODIFICATION: TENTH ANNUAL REPORT (1969); PRESIDENT'S TASK FORCE ON AIR POLLUTION, CLEANER AIR FOR THE NATION 32-34 (1970).

14. Transcript: *NBC's Meet the Press*, Prod. By Lawrence E. Spivak, guest: Dr. Lee A. DuBridge, Science Advisor to the President 2 (Dec. 28, 1969) (on file at b. 7, f. 3: DuBridge, Daniel Patrick Moynihan papers (WHCF:SMOF), RNPL).

15. See generally *West Virginia v. EPA*, 142 S. Ct. 2587 (2022).

16. *Id.* at 2608 (quoting *FDA v. Brown & Williamson Tobacco Corp.*, 529 U.S. 120, 159 (2000)).

17. *Id.* at 2605 (quoting *Utility Air Regulatory Grp. v. EPA*, 573 U.S. 302, 324 (2014)).

18. *Id.* at 2609.

19. *Id.* at 2607 (quoting *Davis v. Michigan Dept. of Treasury*, 489 U.S. 803, 809 (1989)).

20. *Id.* at 2608 (quoting *Brown & Williamson*, 529 U.S. at 159).

21. 42 U.S.C. § 7602(h).

22. 42 U.S.C. § 7411(a)(1).

23. *West Virginia*, 142 S. Ct. at 2609.

Clean Air Act's passage. The majority used history primarily to argue that EPA had only rarely invoked the main statutory provision at issue in the case; the dissent conceded that in 1970 climate change was among those future problems that Congress "knew it couldn't then know."²⁴ The majority sidestepped the fundamental historical question, and the dissent's response was incomplete. Scientists and government officials knew a great deal about global climate change in the 1960s and 1970s, and the architects of the Clean Air Act understood the "vast economic and political significance" of the legislation they were constructing and the task with which they entrusted the EPA in its inaugural year. When Senator Muskie, the Act's preeminent advocate, introduced the 1970 amendments on the floor of the Senate, he warned his colleagues that air pollution, if unchecked, would continue to "threaten irreversible atmospheric and climatic changes."²⁵ The evidence collected in this Article shows that Senator Muskie's words were not mere offhand remarks. They formed part of a broader narrative that extended beyond the formal legislative history of the 1970 Clean Air Act and that helps to define the original public meaning of "weather and climate" as used in the amendments themselves.

Historians have studied the early history of climate science, but there has been relatively little work on scientific communications with government in this early history.²⁶ Historian Joshua Howe has identified the early 1960s as a period when scientists were gaining an understanding of the potential adverse effects of increased atmospheric CO₂.²⁷ Paul Edwards has documented the rise of computer modeling beginning in the late 1960s as a key tool of climate research.²⁸ Highlighting a 1963 meeting convened by the Conservation Foundation, Spencer Weart has noted that in the 1960s increased atmospheric CO₂ was explicitly framed as an environmental problem requiring attention.²⁹

Scholars have also examined connections between climate science in the 1950s and 1960s and nuclear weapons research, the emergence of global atmospheric monitoring, and applied research in weather modification.³⁰ They

24. *Id.* at 2640 (Kagan, J., dissenting).

25. 116 CONG. REC. 32,901 (1970) (statement of Sen. Edmund Muskie).

26. *See generally* JAMES R. FLEMING, HISTORICAL PERSPECTIVES ON CLIMATE CHANGE (1998); SPENCER WEART, THE DISCOVERY OF GLOBAL WARMING (rev. ed. 2008); Spencer Weart, *The Discovery of Global Warming* (last updated Apr. 2022), <https://history.aip.org/climate/index.htm>; PAUL N. EDWARDS, A VAST MACHINE: COMPUTER MODELS, CLIMATE DATA, AND THE POLITICS OF GLOBAL WARMING (2010); DEBORAH R. COEN, CLIMATE IN MOTION: SCIENCE, EMPIRE, AND THE PROBLEM OF SCALE (2018); NAOMI ORESKES, SCIENCE ON A MISSION: HOW MILITARY FUNDING SHAPED WHAT WE DO AND DON'T KNOW ABOUT THE OCEAN (2021).

27. *See generally* JOSHUA HOWE, BEHIND THE CURVE: SCIENCE AND THE POLITICS OF GLOBAL WARMING (2014).

28. *See generally* EDWARDS, *supra* note 26.

29. WEART, *supra* note 26, at 42. On the Conservation Foundation, *see infra* Part II.A.

30. On nuclear power, *see* Paul N. Edwards, *Entangled Histories: Climate Science and Nuclear Weapons Research*, 68 BULL. OF THE ATOMIC SCIENTISTS 28 (2012). On weather modification and prediction, *see generally* KC HARPER, MAKE IT RAIN: STATE CONTROL OF THE ATMOSPHERE IN TWENTIETH CENTURY AMERICA (2017); *see also* Zeke Baker, *Climate State: Science-State Struggles and the Formation of Climate Science in the US from the 1930s to 1960s*, 47 SOC. STUDIES OF SCI. 861, 862–76 (2017). On the International Geophysical Year, *see infra* Part I.D; *id*; Benjamin W. Goossen, A

have linked developments in climate science to the rise of the global environmental movement in the late 1960s and early 1970s, particularly in the context of the 1972 UN Conference on the Human Environment in Stockholm.³¹ Political scientist David Hart has examined early climate knowledge in the federal government, including discussions in certain congressional debates from the 1950s through the 1970s.³²

Existing literature, however, substantially understates the breadth and depth of the relevant discussions, as well as the specific connection between 1950s and 1960s-era climate science and air pollution research and regulation. It also understates the degree to which these discussions informed the debate over and passage of the 1970 Clean Air Act.³³

Lawyers and legal scholars who have discussed the connection between climate science, air pollution, and the 1970 Clean Air Act largely begin their analysis later in the 1970s.³⁴ A recent retrospective masterfully chronicles the legislative machinations and political climate that spawned the 1970 Act, but makes hardly any mention of climate change.³⁵ In one of the few papers to address the question in depth, Professor Richard Revesz has studied many of the legislative materials surrounding the Clean Air Act's passage in 1970 and concluded that members of Congress were "aware of and concerned about the adverse impact of air pollutants, particularly greenhouse gases like carbon

Benchmark for the Environment: Big Science and 'Artificial' Geophysics in the Global 1950s, 15 JOURNAL OF GLOBAL HISTORY 149 (2020); Benjamin W. Goossen, *The Year of the Earth (1957-1958): Cold War Science and the Making of Planetary Consciousness* (2021) (Ph.D. dissertation, Harvard University).

31. See WEART, *supra* note 26; EDWARDS *supra* note 26.

32. David Hart, *Strategies of Research Policy Advocacy: Anthropogenic Climatic Change Research, 1957-1974*, CTR. FOR SCI. AND INT'L AFFS. (1992).

33. This will be discussed in-depth in a follow up article, Lanier-Christensen et al., *Climate Change and the 1970 Clean Air Act Part II: Congressional Debates* (forthcoming).

34. For example, Professor James Gustave Speth dives deep into the extent of early governmental knowledge of climate change, but he largely begins his story in the Carter Administration. JAMES GUSTAVE SPETH, *THEY KNEW: THE US FEDERAL GOVERNMENT'S FIFTY-YEAR ROLE IN CAUSING THE CLIMATE CRISIS 3-5* (2021). See also generally RICHARD J. LAZARUS, *THE MAKING OF ENVIRONMENTAL LAW* (2d ed. 2023); RICHARD N.L. ANDREWS, *MANAGING THE ENVIRONMENT, MANAGING OURSELVES* (3d ed. 2020); Jody Freeman & David B. Spence, *Old Statutes, New Problems*, 163 U. PA. L. REV. 1 (2014); Richard J. Lazarus, *Senator Edmund Muskie's Enduring Legacy in the Courts*, 67 ME. L. REV. 240 (2015); CHRISTOPHER J. BAILEY, *CONGRESS AND AIR POLLUTION: ENVIRONMENTAL POLICIES IN THE USA* (1998). Our question is what the U.S. government knew by 1970, when the Act was written and passed.

35. See generally Brigham Daniels et al., *The Making of the Clean Air Act*, 71 HASTINGS L.J. 901 (2020). On the history of predecessors to the 1970 Act, see generally Adam D. Orford, *The Clean Air Act of 1963: Postwar Environmental Politics and the Debate over Federal Power*, 27 HASTINGS ENV'T L.J. 1 (2021); Christopher D. Ahlers, *Origins of the Clean Air Act: A New Interpretation*, 45 ENV'T L. 75 (2015). Ahlers examined papers published in a 1968 issue of the Arizona Law Review on the issue of air pollution and characterized a statement about the long-term possibility of overloading the earth's atmosphere with CO₂ and radioactive materials as "an avant garde observation for students of global warming." Ahlers, *supra*, at 125 n.391. To say that such a statement was "avant garde," however, overlooks the robust published scientific literature and political debate of the time.

dioxide, on global warming and climate change.”³⁶ We agree with Revesz’s interpretation of these materials and with his argument that the careful study of history should “definitively resolve” the question of whether greenhouse gases are within the ambit of the Clean Air Act.³⁷ Yet, the Court gave these materials little airtime in its *West Virginia* decision, focusing instead on a “common sense” intuition that Congress would have written more clearly had it intended to task EPA with broad powers to combat climate change.³⁸ This Article’s wider historical inquiry provides the fuller “context” and “history” that the new major questions doctrine demands.

That broader history bears directly on the primary statutory question in *West Virginia*: whether the “best system of emission reduction” in section 111 of the Clean Air Act could include a cap-and-trade style regulation for greenhouse gases. In holding that Congress had not spoken with sufficient clarity to authorize such broad-based regulation, the Court argued that EPA’s development of an economy-wide “system” to address greenhouse gas pollution stretched the statutory authorization beyond any “practical understanding of legislative intent.”³⁹ To be sure, the Court is correct that specific authorization of a cap-and-trade program for controlling carbon dioxide pollution is not present in the Clean Air Act. But archival evidence shows that scientists and policymakers in the 1960s did anticipate the increasing threat posed by climate modification that has in fact materialized over the last half century and understood that it would require government action to control carbon dioxide pollution.

Our aim in this Article is two-fold. The first is to show that the historical roots of governmental concern over global climate change trace earlier and wider than previously recognized. Scientists and policymakers in the 1960s understood the “vast economic and political significance” of their work; interpretation of the Clean Air Act cannot be unbundled from these prevailing considerations. The second is to advance a template for the kind of historical analysis that may need to become standard in a post-*West Virginia* world. The new major questions doctrine begets a novel type of legal-historical methodology that is distinct from both that of the bygone era of interpretive reliance on legislative history⁴⁰ and that of the new textualism.⁴¹ Its implications are still being fully understood. We express no normative view about the administrative state—our aim is to understand the Clean Air Act and the precise form of delegation that Congress envisioned when it passed the Act in 1970. What becomes clear is that global

36. Richard L. Revesz, *Bostock and the End of the Climate Change Double Standard*, 46 COLUM. J. ENV’T L. 1, 28 (2020).

37. *See id.* at 6.

38. *West Virginia v. EPA*, 142 S. Ct. 2587, 2609 (2022) (quoting *FDA v. Brown & Williamson Tobacco Corp.*, 529 U.S. 120, 133 (2000)).

39. *Id.*

40. *See, e.g.*, William N. Eskridge, Jr., *Legislative History Values*, 66 CHI.-KENT L. REV. 365 (1990).

41. *See, e.g.*, John F. Manning, *Second-Generation Textualism*, 98 CAL. L. REV. 1287 (2010); John F. Manning, *What Divides Textualists from Purposivists?*, 106 COLUM. L. REV. 70 (2006); William N. Eskridge, Jr., *The New Textualism*, 37 UCLA L. REV. 621 (1990).

climate change was far more closely linked to the original legislation than either the majority or dissent in *West Virginia* appreciated.

Our review of the historical evidence demonstrates (1) that scientists had by 1970 established the concern that greenhouse gases emitted into the atmosphere as a waste product of burning fossil fuel—in other words, as a pollutant—could and in time almost certainly would alter the global climate with potentially serious and destructive effects; (2) that this concern was extensively communicated to both the executive and legislative branches of the U.S. federal government; and (3) that it was specifically and explicitly discussed in hearings pursuant to consideration and passage of the Clean Air Act. In this Article, we document the extent of scientific knowledge of global climate change in the decades leading up to the passage of the Clean Air Act. In a subsequent Article, we will further analyze the through-lines between this scientific understanding and specific debates in Congress over air pollution and the linked environmental crises that the Clean Air Act was meant to solve.

Part I provides a critical overview of the history of climate science since John Tyndall and Svante Arrhenius theorized and quantified the greenhouse effect. We show that robust discussions of carbon dioxide, the greenhouse effect, and global warming were undertaken by prominent scientists and were not an obscure scientific backwater. Part II focuses on the articulation of the “Carbon Dioxide Problem” by scientists and policymakers in the 1960s, centering on several key collaborative ventures across research and policy. Part III analyzes the emergent designation of carbon dioxide as a form of “air pollution” and its legal significance. Crucial to this Part are the ways in which industry scientists contributed to early understandings of climate change and worked extensively with their governmental counterparts. Parts II and III together establish how academic, governmental, and industry-based scientists conceptualized global climate change in the 1950s and 1960s, and their premonitions of its “vast economic and political significance.” Part IV turns to international efforts to address global environmental crises and reveals the extent to which CO₂ as air pollution figured in events such as the preparations for the 1972 UN Stockholm Conference on the Human Environment and several high-profile academic-governmental reports. Finally, Part V presents the little-known cultural uptake of climate issues in the 1950s and 1960s, including a film by Frank Capra and televised interview with Allen Ginsberg. Climate change was an object of scientific study, political discourse, and societal interest—to a lesser extent than today, but to a degree that is often forgotten. The precise legal significance of this information may be debated, but the historical record is clear: any suggestion that Congress in 1970 did not know—or worse, could not have known—about CO₂, the greenhouse effect, and anthropogenic climate change is demonstrably false.

I. A CENTURY OF CLIMATE SCIENCE

In *Massachusetts v. EPA*, the Supreme Court held that the 1970 Clean Air Act granted the Environmental Protection Agency (EPA) the authority to regulate carbon dioxide as a pollutant but expressed skepticism that legislators in 1970 would have been familiar with the climate-altering effects of CO₂ and other heat-trapping gases, in part because, the Court claimed, “the study of climate change was in its infancy.” That claim was incorrect. In this Part, we review the historical development of scientific understanding of the relationships between carbon dioxide, the planetary climate, and the proposition that increased atmospheric concentrations of CO₂, produced by burning fossil fuels, could alter that planetary climate in major, adverse ways. We show that research on this topic was done by scientists in Europe and the United States, and included scientists employed within academia, government agencies, the U.S. Air Force, and the private sector. By the time of the passage of the Clean Air Act in 1970, leading scientists had concluded that if climate change caused by burning fossil fuels was not already underway, it would be soon.

A. “*Man as a Geological Agent*”

Scientists have known since the mid-nineteenth century that CO₂ is a “greenhouse gas,” meaning that it is highly transparent to visible light but relatively opaque to infrared radiation.⁴² The “greenhouse effect” refers to the fact that sunlight reaching the Earth penetrates the atmosphere and warms the planet, but when that warmth is re-radiated back to space, some of it is trapped by greenhouse gases, the most important of which are CO₂ and atmospheric water vapor. The physical basis of the greenhouse effect was established in 1859 by Irish physicist John Tyndall.⁴³ Tyndall noted the implications of this discovery to climatic changes and, following this work, scientists deduced that changing atmospheric CO₂ concentrations could alter the planetary climate. In the late nineteenth century, America’s most famous geologist, T. C. Chamberlin (1843–1928), explained the ice ages with changing CO₂ from natural causes.⁴⁴ (More CO₂ would warm the planet; less would cool it.) Around the same time, the Nobel Laureate Svante Arrhenius—one of the founders of the science of chemical thermodynamics—suggested that there was an additional factor to consider: changing atmospheric CO₂ concentration might also occur from unnatural causes, specifically burning fossil fuels.⁴⁵ Such combustion—at the

42. See generally WEART, *supra* note 26; see FLEMING *supra* note 26, at 135.

43. See generally John Tyndall, *The Bakerian Lecture—On the Absorption and Radiation of Heat by Gases and Vapours, and on the Physical Connexion of Radiation, Absorption, and Conduction*, 151 PHIL. TRANS. 1 (1861).

44. See generally, T.C. Chamberlin, *A Group of Hypotheses Bearing on Climatic Change*, 5 J. GEO 653 (1897); T.C. Chamberlin, *The Influence of Great Epochs of Limestone Formation upon the Constitution of the Atmosphere*, 6 J. GEO 609 (1898); T.C. Chamberlin, *An Attempt to Frame a Working Hypothesis of the Cause of Glacial Periods on the Atmospheric Basis*, 7 J. GEO. 545 (1899).

45. Svante Arrhenius, *On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground*, 5 PHIL. MAG. & J. OF SCI. 237, 266, 270 (1896); See Henning Rodhe et al., *Svante Arrhenius and*

time primarily from coal—added CO₂ to the atmosphere, which would have a net warming effect.

Arrhenius produced the first quantitative estimate of the effect of increased CO₂, finding that doubling the atmospheric concentration would heat the planet by 1.5–4.5°C (2.7–8.1°F).⁴⁶ In other words, the planetary climate was highly sensitive to changes in CO₂. The effect of doubling its concentration (once the climate system had had time to equilibrate with the new conditions) would come to be called the “equilibrium climate sensitivity.”⁴⁷ In 1896, Arrhenius did not necessarily think that planetary warming would be detrimental. Moreover, at prevailing combustion rates the effects would not be discernible for several millennia (although a decade later rates had increased enough for him to revise that to centuries).⁴⁸

In 1900, fellow Swedish scientist Knut Johan Ångström published findings that challenged Arrhenius’ central assertions. Ångström was a pioneer in the field of spectroscopy: the study of how gases absorb and emit heat and light at specific wavelengths known as spectral absorption bands.⁴⁹ In a simple laboratory experiment, he determined that a small amount of CO₂ appeared sufficient to saturate its heat absorption bands, so further additions would have little or no effect. Moreover, infrared radiation is also absorbed by water vapor, and the CO₂ absorption bands appeared to overlap with those of water vapor. Since there is far more water vapor in Earth’s atmosphere than there is CO₂, Ångström concluded that any effect of small changes in CO₂ would be overwhelmed by the much larger effect of water vapor. Therefore, he argued, increased atmospheric CO₂ from burning fossil fuels would have little climatic effect.⁵⁰

Arrhenius disagreed, and the following year published an attempted refutation of Ångström’s work. The problem, Arrhenius argued, was that Ångström had treated the atmosphere as if it were homogenous, when available evidence suggested that it was layered and that the upper atmosphere was very dry. If this was so, then additional CO₂ in the upper atmosphere *would* have a climatic impact since there was little or no water vapor there. But the problem

the Greenhouse Effect, 26 *AMBIO* 2, 2–4 (1997); see also generally Svante Arrhenius, *Über die wärmeabsorption Durch Kohlensäure*, 58 *FOR. SVEN. VETEN.* 25 (1901); Svante Arrhenius, *Über die wärmeabsorption durch kohlenensäure*, 309 *ANNAL. DER PHY.* 690 (1901). SVANTE ARRHENIUS, *LEHRBUCH DER KOMISCHEN PHYSIK 2* (1903). Both Chamberlain and Arrhenius were prominent, distinguished scientists, whose ideas were widely circulated, and in 1903 Arrhenius won the Nobel Prize. See WEART, *supra* note 26.

46. Arrhenius, *On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground*, *supra* note 45, at 237.

47. *Id.*; see also WEART, *supra* note 26, at 5–6.

48. WEART, *supra* note 26, at 5–8; Luke Skinner, *A Long View on Climate Sensitivity*, 337 *SCI.* 917, 918 (2012).

49. He was also the son of Anders Jonas Ångström, for whom the angstrom, a unit of length used to describe wavelengths, is named. *Anders Jonas Ångström*, *BRITANNICA.COM*, <https://www.britannica.com/biography/Anders-Jonas-Angstrom> (last updated Jun 17, 2023).

50. Knut Ångström, *Über die bedeutung des wasserdampfes und der kohlenäures bei der absorption der erdatmosphäre*, 308 *ANNAL. DER PHY.* 720, 724 (1900); see WEART, *supra* note 26, at 7–8.

was not resolved, in part because only scant data were available on the structure and composition of the upper atmosphere. More work was needed to understand the structure of the atmosphere and distribution of heat-absorbing gases in it.⁵¹

Arrhenius' work was replicated in 1930 by U.S. Naval Research Lab physicist E.O. Hulburt, who concluded that the temperature effect of increased CO₂ was sufficiently great as to offer a plausible mechanism of major planetary climatic change. Hulburt noted that "an increase or decrease in world-wide average atmospheric temperatures of a few degrees would give rise to other changes," including increasing atmospheric water vapor, which would further increase the greenhouse effect, affecting vegetation, snow fields, and the CO₂ content of the ocean.⁵² However, he shared Angström's concern about the spectral overlap with water vapor. He presented data that suggested the spectral overlap was only partial, but concluded more work was needed on this issue. Further study was also needed on the question of how much CO₂ would be absorbed by the oceans or taken up by plants.⁵³

By the turn of the century there was scientific support for the idea that increased atmospheric CO₂ would impact the earth's temperature, but debates continued over what the effects would be and when they would occur. In 1923, British geologist R. L. Sherlock published *Man as a Geological Agent*.⁵⁴ The book's thesis was that humans were changing the planetary environment on a scale that rivalled geological processes. He discussed a wide variety of human impacts, including afforestation and deforestation, farming, erosion, mining and quarrying, dams and harbors, and climate change. Drawing on Chamberlin and Arrhenius, Sherlock devoted his final chapter to CO₂-induced climate change. Chamberlin had theorized that CO₂ removal from the atmosphere by natural causes could have caused the Permian glaciation; if this were true, then a "reversal of the process" by unnatural (i.e., human) causes—as suggested by Arrhenius—could lead to global warming.⁵⁵ Sherlock summarized: "Arrhenius thought that if the amount of carbon dioxide in the air were increased three-fold, the temperature of the Arctic regions would rise by 8 or 9° C."⁵⁶

In the 1930s, the topic was also taken up by British engineer Guy Stewart Callendar. Compiling existing data on atmospheric CO₂ and global temperatures, Callendar concluded that coal combustion was adding CO₂ to the atmosphere and that a modest warming trend was already underway.⁵⁷ In a 1940 paper he

51. James Fleming, *T.C. Chamberlin, Climate Change, and Cosmogony*, 31 *STUD. HIST. PHIL. MOD. PHYS.* 293, 299–300 (2000).

52. E.O. Hulburt, *The Temperature of the Lower Atmosphere of the Earth*, 38 *PHYS. REV.* 1876, 1890 (1931).

53. *Id.* at 1890.

54. See generally R. L. SHERLOCK, *MAN AS A GEOLOGICAL AGENT: AN ACCOUNT OF HIS ACTION ON INANIMATE NATURE* (1922).

55. *Id.* at 302–305.

56. *Id.* at 302.

57. G. S. Callendar, *The Artificial Production of Carbon Dioxide and its Influence on Temperature*, 64 *Q. J. ROY. MET. SOC.* 223, 327 (1938); G.S. Callendar, *Can Carbon Dioxide Influence Climate?*, 4 *WEATHER* 310, 312 (1949).

noted the observed CO₂ increase—about 30 parts per million (ppm) since the late nineteenth century—was consistent with the known amount of coal and oil burned, about 50,000 million tons.⁵⁸ This suggested that the oceans had not absorbed much of the CO₂ released to the atmosphere; he attributed this to the slow rate of vertical ocean circulation and concluded that it would “doubtless take many centuries” before ocean CO₂ absorption would have an appreciable mitigating effect.⁵⁹ For the present, the CO₂ released to the atmosphere appeared mostly or entirely to stay in the atmosphere, where it would have a warming effect.⁶⁰ In the coming years, the relationship between CO₂ and climate was often called the “Callendar question” and the impact of CO₂ on climate “the Callendar effect.”⁶¹

B. Post-War Work at the Ford Motor Company, the Scripps Institution of Oceanography, & the Oak Ridge National Laboratory

American scientists turned to the Callendar question in the 1950s, when increased post-war funding for both basic and applied research made it possible to address the question in a sustained and rigorous way. A key figure in advancing understanding of CO₂ and climate was Gilbert Plass because his work resolved the dispute between Arrhenius and Angström over spectral absorption and established that increased atmospheric CO₂ would, in time, warm the planet with potentially serious adverse effects.⁶²

Plass was a Harvard-trained physicist who began his career working for the Manhattan Project at the University of Chicago from 1942 to 1945, after which he took an instructor position at Johns Hopkins and received his PhD in physics from Princeton in 1947.⁶³ His specialty was infrared radiation; his work at Johns Hopkins was funded by the U.S. Office of Naval Research.⁶⁴

Infrared radiation was of interest to the defense industry for its significance to weather forecasting, imaging in the infrared spectrum, and heat-seeking missiles. Thus, both the U.S. military and the aerospace industry actively sought to understand CO₂ theory. In 1955 Plass left academia for industry—first, as a staff scientist at Lockheed Aircraft Corporation and then as a member of the advanced research staff at the Aeronutronic division for Ford Motor Company.⁶⁵ By 1960, Plass was the manager of the theoretical physics research group at Ford,

58. G.S. Callendar, *Variations of the Amount of Carbon Dioxide in Different Air Currents*, 66 Q. J. ROY. MET. SOC. 395, 399 (1940).

59. *Id.* at 400.

60. *Id.* at 395. Callendar continued publishing on this topic for the next decade: a paper on the spectral absorption issue, a 1942 note on the relation of air temperature and the growth and retreat of glaciers, and a 1945 paper on variation in winter temperatures.

61. JAMES ROGER FLEMING, *THE CALLENDAR EFFECT: THE LIFE AND WORK OF GUY STEWART CALLENDAR* xiii–xv (2007).

62. See WEART, *supra* note 26, at 23–24.

63. Gilbert Plass, ATOMIC HERITAGE FOUND., <https://www.atomicheritage.org/profile/gilbert-plass> (last visited June 1, 2022).

64. See WEART, *supra* note 26, at 22.

65. Gilbert Plass, *supra* note 63.

where he had the laboratory facilities to continue his work on infrared physics, carbon dioxide theory, and computer modelling.⁶⁶

In a set of papers published in the mid-1950s, Plass replicated Arrhenius and Hulburt's calculations and found that doubling CO₂ would warm the planet by 3.6° C, a magnitude sufficient to explain past ice ages.⁶⁷ He noted a key difference between past planetary changes, which were oscillatory, and the present steadily warming trend caused by human activity the Earth was now experiencing: "The extra CO₂ released into the atmosphere by industrial processes and other human activities may have caused the temperature rise during the present century. In contrast with other theories of climate, the CO₂ theory predicts that this warming trend will continue, at least for several centuries."⁶⁸ A temperature change of "perhaps only four degrees" would be sufficient to "bring a tropical climate to most of the Earth's surface."⁶⁹ While Plass was unclear on whether or not industrial CO₂ had already had an effect, he concluded there was "no doubt" that it would in time have a "profound influence on our climate."⁷⁰ Unless something changed dramatically in the future, CO₂-driven climate change was a matter of when, not if.⁷¹

Crucially, Plass resolved the dispute between Arrhenius and Angström over the potential effect of added CO₂ in the atmosphere. Advances in spectroscopy permitted him to resolve the spectral lines to a greater degree than previously achieved and show that the spectral overlap was not complete.⁷² That meant that Angström's objection was wrong: increased CO₂ would warm the planet. The question was, how much and how soon?

Plass's work—and its link to industrial activity—was picked up by the *New York Times* in an article entitled "How Industry May Change Climate."⁷³ In the coming years, Plass communicated his work in both specialist and popular

66. James Rodger Fleming et al., *Carbon Dioxide and the Climate*, 98 AM. SCI. 58 (2010), <https://www.americanscientist.org/article/carbon-dioxide-and-the-climate>. Plass was not the only scientist in the 1950s to study CO₂ absorption bands. See generally L.D. Kaplan & D.F. Eggers Jr., *Intensity and Line-Width of the 15-Micron CO₂ Band, Determined by a Curve-of-Growth Method*, 25 J. CHEM. PHYS. 876 (1956); H.J. Kostkowski & L.D. Kaplan, *Absolute Intensities of the 721 and 742 cm⁻¹ Bands of CO₂*, 26 J. CHEM. PHYS. 1252 (1959); and H.J. Kostkowski et al., *Vibrational Intensities. XI. CO₂ and the Wilson-Wells Method*, 30 J. CHEM. PHYS. 532 (1959).

67. Gilbert Plass, *The Influence of the 9.6 Micron Ozone Band on the Atmospheric Infra-red Cooling Rate*, 82 Q. J. ROY. MET. SOC. 30, 42 (1956); see generally Gilbert Plass, *A Method for the Determination of Atmospheric Transmission Functions from Laboratory Absorption Measurements*, 42 J. OPT. SOC. AM. 677 (1952); Gilbert Plass, *Parallel-Beam and Diffuse Radiation in the Atmosphere*, 9 J. ATMO. SCI. 429 (1952); Gilbert Plass & D.I. Fivel, *Influence of Doppler Effect and Damping on Line-Absorption Coefficient and Atmospheric Radiation Transfer* 117 ASTROPHYSICS J. 225 (1953); Gilbert Plass, *Regions of Validity of Various Absorption-Coefficient Approximations*, 11 J. OF METEOROLOGY 163 (1954); Gilbert Plass & D.I. Fivel, *The Influence of Variable Mixing Ratio and Temperature on the Radiation Flux*, 81 Q. J. ROY. MET. SOC. 48 (1955).

68. Gilbert Plass, *The Carbon Dioxide Theory of Climatic Change*, 8 TELLUS 140, 140 (1956).

69. Gilbert Plass, *Carbon Dioxide and the Climate*, 44 AM. SCI. 302, 305 (1956).

70. *Id.* at 312.

71. Plass wrote a popular version of this work. Gilbert Plass, *Carbon Dioxide and Climate*, 201 SCI. AMER. 41, 44 (1959).

72. See generally James Rodger Fleming et al., *supra* note 66.

73. W. K., *How Industry May Change Climate*, N.Y. TIMES, May 24, 1953, at E11.

scientific journals, including *American Scientist* and *Scientific American*.⁷⁴ In 1959 in *Scientific American*, he explained that humans had burned enough fossil fuel to add about 360 billion tons of CO₂ to the atmosphere, which the theory predicted should warm the planet by one degree Fahrenheit. “This is almost exactly the average increase recorded all over the world during the past century!”⁷⁵ Plass specifically called the heating effect of CO₂ “the greenhouse effect,” and reiterated that the effect would not be negated by water vapor.⁷⁶ As Sherlock had earlier, Plass argued that humans were now acting as a “new geological force . . . by burning fossil fuels,” and it was possible to predict quantitatively what impact this would have: “If fuel consumption continues to increase at the present rate, we will have sent more than a trillion tons of carbon dioxide into the air by the year 2000. This should raise the earth’s average temperature 3.6 degrees [F].”⁷⁷ The evidence suggested that the oceans took up at most “about half of any carbon dioxide added to the air.”⁷⁸ The oceans would slow global warming, but they would not stop it.

At the Scripps Institution of Oceanography, oceanographer Roger Revelle and physicist Hans Suess—a pioneer in carbon-14 dating—were also analyzing the link between CO₂, climate, and fossil fuel combustion. Building on Suess’ previous work on C-14, they confirmed Plass’s estimate, stating that most of the excess CO₂ released from burning fossil fuels since the industrial revolution may now be in the oceans.⁷⁹ But that meant that the other half was accumulating in the atmosphere or taken up by plants that would return the CO₂ when they died. In other words, the buildup of atmospheric CO₂ was happening very quickly—on the scale of years to decades, dramatically contrasting with the amount of time it had taken to accumulate the source carbon in fossil fuels. Revelle and Suess thus observed that by “returning to the atmosphere and oceans the concentrated organic carbon stored in sedimentary rocks over hundreds of millions of years,” humans were performing “a large scale geophysical experiment” on the planet. Revelle did not think the results of this experiment were likely to be good.⁸⁰

74. See, e.g., Plass, *supra* note 71.

75. *Id.* at 46.

76. *Id.* at 41.

77. *Id.* at 46. Plass also noted the possibility of ocean acidification, but discounted it, one the grounds of the large volume of water in the ocean:

“Meanwhile the carbon dioxide content of the oceans will have doubled. This raises an incidental question about the welfare of sea organisms. We know that an increase in carbon dioxide concentration increases the acidity of water, and that many marine animals are extremely sensitive to changes in acidity. However, if the carbon dioxide content of the air were to increase sevenfold, the acidity (pH) of sea water would not rise more than .5 above its present value. Thus, changes in carbon dioxide concentration, which have such a profound effect on climate, will probably not disturb future marine life. Perhaps only man will be uncomfortable”

Id. at 47.

78. *Id.* at 46.

79. Roger Revelle & Hans E. Suess, *Carbon Dioxide Exchange Between Atmosphere and Ocean and the Question of an Increase of Atmospheric CO₂ during the Past Decades*, 9 *TELLUS* 18, 19 (1957).

80. *Id.* at 19–20.

According to an interview in TIME magazine, he believed that the added carbon dioxide pollution from burning fossil fuels could have “a violent effect on the earth’s climate.”⁸¹

Revelle’s concern was shared by the director of Oak Ridge National Laboratory, Alvin Weinberg. The two worked together on the President’s Scientific Advisory Council (PSAC) panel, *Scientific Progress, the Universities, and the Federal Government* in 1959–1960.⁸² The following year, Weinberg gave an after-dinner talk at the Ninth Southern Appalachian Science Fair at the University of Tennessee entitled *The Problem of Big Problems*. He defined these as problems “on whose solution the entire future of the human race depends.” After discussing urban air pollution—newly labelled smog—he continued:

An even more fundamental problem is the deterioration of our atmosphere by the accumulation of CO₂. As we burn more and more coal and oil, we throw more and more CO₂ into the atmosphere. Now CO₂ effectively absorbs infra-red energy. Its presence in the atmosphere converts the earth into an enormous greenhouse; the sun’s energy remains partially trapped; and the temperature of the earth increases. It is estimated that, as a result of the current burden of CO₂ in the atmosphere, the average temperature of the earth is increasing about 1° C per century. This is enough to melt the ice caps in a fairly short time with the result that the sea would rise and flood many inhabited areas.⁸³

By 1962, the topic was being so widely discussed that, in a letter to Plass, Guy Callendar complained that the subject of global warming was so widespread that “everyone likes to ‘have a go.’”⁸⁴ The same year, the International Panel of the PSAC—on which Roger Revelle, among others, served—drafted a report recognizing that the “alteration of our environment has reached the point of requiring intensive study and understanding on an urgent basis.” In particular, they said, “never before has man had the power he now has to bring about changes, some of them irreversible, on a scale that can affect people in all parts of the world and that can cause major but indeterminate environmental changes.”⁸⁵ Among the examples provided was the continuous release of CO₂ into the atmosphere from the burning of fossil fuels.

81. *Science: One Big Greenhouse*, TIME (May 28, 1956), <https://content.time.com/time/subscriber/article/0,33009,937403,00.html>. See also, Lloyd Norman, *Fumes Seen Warming Arctic Seas*, THE WASH. POST AND TIMES HERALD, Mar. 19, 1956, at 3.

82. PRESIDENT’S SCI. ADVISORY COMM., *SCIENTIFIC PROGRESS, THE UNIVERSITIES, AND THE FEDERAL GOVERNMENT* 32 (1960).

83. Alvin M. Weinberg, “Problem of big problems” Ninth Southern Appalachian Science Fair Banquet Talk (Apr. 7, 1961) (on file at Alvin Weinberg Papers, MPA.0332, b. 106, f. 6, University of Tennessee Libraries, Knoxville, Special Collections).

84. Letter from G.S. Callendar to Gilbert Plass (Feb. 5, 1962) (on file at the Niels Bohr Library & Archives, American Institute of Physics).

85. E.B. SKOLNIKOFF, INT’L SCI. PANEL, THE PRESIDENT’S SCI. ADVISORY COMM., *THE PROBLEM OF LARGE-SCALE EXPERIMENTATION WITH POSSIBLE ENVIRONMENTAL EFFECTS* 3 (1962) (on file at b. 46, f. 4, I. I. Rabi Papers, Manuscript Division, Library of Congress.); see also Audrey Lara Loetscher, *A History of Unsustainability: The U.S. Government, the Fossil Fuel Industry, and Climate Change* (1957–

C. *The Air Force and Air Pollution*

At the Air Force Cambridge Research Center (AFCRC) in the 1950s, the Geophysics Research Division studied the effects of CO₂ within the context of meteorology, military preparedness, and human health. In 1951 they commissioned the American Meteorological Society to publish a *Compendium of Meteorology* appraising the state of the field.⁸⁶ The compendium was organized by a committee that included Helmut Landsberg, a geophysicist at the AFCRC and expert on cloud formation who would later do important work on air pollution and health, and Harry Wexler, the chief scientist of the U.S. Weather Bureau and a developer of TIROS-1, the world's first weather satellite.⁸⁷ The highly influential compendium was edited by Thomas Malone, at the time an assistant professor at MIT and later a scientific leader in the establishment of the National Center for Atmospheric Research (NCAR).⁸⁸ Several chapters of this 1951 compendium discussed CO₂. Two of these—"The Composition of Atmospheric Air" and "Geological and Historical Aspects of Climatic Change"—directly discussed planetary climatic change and CO₂.⁸⁹

E. Wendell Hewson, an engineering professor at the University of Michigan, contributed a chapter on air pollution that did not discuss CO₂, but two years later he submitted a follow-up report produced under contract to the AFCRC that did.⁹⁰ Hewson began his "Scientific Report No. 1" with a discussion of "pollution and climate" and the "radiational effects [of] carbon dioxide," which placed CO₂ in the context of substances that were unequivocally understood as air pollutants. Moreover, he situated that concern in the context of air pollution's harmful effects on human health.⁹¹

Drawing on Callendar's 1940 paper, Hewson included a table summarizing CO₂ levels from 1866–1935 and observed that there "seems to be no doubt that surface concentrations of CO₂ have increased significantly since the beginning of the present century."⁹² While he debated the source of that carbon dioxide—noting that the correlation between a rise in atmospheric CO₂ and industrial

1992) 50-51 (2022) (Ph.D. Dissertation, Université de Lausanne). Lloyd Bernker, one of the main architects of the IGY, was also on the panel.

86. The 1300-page assessment included 102 international authors. *See generally* H.R. BYERS ET AL., COMPENDIUM OF METEOROLOGY (Thomas F. Malone ed., 1951).

87. Wexler was also a commissioned officer of the Army Air Corps serving as a captain to lieutenant colonel from 1942–1946. G. de Q. Robin, *Harry Wexler 1911–1962*, 4 J. OF GLACIOLOGY 496 (1963).

88. W. W. VAUGHAN, NASA, COMPENDIUM OF METEOROLOGY: SCIENTIFIC ISSUES OF 1950 STILL OUTSTANDING 1167 (1986). In 1958, Malone helped prepare and write the "Blue Book" agenda for NCAR, and later served as one of its trustees. *See* DAVID T. MALONE, THOMAS F. MALONE, 1917–2013 3 (2014). On the Blue Book, *see* HOWE, *supra* note 27, at 31–32.

89. E. Glueckauf, *The Composition of Atmospheric Air*, in COMPENDIUM OF METEOROLOGY 3 (Thomas F. Malone ed., 1951) and C. E. P. Brooks, *Geological and Historical Aspects of Climatic Change*, in COMPENDIUM OF METEOROLOGY 1004 (Thomas F. Malone ed., 1951).

90. E. Wendell Hewson, *Atmospheric Pollution*, in COMPENDIUM OF METEOROLOGY 1139 (Thomas F. Malone ed., 1951).

91. HEWSON, *supra* note 7, at 1, 2.

92. *Id.* at 3.

production did not prove causation—he concluded that changes in atmospheric CO₂ levels could “modify the climate in various ways.”⁹³ In the third section of the report, Hewson compared CO₂ to other kinds of air pollution—including pollen, smoke, dust, sulfur dioxide—and their relations to pneumonia, bronchitis, asthma, cancer, and other diseases. Unlike these conventionally understood forms of pollution, which did not remain in the atmosphere for long, he noted that the “evidence was clear” that carbon dioxide was removed from the atmosphere slowly and that, if atmospheric CO₂ levels were indeed tied to industrial releases, we could anticipate continued warming “concurrent” with those releases.⁹⁴ His conclusion echoed this concern: “Industrial pollution of the atmosphere by CO₂ may be modifying world climate, causing a temperature rise.”⁹⁵

In 1953, Landsberg recruited the German physicist Christian Junge, one of the world’s leading atmospheric scientists, to the AFCRC.⁹⁶ Over the next eight years, Junge’s research at the AFCRC focused on aerosols—mixtures of gases and particles in the atmosphere that could affect both local weather and global climate. In 1958, his article “Atmospheric Chemistry” in *Advances in Geophysics* addressed conventional pollutants such as sulfur dioxide, nitrogen oxides, ozone, and carbon monoxide, and included an entire section on carbon dioxide. Junge argued CO₂ was important because of its “increase during the last fifty years” and its role “in the heat budget of our atmosphere.” The observed increase in CO₂ should “raise the average temperature of the atmosphere by a small, though measurable, amount,” and such a “phenomenon has actually been observed in various parts of the world; the problem of a CO₂ increase, therefore, is of basic importance for meteorology.”⁹⁷ Two years later, Junge presented a paper at the U.S. Public Health Service-sponsored Third Air Pollution Research Seminar in which he argued that “the concentrations of two atmospheric constituents, carbon dioxide and sulfur dioxide, have increased on a global scale as a result of human activity,” and that the fluctuations in atmospheric CO₂ would have a “profound influence on world climate.”⁹⁸

93. *Id.* at 4-5. Sadly, the rest of page 5 is missing from the historical record.

94. *Id.* at 28-37.

95. *Id.* at 39. In his acknowledgments, Hewson also thanked Gilbert Plass. *Id.* at 41.

96. Robert A. Duce et al., *Christian Junge—a Pioneer in Global Atmospheric Chemistry*, 79 J. ATMOS. CHEM. 219, 221, 247-48 (2022). From 1953-1961, Junge worked for the AFCRC, before returning to Germany to become a Professor of Meteorology at the University of Mainz and later the Director of the Max Planck Institute for Chemistry. In 1960, he discovered the Junge layer, a zone of aerosol particles, which, by screening sunlight, has a major impact on planetary heat balance. *Id.* at 223-225.

97. Christian E. Junge, *Atmospheric Chemistry*, 4 ADV. IN GEOPHYS. 1, 45 (1958).

98. *Research in Air Pollution: Conference Report*, 75 PUB. HEALTH REP. 1173, 1173 (1960). Junge later participated in the 1971 Study of Man’s Impact on Climate (SMIC) Report on Inadvertent Climate Modification. See generally INADVERTENT CLIMATE MODIFICATION: REPORT OF THE STUDY OF MAN’S IMPACT ON CLIMATE (SMIC) (Study of Man’s Impact on Climate (SMIC) ed., 1971). We discuss the SMIC report in *infra* Part IV.B.3 below.

D. *IGY and the Establishment of Mauna Loa CO₂ Measurements*

The International Geophysical Year (IGY) was a massive, international collaborative scientific effort to collect geophysical data from around the globe. It was also widely publicized, inspiring countless newspaper and magazine articles, films, and television series, and even a pop song.⁹⁹ The “year” lasted for eighteen months, from 1957 to 1958, and one of its scientific leaders was Roger Revelle, who arranged for atmospheric CO₂ measurement to be an IGY project.¹⁰⁰

Revelle wanted this scientific work to answer two questions: was atmospheric CO₂ increasing, and if so, was the increase having a discernible impact on the global climate? The systematic measurement of atmospheric CO₂ became the life work of his colleague, geochemist (and 2001 National Medal of Science winner) Charles David Keeling.¹⁰¹ In 1958, Keeling established an observatory at Mauna Loa, Hawaii, to make precise daily measurements; within a year, Keeling had demonstrated that accurate, systematic measurement was possible.¹⁰² By 1965, he had the answer to the first question: CO₂ was increasing, and his analysis confirmed that about half of the released CO₂ was “missing” and presumed absorbed into the oceans or taken up by plants. The remainder was in the atmosphere, where its concentration was on an upward march.¹⁰³ This led scientists to focus on the second question: was this increase affecting the planetary climate?

E. *Studies of Weather Modification*

A major area of interest in CO₂ and climate appeared in the context of deliberate or purposeful weather modification.¹⁰⁴ Shortly after World War II, the U.S. government funded projects to study techniques of weather modification, including cloud seeding and hurricane weakening (Projects Cirrus and Stormfury). Much of this work was undertaken by a research group at the

99. Fae L. Korsmo, *Shaping Up Planet Earth: The International Geophysical Year (1957–1958) and Communicating Science Through Print and Film Media*, 26 SCI. COMM. 162, 162-68 (2004).

100. *Id.* at 174; Walter H. Munk, *Tribute to Roger Revelle and his Contribution to Studies of Carbon Dioxide and Climate Change*, 94 PROC. OF THE NAT'L ACAD. OF SCI. 8275, 8276 (1997).

101. See Charles D. Keeling, *Rewards and Penalties*, 23 ANN. REV. ENERGY & ENV'T 25, 26 (1998); *Scientists, Engineers Honored with National Medals*, 55 PHYSICS TODAY 71, 71 (2002); Munk, *supra* note 100, at 8276.

102. See generally HOWE, *supra* note 27, particularly *Introduction* and *Chapter 1*.

103. In hindsight, the increase is visible even in the first year, but it is in the mid-1960s that Keeling and Revelle begin to speak publicly about the results. See J.C. Pales & C.D. Keeling, *The Concentration of Atmospheric Carbon Dioxide in Hawaii*, 70 J. GEOPHYS. RES. 6053, 6062 (1965); see also C.W. Brown & C.D. Keeling, *The concentration of atmospheric carbon dioxide in Antarctica*, 70 J. GEOPHYS. RES. 6077, 6077 (1965); Charles D. Keeling, *Is Carbon Dioxide Fossil Fuel Changing Man's Environment*, 114 PROC. AM. PHIL. SOC'Y 10, 10-13 (1970).

104. See HOWE, *supra* note 27, at 25–27; WEART *supra* note 26, at 20–22; EDWARDS, *supra* note 26, at 359–361; Chunglin Kwa, *The Rise and Fall of Weather Modification: Changes in American Attitudes Toward Technology, Nature, and Society*, in CHANGING THE ATMOSPHERE: EXPERT KNOWLEDGE AND ENVIRONMENTAL GOVERNANCE 135 (Clark A. Miller & Paul N. Edwards eds., 2001).

General Electric Corporation, led by Nobel Laureate Irving Langmuir, Vincent Schaefer, and Bernard Vonnegut (brother of novelist Kurt).¹⁰⁵ Study reports from this domain contained discussions of a concept their authors termed “inadvertent weather modification”—what scientists today would call anthropogenic (human-caused) climate change.¹⁰⁶ During the Cold War, many scientists argued that purposeful weather modification was possible: Hewson mentioned weather modification in the introduction to his 1953 report; Schaefer induced cloud seeding in a small-scale laboratory experiment using dry ice; and the U.S. military was intensely interested in the prospects of deliberate weather modification in warfare.¹⁰⁷ Discussions and research into the effects of atmospheric pollutants like carbon dioxide led some scientists to assert that accidental alterations of weather and climate might already be occurring.

In 1958, President John F. Kennedy approved PL 85-510, which authorized government funding of weather modification research through the National Science Foundation (NSF). In the early to mid-1960s, the NSF reviewed the existing scientific research projects on weather modification, and then released annual reports (ten in total) in accordance with that funding.¹⁰⁸ The National Academy of Sciences also released several reports on the topic at this time, suggesting the importance with which both the scientific community and the federal government viewed the topic. Indeed, it is in discussions of deliberate weather modification that we see the emergence of the language of “inadvertent weather modification” to refer to what scientists now call anthropogenic climate change, and the explicit recognition that such change could be of large consequence.

In 1964 the NSF director announced the creation of a Special Commission on Weather Modification to review the state of knowledge and respond to a 1963 request from the federal government Council for Science and Technology to analyze potential purposes of weather modification and control. The Commission was chaired by Colorado State University Dean A.R. Chamberlain; its final report was issued in 1965. The Commission discussed CO₂ and the problem of “inadvertent” climate change, which might be either “transient or permanent,” local or global, and desirable or undesirable. Significantly, the

105. JAMES R. FLEMING, *FIXING THE SKY: THE CHECKERED HISTORY OF WEATHER AND CLIMATE CONTROL* 137–57, 165–87 (2012).

106. Vincent R. Schaefer, *Inadvertent Modification of the Atmosphere by Air Pollution*, 50 BULL. AM. METEOROLOGICAL SOC'Y 199, 205 (1969). For recent use of this terminology, see Philip B. Duffy et al., *Strengthened Scientific Support for the Endangerment Finding for Atmospheric Greenhouse Gases*, 363 SCIENCE 597, 600 (2019) (“One area of scientific progress since the [Endangerment Finding] is the attribution of extreme weather events . . . to human-caused climate change.”).

107. HEWSON, *supra* note 7, at 1, 2; FLEMING, *supra* note 105, at 142–44, 170–88.

108. National Science Foundation Act of 1950, Pub. L. No. 85-510, § 72 Stat. 353 (1958). This amendment to the National Science Foundation Act of 1950 made NSF the official coordinating agency for weather modification research projects and required that the agency report annually. For a summary of federal laws governing U.S. federal weather modification programs, see Rachel Hauser, *Using Twentieth-Century U.S. Weather Modification Policy to Gain Insight into Global Climate Remediation Governance Issues*, 5 WEATHER CLIMATE & SOC'Y 180, 185 (2013).

report discussed weather and climate modification—whether deliberate or accidental—as *already underway and not merely as a local effect*:

Weather and climate modification is becoming a reality [T]he inadvertent modification of the weather and climate by such influences as the products of urban development, surface modification for agriculture and silviculture, [and] compositional changes through the combustion of fossil fuels and other exhausts are becoming of sufficient consequence to affect the weather and climate of large areas and ultimately the entire planet.¹⁰⁹

The report called for further research

to understand the factors involved in climatic change and thus to be able to predict inadvertent changes in weather and climate produced by present and future activities of man. Some beginnings in this direction are . . . an attempt to assess consequences of the increasing carbon dioxide content of the atmosphere caused by the burning of fossil fuels . . . ‘the implications of this upon tropospheric stability cannot be ignored.’

Nothing less than “the future welfare of mankind” was at stake.¹¹⁰

The U.S. National Academy of Sciences (NAS) also addressed the issue, through its research arm, the National Research Council (NAS-NRC). In 1963, the Academy created a panel on weather and climate modification “to undertake a deliberate and thoughtful review of the present status and activities in this field, and of its potential and limitations for the future.”¹¹¹ Central to much of its work was geophysicist Gordon J.F. MacDonald, who chaired the panel and later served on the Council on Environmental Quality in the Nixon Administration. The NAS-NRC panel released its two-volume final report, “Weather and Climate Modification Problems and Prospects,” in 1966, and it gave particular attention to inadvertent, carbon dioxide-fueled weather modification. A full section of the report’s second volume was devoted to “Inadvertent Modification of Atmospheric Processes,” which began with a detailed discussion of the potential effects of increased carbon dioxide in the atmosphere.¹¹² When the National Academy panel made its recommendations, it listed as among its “highest priority” studies that investigated the “meteorological effects of atmospheric pollution (including carbon dioxide).”¹¹³

109. NAT’L SCI. FOUND. SPECIAL COMM. ON WEATHER MODIFICATION, WEATHER AND CLIMATE MODIFICATION 8 (1965).

110. *Id.* at 42 (quoting NATIONAL RESEARCH COUNCIL COMMITTEE ON ATMOSPHERIC SCIENCES, WEATHER AND CLIMATE MODIFICATION PROBLEMS AND PROSPECTS: FINAL REPORT OF THE PANEL ON WEATHER AND CLIMATE MODIFICATION Vols. I and II (NAS 1966), which had not yet been publicly released but evidently had been shared with the NSF.).

111. Gordon J.F. MacDonald, *Preface to NAT’L RSCH. COUNCIL COMM. ON ATMOSPHERIC SCI., WEATHER AND CLIMATE MODIFICATION PROBLEMS AND PROSPECTS: FINAL REPORT OF THE PANEL ON WEATHER AND CLIMATE MODIFICATION*, Vols. I and II (1966).

112. *Id.* Vol. II at 82–83.

113. *Id.* Vol. I at 25. MacDonald explored this issue further in a 1968 book chapter entitled “How to Wreck the Environment.” He suggested that the deliberate addition or subtraction of atmospheric components could alter the climate so much as to be a potentially potent instrument of war; he called this “geophysical warfare.” The “key to geophysical warfare” he explained, was “the identification of the

These reports focused on research efforts to modify and control weather and climate deliberately, often through cloud seeding, for both military and civilian purposes, but they also addressed inadvertent alterations. The NSF's 1962 annual report (released in 1963), for example, cited a 1962 seminar in which the Weather Bureau's Harry Wexler had analyzed a variety of factors that could modify Earth's radiation balance, including changing the carbon dioxide content of the atmosphere.¹¹⁴ The report suggested that this was cause for concern, as Plass had "suggested that man may already be inadvertently modifying the atmosphere at an alarming rate by burning ever-increasing amounts of fossilized fuel, thus releasing larger amounts of carbon dioxide than ever before in historical times."¹¹⁵ Such warming, it continued, could cause the icepack to "vanish from the frozen north and frozen tundra would thaw."¹¹⁶ The framing of the project in terms of Plass's work—as well as the reference to the Arctic icepack, frozen north, and tundra—make clear that the scientists were addressing planetary-scale effects of CO₂-induced global warming.

Weather modification was also reviewed by the Texas Water Commission, which in 1964 released *The Current Status of Weather Modification*. The report focused on the need for weather modification to prevent damaging weather—hail, floods, tornadoes, hurricanes and drought—but also discussed military uses, such as aiding civilian aviation.¹¹⁷ The Commission distinguished between weather modification—related to specific events like hurricanes and activities such as cloud seeding—and climate control, which they defined as the "control or significant alteration of the climate over vast areas of the earth," such as "controlling the horizontal wind circulation patterns over millions of square miles." Envisaging possible attempts to deliberately alter the planetary climate, they wrote, "Such undertakings would most certainly require international effort and agreement, because what seems to benefit one large area may be harmful to another."¹¹⁸ While the report was broadly in favor of attempts to modify the weather, it also warned of inadvertent modification, linking it explicitly to atmospheric pollution. Citing the NSF's Fourth Annual Report on weather modification (1962), the Texas report stated:

environmental instabilities in which the addition of a small amount of energy would release vastly greater amounts of energy." MacDonald's paper was highly speculative, including discussion of using nuclear weapons to alter ice sheets and change global reflectivity, but he did note that if a nation thought it to their advantage, it could alter the climate by adding CO₂ to the atmosphere: "If a nation's meteorologists calculated that a general warming or cooling of the earth was in their national interest, improving their climate while worsening others, the temptation to release materials from high-altitude rockets might exist." Gordon MacDonald, *How to Wreck the Environment*, in *UNLESS PEACE COMES: A SCIENTIFIC FORECAST OF NEW WEAPONS* 181, 190 (Nigel Calder ed., 1968).

114. NAT'L SCI. FOUND., *WEATHER MODIFICATION: FOURTH ANNUAL REPORT* 19 (1962), citing Harry Wexler, Seminar on weather control, Dept. of Meteorology, UCLA (Feb. 1962).

115. *Id.*, citing G.N. Plass, *The Influence of Infrared Absorptive Molecules on the Climate*, 95 *ANNALS OF THE N.Y. ACAD. SCI.* 61, 61–71 (1961).

116. NAT'L SCI. FOUND., *supra* note 114, at 20.

117. *See generally* JOHN T. CARR, JR., TEXAS WATER COMMISSION, BULLETIN 6504, *THE CURRENT STATUS OF WEATHER MODIFICATION: A SUMMARY* (1964).

118. *Id.* at 47.

[We] must consider and try to understand the effects of inadvertent artificial modification . . . [T]he atmosphere is polluted at all levels by industrial effluents, by rocket exhausts, and by the activity involved in living in a highly technological society. We suspect that such events affect the weather or climate or both.¹¹⁹

Weather and climate modification was also addressed by the U.S. Interdepartmental Committee on Atmospheric Sciences (ICAS), which issued a report in 1966. Authored by National Aeronautics and Space Administration (NASA) assistant Administrator Homer Newell, the report mirrored the language of Volume I of the 1966 NAS-NRC report in its discussions of “inadvertent modifications of weather and climate.” But it also specifically identified as a research priority “new and comprehensive studies of the meteorological effects of atmospheric pollution (including carbon dioxide)” and referred to carbon dioxide as “atmospheric pollution.”¹²⁰ This report was transmitted by the Assistant Secretary of Commerce for Science and Technology and chair of ICAS, J. Herbert Hollomon, to Presidential Science Advisor Donald Hornig.

F. *The National Center for Atmospheric Research*

Another line of research recognizing the potential importance of CO₂ in relation to climate emerged at the U.S. National Center for Atmospheric Research (NCAR). NCAR was established in 1960 by the NSF as a central facility to consolidate and strengthen basic research in atmospheric science and be a focal point for analyzing data from the IGY.¹²¹ In later years, NCAR would become a leading scientific center for climate modelling.¹²²

Historian Joshua Howe describes early NCAR research as organized around four themes: “radiation budget modeling, general circulation modeling, the study of weather and climate control, and the CO₂ question.”¹²³ While the motivation was to advance basic science—in a field that had been heavily oriented towards applied science, particularly weather forecasting—the scientists involved in establishing NCAR recognized that the impact of human activities on the environment demanded attention, too. One of these impacts involved fossil fuels and CO₂. In a report prepared for the NSF in 1959, arguing the case for establishing NCAR, scientists explained,

119. *Id.* at 48 citing NAT’L SCI. FOUND., *supra* note 114.

120. HOMER E. NEWELL, A RECOMMENDED NATIONAL PROGRAM IN WEATHER MODIFICATION I-4 (1966). ICAS, which was established by and reported to the Federal Council for Science and Technology, Executive Office of the President, coordinated atmospheric research across disparate federal government offices.

121. On the history of NCAR, *see* HOWE, *supra* note 27, at 27–32; *see also* JOSHUA HOWE, MAKING CLIMATE CHANGE HISTORY: DOCUMENTS FROM GLOBAL WARMING’S PAST 77–84 (2017); *see generally* Walter Orr Roberts, *Atmospheric Research: A Powerful Concept Emerges*, 5 SCI. 1093 (1965); JAMES RODGER FLEMING, INVENTING ATMOSPHERIC SCIENCE: BJERKNES, ROSSBY, WEXLER, AND THE FOUNDATIONS OF MODERN METEOROLOGY 203–207 (2016).

122. HOWE, *supra* note 27, at 27–32.

123. HOWE, *supra* note 27, at 32–33.

[M]an's activities in consuming fossil fuels during the past hundred years, and in detonating nuclear weapons in the last decade, have been on a sufficient scale to make it worthwhile to examine the effects these activities have had upon the atmosphere. Reference is made here to the still unsolved question of whether the carbon dioxide content of the atmosphere is increasing as a result of combustion processes¹²⁴

Within a few years, Keeling's Mauna Loa measurements had convinced most scientists that the question of increasing CO₂ was no longer "unsolved;" the question had moved to its effects. With NCAR firmly established, the April 1965 issue of the NCAR quarterly linked their basic science to air pollution and climate control.¹²⁵ That same year, NCAR staff chemist James P. Dixon co-authored a paper in *Science* magazine reporting on the work of the Air Conservation Commission of the American Association for the Advancement of Science.¹²⁶ The paper began by noting that CO₂ was the most important waste product of using fuels by quantity, second only to water, and that its global atmospheric content had already increased by 5 percent. This increase was potentially concerning because "carbon dioxide is intimately involved in the mechanism that maintains the overall temperature of the earth . . . [and] it is possible that a continued increase over a long period would change the global climate."¹²⁷

G. Keeling's 1969 Assessment of the State of the Science

By 1969, Keeling had compiled sufficient data from Mauna Loa to pose and answer the question, "Is Carbon Dioxide from Fossil Fuel Changing Man's Environment?"¹²⁸ In a symposium on atmospheric air pollution sponsored by the American Philosophical Society, he explained that scientists had good data on how much fossil fuel had been burned since the mid-nineteenth century, and to show that about 40 percent of the CO₂ produced was now in the atmosphere. Over the decade 1958–1968, since he began making systematic measurements, atmospheric CO₂ had risen by approximately 0.7 ppm per year—a small but discernible effect. Overall, data suggested that CO₂ had increased thirty ppm since 1850—about a 10 percent increase—and the rate of increase was rising in tandem with fossil fuel use.¹²⁹

What was the climatic response to this increase? Keeling drew on theoretical calculations and newly developed climate models, particularly the

124. HOWE, *supra* note 121, at 83.

125. See generally NCAR, NCAR QUARTERLY, April 1965, (1965) (on file at Edmund S. Muskie Papers, Edmund S. Muskie Archives and Special Collections Library, Bates College [*hereinafter* BC-ESM] at s. V.A.5, b. 373, f. 13).

126. See *infra* Part II.C.

127. James P. Dixon & James P. Lodge, *Air Conservation Report Reflects National Concern*, 148 SCIENCE 1060, 1060 (1965) (on file at s. V.A.5, b. 373, f. 13, BC-ESM). We discuss this report in depth below.

128. Keeling, *supra* note 103, at 10.

129. See *id.* at 10-13.

work of Syukuro Manabe (who in 2021 would win the Nobel Prize in Physics) suggesting a climate sensitivity of 2.8°C for doubling CO₂ (i.e., a 100 percent increase). If there were no other factors involved, that might mean that the planet had already warmed somewhat.¹³⁰ Scientists held “widely divergent views concerning a possible peril,” but Keeling’s read of the situation was that “no atmospheric scientist doubts that a sufficiently large change in atmospheric CO₂ would change the climate.”¹³¹ Was this an immediate threat? Keeling did not think so, but he thought it might in time become serious: “If the human race survives into the twenty-first century with the vast population increase that now seems inevitable, the people [still] living . . . may also face the threat of climatic change brought about by an uncontrolled increase in atmospheric CO₂ from fossil fuels.”¹³²

H. Summary

By 1969, when Congress held hearings pursuant to the Clean Air Act, scientists had been working on the foundations of understanding the relationship between CO₂ and global climate for more than a century. While climate modelling was in its infancy, climate science was not; there had already been a wide and deep scientific conversation—among atmospheric scientists, climate modelers, geochemists making atmospheric and oceanic measurements, and meteorologists—affirming that the earlier concerns of Arrhenius and Hurlburt were not misplaced. CO₂ was increasing, and there was good scientific reason to think that that increase would alter the climate in substantive, deleterious ways. Policymakers at the end of the decade had this foundation on which to base decisions. The scientific basis for a clear statement was established. An important part of this was the recognition of CO₂ as a pollutant. We turn now to that issue.

II. UNDERSTANDING “THE CARBON DIOXIDE PROBLEM”

The preceding discussion demonstrates that climate science was not “in its infancy” when the Clean Air Act was passed in 1970. Rather, we have shown that, beginning in the late nineteenth century, leading scientists, including Nobel Laureates and some of the most famous names in the history of atmospheric science, recognized the risk that by releasing carbon dioxide to the atmosphere fossil fuel combustion could cause significant changes to the global climate. By the mid-twentieth century, the conversation had enlarged to include leading

130. See *id.* at 10, 14.

131. See *id.* at 14, 17.

132. *Id.* at 17. Keeling underestimated the threat, suggesting “most of us today will, every likely, live out our lives without perceiving that a problem may exist.” *Id.* at 14. He died in 2005, well after the IPCC had declared a “discernible human influence on global climate,” and significant effects had been documented. Kenneth Chang, *Charles D. Keeling, 77, Who Raised Global Warming Issue, Dies*, N.Y. TIMES (June 23, 2005), https://www.nytimes.com/2005/06/23/science/charles-d-keeling-77-who-raised-global-warming-issue-dies.html?unlocked_article_code=1.PE0.1QZ_.9KgYvo10sjp2&smid=url-share; Intergov’t Panel on Climate Change, *Summary for Policymakers: The Science of Climate Change*, in CLIMATE CHANGE 1995: IPCC SECOND ASSESSMENT REPORT 22 (1995).

scientists employed within academia, government agencies, the U.S. Air Force, and the private sector. A key objection—that the spectral absorption of carbon dioxide overlapped with water vapor, and therefore adding carbon dioxide to the atmosphere would have little if any effect—was shown to be incorrect. Leading scientists, including those involved in debates over urban air pollution, recognized carbon dioxide as a pollutant. In this Part, we document how this understanding was communicated beyond the scientific community.

A. *The Conservation Foundation*

Established in 1948 as an affiliated organization of the New York Zoological Society, the Conservation Foundation (CF) of New York funded influential education and research that supported natural resource conservation.¹³³ From 1965 to 1969, former Republican judge and World Wildlife Fund founder, Russell Train, took over as the organization's president and moved its operations from New York to Washington, D.C. as part of his work to develop both national and global environmental policies at the federal level.¹³⁴

In March of 1963 the CF held a conference to discuss “the implications of rising carbon dioxide content in the atmosphere.” A group of seven experts brought together for the discussion included Keeling, Plass, Erik Eriksson of the International Meteorological Institute in Stockholm, biologists from Yale and the Atlantic Marine Lab, and the aerial landscape photographer William Garnett. Their purpose was to clarify the current state of knowledge and propose ideas for the future of scientific research. The final report of the conference was a consensus statement of scientific thinking about the increasing accumulation of atmospheric CO₂, an issue the scholars thought should be one of “considerable concern and controversy.”¹³⁵ In the forward, the authors wrote,

It is known that the carbon dioxide situation, as it has been observed within the last century, is one which might have considerable biological, geographical, and economic consequences within the not too distant future. What is important is that with the rise of carbon dioxide, by way of exhaust gases from engines and other sources, there is a rise in the temperature of the atmosphere and oceans. It is estimated that a doubling of the carbon dioxide

133. CF-funded research was cited in RACHEL CARSON, *SILENT SPRING* (1962). *70th Anniversary of the Conservation Foundation*, WILDLIFE CONSERVATION SOC'Y ARCHIVES BLOG (March 30, 2018), <http://www.wcsarchivesblog.org/70th-anniversary-of-the-conservation-foundation-instagram/>.

134. Train credited his interest in global environmentalism with his experiences on wildlife safaris in Africa in the 1960s. The CF became an affiliate of the World Wildlife Fund in 1985 under Train's chairmanship and officially merged with the organization in 1990. *History*, WORLD WILDLIFE FUND, <https://www.worldwildlife.org/about/history> (last visited July 21, 2023); *Russell E. Train*, WORLD WILDLIFE FUND, <https://www.worldwildlife.org/leaders/russell-e-train> (last visited July 21, 2023); Meir Rinde, *Richard Nixon and the Rise of American Environmentalism: How a Republican president ushered in the EPA*, DISTILLATIONS MAG. (June 2, 2017), <https://www.sciencehistory.org/stories/magazine/richard-nixon-and-the-rise-of-american-environmentalism/>.

135. CONSERVATION FOUND., *IMPLICATIONS OF RISING CARBON DIOXIDE CONTENT OF THE ATMOSPHERE* i (1963).

content of the atmosphere would produce an average atmospheric temperature rise of 3.8 degrees Fahrenheit.¹³⁶

The report defined CO₂ as “not a pollutant in the ordinary sense. It is colorless and odorless. It has no immediate nasty effects.”¹³⁷ Unlike other pollutants, atmospheric accumulation of CO₂ by itself would not lead to any detrimental effects to life on the planet. The threat came from the effect of that accumulation on atmospheric and ocean temperatures, and “immense flooding of the lower portions of the world’s land surface, resulting from increased melting of glaciers.”¹³⁸ Concluding their introduction, the authors emphasized the global and intergenerational nature of climate change: “The effects of a rise in atmospheric carbon dioxide are world-wide. They are significant not to us but to the generations to follow.”¹³⁹

One important uncertainty, already raised by Callendar, Hulburt, Plass, Revelle, and others, was whether CO₂ uptake by plants or absorption into the ocean might prevent, or at least greatly slow, the accumulation of carbon dioxide in the atmosphere and therefore prevent adverse effects. Despite this question, they wrote,

It seems quite certain that a continuing rise in the amount of atmospheric carbon dioxide is likely to be accompanied by a significant warming of the surface of the earth which by melting the polar ice caps would raise sea level and by warming the oceans would change considerably the distributions of marine species including commercial fisheries.¹⁴⁰

The authors recognized that there were naturally occurring checks and balances that might offset these effects. Ocean absorption—already mentioned—was the most obvious one, but a more subtle effect involved sulfur dioxide. An increase in atmospheric sulfur dioxide (also from burning fossil fuels) could change ocean acidity or increase marine biologic activity, increasing the amount of CO₂ that the ocean and ocean sediments could absorb. On land, a carbon dioxide-rich environment could lead to an addition in plant biomass, which would in turn reduce atmospheric CO₂ by “locking it up” in the woody trunks of trees.¹⁴¹ The natural exchange of carbon dioxide between the atmosphere, the biosphere, and the oceans would work to maintain a balance despite the increased output of anthropogenic carbon dioxide emissions.

But now that balance was being disrupted. Measurements showed that between 1890 and 1953 atmospheric carbon dioxide had increased by twenty-five ppm. And in one of the first instances to highlight the emerging data from Keeling’s Mauna Loa work, begun during the IGY, the authors noted that data

136. *Id.*

137. *Id.* at 1.

138. *Id.* at i.

139. *Id.* at 1.

140. *Id.*

141. *Id.* at 3.

coming in from Keeling's monitoring station demonstrated consistent yearly increases in CO₂, as expected from the burning of fossil fuels.¹⁴²

The attendees of the conference could not pinpoint any natural check on the increase of atmospheric CO₂ that they felt could reliably offset the most damaging possible effects of anthropogenic climate change. Each of the situations they presented lacked concrete supporting data that the carbon system could adequately balance itself at the present rate of increase—estimated to be 0.7 ppm or around 0.2 percent. They calculated that it would take thousands of years for the ocean to balance out oceanic and atmospheric carbon dioxide at present rates of emissions, and once it did the new equilibrium would still result in higher atmospheric CO₂ levels than at present.¹⁴³ The earth had been able to balance its carbon system in the past through a variety of “checks and balances,” but the authors strongly cautioned against disregarding the rising levels of carbon dioxide in the atmosphere on those grounds. They wrote:

The present liberation of such large amounts of fossil carbon in such a short time is unique in the history of the earth and there is no guarantee that past buffering mechanisms are really adequate. It is not a cause for complacency that nature seems to have a lot of checks and that these checks seem thus far to be controlling any artificial imbalances. There may be processes presently going on which are due to man's activities and which will eventually be alarming.¹⁴⁴

Throughout Train's tenure as CF president, the Foundation paid substantial attention to the CO₂ problem. Of particular interest is a February 1968 edition of the organization's publication the *CF Letter* that featured the article “Is Mankind Playing a Game of Environmental Russian Roulette?,” which was retained by Senator Muskie's staff and can be found in his archives at Bates College, Maine. The wide-ranging article quoted an array of scientists and discussed a variety of congressional proposals on environmental issues. On the article's first page, the CF noted:

“While some might question the degree of seriousness or urgency of the threat, it exists. As a congressional committee tells us, ‘our power to disturb or alter the ponderous forces and rhythms of nature by man-induced manipulations has increased to the point where mistakes or unknown effects may be profound and irreversible.’”¹⁴⁵

The paragraph of the House report from which this quotation was taken offered several examples of “manmade disruptions” that were “familiar to

142. *Id.* at 2, 6.

143. *Id.* at 6.

144. *Id.* at 5.

145. IS MANKIND PLAYING A GAME OF ENVIRONMENTAL RUSSIAN ROULETTE?, *CF LETTER* 1 (1968) (on file at s. V.A.6, b. 598, f. 5, BC-ESM) (quoting SUBCOMM. ON SCI., RSCH. AND DEV. REPORT TO THE H. COMM. ON SCI. AND ASTRONAUTICS, 89TH CONG., 2D SESS., ENVIRONMENTAL POLLUTION: A CHALLENGE TO SCIENCE AND TECHNOLOGY 3 (Comm. Print 1966)). Other materials from the Conservation Foundation can also be found in the Muskie archive, including a 1966 commentary that referenced the organization's 1963 report RISING CARBON DIOXIDE CONTENT OF THE ATMOSPHERE. (On file at s. V.A.5, b. 368, BC-ESM.)

everyone,” including carbon dioxide: “Carbon dioxide accumulations from the burning of gas, petroleum, and coal change the nature of the atmosphere. Weather patterns can be altered purposefully or accidentally by human activity. These powerful forces have only come about recently and are not well understood.”¹⁴⁶ The *CF Letter* enumerated several problems that “illustrate our lack of knowledge and foresight.” Among them: “We release carbon dioxide into the air in great quantities—faster than it can be used up by plants or dissolved into the oceans.”¹⁴⁷ On February 28, 1968, U.S. Senator Henry “Scoop” Jackson of Washington inserted the article into the Congressional Record. Jackson commented that it was

devoted to a review and discussion of the need for developing intelligent, long-range Federal policies on environmental quality management. I commend the newsletter to the attention of the Senate, because the problem of maintaining the quality of our environment is a matter of critical concern to all of us and, in some respects, is the shared responsibility of at least four or five of the standing committees of the Senate.¹⁴⁸

Train left his position at the CF in 1969 to work in the emerging environmental regulatory agencies of the U.S. government. He served as the head of President-elect Nixon’s Task Force on Environment in 1968, as Under Secretary of the Department of the Interior from 1969 to 1970, and as the first Chairman of the Council on Environmental Quality, where his staff included geophysicist Gordon MacDonald. He was the second administrator of the Environmental Protection Agency under Presidents Nixon and Ford and was influential in the passage of the National Environmental Policy Act of 1970.¹⁴⁹

B. *The 1965 Report of the President’s Scientific Advisory Committee*

Revelle and Keeling served on the Environmental Pollution Panel of the President’s Scientific Advisory Committee (PSAC) under President Lyndon Johnson. The Panel was led by Princeton professor John Tukey, one of America’s (and the world’s) leading mathematicians and statisticians.¹⁵⁰ During

146. H. SUBCOMM. ON SCI., RSCH. AND DEV., 89TH CONG., ENVIRONMENTAL POLLUTION: A CHALLENGE TO SCIENCE AND TECHNOLOGY 3 (Comm. Print 1966). This House report, and the hearings from which it emerged, considered the carbon dioxide issue at some length and will be discussed further in Lanier-Christensen et al., *Climate Change and the 1970 Clean Air Act Part II: Congressional Debates* (forthcoming).

147. *CF LETTER*, *supra* note 145, at 6.

148. 114 Cong. Rec. S4,515-18 (daily ed. Feb. 28, 1968) (statement of Sen. Henry Jackson). Jackson’s interest in the article was no doubt heightened by the fact that his name appeared in the newsletter article several times, including for discussion of a bill he was cosponsoring which, along with a number of bills under consideration, called for the establishment of a Council of Environmental Quality in the executive office of the president.

149. *Biography of Russell E. Train*, EPA (last updated Sept. 8, 2016), <https://www.epa.gov/archive/epa/aboutepa/biography-russell-e-train.html>; *see also* Meir Rinde, *supra* note 134.

150. Among other things, Tukey was known for the invention of the Fast Fourier transform algorithm, a major tool in modern signal processing, digital recording, and computer science. Tukey also served on numerous government and NAS committees and panels on air pollution, weather modification,

its tenure (1957–73), the President’s Science Advisory Committee was (as its name suggests) the most important conduit by which scientific information and advice was transmitted to the White House.¹⁵¹

In 1965, the PSAC issued a major report entitled “Restoring the Quality of our Environment.” The panel included a subpanel on “Atmospheric Carbon Dioxide,” and their concern over carbon dioxide made it to the first page of the report’s introduction: “pollutants have altered on a global scale the carbon dioxide content of the air and the lead concentrations in ocean waters and human populations.”¹⁵² The issue was raised again throughout the report. In examining the climatic effects of pollution, the authors asserted, “By the year 2000 there will be about 25% more CO₂ in our atmosphere than at present. This will modify the heat balance of the atmosphere to such an extent that marked changes in climate, not controllable through local or even national efforts, could occur.”¹⁵³ The report placed CO₂ into context with other conventionally understood pollutants:

The combustion of coal, oil, and gas in our homes, vehicles, and factories results in the discharge into the air of sulfur dioxide, carbon dioxide, carbon monoxide, oxides of nitrogen, and partially burned hydrocarbons. Some of these gases, together with gasoline and natural gas vapors, undergo chemical change in air and in sunlight, and become the noxious constituents of smog; others, like carbon dioxide, are accumulating in such large quantities that they may eventually produce marked climatic change. Large amounts of lead are dispersed into the atmosphere from motor vehicle exhausts.¹⁵⁴

The panel recommended new investments in baseline measuring programs under the Environmental Science Services Administration (ESSA, part of the Commerce Department) to determine precise levels of CO₂ in the atmosphere “where its effects on our climate are likely to be significant,” as well as to expand research into the mechanisms by which the ocean or biological processes might remove CO₂ from the atmosphere.¹⁵⁵ The full findings of the subpanel were transmitted over twenty-two pages in Appendix Y4, where the authors discussed possible effects of increased atmospheric CO₂ such as global temperature increases, melting of the Antarctic ice cap, sea level rise, and sea water warming.¹⁵⁶

and other matters as well as on an American Statistical Association review of Alfred Kinsey’s path-breaking work on human sexuality. *See generally* DAVID R. BRILLINGER, JOHN W. TUKEY 1915–2000 (2018).

151. *See generally* ZUOYUE WANG, IN SPUTNIK’S SHADOW: THE PRESIDENT’S SCIENCE ADVISORY COMMITTEE AND COLD WAR AMERICA (2009); *see United States. President’s Science Advisory Committee*, AM. INST. OF PHYSICS, <https://history.aip.org/phn/21612015.html#:~:text=This%20committee%20operated%20between%201957,in%201973%20by%20President%20Nixon>, (last visited July 18, 2023).

152. ENV’T POLLUTION PANEL, *supra* note 13, at 1.

153. *Id.* at 9.

154. *Id.* at 12.

155. *Id.* at 26.

156. *Id.* at 121–124.

One source of potential disagreement over the impact of added atmospheric CO₂, the panel noted, involved the complication of natural climate variability and the countervailing effects of other forms of pollution, particularly particulate matter. For example, worldwide cooling appeared to have taken place between 1940 and 1960, a period when more than 40 percent of the total CO₂ increase from fossil fuels took place. This enigma led the panel to posit that “climatic ‘noise’” from other processes had at least partially “masked any effects on climate due to past increases in atmospheric CO₂ content.”¹⁵⁷ One such process included particulate pollution—dust, soot, sulfuric acid aerosols, and other substances that could block the sun. (They proffered the possibility of exploring “countervailing climatic changes” such as deliberately spreading buoyant reflective particles over large oceanic areas to change the earth’s albedo.) This prompted debate about whether the warming effect of CO₂ or the cooling effect of particulates would dominate, since pollution contributed both to the atmosphere.¹⁵⁸ Other reports at this time also noted the potential cooling effect of particulates; in coming years scientists would conclude that the mid-century cooling was due to emissions of particulate matter, which had affected planetary reflectivity.¹⁵⁹

Three days after the PSAC report’s publication, Frank Ikard, president of the American Petroleum Institute (API), discussed it at the organization’s annual meeting in 1965, specifically noting that addressing the CO₂ problem might include changes such as finding alternatives to internal combustion engines in automobiles:

One of the most important predictions of the [PSAC] report is that carbon dioxide is being added to the Earth’s atmosphere by the burning of coal, oil, and natural gas at such a rate that by the year 2000 the heat balance will be so modified as possibly to cause marked changes in climate beyond local or even national efforts. The report further states, and I quote: “. . . the pollution from internal combustion engines is so serious, and is growing so fast, that an alternative nonpolluting means of powering automobiles, buses, and trucks is likely to become a national necessity.”¹⁶⁰

Ikard emphasized that the “substance of the report is that there is still time to save the world’s peoples from the catastrophic consequence of pollution, but

157. *Id.* at 123.

158. *Id.* at 127; *see generally* Robert A. McCormick & John H. Ludwig, *Climate Modification by Atmospheric Aerosols*, 156 *SCIENCE* 1358 (1967); WALTER MUNK ET AL., GORDAN JAMES FRASER MACDONALD 1930–2002 (2004).

159. *See generally* Martin Wild et al., *Impact of Global Dimming and Brightening on Global Warming*, 34 *GEOPHYSICAL RSCH. LETTERS* L04702 (2007); P.V. Forster et al., *Changes in Atmospheric Constituents and in Radiative Forcing*, in *CLIMATE CHANGE 2007: THE PHYSICAL SCIENCE BASIS. CONTRIBUTION OF WORKING GROUP I TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE* 131 (2007); Thomas C. Peterson et al., *The Myth of the 1970s Global Cooling Scientific Consensus*, 89 *BULL. AM. METEOROLOGICAL SOC’Y* 1325, 1328 (2008).

160. F.N. Ikard, *Meeting the Challenges of 1966*, 45 *PROC. OF AM. PETROLEUM INST.* 12, 13 (1965); *see also*, Benjamin Franta, *Early Oil Industry Knowledge of CO₂ and Global Warming*, 8 *NAT. CLIMATE CHANGE* 1024, 1024–1025 (2018).

time is running out.”¹⁶¹ In the years to come, this report—including its prediction of rising CO₂—was repeatedly referenced and cited.¹⁶²

C. *The Air Conservation Commission of the American Association for the Advancement of Science*

In 1962, the American Association for the Advancement of Science (AAAS) created an Air Conservation Commission, which in 1965 issued what would become a landmark report on air pollution.¹⁶³ This report, as with others from the period, was not limited to local air pollution. Rather, it considered the global effects of air pollution including carbon dioxide: the report discussed CO₂ in the same framework as pollutants with documented health impacts. The commission was chaired by James Dixon, President of Antioch College, and included prominent figures in the air pollution field such as James P. Lodge, Jr. of the National Center for Atmospheric Research (NCAR) and Caltech professor Arie J. Haagen-Smit.¹⁶⁴ The report itself was written for a wide readership and was reprinted in 1968. In his introduction, Dixon emphasized that the Commission had to condense or omit “a considerable amount of material.”¹⁶⁵ Yet, despite this limitation, the Commission devoted considerable space to carbon dioxide.

Part I of the report, “Air Conservation and Public Policy,” aimed for the widest audience. Here, the Commission offered four major recommendations, of which the third was “that air pollution be viewed as a problem that transcends political boundaries and as one that has global significance.” Just as nuclear weapons testing resulted in pollution around the world, “Other pollutants also have global significance.” Specifically, the report highlighted, the “gradually increasing concentration of carbon dioxide in the earth’s atmosphere may cause

161. Ikard, *supra* note 160, at 13; Franta, *supra* note 160, at 1025.

162. See, e.g., Leon Green, *Energy Needs versus Environmental Pollution: A Reconciliation?: A Power Generation Concept by Which Pollution of Air and Water Can Be Reduced Is Proposed*, 156 SCI. 1448, 1448 (1967); Philip H. Abelson, *Man-Made Environmental Hazards. I. How Man Shapes His Environment*, 58 AM. J. PUB. HEALTH & NAT. HEALTH 2043, 2043-44 (1968); Fred Sargent, *Man-Environment—Problems for Public Health*, 62 AM. J. OF PUB. HEALTH 628 (1972). It was also frequently referenced and excerpted in congressional materials. See, e.g., *Air Pollution—1966, Hearing on S. 3112 and H.R. 13199 Before the Subcommittee on Air & Water Pollution of the S. Comm. on Public Works*, 89th Cong. (1966); SUBCOMM. ON SCI., RSCH. AND DEV., *supra* note 146, at 51 (summary of the 1965 PSAC report, which specifically noted the CO₂ subpanel, the recommendation for baseline CO₂ measurements, and the recommendation for research on CO₂ flows to and from atmosphere).

163. See generally AIR CONSERVATION COMM’N OF THE AAAS, AIR CONSERVATION (1965). The AAAS Committee on Science in the Promotion of Human Welfare convened the Air Conservation Commission in 1962. After two years’ work, the Commission released its report in 1965. See generally AAAS Comm. on Sci. in the Promotion of Human Welfare, *Air Conservation*, 137 SCI. 9 (1962).

164. The interdisciplinary committee included public officials and professors from diverse fields (e.g., biology, economics, city planning). Notable members included John W. Bodine, President of Penjerdel (the Pennsylvania-New Jersey-Delaware Project, Inc); Arie J. Haagen-Smit (professor of biology, California Institute of Technology); James P. Lodge, Jr. (staff chemist, NCAR); and Norton Nelson (director, Institute of Industrial Medicine, New York University Medical Center). *Scientists in the News*, 137 SCIENCE 27, 27 (1962).

165. AIR CONSERVATION COMM’N OF THE AAAS, *supra* note 163, at x.

a slow increase in world temperature, and it may cause glacial melting and higher sea levels. Such a change, if it is occurring, or if it should occur, would be difficult or impossible to stop.”¹⁶⁶ Part 2 of the report, “Summary of the Facts,” emphasized that while there were a great number of pollutants, only a small number of substances made up the majority of industrial emissions and were therefore “singled out for special attention.” CO₂ was one of them. While increased emissions of CO₂ to date had “no effect on any known living organism,” the report emphasized the potential for major impacts, including economic ones:

Carbon dioxide is intimately involved in the mechanism that maintains the overall temperature of the earth. Although . . . it is impossible to evaluate the effect of any given increase in atmospheric carbon dioxide, a continued increase over a long period could possibly change the global climate. And, if such a change were to involve an increase of the earth’s temperature, thereby causing a large portion of the global ice caps to melt and the oceans to rise, available land area would be reduced at precisely the time when more land is needed for an increasing population. In the light of this possibility, the use of fossil fuels as the principal source of our energy should be continually evaluated.¹⁶⁷

The authors further noted that the ocean was “the disposal point for most of the soluble inorganic substances” and it did indeed absorb CO₂, but human production of CO₂ appeared to be “outstripping the ocean’s ability to remove it from the atmosphere.” They estimated that about one-third of CO₂ emissions would remain in the atmosphere and “may have an effect on the world’s weather.”¹⁶⁸ This was less than Plass and Keeling’s estimate of about half of all emissions, but it was still substantial. Among other things, the report clearly qualified CO₂ as a pollutant: the “atmosphere has tremendous powers to dilute, disperse, and destroy a large variety of substances that man, for one reason or another, elects to discharge into it,” but a substance became a pollutant when “these processes cannot keep up with the rate of discharge.”¹⁶⁹

The idea that CO₂ only became a pollutant when it reached some level of accumulation was part of a larger argument about what *kind* of pollutant CO₂ was. Most scientists at the time agreed that CO₂ *was* a pollutant but saw it as distinct from other substances conventionally understood as pollutants because it was not visible, it was naturally occurring, and it did not have acute health effects at the levels under consideration.¹⁷⁰ Others saw it as distinct because it was necessary for life.¹⁷¹ This perspective was offered in in Part 3 of the AAAS

166. *Id.* at 7.

167. *Id.* at 26–27.

168. *Id.* at 35.

169. *Id.* at 36.

170. *See infra* Part III.

171. The “necessary for life” argument was unsound, because many trace elements that are necessary for life are nonetheless toxic in large doses, or because they differentially affect different life forms. One environmentally important example is selenium, which was implicated in the death of migratory waterfowl in the Kesterson Reservoir, California. *See generally* Harry Ohlendorf et al., *Bioaccumulation*

report, "Background Reports," which included an extensive section on "Pollutants and Their Effects," including a section on CO₂.¹⁷² It began: "Carbon dioxide is not normally considered an air pollutant because (i) the uncontaminated atmosphere has a concentration of approximately 300 ppm, (ii) it is essential for animal and plant life, and (iii) there must be at least 5000 ppm in the air before man's respiration is adversely affected . . ." ¹⁷³

On the other hand, the report noted, CO₂ was rising because of *industrial activity*, which made it comparable to other substances conventionally recognized as pollutants: "[S]ince about the middle of the 19th century, worldwide atmospheric concentrations of carbon dioxide have been rising steadily because of the increasing dependence of our industrial era on fossil fuels,"¹⁷⁴ and "the extra amounts of atmospheric carbon dioxide . . . from the combustion of fossil fuel" could affect the earth's "heat balance, and hence on the climate of the whole earth."¹⁷⁵ Ultimately, the Commission concluded, "the fear seems legitimate that an unchecked increase in the rate of combustion of carbon fuels may eventually extend carbon dioxide levels to meteorological and physical significance, and that carbon dioxide concentrations may become great enough to cause climatic changes."¹⁷⁶

An important feature of this discussion is that the scientists recognized that controlling CO₂ could require major changes to prevailing patterns of power generation. They wrote,

Significant effects may occur in the coming centuries . . . if the combustion of fossil fuels continues to increase—and it will keep rising if the fuel and power requirements of our worldwide industrial civilization continue to rise exponentially, and if these needs are met only to a limited degree by the development of tidal, solar, and nuclear power.¹⁷⁷

In the event of undesirable climatic changes, humans "may be forced to turn to new sources of energy in order to reestablish a viable carbon dioxide equilibrium."¹⁷⁸

Dixon summarized the Commission's report in articles in *Science* and the *Bulletin of the Atomic Scientists* and discussed carbon dioxide in both.¹⁷⁹ In the *Science* article, co-authored by Commission member and NCAR staff chemist James Lodge, Dixon particularly emphasized CO₂ and climate; this article was

of selenium in birds at Kesterson Reservoir, California, 19 ARCHIVES OF ENV'T CONTAMINATION AND TOXICOLOGY 495 (1990). Still, the argument was made.

172. The eleven sections covered: "Sulfur and Its Compounds, Carbon Monoxide, Carbon Dioxide, Oxides of Nitrogen, Photochemicals, Particulate Matter, Lead and Other Metals, Fluorides, Environmental Carcinogenesis, Economic Poisons, and Radioactive Pollution." AIR CONSERVATION COMM'N OF THE AAAS, *supra* note 163, at xi.

173. *Id.* at 78.

174. *Id.*

175. *Id.* at 79.

176. *Id.* at 81.

177. *Id.* at 80.

178. *Id.* at 81.

179. Dixon & Lodge, *supra* note 127, at 1060, 1063; James P. Dixon, *For Air Conservation*, 21 BULL. OF THE ATOMIC SCI. 7, 6-9 (1965).

sent to Senator Muskie at least twice in 1965, including by NCAR's Walter Orr Roberts.¹⁸⁰ In correspondence with Lodge in October 1965, Muskie wrote that he had read the paper and was looking forward to reading the report.¹⁸¹

Regulatory and public health discussions of air pollution in the subsequent years often cited the Commission's report.¹⁸² Significantly, the observation that CO₂ was "not normally considered an air pollutant" would largely drop away, as numerous leading scientists explicitly discussed CO₂ as a pollutant even though it was naturally occurring and necessary for life. For example, physicist and *Science* editor Philip Abelson drew on the Commission's report in a 1968 article on "Man-made environmental hazards" published in the *American Journal of Public Health*, citing it as an example of "air pollution . . . getting the considerable attention [it] deserve[s]."¹⁸³ Abelson reminded readers that "today man is changing his environment on a planetary scale," repeating the prediction—made by the 1965 PSAC report—of a 25 percent increase in atmospheric CO₂ by the year 2000, and warning of its potential to increase global temperature.¹⁸⁴

D. Summary

In this Part, we have focused on the articulation of the "Carbon Dioxide Problem" by scientists and policymakers in the 1960s, centering on several key collaborative ventures across research and policy. The history recounted shows that, by the late 1960s, there was an emerging consensus among leading scientists—including the President's Science Advisory Committee—that planetary-scale climate change was likely to occur from increased CO₂ released into the atmosphere from burning fossil fuels. This emerging consensus was communicated beyond the expert scientific community. In the next Part we turn to the designation of carbon dioxide as a pollutant.

III. ESTABLISHING CO₂ AS AN AIR POLLUTANT

In the 1950s and 1960s, the subject of air pollution spurred a vast scientific literature. A complete review of the air pollution literature from this period is

180. Correspondence from Walter Orr Roberts to Muskie, Aug. 20, 1965 (on file at s. V.A.5, b. 373, f. 13, BC-ESM); Dixon & Lodge, *supra* note 127. Reprint sent from Gene Malecki to Muskie, May 24, 1965 (on file at BC-ESM, s.V.A.5, b. 375, f. 8, BC-ESM).

181. Correspondence from Muskie to James Lodge, Oct. 1, 1965 (on file at BC-ESM, s. V.A.5, b. 376, f. 2).

182. See, e.g., *Clean Air Act Amendments of 1966: Hearings before the Subcomm. on Pub. Health and Welfare of the H. Comm. on Interstate and Foreign Com.*, 89th Cong. 69 (1966); US DEP'T OF HEALTH, EDUC., AND WELFARE, A STRATEGY FOR A LIVABLE ENVIRONMENT: A REPORT TO THE SECRETARY OF HEALTH, EDUCATION, AND WELFARE BY THE TASK FORCE ON ENVIRONMENTAL HEALTH AND RELATED PROBLEMS 67 (1967); COUNCIL ON ENV'T QUALITY, *supra* note 6, at 93; EPA, GUIDE FOR AIR POLLUTION EPISODE AVOIDANCE 43 (1971).

183. Abelson, *supra* note 162, at 2044.

184. *Id.* at 2046. Abelson cited the 1965 PSAC report for the statistic on carbon dioxide increases. He also discussed the counterargument for the effects of particulate matter. See also generally Philip H. Abelson, *Social Responsibilities of Scientists*, 167 SCIENCE 241 (1970).

beyond the scope of this paper, but a few examples will make the point: by the late 1950s and 1960s, CO₂ was being discussed not just as a factor in meteorology, atmospheric physics, and climate science, but in air pollution science and public health. This included conferences sponsored by the federal government. We show that the ambiguity sometimes expressed in the 1950s as to whether carbon dioxide was or was not a pollutant largely gave way in the 1960s to the recognition that it was a pollutant, albeit one that had different characteristics than other pollutants, such as sulfur dioxide, that had come to attention in the context of urban air pollution.

A. *U.S. Public Health Service Air Pollution Conferences*

Federal responsibility for air pollution rested with the U.S. Public Health Services (PHS, a division of the Department of Health, Education, and Welfare (HEW)). Control efforts expanded over the course of the 1960s, with the creation of the National Center for Air Pollution Control (NCAPC), which in 1968 was reconstituted as the National Air Pollution Control Administration (NAPCA).¹⁸⁵ Until that time, most federal efforts were restricted to research and technical cooperation with state and local officials. National conferences were an important means of exchanging information on the latest research, bringing together leaders in the field.¹⁸⁶

Most of the air pollution literature in the late 1950s and 1960s focused on urban air pollution in relation to public health, which at the time was the major impetus for air pollution legislation. Even though CO₂ was not considered an immediate threat to public health, it was, nonetheless, often discussed in this context. We have already noted Christian Junge's presentation at the 1960 PHS-sponsored Third Air Pollution Research Seminar, which demonstrates that the work by the meteorologists and atmospheric physicists was known to participants in the air pollution fields.¹⁸⁷ Additional examples will help to make the point.

The first National Conference on Air Pollution, sponsored by the PHS, was held November 18–20, 1958.¹⁸⁸ The conference's purpose was to "discuss the current state of knowledge in the field and chart a practicable future course of

185. Federal work on air pollution began with the Air Pollution Control Act of 1955 which provided PHS funds to conduct research on the "national problem" of air pollution. Responsibility for air pollution control remained largely a state-level problem throughout the decade. The 1963 Clean Air Act was the first federal level U.S. law to allow for setting emissions standards (the Senate Subcommittee on Air and Water Pollution was created the same year), but control efforts remained a largely state-level affair. That began to change with the creation of NCAPC within the PHS in 1966 and the passage of the 1967 Air Quality Act amendments established national emissions standards (for stationary sources) and air quality criteria. On the history of federal air pollution control efforts, including NAPCA, *see generally* CHARLES O. JONES, CLEAN AIR: THE POLICIES AND POLITICS OF POLLUTION CONTROL (1975).

186. *See generally* Orford, *supra* note 35; BAILEY, *supra* note 34.

187. *See Junge, supra* note 97, at 45.

188. US DEP'T OF HEALTH, EDUC., AND WELFARE, PUB. HEALTH SERV., PROCEEDINGS: NATIONAL CONFERENCE ON AIR POLLUTION vii–ix (1959).

action.”¹⁸⁹ Participants included scientific experts such as Caltech chemistry professor Arie Haagen-Smit, politicians such as California Senator Thomas Kuchel, representatives from the steel, automobile, chemical, and petroleum industries, and representatives from environmental groups.

CO₂ was not discussed in the published 1959 conference summary, but it was discussed in the full conference proceedings.¹⁹⁰ Dr. Chauncey Leake, Assistant Dean of the College of Medicine at Ohio State University, spoke on “Social Aspects of Air Pollution,” asking,

What about the tremendous increase in the blanket of carbon dioxide that we are throwing above us, and which will inevitably tend to increase heat capture from the sun? What will we do if this occurs, with gradual melting of the huge polar ice caps, and the gradual rise of our oceans, drowning out still further our shore lines?

Leake suggested that CO₂ accumulation, “which even in a very slight degree may alter the extent of heat capture,” might be slowed somewhat by planting trees.¹⁹¹

Haagen-Smit, one of America’s leading experts on urban smog, noted that it was not always easy to distinguish between toxic effects of air pollution and nuisance effects, because they both could hinge on concentration levels and exposure times. He cited CO₂ as an example:

All chemicals, whatever their nature, may be harmful to humans when a certain concentration is reached and maintained for sufficiently long time. This is true for natural constituents of the air—oxygen, nitrogen and carbon dioxide—as well as the group of poisonous gases such as cyanides, sulfur dioxide or trioxide, chlorine, and many others.¹⁹²

Wendell Hewson—the University of Michigan Professor who had been working with the Air Force Cambridge Research Center on the issue since the early 1950s—offered a list of seven “outstanding problems or tasks.” Number four was “[a]tmospheric contaminants, such as carbon dioxide, which may be causing long-period changes in our climate, [and which] should be monitored on a national basis at appropriate stations.”¹⁹³

Industry representatives stood on both sides of the debate over the possible harmful effects of carbon dioxide. Representing the Smoke and Fumes Committee of the American Petroleum Institute, Charles A. Jones described CO₂ as a “harmless” product of combustion.¹⁹⁴ Dr. Charles Lapple, of the industry-oriented Stanford Research Institute, referred to carbon dioxide as a “relatively innocuous” gas.¹⁹⁵ However, Harry Ballman of the Bituminous Coal Institute

189. Leroy Burney, *Foreword* to US DEP’T OF HEALTH, EDUC, AND WELFARE, PUB. HEALTH SERV., PROCEEDINGS: NATIONAL CONFERENCE ON AIR POLLUTION iii (1959).

190. James P. Dixon et al., *National Conference on Air Pollution: Conference Report*, 74 PUB. HEALTH REP. 409 (1959).

191. U.S. DEP’T OF HEALTH, EDUC., AND WELFARE, *supra* note 188, at 23.

192. *Id.* at 81.

193. *Id.* at 108.

194. *Id.* at 177.

195. *Id.* at 303.

recognized that CO₂ was a form of pollution, even if he did not necessarily think anything could be done about it. He argued that “[o]xides of nitrogen, hydrocarbons, moisture, and carbon dioxide play a large part in air pollution, and many people are concerned about them.” The problem, he felt, was that “no recommended practices for control are available.”¹⁹⁶

In 1961, the U.S. Public Health Service hosted a symposium on “Air Over Cities.”¹⁹⁷ Like many meetings of its type, its primary focus was urban air pollution, widely recognized as a threat to public health. Carbon dioxide frequently appeared in its discussions. Helmut Landsberg, Director of the Office of Climatology for the U.S. Weather Bureau, included it in a table labelled “Concentration of Some Air Pollutants in the Atmosphere of urban areas.” Carbon dioxide was the first pollutant listed, followed by carbon monoxide, oxides of nitrogen, sulfur dioxide, aldehydes, chlorides, and others.¹⁹⁸ James Lodge of NCAR also highlighted CO₂, noting that it was “generally agreed that the concentration of this compound in the earth’s atmosphere has increased since the turn of the century”¹⁹⁹ Lodge agreed that more research was needed, particularly to improve measurement techniques.²⁰⁰ Wendell Hewson also attended this meeting and argued for more research to better understand “[t]he possible influence on our climate of increased CO₂ in the atmosphere resulting from our combustion of fossil fuels”²⁰¹

In a February 1962 Special Message to Congress, President John F. Kennedy asked for legislation that would give the PHS more authority on air pollution; as part of that framework, HEW Secretary (later Connecticut Senator) Abraham Ribicoff called for another conference. This resulted in the second National Conference on Air Pollution, held in December 1962.²⁰² While the focus of the conference was once again primarily on urban air pollution and health—and some participants continued to hold that CO₂ was “harmless”—others reminded the meeting that CO₂ could pose a significant long-range threat.²⁰³ For example, John E. Bebout, Director of the Urban Studies Center at

196. *Id.* at 320.

197. U.S. PUB. HEALTH SERV., SYMPOSIUM: AIR OVER CITIES (1961) [*hereinafter* 1961 PHS SYMPOSIUM].

198. H.E. Landsberg, *City Air—Better or Worse*, in 1961 PHS SYMPOSIUM 1, 4.

199. James P. Lodge, *Recent Developments in the Chemistry of Urban Atmospheres*, in 1961 PHS SYMPOSIUM 31, 31.

200. *Id.* at 35. Lodge argued that measurement methods had greatly improved since the start of the century and referenced Keeling’s measurements as an “fine example.”

201. E.W. Hewson et. al, *Measurement Programs Required for Evolution of Man-Made and Natural Contaminants in Urban Areas*, in 1961 PHS SYMPOSIUM 239, 254.

202. Arthur C. Stern, *History of Air Pollution Legislation in the United States*, 32 J. APCA 44, 51 (1982); US DEP’T OF HEALTH, EDUC., AND WELFARE, PUB. HEALTH SERV., PROCEEDINGS: NATIONAL CONFERENCE ON AIR POLLUTION (1963) [*hereinafter* 1963 PHS PROCEEDINGS].

203. For example: Wolfgang E. Meyer, an engineering professor at Penn State, noted that “When the hydrogen and carbon that are the elements that make up petroleum fuels combine with oxygen, water vapor and carbon dioxide are formed. Both of these products of the ideal, complete combustion are invisible, cannot be smelled, and are harmless.” Wolfgang E. Meyer, *Air Pollutants from Motor Vehicles*, in 1963 PHS PROCEEDINGS 46, 46.

Rutgers University, referred back to Leake's comments at the 1958 meeting, recalling that he had advocated planting trees "to keep down the increase in the blanket of carbon dioxide which threatens to make drastic and very uncomfortable changes in our climate and the distribution of water over the globe." Bebout suggested the need for policy attention: the possible long range

concern of mankind over the mounting pollution resulting from the general increase in the burning of hydrocarbons throughout the world, including the burning of them in fast-moving jetplanes and other long range vehicles, simply underscores the necessity for acceptance of the ultimate responsibility for conservation of the air we breathe at the highest possible levels of public decision making.²⁰⁴

John W. Bodine, President of Penjerdel (the Pennsylvania-New Jersey-Delaware Project, Inc.), also noted the "possibility that further emissions of carbon dioxide may alter the climate of our planet or the level of our oceans"²⁰⁵

At the Third National Conference on Air Pollution, held in December 1966, there was extensive discussion of carbon dioxide. The chair of the AAAS Air Conservation Commission, James P. Dixon, gave a broad address on "The State of Our Atmosphere," in which he suggested there was no doubt that carbon dioxide could and should be included among pollutants. He noted that the "principal pollutants" could be divided into inorganic gases, organic gases, and particulates:

Carbon dioxide and monoxide, sulfur dioxide, some hydrogen sulfide, nitric oxide and dioxide, are the main inorganic gases produced from the combustion of fossil fuels . . . Described in chemical terms, the major air pollutants arise because of the combustion of fossil fuels. The burning of hydrocarbon fuels in internal combustion engines is the single most important pollutant source. Small wonder, then, that there is a revived interest in the electric-powered automobile.²⁰⁶

While some speakers stressed that the effects of increased atmospheric carbon dioxide were speculative, others argued otherwise. John S. Chapman, Assistant Dean at University of Texas, Dallas Medical School and member of the American Medical Association Council on Environmental and Public Health, stressed that the effects were at least "roughly predictable and would not meet with unqualified approval."²⁰⁷ Morris Neiburger, Professor of Meteorology at the University of California, Los Angeles and a past president of American Meteorological Society, argued that important aspects of the problem were not speculative. In fact, carbon dioxide was one of the better studied pollutants, he

204. John E. Bebout, *How Can We Get Action for Clear Air Through—and at—All Levels of Government?*, in 1963 PHS PROCEEDINGS 352, 355.

205. John W. Bodine, *How Can We Get Action for Cleaner Air Through Community Action?*, in 1963 PHS PROCEEDINGS 360, 361. Bodine served on the AAAS Air Conservation Commission a few years prior.

206. James P. Dixon, *The State of Our Atmosphere*, in US DEP'T OF HEALTH, EDUC., AND WELFARE, PUB. HEALTH SERV., PROCEEDINGS: THIRD NATIONAL CONFERENCE ON AIR POLLUTION 18, 19–20 (1967) [*hereinafter* 1967 PHS PROCEEDINGS].

207. John S. Chapman, *Air Pollution and Our Health*, in 1967 PHS PROCEEDINGS 23, 24.

suggested, at least in terms of its atmospheric concentration, as well as its potential to alter the climate. Like others at the conference, Neiburger specifically called carbon dioxide a pollutant, akin to sulfur dioxide and carbon monoxide, noting that its increase had received “much attention.”

We do not really know whether the worldwide average concentration of such toxic pollutants as sulfur dioxide, nitrogen dioxide, and carbon monoxide has been rising through the years, since suitable measurements for the past are not available. *In the case of one pollutant, carbon dioxide, however, there is definite evidence that the concentration for the atmosphere as a whole has risen about 10 percent of its value, from approximately 0.029 percent in 1900 to over 0.032 percent at present. There are no direct toxic effects to humans from an increase of carbon dioxide as long as it does not greatly reduce the available oxygen, and even a tenfold increase in CO₂ would still leave plenty of oxygen for animal respiration*

A possible indirect adverse effect has received much attention, namely, the influence of the increase of carbon dioxide on the balance of heat and temperature of the atmosphere. Carbon dioxide . . . is largely responsible for the “greenhouse” effect The increase in carbon dioxide which has taken place must have altered the greenhouse effect, producing an increase of average temperature of the earth’s surface. . . . [S]ince continuation of this temperature rise with continued increase in CO₂ concentration may result in the melting of the ice caps over Antarctica and Greenland and cause a rise of sea level and flooding of populated coastal areas, it is important to evaluate this effect, and perhaps to limit or eliminate the use of fossil fuels to prevent an excessive [sic] increase of carbon dioxide.²⁰⁸

He concluded that “[w]hether or not we are already exceeding the limit of the air’s capacity to cleanse itself, we certainly will do so in the future unless prompt and effective steps are taken to prevent it.”²⁰⁹

John T. Middleton, former professor at the University of California, Riverside and NCAPC director, also spoke at the 1966 conference. (Middleton would continue as the director of NAPCA in 1968, and later, when NAPCA was folded into the newly established EPA, he served as its first deputy assistant administrator for the Air Program.) He was an expert on the impacts of air pollution on plants, including agricultural crops; he placed carbon dioxide into the context of air pollution—particularly from motor vehicles—and was explicit that carbon dioxide was a pollutant of concern:

The array of pollutant chemical compounds emitted by motor vehicles is extensive and includes carbon dioxide, carbon monoxide, gasoline, hydrocarbons, oxygenated hydrocarbons, nitrogen oxides, nitrogen-containing organics, sulfur oxides, aldehydes and acids, phenols, polynuclear hydrocarbons, particulate matter, and lead salts. These materials are air pollutants as emitted to the atmosphere or participate in atmospheric

208. Morris Neiburger, *What Factors Determine the Optimum Size Area for an Air Pollution Control Program?*, in 1967 PHS PROCEEDINGS 442, 447 (emphasis added).

209. *Id.*

photochemical reactions which lead to the production of other pollutants, such as nitrogen dioxide, ozone, and the peroxyacyl nitrates.²¹⁰

In language similar to what would soon be written in the definition of welfare in the 1970s Clean Air Act, Middleton explained that pollutants from motor vehicles, “alone and in conjunction with those from other emission sources, create[] adverse effects upon the public health and welfare; it affects man’s health, irritates the senses, damages property, and interferes with visibility.”²¹¹

Another prominent conference speaker was physicist and Nobel Laureate Glenn Seaborg, who was at that time the Chairman of the Atomic Energy Commission (AEC). Seaborg offered carbon dioxide pollution as a reason to develop nuclear power, which had the “decided advantage” over fossil fuel plants in terms of air pollution, because “the stacks of fossil fueled plants must release to the atmosphere effluents containing amounts of carbon dioxide which cannot be reduced, and of sulfur dioxide for which no effective removal system has yet been developed.”²¹²

Several politicians spoke at this conference, including U.S. Representative Emilio Q. Daddario of Connecticut, New Jersey Governor Richard Hughes, Cleveland Ohio Mayor Ralph S. Locher, and Wisconsin Senator Gaylord Nelson. These men discussed CO₂ in terms of long-range policy, nuclear power, public understanding of science, and the role of the U.S. Congress. Also present was Senator Edmund Muskie and his staff member, Leon Billings.²¹³

Representative Daddario—who spoke earlier that year on CO₂ in House hearings on pollution abatement technology—argued that we should not use the long timeline for environmental damage as an excuse for inaction.²¹⁴ He advocated developing “an ‘early warning’ capability for environmental effects,” analogous to national security early warning systems, which would “give us the time to revise the activities of society, or to take countermeasures, when manmade disruptions appear to be going contrary to our best interests.”²¹⁵ A

210. John T. Middleton, *Future Air Quality Standards and Motor Vehicle Emission Restrictions*, in 1967 PHS PROCEEDINGS 45, 46 (emphasis added).

211. *Id.*

212. Glenn T. Seaborg, *Development of National Policy with respect to Nuclear and Other New Sources of Power*, in 1967 PHS PROCEEDINGS at 131, 132.

213. US DEP’T OF HEALTH, EDUC., AND WELFARE, PUB. HEALTH SERV., ATTENDANCE LIST, NATIONAL CONFERENCE ON AIR POLLUTION DECEMBER 12–14, 1966 at 24, 43 (1967). This attendance list was transmitted directly to Muskie from the NCAPC, see Letter from Nat’l Ctr. for Air Pollution Control to Edmund Muskie, U.S. Senator of Me. (Apr. 3, 1967) (on file at s. V.A.6, b. 540, f. 1, BC-ESM).

214. As Chairman of the Subcommittee on Science, Research, and Development of the House Committee on Science and Astronautics, Daddario presided over a month of hearings on pollution abatement technologies, in which CO₂ was discussed at length. The Subcommittee produced two associated reports, both of which considered CO₂. See *The Adequacy of Technology for Pollution Abatement: Hearing Before the Subcomm. on Sci., Rsch., and Dev. of the H. Comm. on Sci. and Astro.*, 89th Cong. (1966); SUBCOMM. ON SCI., RSCH., AND DEV., *supra* note 146, at 321–322. These reports are discussed further in Lanier-Christensen et. al., *Climate Change and the 1970 Clean Air Act Part II: Congressional Debates* (forthcoming).

215. Emilio Q. Daddario, *A Congressional View of the Problem*, in 1967 PHS PROCEEDINGS 183, 185. Daddario’s Subcommittee on Science, Research and Development first proposed this warning system

specific example was carbon dioxide: “The complex problem of the increase in carbon dioxide in the atmosphere from fossil fuel combustion” is an example “where an early warning is needed to direct research, development, and deployment of technology.”²¹⁶ Daddario echoed Seaborg’s suggestion that the emerging effects of CO₂ might warrant a “crash program” for nuclear power plants: “[N]uclear energy . . . is a most promising answer to pollution of the air. Adverse reports in the next few years on the carbon dioxide effect might bring a crash program to install nuclear electric power.”²¹⁷

Governor Hughes offered seven points on what New Jersey’s experience could offer to other states and their air pollution programs. The seventh was public understanding of air pollution “in both its importance and its complexity.” He explained:

Air pollution is complex. It can exist as a threat to public health or simply as a minor source of discomfort. It can and does affect crops, trees, flowers and buildings visibly. It can also affect the permanent condition of the atmosphere which surrounds the earth. Some scientists argue, for example, that the uncontrolled discharge of carbon dioxide could have very dangerous results.²¹⁸

Cleveland Mayor Ralph Locher also addressed CO₂ and climate: “The conservationists tell us . . . [that t]he average temperature will rise as more carbon dioxide is pumped into the air”²¹⁹

One of the most extensive and well-informed discussions came from Wisconsin Senator Gaylord Nelson, known for his commitment to environmental protection and later for co-founding Earth Day (in 1970). Nelson offered “A Congressional View of the Problem,” noting that the Senate Interior committee had already heard testimony on carbon dioxide and climate change.

[U]p there in the once blue sky, concealed behind a blanket of smog, things are happening which no average person can detect.

A Cornell University scientist, Dr. LaMont Cole, testified before our Senate Interior Committee [and] said: ‘Man is burning fossil fuel at an ever-increasing rate and it is probable that more than half of the fuel ever burned by man has been burned in this century. One result of this is to release carbon dioxide into the atmosphere more rapidly than it can be taken up by green plants or dissolved in the oceans and eventually precipitated It appears probable that the carbon dioxide content of the atmosphere has increased by

in their 1966 progress report in which they referenced atmospheric CO₂, shifting weather patterns, “disturbed planetary temperatures,” melting ice caps and sea level rise that would leave “Seattle or San Diego . . . no longer on the map” as possible concerns that merited such a system. *See*, SUBCOMM. ON SCI., RSCH., AND DEV. OF THE H. COMM. ON SCI. AND ASTRONAUTICS, 89TH CONG., PROGRESS REPORT 26 (Comm. Print 1966).

216. *Id.* at 185–186.

217. *Id.* at 187.

218. Richard J. Hughes, *The Case for a State Air Pollution Control Program*, in 1967 PHS PROCEEDINGS 364, 367.

219. Ralph S. Locher, *The Case for a Local or Regional Air Pollution Control Program*, in 1967 PHS PROCEEDINGS 400, 402.

at least 10 percent since the turn of the century. Atmosphere [sic] carbon dioxide is believed to have drastic effects on climate’

The scientists also remind us that this orgy of fuel burning—which stokes the fires of American industries and powers our autos and planes—is using up oxygen at an accelerating rate.²²⁰

Critical to the perspective of congressional awareness of the CO₂ problem and intent in passing the Clean Air Act was the work of Maine Senator Edmund Muskie. Among the materials that can be found in the Muskie archives from this time is an article published in the April–May 1966 edition of *National Wildlife*. The article, written by National Wildlife foundation Executive Director Thomas Kimball, and reprinted for the Air Pollution Conference, explained that

[An] apparent result of our profligacy with our atmosphere sounds like a chapter from a science fiction novel, but is unfortunately true: Carbon dioxide is an innocuous, important gas in our atmosphere. Among other things, it supports our plants, which inhale it and exhale oxygen. The natural envelope of carbon dioxide in our atmosphere is the primary retainer of the sun’s heat around the earth. But as we increase the carbon dioxide content of our atmosphere—and remove vegetation that might have absorbed it—we increase the amount of heat the earth can hold, with potentially disastrous results.²²¹

Muskie spoke at the conference on December 13, and while his conference speech did not specifically address CO₂, it did indicate his approach to air pollution. This was to address not only immediate health effects of single pollutants but also to develop a framework that would include long-term effects on health and well-being and embrace flexibility to address issues that arose in the future that had not yet been predicted:

[Air quality] criteria need to go beyond questions of clinical injury or gross insults from specific pollutants. They need to include considerations of subtle, long-term effects of pollutants on our health and well-being. Those criteria must take into account health, esthetics, conservation of natural resources and the protection of public and private property. The criteria must be modified, as our knowledge expands, to provide added protection against unforeseen pollution hazards.²²²

The federal government was “the logical entity to develop the criteria,” Muskie explained, because “[c]ommunity or State jurisdictions bear little or no

220. Gaylord Nelson, *A Congressional View of the Problem*, in 1967 PHS PROCEEDINGS 450, 451–52. The quotation from Cole is reproduced as it reads in the text, which has minor typographical changes from the original Senate testimony. Senator Nelson was quoting from a hearing over which he had presided earlier that year. *Ecological Research and Surveys, Hearing on S. 2282 Before the S. Comm. on Interior and Insular Aff.*, 89th Cong. 65 (1966) (statement of Dr. Lamont Cole, Professor of Zoology, Cornell University).

221. Thomas Kimball, *Air Pollution*, 4 NAT’L WILDLIFE 12 (1966), reprinted for US DEP’T OF HEALTH, EDUC., AND WELFARE, PUB. HEALTH SERV., NATIONAL CONFERENCE ON AIR POLLUTION, DEC 12–14 (1966) (on file at s. V.A.5, b. 368, f. 10, BC-ESM).

222. Edmund S. Muskie, *Setting Goals for Clean Air*, in 1967 PHS PROCEEDINGS 596, 597 (copy of speech also on file at s. V.D, b. 31, f. 3, BC-ESM).

relationship to the geographic spread of air pollution. Because metropolitan areas are not consistent with meteorological areas, the old institutional arrangements for air pollution control are not really adequate to the task.”²²³ Moreover, “the traditional interstate compact has not given sufficient attention to the changing requirements of a complex modern society. *It has not been flexible enough to deal with changing concepts of pollution control . . .*”²²⁴

The Senator discussed plans for congressional hearings related to the Clean Air Act and exploring alternative energy vehicles, including the “battery-driven electric car.” He concluded by emphasizing that air quality was a question of general welfare: “[W]e must all realize that no narrow personal or private motive can be allowed to outweigh the importance of the public health and welfare of the people of the United States.”²²⁵

B. *The Automobile and Air Pollution: A 1967 Report*

On October 18, 1967, Secretary of Commerce Alexander Trowbridge forwarded a report to Senator Muskie: *The Automobile and Air Pollution: A Program for Progress Part I*. Trowbridge sent the report to Muskie one day before its public release; Muskie replied immediately, requesting Part II as soon as it was available.²²⁶ The Department of Commerce had begun expressing interest in examining the effects of automobile usage on air pollution in late 1966, and in January 1967, then-Secretary John Connor appointed the Panel on Electrically Powered Vehicles.

The panel was chaired by Richard Morse from MIT’s Sloan School of Management and consisted of both academic researchers and industry affiliates.²²⁷ The original charge was to produce a report on the feasibility of electric vehicles for mass market, but panel members decided to expand the scope to explore air pollution related to automotive transportation broadly, to present recommendations for action, and to investigate all possible alternatives to the gasoline engine. The timeline was also accelerated in response to

223. *Id.* at 597–98.

224. *Id.* (emphasis added).

225. *Id.* at 599.

226. Letter from A.B. Trowbridge, Secretary of Commerce, to Edmund S. Muskie, U.S. Senator of Me. (Oct. 18, 1967) (on file at s. V.A.6, b. 485, f. 8, BC-ESM); Letter from Edmund S. Muskie, U.S. Senator of Me., to A.B. Trowbridge, Secretary of Commerce (Oct. 18, 1967) (on file at s. V.A.6, b. 485, f. 8, BC-ESM). The report itself can be found on file at b. 478, f. 7, BC-ESM.

227. The group was conducted in cooperation with a Commerce Department advisory board with support from the Department of Defense, HEW, Housing and Urban Development, Department of Transportation (DOT), Post Office, AEC, and Federal Power Commission (FPC). Membership was skewed towards industry, and two of the seven academics had industry ties in addition to their academic appointments. Nine representatives from Ford, Consolidation Coal, Esso, Westinghouse, R.C.A., GM, Chrysler, Gulton, and AEP comprised the bulk of the panel, rounded out by Paul O’Day, from Trowbridge’s office. The subpanel on Air Pollution was less representative of industry interests—chaired by Rolf Eliassen of Stanford, the other members included representatives from the State of California, the Los Angeles and New York City air pollution Control Boards, the Harvard School of Public Health, Arthur Stern from NCAPC and HEW, and representatives from Chrysler and Mobil. In 1969, Morse served on the steering committee for the MIT Study of Critical Environmental Problems (SCEP).

“pressures from Congress, the Executive Branch, the press, and the public.”²²⁸ Instead of taking a year, the panel finished their preliminary report in less than seven months. Muskie later credited the panel’s work with creating “renewed interest in alternatives to internal combustion”²²⁹ Upon its completion, the report was transmitted widely to the leaders of relevant executive branch agencies. Besides Trowbridge, copies were sent to Defense Secretary Robert McNamara; Department of Interior Secretary Stewart Udall; Department of Health, Education, and Welfare Secretary John William Garner; Department of Housing and Urban Development Secretary Robert C. Weaver; Transportation Secretary Alan S. Boyd; as well as Atomic Energy Commission Chairman Glenn Seaborg; Federal Power Commission Chairman²³⁰ Lee C. White; and Postmaster General Lawrence O’Brien.²³¹

In defining the problem of air pollution, the panel used language similar to the definition of welfare that would soon appear in the Clean Air Act:

The atmospheric contamination which accompanies industrial society is a continuing insult to man and his environment. This pollution shortens life, destroys vegetation, damages property, and threatens to alter basic meteorological processes.”²³² Like other reports from this era, the group emphasized that exact research on the effects of many specific pollutants was lacking, but that should not be reason for delay: a “delay in action pending availability of conclusive evidence which identifies the precise damage associated with various levels of each pollutant currently contaminating the air is unreasonable.”²³³ Testing should be increased as soon as “economics and advancing technology will allow,” but the evidence available was

228. US DEP’T OF COM., PANEL ON ELECTRICALLY POWERED VEHICLES, THE AUTOMOBILE AND AIR POLLUTION: A PROGRAM FOR PROGRESS 8 (1967). In April a revised schedule was announced because “hearings on bills presented before the US Senate by Senator Warren Magnuson and Senator Edmund Muskie, as well as several national professional conferences, increased interest in the problem.” The proposed bills from Magnuson and Muskie are presumably S. 451, 90th Cong. (1967) and S. 453, 90th Cong. (1967), the first a bill to fund research on less polluting vehicles, the second specifically for funding research on electric vehicles. *See* 113 CONG. REC., S. 612–617 (daily ed. Jan. 17, 1967). A preliminary report was submitted in July, with the final publication in October.

229. Edmund S. Muskie, U.S. Senator of Me., to Robert Ayres of Resources for the Future (May 8, 1968) (inviting Ayres to a hearing) (on file at s. V.A.6, b. 597, f. 6, BC-ESM). Very similar letters were sent to Ford and GM Presidents and Ralph Nader—those ones co-signed by Warren Magnuson (chairman of Commerce Committee). *See, e.g.*, Edmund S. Muskie & Warren G. Magnuson, U.S. Senators, to Edward N. Cole, President of General Motors (May 8, 1968) (on file at s. V.A. 6, b.597, f. 6, BC-ESM); Edmund S. Muskie & Warren G. Magnuson, U.S. Senators, to Ralph Nader (May 8, 1968) (on file at s. V.A. 6, b. 597, f. 6, BC-ESM). Edmund S. Muskie also corresponded with Richard Morse about the panel’s report while their work was underway. *See* Edmund S. Muskie, U.S. Senator of Me., to Richard Morse, senior lecturer at Sloan School of Management of Massachusetts Institute of Technology (May 22, 1967) (on file at s. V.A.6, b. 485, f. 8, BC-ESM).

230. The FPC became the Federal Energy Regulatory Commission (FERC) in 1977. *Federal Power Commission*, SCIENCE DIRECT, <https://www.sciencedirect.com/topics/engineering/federal-power-commission> (last visited Jan. 14, 2024).

231. Letter from A.B. Trowbridge to Edmund S. Muskie, *supra* note 226; Letter from Edmund S. Muskie to A.B. Trowbridge, *supra* note 226; Letter of Transmittal from Richard S. Morse, Chairman of the Panel on Electrically Powered Vehicles (Oct. 1967) (on file at V.A.6, b. 478, f. 7, BC-ESM).

232. U.S. DEP’T OF COM., *supra* note 228, at 9.

233. *Id.* at 12.

enough to serve as a “basis for action until more definitive studies are completed.”²³⁴

The fourth subsection, “Weather modification,” concisely summarized the possible meteorological effects of carbon dioxide:

Attention has been focused for some time on the effects of rising levels of carbon dioxide in the atmosphere due to increasing rates of combustion of fossil fuels. The infra-red absorption properties of CO₂ cause out-going radiant heat from the earth to be captured near the surface, resulting in an increase in the temperature of the atmosphere. This phenomenon is popularly known as the “greenhouse effect.” Should carbon dioxide levels be allowed to rise continually at current rates, it has been suggested that the resulting temperature rise would have dire meteorological effects, resulting in melting of the polar ice caps and raising ocean levels.²³⁵

Given the significance of this issue, more work was needed. The Panel had been “surprised and disturbed to learn that the existing knowledge about atmospheric processes is so inadequate,” and recommended that the Environmental Science Services Administration (ESSA)—which was responsible for research on inadvertent weather modification—establish a robust research program on the effects of air pollution on atmospheric processes as soon as possible.²³⁶ Here, the panel emphasized the global implications and explicitly linked the problem to human welfare:

To date, very little research has been undertaken on the interrelationships between pollution in the atmosphere and the basic meteorological processes which govern weather. These effects could have extremely significant implications upon the welfare of the world’s population and a start should be made as soon as possible to learn more about this potentially important aspect of air pollution. Since the problems in this area have obvious worldwide implications, an attempt should be made in such a program to construct and cooperate in international research and monitoring efforts.²³⁷

The global nature of air pollution resurfaced later in the report. Under a section examining the role of government for air pollution research and regulation, the panel differentiated what they termed “micrometeorology”—“small-scale atmospheric convection and diffusion,” which they classified as one area of “uncertainties in air pollution control”—from world air pollution, which was given its own subsection.²³⁸ Carbon dioxide was not directly addressed in this section, but the panel alluded to it when it wrote that

although this aspect of the problem has not yet fired public opinion, the world-wide significance of air pollution is, at least today, probably more serious in terms of health and welfare than that of radioactive fallout from

234. *Id.* at 12–13.

235. *Id.* at 15.

236. *Id.* at 16.

237. *Id.* at 16.

238. *Id.* at 37, 40.

nuclear tests. The need is clear for early action and the establishment of cooperative programs should be delayed no longer.²³⁹

The work of the Panel on Electrically Powered Vehicles reflects the recognition by the mid-1960s that matters of pollution—including CO₂—had significant economic ramifications, in this case potentially for the entire automobile industry. As Robert White framed it, ESSA was created “to enable the Department of Commerce to treat the physical environment as a whole . . . because various aspects of the physical environment relate one to the other.”²⁴⁰ ESSA’s weather modification work was related to their other weather activities (such as the Weather Bureau) and was guided by the goals articulated by the NAS Panel on Weather and Climate Modification and the NSF Special Commission on Weather Modification. This included work on the “[m]odification of weather and climate by air pollution.” One description of this research arena specifically noted the Mauna Loa CO₂ measurements and the relationship between fossil fuels, pollution, and human-caused climate change:

Research on the degree to which both global and local climates are being affected by industrialization, urbanization, and agricultural practices is an important element of the ESSA program. Air pollution from the burning of coal and oil in particular may produce long-term effects on the natural climate of the earth. Long-term pollutant concentration trends are being monitored by an observatory on Mauna Loa, Hawaii, and measurements of ozone and other atmospheric properties are being made to provide data for evaluating possible man-made climatic changes.²⁴¹

C. NAPCA-North Carolina Consortium on Air Pollution Conference

In October 1969, NAPCA co-sponsored a symposium with the North Carolina Consortium on Air Pollution. John Middleton was now NAPCA director, and he delivered the keynote speech, with CO₂ on his agenda.²⁴² He

239. *Id.* at 41.

240. *Departments of State, Justice, and Commerce, the Judiciary, and Related Agencies Appropriations for 1970: Hearing on Environmental Science Services Administration Before a H. Subcomm. of the Comm. On Appropriations H. of Rep.* 91st Cong., 1st Sess., pt. 3, 616, 634 (1969) (testimony of Robert White, Administrator, ESSA).

241. *Id.* at 738 (Explanation and Justification of Adjustments to Base Program). Three years later, a 1970 ESSA publication would reiterate this point:

Research is underway on the effects of industrialization, urbanization, and agricultural practices upon global and local climates. The role of air pollution is under study to determine its long-term effects on the natural climate of the earth. Specifically, the R&D program in air pollution deals with the radiation energy budget and with inadvertent weather modification caused by the action of gases (carbon dioxide and ozone), particulate matter (cirrus clouds), and surfaces (albedo).

Weather Modification Research and Development Programs, 52 ESSA SCI. & AND ENG. 48, 49 (1970). In 1968, Commerce became the lead US agency for participating in GARP—the Global Atmospheric Research Program—as established by Presidential memorandum and Senate endorsement in 1968. *See Departments of State, Justice, and Commerce, the Judiciary, supra*, note 240, at 629.

242. The symposium was held October 27–30, 1969, at Research Triangle Park in North Carolina. NAPCA functions were transferred to the Air Pollution Control Office within the EPA on December 4, 1970, and thus it was published by EPA and all references to NAPCA were changed to APCO of the EPA.

acknowledged that the science surrounding the effects of increased atmospheric CO₂ was not certain, but they could not for that reason be dismissed as insignificant.

Estimates differ about the potential effects on world temperature and climate due to increased atmospheric carbon dioxide and particulate concentrations. . . . [O]pinions differ about the details of processes involving temperature trends, climate, melting of polar ice caps, sea level, photosynthesis, and the distribution of fish, to name a few.

There are, of course, many other examples. The point is, that when man alters the balance of Nature, it is like tossing a pebble into a pond: the resulting ripples spread out concentrically from the entry point until they touch every point on the shore. Continued small alterations of our environment may have drastic effects later, effects we cannot foresee now.²⁴³

Morris Neiburger gave the banquet speech, with the title, "Progress + Profits + Population = Pollution." He returned to a point he had made earlier in the 1960s that the rate at which pollutants were being added to the atmosphere might be greater than the natural processes that removed them. With respect to CO₂, this was definitely the case.

[W]e do not know whether, on a world-wide basis, toxic contaminants are being put into the air faster than the natural cleansing processes of the atmosphere remove them We do know of one pollutant, though not a toxic one, of which there is an accumulation in the atmosphere. Carbon dioxide has been sampled long enough, and with enough accuracy, to show that the total amount is increasing steadily year by year.²⁴⁴

These insights were summarized in an April 1970 conference report of the American Public Health Association, published in the journal *Public Health Reports*. In a section entitled "Pollutants Can Unbalance Earth's Delicate Ecosystems," the report recounted a lecture by Barry Commoner, the Director of the Center for the Biology of Natural Systems at Washington University, St. Louis, in which he discussed the competing effects of particulates and CO₂.

The future of the temperature of the earth, he pointed out, depends on balancing the effects of two pollution processes—a rise in the fraction of solar radiation retained in the atmosphere because of the accumulation of carbon dioxide and a decline in this fraction caused by the shielding effects of pollutant aerosols. If the carbon dioxide accumulation is too great, the rise in temperature may melt the polar ice cap and cause huge floods.²⁴⁵

For this reason, NAPCA nearly disappears historically, its work hard to reconstruct. It is also easily confused with APCA, the industry group. EPA, PROCEEDINGS OF SYMPOSIUM ON MULTIPLE-SOURCE URBAN DIFFUSION MODELS iii (Arthur C. Stern ed., 1970) [*hereinafter* 1970 EPA PROCEEDINGS].

243. John T. Middleton, *Diffusion Modeling for Air Pollution Abatement and Control*, in 1970 EPA PROCEEDINGS at 1-1, 1-2.

244. Morris Neiburger, *Progress + Profits + Population = Pollution*, in 1970 EPA PROCEEDINGS 12-1, 12-8-9.

245. *APHA Conference Report, 1969*, 85 PUB. HEAL. REP. 283, 343 (1970).

D. *The Air Pollution Control Association and Industry Awareness*

The Air Pollution Control Association (APCA, not to be confused with NAPCA), was an industry group dating back to 1907.²⁴⁶ Throughout the 1960s, the APCA worked alongside the PHS and independent scientists to understand air pollution issues that might affect its members. At the APCA's 60th annual meeting in June 1967, NCAR's James Lodge chaired a session on "Long Lived Pollutants," and Keeling spoke on "Carbon Dioxide from Fossil Fuel—A Potential World-Wide Air Pollutant."²⁴⁷ On the same day, Don Nicoll, administrative assistant to Senator Muskie, also delivered a talk.²⁴⁸ While neither the proceedings nor a summary was published in the *Journal of the Air Pollution Control Association*, Senator Muskie's office retained a copy of the conference program.

In 1969, the Association held a meeting featuring a keynote speech by Guyford Stever, President of Carnegie-Mellon University and later (1972–1976) Director of the National Science Foundation. Stever called attention to the diversity of air pollution, including carbon dioxide, which could threaten "major changes." There were many kinds of air pollution, but

our problem today is concentrated in the air pollution produced as a result of largescale activities of man. I am always amazed at the range of kinds of air pollutants and causes that we have. The air is polluted with radioactive material from the explosion of atomic bombs; the air is heated by the tremendous and growing combustion of fossil fuels for heating and cooling as well as processing our materials; we are told that the carbon dioxide balance is also being upset, with the consequent threatening of major changes in the absorption and reflection of sunlight by the earth²⁴⁹

In 1970, APCA heard again about the CO₂ problem, this time from Russell Train, Assistant Secretary of Interior (1969–1970) and, at the time of his presentation, the first head of the Council on Environmental Quality (1970–1973) under President Richard Nixon. As assistant secretary, Train had given many public speeches on carbon dioxide and climate.²⁵⁰ He now explained how

246. APCA began as the International Association for the Prevention of Smoke in 1907. In 1915 it changed its name to the Smoke Prevention Association of America, and in 1950 to the Air Pollution Control Association. The 1950 name change was part of broader discussions in the association about the need to control all forms of air pollution, rather than just visible "smoke." Over the years, the association had several cooperative programs with the federal government and a number of federal employees served on the APCA board of directors, including Arthur Stern and John Middleton. See John S. Lagarias, *The Story of the Air Pollution Control Association: Seventy-Five Years of Growth*, 32 J. APCA 31, 32, 41 (1982).

247. AIR POLLUTION CONTROL ASS'N, 60TH ANNUAL MEETING, AIR POLLUTION CONTROL ASSOCIATION, JUNE 11-16, 1967, PROGRAM 22 (1967) (on file at s. V.C, b. 32, f. 4, BC-ESM).

248. Donald E. Nicoll, Administrative Assistant to U.S. Senator of Me., Edmund S. Muskie, Speech at the Eastern Regional Conference, Council of State Governments in Stowe, Vermont (Jun. 14, 1967) (on file at s. V.C, b. 39, f. 1, BC-ESM).

249. *62nd Annual Meeting Summary of Activities*, 19 J. APCA 548, 549 (1969).

250. See e.g., Russel E. Train, Undersecretary of the Interior, Remarks Before the 100th Anniversary the American Museum of Natural History (Apr. 9, 1969) (on file at b. 69, f. 5, Russel E. Train Papers,

the new Council would have to address “different forms of pollution” from what had garnered attention in the past, and one of these was carbon dioxide:

The environmental problems of the future will increasingly cut across the somewhat arbitrary categories of air pollution, water pollution, and so forth, which have evolved over the years. . . . The ecological problems we face, whether it be the accumulation of carbon dioxide in the atmosphere or the construction of an Everglades jetport, defy analysis solely in terms of the separate established categories. We need new ways of looking at the environment, and the Council will be working to develop these new perspectives.²⁵¹

Train made it clear that carbon dioxide was not of concern merely as a local effect, but as a global one. He stressed that many “aspects of the environment” were “truly global,” and CO₂ was one of them. “The worldwide fallout from nuclear testing underlined the unity of the atmosphere. How long will it be until California has to deal with the pollution from Japan? How long will it be until the carbon dioxide from North America and Europe begins to affect the climate in Asia and Africa?”²⁵²

Industry leaders were aware of Train’s work, including his earlier work with the Conservation Foundation, and understood that the carbon dioxide “problem” was a global one. In 1966, for example, J.H. Huguet, an engineer and the Industrial Conservation Coordinator for the Ethyl Corporation (formed in the 1920s as a joint venture between General Motors and Standard Oil to produce leaded gasoline), presented the North American report on air pollution at the International Clean Air Congress held in London in October 1966.²⁵³ One section of his report, published in the *Journal of the Air Pollution Control Association*, addressed carbon dioxide in the context of the 1963 Conservation Foundation Report, and suggested that the remedy might involve new ways of generating energy, including solar power:

Additional problems arising from our mounting production of energy are oxides of nitrogen and carbon dioxide. . . . A report issued in 1963 by the Conservation Foundation indicates that the carbon dioxide content of the atmosphere is rising at a rate which may cause the temperature of the earth’s surface to increase. There is much speculation as to the effects that this temperature increase will have on the world. The use of atomic power, solar energy, increased use of hydraulic power, and new concepts show some promise for reducing the combustion requirements and problems associated with products of combustion.²⁵⁴

Manuscript Division, Library of Congress, Washington, D.C. [*hereinafter* LOC-RET]; *see also* boxes 69, 70, and 71, various folders, LOC-RET).

251. 63rd Annual Meeting Summary of Activities, 20 J. APCA 508, 510 (1970).

252. *Id.* at 511.

253. This was the first conference of the International Union of Air Pollution Prevention Associations (IUAPPA). On the history of APCA, including IUAPPA, *see generally* Lagarias, *supra* note 246.

254. *A Survey of Global Air Pollution*, 16 J. APCA 573, 587 (1966).

The International Clean Air Congress met again in December 1969, in Washington, DC, hosted by APCA, with a keynote speech by U.S. Senator Jennings Randolph. Randolph—the chair of the Senate Public Works Committee, where the 1970 Clean Air Act originated—spoke at length about carbon dioxide from burning fossil fuels, its character as a global problem, and the need for global monitoring:

There is a need for a coordinated worldwide system to monitor pollution in the total environment. We know from past experience with nuclear fallout that radioactive wastes are transported widely and rapidly through the environment. However, we do not have comparable information on chemical pollutants, and there is a demand for more extensive, continuous data on which to base an international control effort.

For example, such a system would be invaluable in adding to our knowledge of the worldwide increase in carbon dioxide resulting from the burning of fossil fuels. There are many theoretical implications of higher concentrations of carbon dioxide, but they cannot be verified unless there is more information of the kind that can be obtained only by global monitoring. Scientists need to know to what extent and where carbon dioxide concentrations are increasing, the interaction of carbon dioxide with the oceans, and its effect on weather and climate.²⁵⁵

E. *Air Pollution Textbooks*

One measure of the establishment of a subject as part of mainstream scientific research is its inclusion in textbooks.²⁵⁶ In 1968, Academic Press published a three-volume compendium, entitled *Air Pollution*. In the first volume, *Air Pollution and Its Effects*, Leslie Chambers of the University of Southern California offered a discussion of “Classification and Extent of Air Pollution Problems.” Like other scientists, he noted that there was some ambiguity about how to think about carbon dioxide, particularly as compared with other substances that had long been recognized as pollutants. He also noted that the ultimate solution, if required, would involve shifting sources of electricity generation. “Carbon dioxide is not often considered to be an air pollutant,” he wrote, “since it produces adverse physiological effects only at relatively high concentration, and because biological and geochemical processes are known to provide a sufficient natural disposal system.” However, the “[u]nchecked increase in the rate of combustion of carbon fuels apparently will increase general CO₂ levels eventually to meteorologically and physiologically significant levels. Perhaps it may, within a few generations, compete with radioactive wastes for the dubious distinction of being a worldwide air polluter.” The “planetary CO₂ equilibrium,” he continued, would be re-established by

255. Jennings Randolph, *A Worldwide Commitment*, 21 J. APCA 57, 58 (1971). The conference took place in December 1969, but the full proceedings were not published until 1971: THE AIR POLLUTION CONTROL ADMINISTRATION, PROCEEDINGS OF THE SECOND INTERNATIONAL CLEAN AIR CONGRESS (H.M. Englund & W.T. Beery eds., 1971).

256. See THOMAS S. KUHN, THE STRUCTURE OF SCIENTIFIC REVOLUTIONS 136–43 (1962).

shifting from fossil fuels to nuclear or solar power, in which case the “community air pollution problem would be reduced to more or less routine policing of localized sources.”²⁵⁷

The most extensive discussion of CO₂ in the textbook came from Elmer Robinson of the Stanford Research Institute, whose chapter, “Effect on the Physical Properties of the Atmosphere,” concerned “the more permanent effects of air pollutants on various properties of the earth’s atmosphere.”²⁵⁸ In the chapter’s introduction, Robinson wrote, “[g]aseous air pollutants have been emitted in sufficient quantities to significantly alter worldwide atmospheric concentrations of a number of materials. Carbon dioxide is the classic example of such an accumulating pollutant.” Like others, he commented that CO₂ was not “usually” considered to be a pollutant, but suggested it was time for that to change:

The fact that air pollution emissions can cause changes in the atmosphere on a worldwide scale must be of serious concern to all those associated with the field of air pollution. In this regard it seems ironic that although emissions of carbon dioxide from air pollution sources have caused well-documented changes in atmospheric composition on a worldwide scale and have produced arguments among geophysicists and atmospheric chemists as to the seriousness of possible worldwide and long-term consequences of these changes, CO₂ is not usually considered to be an “air pollutant” by the air pollution investigator. It is perhaps time for an awakening on the part of serious analysts to the fact that significant air pollution effects can extend beyond fly ash-soiled laundry and tear-producing automobile exhaust.²⁵⁹

A review of the textbook that year deemed the content on CO₂ to be significant enough to highlight, noting that the volume’s final section dealt with the effects of air pollution, including “changes in the atmosphere as a whole, of which the most important because of their possible effect on radiation are the increase in carbon dioxide and fine particle content.”²⁶⁰

While not a textbook, Robinson also co-authored a report that year for the American Petroleum Institute (API), which made much the same argument. The discussion of carbon dioxide was based on the summary article “Atmospheric Carbon Dioxide” prepared by a committee led by Revelle for the PSAC Environmental Pollution Panel. The authors noted that the possibility of CO₂ changing “world climate” was not a new idea but had been “the source of much

257. Leslie A. Chambers, *Classification and Extent of Air Pollution Problems*, in AIR POLLUTION AND ITS EFFECTS 1, 10–11 (Arthur C. Stern ed., 2d ed. 1968); see also Bernard Tebbens, *Gaseous Pollutants in the Air* in AIR POLLUTION AND ITS EFFECTS 23, 38; AJ Haagen-Smit and Lowell G Wayne, *Atmospheric Reactions and Scavenging Processes* in AIR POLLUTION AND ITS EFFECTS 149, 151, 180–181.

258. Elmer Robinson, *Effect on the Physical Properties of the Atmosphere*, in AIR POLLUTION AND ITS EFFECTS 349, 351.

259. *Id.*

260. C.F.B., *Review: Air Pollution. In Three Volumes, Volume I: Air Pollution and Its Effects*. A. C. Stern (Ed.), New York and London (Academic Press), 2nd Edition, 1968, 94 Q. J. ROY. MET. SOC. 435, 436 (1968).

discussion and investigation” since Chamberlain and Arrhenius proposed it in 1899 and 1903, respectively.²⁶¹ Research since then indicated it was “likely that noticeable increases in temperature could occur” due to increasing CO₂, which could cause “major changes in the earth’s environment” including melting polar ice caps. It “seem[ed] ironic that given this picture of the likely result of massive CO₂ emissions so little concern is given to CO₂ as an important air pollutant.”²⁶² In fact, CO₂ was “[t]he most commonly emitted air pollutant.” It was “so common and such an integral part of all our activities,” that it sometimes went unrecognized as a pollutant, which was “perhaps fortunate for our present mode of living, centered as it is around carbon combustion.”²⁶³ In 1969, Robinson published a supplemental final report for the API based on new research that included a significantly expanded discussion of CO₂. In the introduction Robinson argued that

the CO₂ emission, is the only air pollutant . . . that has been shown to be of global importance as a factor that could change man’s environment on the basis of a long period of scientific investigation. Because of this obvious relation, we believe that any discussion of atmospheric pollutants should also include a discussion of CO₂.²⁶⁴

F. *The American Chemical Society*

By the late 1960s, many scientists felt confident calling CO₂ a pollutant, but some still perceived a tension in defining it so. On the one hand, like other recognized pollutants—smoke, smog, sulfur dioxide, oxides of nitrogen, and carbon monoxide—CO₂ was a byproduct of industrial activity, and like these pollutants it could do harm. On the other hand, it was different from the chemicals and particles responsible for urban air pollution in that it was not visible, it did not appear to be a direct threat to human health, and its effects might not be discerned for some time. Some scientists also noted that unlike some pollutants, such as synthetic pesticides, CO₂ was a naturally occurring substance. Yet, other naturally occurring materials, such as pollen, were discussed as pollutants, so this distinction was not dispositive.²⁶⁵

The view that carbon dioxide was not a pollutant—because it occurs naturally in air and does not immediately affect health—can be found in public health literature at this time. An example is a paper written in 1965 by a British medical researcher and published in the *Bulletin of the World Health*

261. E. ROBINSON AND R.C. ROBBINS, SOURCES, ABUNDANCE AND FATE OF GASEOUS ATMOSPHERIC POLLUTANTS, STANFORD RESEARCH INSTITUTE PROJ. NO. PR-6755 105 (1968) (prepared for the American Petroleum Institute).

262. *Id.* at 8.

263. *Id.* at 105 (emphasis added).

264. E. ROBINSON AND R.C. ROBBINS, SOURCES, ABUNDANCE AND FATE OF GASEOUS ATMOSPHERIC POLLUTANTS SUPPLEMENT, STANFORD RESEARCH INSTITUTE PROJ. NO. PR-6755 7 (1969) (prepared for the American Petroleum Institute). Similar language was in 1968 report’s original brief section on CO₂. ROBINSON AND ROBBINS, *supra* note 261, at 105.

265. See, e.g., Dixon *supra* note 190, at 424; Alvin R. Jacobson, *Viable Particles in the Air*, in AIR POLLUTION AND ITS EFFECTS 95, 95, 116.

Organization, on “the Nature of Air Pollution and the Methods Available for Measuring It,” which stated, “The two main products of efficient combustion, carbon dioxide and water, are not regarded as pollutants because they are normally present in air and the quantities that man releases do not normally alter the concentration in the atmosphere to a sufficient extent to affect health.”²⁶⁶ On the other hand, scientific papers dealing with air pollution in the 1960s often included carbon dioxide among the “gaseous air pollutants” alongside sulfur dioxide, nitrogen oxide, hydrocarbons, carbon monoxide and ozone, in some cases measuring CO₂ along with those other pollutants.²⁶⁷

A 1969 monograph produced by the American Chemical Society (ACS) tried to square this circle. A “pollutant,” the ACS authors wrote, was defined as a “contaminant” that “adversely affect[s] something that man values and is present in high enough concentration to do so.” By this definition CO₂ was both a contaminant and a pollutant. On the other hand, the ACS concluded,

[c]arbon dioxide is not commonly regarded as an air pollutant, although man generates an enormous amount of it in combustion processes using fossil fuels such as coal, oil, and natural gas. Carbon dioxide is a normal constituent of the air However, its global concentration is rising above the natural level by an amount that could increase global temperature enough to affect climate markedly.²⁶⁸

The ACS noted that the definition of a pollutant could and would change over time, if, for example, people began to see effects that they had not previously noticed. “If the substance is to be formally classified as a pollutant, its effects must be perceived,” and perceptions changed over time, both because of changing scientific knowledge and changing cultural concerns. Perceptions of pollution were once “nearly limited to soiling of houses and laundry by soot,” but scientists “look now for subtle effects on the human lifespan, and they are beginning to look for even broader effects, such as modification of regional and even global climate.”²⁶⁹ Under this framework, if CO₂ did not yet meet the definition for “contaminant” and “pollutant,” it could in the future when its effects were evident.

Strikingly, the 1969 ACS discussion as to what kind of a pollutant CO₂ was added an extra-scientific twist directly relevant to the legal standard raised by the Court in *West Virginia v EPA*: the question of the economic consequences of addressing carbon dioxide pollution. The ACS suggested that CO₂ might be treated separately from other pollutants *not* because it was invisible, nor because it might not directly affect health, but “because it is not considered a contaminant that can be controlled, except by replacing the combustion process with

266. J.M.K. Ellison, *The Nature of Air Pollution and the Methods Available for Measuring It*, 32 BULL. WORLD HEALTH ORG. 399, 399 (1965).

267. See, e.g., Arthur C. Stern, *Present Status of Atmospheric Air Pollution in the United States*, 50 AM. J. OF PUB. HEALTH 346, 351 (1960).

268. AM. CHEM. SOC'Y, CLEANING OUR ENVIRONMENT: THE CHEMICAL BASIS FOR ACTION 39 (1969).

269. *Id.* at 6.

another source of energy, such as nuclear power.”²⁷⁰ Here as elsewhere, we see the recognition that addressing CO₂ pollution might require generation shifting.

Overall, we find that the majority view at this time, particularly among physical scientists who were calling attention to long-term environmental consequences as something to consider in addition to immediate public health ones, was that CO₂ was a pollutant, albeit one with different characteristics and consequences than the more commonly recognized ones. Howe has characterized this view as recognizing CO₂ as an “unconventional” pollutant.²⁷¹

G. President Nixon Sounds an Alarm

In 1968, the National Science Foundation issued its tenth annual report of the topic of weather modification, and in 1969 President Richard Nixon and his staff drafted a two-page, impassioned message to Congress on the “special interest” of this report in the aftermath of Hurricane Camille. Nixon’s message was vivid: “In recent months many American communities were ravaged by storms that were among the most violent and destructive in our history Swept away by wind and water were families, homes, businesses, and dreams for the future.” Writing two months after the hurricane, Nixon stated that “the residue of suffering for the thousands of Americans affected” remained incalculable. He linked the storm wreckage to “mounting concern with the quality of the environment generally,” and emphasized to Congress the importance of a research program in “facing the issue of air pollution, including the possible effect on weather and climate.”²⁷²

In November 1969, Nixon appointed the Task Force on Air Pollution to evaluate the effectiveness of existing air pollution control efforts. Arie Haagen-Smit chaired the task force, which included representatives of the United Steelworkers of America, the U.S. Steel Corporation, Ford Motor Company, an array of prominent scientists, and Princeton statistician John Tukey. The resulting report, *Cleaner Air for the Nation*, was transmitted to the President in June 1970 and publicly released in August, contemporaneous with the first Council on Environmental Quality report. In a section on “Climatic Effects of Pollutants,” the report proclaimed, “the greatest consequences of air pollution for man’s continued life on earth are its effects on the earth’s climate.”²⁷³

H. Summary

The discussion presented here does not exhaust all the instances we have encountered of sustained scientific discussion of the problem of CO₂ as a

270. *Id.* at 25; *see generally* West Virginia v. EPA, 142 S. Ct. 2587 (2022).

271. HOWE, *supra* note 27, at 42.

272. Letter of Transmittal from Richard Nixon, President of the United States, to the Congress of the United States (Oct. 27, 1969) (on file at f. Atmos. Sci. [Oversized Materials, 1969–70], b. 4, Edward E. David papers (WHCF:SMOF), RNPL). For the full report; *see generally* NAT’L SCI. FOUND., *supra* note 13.

273. THE REP. OF THE PRESIDENT’S TASK FORCE ON AIR POLLUTION, *supra* note 13, at 34.

pollutant, produced by industrial activity, that could adversely affect the climate system and in that way adversely affect public welfare. More could be said about the scientific background, particularly regarding research in Europe and the Soviet Union.²⁷⁴ However, our discussion suffices to demonstrate that by the mid-1960s, scientists had articulated the “CO₂ problem” as a problem of *pollution*, one that could, and if left unaddressed almost certainly would, alter the global climate, and that dramatic and consequential global changes could ensue. By the late 1960s, scientists involved in this research accepted that CO₂ was a pollutant, even if in some respects different from the other gases and particulates that had been studied in the context of urban air pollution. Indeed, many of the conferences and reports discussed here took place explicitly in the context of the urban air pollution that the Clean Air Act was explicitly and unequivocally intended to address.

The scientists involved in these discussions included John Middleton, the director of the first U.S. agency dedicated specifically to air pollution, who discussed carbon dioxide alongside established air pollutants such as carbon monoxide and the oxides of nitrogen and sulfur—and explicitly stated, “These materials are air pollutants”²⁷⁵ Middleton also specifically used the language of “health and welfare effects” similar to what would be included three years later in the language of the Clean Air Act. Middleton would later testify to similar effect in congressional hearings pursuant to the Act.²⁷⁶

By the late 1960s Senators involved in the writing and passage of the Clean Air Act were participating in these conferences including Senator Edmund Muskie, chair of the Senate subcommittee on Air and Water Pollution of the Committee on Public Works where the 1970 Clean Air Act originated, and Jennings Randolph, the Chair of the Committee on Public Works. Senator Muskie specifically invoked the idea that air pollution legislation would need to account for subtle long-term effects of air pollution and have the flexibility to address “unforeseen” problems as they arose. We also see that participants in these discussions, including U.S. Atomic Energy Commission Chair Glenn Seaborg, noted that addressing carbon dioxide pollution might require large scale technological change such as a shift to electric cars or generating electricity from nuclear power with possible major economic consequences. As early as 1965, observers articulated concerns that, because of the threat of global climate change, humans “may be forced to turn to new sources of energy in order to reestablish a viable carbon dioxide equilibrium.”²⁷⁷

274. For some discussions of this work, *see generally* EDWARDS, *supra* note 26, at 49–51, 126; HOWE, *supra* note 27, at 27; WEART, *supra* note 26, at 81–83; FLEMING, *supra* note 121.

275. Middleton, *supra* note 210, at 46.

276. These hearings will be discussed further in Lanier-Christensen et. al., *Climate Change and the 1970 Clean Air Act Part 2: Congressional Debates* (forthcoming).

277. AIR CONSERVATION COMM’N OF THE AAAS, *supra* note 163, at 81.

IV. INTERNATIONAL EFFORTS

In 1967, NCAR director Walter Orr Roberts wrote a paper for *Physics Today*—a semi-popular science magazine—proposing a new large scientific initiative, the Global Atmospheric Research Program (GARP). Roberts made the case that society needed to understand the atmosphere because the practical demands of life—food, travel, recreation, commerce—all hinged on weather and climate, as did the “subtle joys of life,” which might rest upon “wind and storm . . . the smell of rain in a wheat field, the flowers on a mountain hillside, the beauty of a sunset, or even the opportunity to see a sunset at all.” But the most urgent reason was the problem of “deliberate and inadvertent actions” that could change the climate and were “becoming increasingly crucial to the welfare of man,” and they could not be understood purely in a local or even national context.²⁷⁸

While scientists in the 1950s had not come to consensus as to whether the climate was already changing, Roberts now suggested that it was, and because of its global character international regulation might be in order.

Man appears, indeed, already to be influencing this climate, his atmospheric environment, to an alarming degree. If this is actually so, it suggests that international regulation of deliberate and inadvertent actions that change our atmosphere has become a necessity The problem may soon be even more pressing than the A-bomb!²⁷⁹

GARP would provide the scientific basis required to properly understand the challenge and inform decision making. While Roberts did not discuss CO₂ specifically, he did discuss the evidence that large volcanic explosions could cool the planet and noted that “large climatic changes can be triggered by small causes.”²⁸⁰ This idea—that climate was a global problem that would require global attention—was, by the mid-1960s, becoming a scientific commonplace and expressing itself in a number of different venues, both scientific and political.

A. *Carbon Dioxide and the International Biological Program*

The relationship between carbon dioxide pollution and climate played a role in debates surrounding U.S. participation in the International Biological Program (IBP), a global effort to advance environmental biology that stretched from 1964 to 1974. Building on the success of the IGY, the IBP’s early proponents pitched the initiative as a large-scale collaborative effort to study “human genetics, conservation, and improvements in the use of natural resources.”²⁸¹ Over the course of its decade-long operation, the IBP effected a major pivot towards the

278. Walter Orr Roberts, *Climate Control*, 20 PHYSICS TODAY 30, 30 (1967).

279. *Id.*

280. *Id.* at 32.

281. SHARON KINGSLAND, THE EVOLUTION OF AMERICAN ECOLOGY 1890–2000 221 (2008). See generally Elena Aronova et. al., *Big Science and Big Data in Biology: From the International Geophysical Year through the International Biological Program to the Long Term Ecological Research (LTER) Network, 1957–Present*, 40 HIST. STUD. NAT. SCI. 183 (2010).

collection of synoptic data in ecology. It was also rooted in the same emergent environmental awareness that buttressed the increased anti-pollution drives of the decade. Introducing the program to both the scientific and political communities, inaugural IBP director Roger Revelle presented it as a response to the “destructive changes in the web of life that is stretched so thinly over the surface of our planet.”²⁸²

While anthropogenic climate change did not form a focus of the IBP research agenda in its initial years, key figures in the IBP’s institutional apparatus engaged with political leaders on the ecological implications of a disrupted climate system. During testimony on governmental funding of the U.S. contribution to the IBP, geophysicist and botanist David Gates, a Professor at Washington University in St. Louis, discussed concerns over “man-made changes of climate.”²⁸³ When Professor Gates noted that “if the climate was getting warmer,” it could have a profoundly negative effect on ecological systems, staff consultant Philip B. Yeager immediately extrapolated to the greenhouse effect, asking, “According to the CO₂ greenhouse theory, isn’t there a possibility that there might be a warming trend?”²⁸⁴

Scientists in the 1960s remained unsure of the precise interplay of warming and cooling effects on the world’s climate, but Professor Gates expected a warming trend to be far more damaging to the earth’s flora and fauna than any possible cooling trend. He responded to Yeager that “considerable evidence through calculations and measurement showed that the increase in carbon dioxide from industrialization caused the greenhouse effect.”²⁸⁵

The term “climate” as used in this context referred almost exclusively to “global climate.” Notably, when speakers intended to refer to a more localized climate system, they would use the term “microclimate,” or the plural form,

282. *International Biological Program: Hearing on H. Con. Res. 273 Before the Subcomm. on Sci., Resch., and Dev. of the H. Comm. on Sci. and Astronautics*, 90th Cong. 2 (1967) (statement of Dr. Roger Revelle, Chairman, US Nat’l Comm. For the IBP). A shortened, public-facing version of Revelle’s statement was also printed as Roger Revelle, *International Biological Program*, 155 SCIENCE 957 (1967).

283. *Id.* at 364; *see id.* at 153-58. The full statement of Dr. David M. Gates, Director, Missouri Botanical Garden begins at 153, and his article *Conservation and Understanding*, 55 MO. BOTANICAL GARDEN BULL. 1 (1967) was included at 363.

284. *Id.* at 158. Philip B. Yeager was a former Naval Reserve Officer, Naval Research Laboratory administrator, and lawyer who served as Staff Consultant for the H. Comm. On Astronautics and Space Exploration from its inception in 1958 to at least 1979 (the committee’s name changed to the H. Comm. on Science and Technology in 1974, and in 1979 Yeager was appointed the full committee’s general counsel. The exact end date of Yeager’s service is unclear). He also served as Daddario’s chief of staff for the committee for over a decade. *See* KEN HECHLER, US HOUSE OF REPRESENTATIVES, TOWARD THE ENDLESS FRONTIER: HISTORY OF THE COMMITTEE ON SCIENCE AND TECHNOLOGY 133 (Comm. Print 1980). In 1958, Yeager published a detailed discussion of carbon dioxide related to global climate change, and the possible impacts of sea-level rise on Naval operations in the UNITED STATES NAVAL INSTITUTE PROCEEDINGS. He also discussed the possible impacts of global climate change on national and international legislation in his 1960 book YOUR INALIENABLE RIGHTS. *See* Philip B. Yeager, *Carbon, Oxygen, and a Rising Sea*, 84 US NAV. INST. PROC. 51 (1958); PHILIP B. YEAGER & JOHN R. STARK, YOUR INALIENABLE RIGHTS 244-245 (1960).

285. *International Biological Program: Hearing on H. Con. Res. 273 Before the Subcomm. on Sci., Resch., and Dev. of the H. Comm. on Sci. and Astronautics*, *supra* note 282, at 158.

“climates.” When congressmen and scientists discussed “climate” in these 1967 hearings, it was in the context of the “earth’s atmosphere” or the “chemistry of the biosphere.” The “natural meaning” of “climate” in this context was the world’s climate system.²⁸⁶

In 1968, the House Subcommittee on Science, Research, and Development issued a report on the IBP, devoting significant passages to human-caused changes to global climate. Discussing the evidence supporting the necessity of U.S. participation in the international program, the report stated that “the effects of human activity are undoubtedly being felt by another instrumental ecological element—the climate.” Again, the report used the term climate to refer to the global climate, linking it to broad-scale ecological effects that could be tackled by an international research program. The report treated climate as synonymous with the atmospheric system. Quoting NCAR Director Roberts, it noted, “[m]an appears, indeed, already to be influencing his climate, his atmospheric environment, to an alarming degree.” The report also made a critical pivot from research to regulation, again quoting Roberts for the proposition that, if changes to the climate were occurring, “it suggests that international regulation of deliberate and inadvertent actions that change our atmosphere has become a necessity, and that major measures should be taken for the welfare of mankind.”²⁸⁷

B. *Planning for 1972 UN Conference on the Human Environment*

One more topic will help to demonstrate the range and depth of scientific discussions of carbon dioxide, the greenhouse effect, and climate change prior to the passage of the Clean Air Act, and to place those discussions in political context. It is the preparations for the first UN Conference on the Human Environment (UNCHE), held in Stockholm, Sweden in 1972. While the conference did not take place until two years after the passage of the Clean Air Act, preparations began in the fall of 1968, and the delegation included numerous individuals involved in the debate over CO₂, air pollution control, and American federal legislation, such as Robert White, Gordon MacDonald, John Tukey, and Russell Train. The leadership of the delegation also included Republican Senator Howard H. Baker, Jr. of Tennessee, who served on the Senate Committee on Public Works, where the 1970 Clean Air Act originated (and later served as Senate Majority leader and then Chief of Staff to President Ronald Reagan).²⁸⁸ As part of this planning, the delegation prepared two major scientific reports: the

286. *See generally id.*

287. SUBCOMM. ON SCI., RSRCH., AND DEV. OF THE H. COMM. ON SCI. AND ASTRONAUTICS, 90TH CONG., REP. ON THE INTERNATIONAL BIOLOGICAL PROGRAM: ITS MEANING AND NEEDS 5 (Comm. Print 1969) (quoting Roberts, *Climate Control*, 20 PHYSICS TODAY at 30).

288. Baker did not chair the delegation; that distinction went to Russell Train. But he was the Chairman of the US Advisory Committee on the UN Conference on the Human Environment, so in the role was closely involved. *See MEMBERS OF THE DELEGATION OF THE US TO THE UNCHE*, S. COMM. ON FOREIGN REL., 92ND CONG., REP. ON UNITED NATIONS CONFERENCE ON THE HUMAN ENVIRONMENT 11 (Comm. Print 1972).

MIT-led Study of Critical Environmental Problems (SCEP) and the Study of Man's Impact on Climate (SMIC).

1. *UNESCO and UN Declaration*

By the late 1960s, scientists had stressed on various occasions that carbon dioxide was a global problem because increased atmospheric concentrations would alter the *global* climate. Therefore, some argued, it warranted international attention and cooperation. In a panel discussion on the Economic and Social Aspect of Air Pollution Control at the 1966 Third National Air Pollution Conference (where several American political leaders were in attendance), Morris Neiburger stressed this point:

In the case of carbon dioxide . . . we can expect the gradual build-up . . . possibly leading to an intolerable concentration, a concentration too noxious for the sustenance of human life, not just in metropolitan areas like New York and Los Angeles, but all over the world.

It seems to me that it's important to recognize this development at an early stage. . . . Unless, on an international basis as well as on national and local and interstate bases, we start developing standards and control programs, we may find that even though we clean up the air here in the United States the activities in other countries will raise the background concentration of pollution on a worldwide basis to an intolerable level. Therefore it seems to me vital that we begin now, through international agencies and by international compacts, to attempt to establish standards of clean air on a worldwide basis.²⁸⁹

His respondent, Vernon MacKenzie, Director of the Division of Air Pollution Control at the Public Health Service, noted that several international organizations were discussing the issues, including the World Health Organization (WHO), the World Meteorological Organization (WMO), and the Organisation for Economic Co-operation and Development (OECD). "There is not only interest in these international agencies, but there have been specific recommendations by the President's Science Advisory Committee that so-called base-level measurements (and this is the worldwide problem) should be given greater emphasis and attention than they have received up to now."²⁹⁰

By 1968, planning for the UNCHE was underway. In September, the United Nations Educational, Scientific, and Cultural Organization (UNESCO) held an Intergovernmental Conference of Experts on the Scientific Basis for Rational Use of Conservation of the Resources of the Biosphere. This was the first time that any arm of the United Nations had devoted an international conference to the subject of conservation and the environment, and the Paris meeting brought together "some 320 experts from 63 nations and 23 international

289. 1967 PHS PROCEEDINGS, *supra* note 206, at 627.

290. *Id.* at 628.

organizations.”²⁹¹ A provisional report circulated in October that year detailed twenty recommendations from the experts. A copy was sent to the U.S. Department of Health, Education, and Welfare. (UNESCO published the full proceedings report in 1970.)

The report’s first recommendation was for an international research program on “man and the biosphere,” and the second paragraph of that recommendation identified atmospheric carbon dioxide as a major problem of pollution, caused by industrial activity:

Noting that the technological developments of man as shown by his achievements in industry, transport, communications, and urbanization, all of which are essential aspects of human welfare, have nevertheless resulted in major problems of pollution: the carbon dioxide balance in the atmosphere is being altered and a variety of pollutants, including radio-active [sic] materials and a wide range of toxic chemicals, is being added to the biosphere. . . .²⁹²

The recommendation emphasized the necessity of international action, because “many of the changes produced by man affect the biosphere as a whole and are not confined within regional or national boundaries. . . these problems cannot be solved on a regional, national or local basis but require attention on a global scale.”²⁹³ They cited the IBP alongside the International Council of Scientific Unions and the International Union for Conservation of Nature and the Natural Resources as important precedents, but were concerned that the end of the IBP in 1972 would leave many aspects of environmental concern only “partially explored,” with few “studied to conclusion. . . .”²⁹⁴ The report specifically called for a swift approval at the forthcoming UN General Assembly session of a United Nations Conference on the Human Environment, at which the UN would consider “the advisability of a Universal Declaration on the Protection and Betterment of the Human Environment.”²⁹⁵

On December 3, 1968, the United Nations General Assembly unanimously adopted the resolution to hold a the UNCHE in 1972. The resolution, put forward by Sweden and co-sponsored by fifty-one other nations including the United States, stated that the UN was “convinced of the need for intensified action at the national, regional, and international level in order to limit and, where possible, eliminate the impairment of the human environment”²⁹⁶ The UN

291. THE CONSERVATION FOUND., UN VOTES TO HOLD CONFERENCE ON HUMAN ENVIRONMENT IN 1971 5 (Feb. 24, 1969) (on file at b. 3 f. 12, Records of Predecessors of the Environmental Protection Agency 1944–71, Records of the Environmental Protection Agency, Record Group 412, held at Lees Summit, MO FRC, accessed at National Archives and Record Administration- Kansas City, MO [hereinafter NARA-NAPCA]).

292. UNITED NATIONS EDUC., SCI., AND CULTURAL ORG., INTERGOVERNMENTAL CONFERENCE OF EXPERTS ON THE SCIENTIFIC BASIS FOR RATIONAL USE AND CONSERVATION OF THE RESOURCES OF THE BIOSPHERE 2 (1968).

293. *Id.* at 3.

294. *Id.* at 3.

295. *Id.* at 24.

296. G.A. Res. 2389 (XXIII), at 2 (Dec. 3 1968) (on file at b. 3, f. 12, NARA-NAPCA).

Ambassador from Sweden, Sverker Aström, noted that the “risks inherent in the uncontrolled application of modern technology are very real and very frightening,”²⁹⁷

The U.S. Delegation submitted a statement to the General Assembly in support of the resolution from Ambassador James Russell Wiggins. Wiggins argued that pollution was a “world concern,” because

our cities, industries, and farms operate on such a scale that their physical environment is literally the whole planet, with its all-encircling ocean of both air and water. Man-made pollution crosses every boundary, riding the wind and rain, the rivers and ocean currents, [and] the bodies of migrating fish and birds

Wiggins included carbon dioxide among the forms of pollution.²⁹⁸

And what are we going to do about the steadily rising burden of carbon dioxide in the earth’s atmosphere? Already in the past 100 years, since fossil fuels began to be burned in huge quantities atmospheric carbon has increased close to 10 per cent. This increase will probably total about 25 per cent by the year 2000, given the rapidly accelerating rate of fuel consumption. Will the resulting “greenhouse” effect cause a permanent warming of the earth’s climate—and perhaps even a rise in the world sea level as the polar ice caps melt? . . . [M]uch of human destiny could depend on the answer.²⁹⁹

Wiggins implored UN countries to not wait until 1972 before taking “energetic action to relieve the wounds we have inflicted on nature and on ourselves,” urging “all in authority” to “act without delay . . . the period between now and 1972 should be one of ferment, not only of preparation for the conference, but of practical action in every field: new scientific work, technical and administrative development, training of qualified manpower, public education, and political decision.”³⁰⁰

In April 1969, the United States released an official statement expressing unequivocal support for the proposed Stockholm conference: “The United States Wished to Reiterate that it considers this United Nations Conference on Human Environment to be held in 1972 as of great importance, dealing as it will with a broad range of highly critical problems.” The statement detailed “objectives” and “problem areas” that should be addressed at the conference; under the latter it identified CO₂ as among the issues that “cover problems of international significance, transcending national boundaries and calling for international action; e.g., the nitrogen cycle, carbon dioxide, the oceans, capacity of the

297. CONSERVATION FOUND., *supra* note 291, at 1. The article was also provided by Democratic Texas Senator Ralph Yaborough for the Congressional Record on October 6, 1969. *See* 115 Cong. Rec. 28598 (1969).

298. JAMES RUSSELL WIGGINS, STATEMENT TO THE UNITED NATIONS GENERAL ASSEMBLY ON THE PROBLEMS OF HUMAN ENVIRONMENT 5 (1968) (on file at b. 3, f. 12, NARA-NAPCA).

299. *Id.* at 6.

300. *Id.* at 8.

biosphere to support the population, etc.”³⁰¹ The same month, Russell Train, then Nixon’s Undersecretary of the Interior, spoke about fossil fuel combustion and atmospheric CO₂ levels and their implications for global climate in the context of the upcoming Stockholm conference.³⁰² Conference planning accelerated in 1970 and Gordon MacDonald and Russell Train both emphasized the need for global monitoring to measure increasing carbon dioxide and inadvertent weather and climate modifications.³⁰³

The UNESCO meeting, and subsequent UN declaration, spurred immediate organizational efforts. The International Council of Scientific Unions (ICSU) general assembly met in Paris from September 28 to October 2 of 1968, where they created an “Ad Hoc Committee on Problems of the Human Environment.”³⁰⁴ On December 30, the president of the International Union on Geodesy and Geophysics, G.D. Garland, sent a memo to the members of the committee suggesting topics for consideration. Number one on his list was “possible effects of climate and living creatures brought about by increase of CO₂ in the atmosphere from the burning of fossil fuels.”³⁰⁵ In early 1969, the ad hoc committee proposed the creation of a more permanent structure: the ICSU Scientific Committee on Problems of the Environment (SCOPE), which held its first meeting in Madrid in September 1970.³⁰⁶ At the request of Maurice Strong, the secretary general of the UNCHE, SCOPE began to prepare a set of suggestions on the development of a global environmental monitoring system, to be presented at the 1972 conference. These suggestions relied heavily on a report that had already been undertaken by the MIT-led Study of Critical Environmental Problems (SCEP).

2. Study of Critical Environmental Problems (SCEP)

The Study of Critical Environmental Problems was sponsored by the Massachusetts Institute of Technology (MIT). Convened in July of 1969, the group issued a report in 1970 titled “Man’s Impact on the Global Environment.” According to the study report, the impetus came from discussions between

301. U.S. Dep’t of State to USUN N.Y., USUN Ref. No. A-150, United States Response to United Nations Concerning 1972 United Nations Conference on Human Environment, 1, 4, (April 7, 1969) (on file at b. 3 f. 12, NARA-NAPCA).

302. Russel E. Train, Speech to American Museum of Natural History: Man’s Survival in a world worth living in (April 9, 1969) (on file at b. 69, f. 5, LOC-RET).

303. Memorandum from Gordon J. MacDonald on LDC’s and Environmental Problems (April 30, 1970) (on file at b. 80, f. OCMS, John W. Whitaker papers (WHCF:SMOF), RNPL); Memorandum from Russel E. Train on Dr. Dubridge’s Report to the President on “Protecting the World Environment in Light of Population Increases” (May 22, 1970) (on file at b. 11, f. 10, LOC-RET).

304. *International Union of Crystallography Report of Executive Committee for 1968*, 25 ACTA CRYSTALLOGRAPHICA SECTION A 719, 725 (1969).

305. Letter from G.D Garland to Members of the ISCU/IUBS-IUGG Ad Hoc Committee on the Environment (Dec. 30, 1968) (on file at b. 3, f. 12, NARA-NAPCA). This letter and list were also transmitted to John Ludwig at NAPCA and R.A. McCormick of NAPCA and NOAA at the Air Resources Cincinnati Laboratory.

306. Gilbert F. White, *SCOPE: The First Sixteen Years*, 14 ENV’T CONSERVATION 7, 7–9 (1987).

scientists and public officials in the context of the scheduled UN Conference on the Human Environment. The authors wrote, "In examining the status of governmental and nongovernmental preparations for the 1972 UNCHE, several of us concluded that an initiative such as this study would provide an important input into planning for that conference and for numerous other national and international activities."³⁰⁷

The forty-member study was chaired by MIT Professor of Management (and from 1947 to 1950 General Manager of the AEC) Carroll L. Wilson. Members included leading academic scientists such as Christian Junge, Charles Keeling, Penn State Professor Hans Panofsky, and NCAR's William Kellogg, as well as important agency officials including Lester Machta, Director of the Air Resources Laboratory at ESSA, James T. Peterson, research meteorologist at NAPCA, and Joseph Smagorinsky, head of the National Weather Service's Geophysical Fluid Dynamics Laboratory. Their report was intended to focus on problems "arising from the impact of man's activities on the global environment."³⁰⁸

Several federal departments and agencies supported the study, either financially through grants and contracts, or through preparation of background materials. These included the U.S. Forest Service, the U.S. Geological Survey, ESSA, NASA, NAPCA, the NSF, the AEC, and the Department of State, Department of Agriculture, and Department of Transportation. The study also received support from the Ford, Rockefeller, and Sloan Foundations; from the National Academy of Sciences, NCAR, the Oak Ridge National Laboratory, and the Rand Corporation; and from the private corporations Allied Chemical, American Electric Power, Consolidated Edison of New York, ESSO Research and Engineering, and General Electric.³⁰⁹

The report dealt with various environmental pollutants, including DDT and other persistent chlorinated hydrocarbons; mercury and other toxic heavy metals; potential effects of supersonic transport aircraft; ecological effects of petroleum in the oceans; and ecological effects of nutrients in estuaries, lakes, and rivers. But a major focus was the radiation balance of the atmosphere and, within that, carbon dioxide. Indeed, CO₂ was the first topic specifically mentioned in the introduction, which discussed the issue at length and in some detail:

All combustion of fossil fuels produces carbon dioxide (CO₂) which has been steadily increasing in the atmosphere at 0.2 percent per year since 1958. Half of the amount man puts into the atmosphere stays and produces this rise in concentration A projected 18 percent increase resulting from fossil fuel combustion to the year 2000 (from 320 ppm to 379 ppm) might increase the surface temperature of the earth 0.5 degrees celsius; a doubling of the CO₂ might increase mean annual surface temperatures 2 degrees celsius. This latter change could lead to long-term warming of the planet. . . . [T]he

307. STUDY OF CRITICAL ENVIRONMENTAL PROBLEMS (SCEP), MAN'S IMPACT ON THE GLOBAL ENVIRONMENT: ASSESSMENT AND RECOMMENDATION FOR ACTION xi (1970).

308. *Id.*

309. *Id.* at xv.

long-term potential consequences of CO₂ effects on the climate or of societal reaction to such threats are so serious that much more must be learned about future trends of climate change. Only through these measures can societies hope to have time to adjust to changes that may ultimately be necessary.³¹⁰

The scientists involved were not environmental activists; most worked at universities with strong links to the private sector, including energy and chemical companies, and the report was supported by several corporations. Yet, these scientists did not assume that the carbon dioxide problem was negligible, that technologies would necessarily develop to address it, or that “the economy” would have to take precedence over “the environment.” They explained,

In the effort to arrive at an optimal balance in specific situations, something will have to give. But the old routine assumption that it is the environment that must give has become intolerable. This assumption must be rejected in favor of an optimal balance to be reached from a point of departure in affixing the responsibilities for pollution.³¹¹

The committee’s working group on climate, which included Keeling and Junge, differentiated between the global effect of CO₂ on climate and local problems “such as local weather modification and urban air pollution.”³¹² They also differentiated anthropogenic change from natural climate variability; the recent changes in the concentration of carbon dioxide were the result of human activity. So far, any effects from that concentration change were “not larger than natural changes,” but the future would likely be different. Therefore, a key scientific challenge was

to identify those ‘leverage points’ that man can reach, points where his relatively subtle alterations of the environment could influence significantly the global climate. It is in the interest of rational society to be on the lookout for any such changes and to develop theories of atmospheric behavior sufficient to allow us to forecast the atmosphere’s future course, give a knowledge of what man will be doing. The effort expended will certainly be trivial compared to the possible return. . . .³¹³

Despite the considerable uncertainties and the primitive state of climate models at that time, they argued that the available evidence indicated what to expect:

Radiative equilibrium computations . . . suggest that the projected 18 percent increase of the carbon dioxide concentration by the year 2000 (to about 379 ppm) would result in an increase of the surface temperature of about one-half degree . . . a doubling of the carbon dioxide concentration over the present level would result in an increase of the surface temperature of about

310. *Id.* at 11–12.

311. *Id.* at 32.

312. *Id.* at 40.

313. *Id.* at 45–46.

2 degrees Celsius and a 2 to 4 degrees Celsius decrease in the stratosphere at the same level.³¹⁴

Global monitoring would be necessary to track developments and improve scientific understanding to be able to answer the question, “[c]an man’s activities produce catastrophic changes of climate?”³¹⁵

The study also included a working group on “Implications of Change,” which specifically addressed the question of what kind of a pollutant CO₂ should be understood to be. They differentiated between “residuals” or “waste,” which they defined as “generated in all stages of the production and consumption of goods or services” and not necessarily harmful, like the carbon dioxide people exhale. But “residuals” became “pollutants” or an “environmental problem” when they began to have “harmful effects in the atmosphere, the oceans, or the terrestrial environment. ‘Harmful effects,’ are effects that are harmful to man, or to animals, plants, or inanimate objects or conditions that are important to man. Their importance to man may be biological, economic, religious, moral, aesthetic, or intellectual.”³¹⁶

SCEP was particularly concerned with what it called “key pollutants,” meaning pollutants that had global effects, and whose effects were serious. CO₂ was one of the most important:

[T]his . . . SCEP has defined its mission in terms of key pollutants that have global effects. ‘Global effects’ have been taken to compromise [sic] effects on climate and on ocean and terrestrial ecology, together with such effects as recur on a significant scale in many countries in a kind of worldwide pattern. The ‘key pollutants’ are those whose global effects are such as to make it especially important to bring them under satisfactory control These include carbon dioxide; particulate matter; sulfur dioxide; oxides of nitrogen; toxic heavy metals (lead, mercury, arsenic, chromium, cadmium, nickel, manganese, copper, zinc); oil, chlorinated hydrocarbons, especially DDT and polychlorinated biphenyls, other hydrocarbons; radionuclides heat; and nutrients.³¹⁷

CO₂ was given its own section. Here, the authors paused to review the terms of their analysis, stressing that they considered the matter of “what should be done and what the doing may involve” in terms of two variables: “[T]he fact that [CO₂] is a key pollutant with harmful global effects has been established with a sufficient approximation of certainty or degree of probability to warrant remedial action,” and that “informed scientific and professional opinion, or public and political opinion, or both, view with sufficient apprehension or concern to warrant appropriate measure.” CO₂ met those criteria. However, it also introduced

314. *Id.* at 88. They were very close to correct: the actual value would be 369, *see* NOAA Global Monitoring Laboratory data, available on the NOAA operated website https://gml.noaa.gov/webdata/ccgg/trends/co2/co2_annmean_gl.txt (last updated September 5, 2022).

315. *Id.* at 191.

316. *Id.* at 224.

317. *Id.* at 227.

an element not previously mentioned, relating to scale and intensity of possible effects. In the usual case, if there appears to be only a remote and highly speculative possibility that a residual might have harmful global effects, little time and effort will be put into a program of inquiry affecting it. However, if the speculative effects are of such a nature that they would be devastating if they should occur and if it would require long years of arduous preparation to afford a realistic possibility of achieving preventive or corrective measures, prudence might indicate that a serious program of inquiry should be instituted and sustained³¹⁸

CO₂ met that latter standard: “[T]he consequences for the human condition and human endeavor could be enormous. They could threaten man’s agriculture and food supply, his warmth in winter and his cooling in summer, and could throw his entire transportation system out of gear,” and addressing the problem could require a “radical curtailment of man’s consumption of fossil fuels”³¹⁹

The authors concluded with a cautionary note about how hard the problem might be to fix. It was, they wrote,

hard to conceive of an effect more authentically global than an effect on the world’s climate, and corrective action to be effective would have to be correspondingly universal. It is not hard to imagine the bitterness and recriminations that might be injected into international relations by mutual suspicions concerning the scale and pace of the reduction in the consumption of fossil fuels in different countries. The requirements of the occasion would test to the limit mankind’s political and administrative capacity to establish and manage international controls.³²⁰

3. 1971 Study of Man’s Impact on Climate (SMIC)

During the SCEP meetings, participants noted a need for a review of their findings with a particular eye at understanding and clarifying the state of the available science on the human impact on the global climate. Towards this end, the scientists organized a second report, the Study of Man’s Impact on Climate (SMIC), undertaken with the explicit goal of informing legislative and regulatory bodies. While the report, “Inadvertent Climate Modification,” was not issued until 1971, much of the planning committee work was done in the fall of 1970 and communicated along the way to the sponsoring agencies, which included NAPCA, ESSA, and the National Oceanic and Atmospheric Administration (NOAA). Therefore, the justification for the report and its general thrust are worth including as one further piece of evidence as to the science that was communicated to federal agencies at this time.

318. *Id.* at 244.

319. *Id.* at 245.

320. *Id.* at 245. The report also included two charts on fossil fuel production and CO₂ emissions from those fuels, “modeled on . . . the one contained in Appendix Y4 of *Restoring the Quality of our Environment* (PSAC 1965).” *Id.*, figures 7.A.1 and 7.A.2 at 303–05.

The Principal Investigators were MIT Professors Carroll L. Wilson (the chair of SCEP) and William H. Matthews, a professor of environmental engineering. In the study proposal, they wrote,

A major component of the SCEP Report dealt with the climatic effects of man's activities. The consequences and implications of any remedial actions to alleviate environmental problems which might be caused by buildup of carbon dioxide, particles, and other waste products in the atmosphere are so profound that it is highly desirable to obtain an international consensus on the nature of these effects at the earliest possible time

The report of SMIC will present the collective judgement and assessment of noted international scientists on the state of information and understanding of these important issues in 1971 and their recommendations for future action. This report should provide an important input for both national and international programs and would be particularly helpful in the preparations for the 1972 United Nations conference on the Human Environment. Major policy decisions on global environmental problems will require such firm foundations of broad and multinational scientific consensus on the nature and extent of those problems.³²¹

Most important for our discussion, these scientific authors—working on behalf of the U.S. government—framed the effect of CO₂ explicitly as a problem of pollution. When the report was finished, they wrote, “[d]irect man-made pollution is pollution by processes in which the atmosphere is deliberately used by man for disposal of waste products.”³²² The result of this pollution? “Doubling of the CO₂ concentration could effect an increase of the temperature near the surface by about 2°C The 2°C change would constitute a modification of the climate which could trigger other warming mechanisms and possibly lead to irreversible effects. . . .”³²³

4. U.S. Government Agencies Engagement with International Developments

These international developments—the UNESCO meetings, SCOPE, SMIC and SCEP—were closely monitored by officials engaged in the planning for the UNCHE and officials in the U.S. government, including John Ludwig, Assistant Commissioner at NAPCA, R.A. McCormick, Director of Meteorology at NOAA, and Robert White at ESSA. Indeed, these agency officials were engaged in international questions to an extensive degree. Since 1967, NAPCA, NOAA, and ESSA representatives had been traveling internationally and submitting reports on global monitoring efforts, with a specific focus on Western Europe as well as a two-week tour of the emissions laboratories of major car makers in Japan at the invitation of the executive vice president of Nissan in the

321. CARROL L. WILSON & WILLIAM H. MATTHEWS, PROPOSAL FOR THE SUPPORT OF A 1971 INTERNATIONAL SUMMER STUDY OF MAN'S IMPACT ON CLIMATE, 2-3 (1971) (on file at b. 11, f. 22, NARA-NAPCA).

322. INADVERTENT CLIMATE MODIFICATION: REPORT OF THE STUDY OF MAN'S IMPACT ON CLIMATE (SMIC) *supra* note 98, at 187.

323. *Id.* at 239.

fall of 1969.³²⁴ U.S. officials also participated in meetings of the OECD Air Management Research Group, as well as work at the WMO and WHO. In March of 1969, McCormick traveled to the WMO Working Group on Atmospheric Pollution meeting in Geneva.³²⁵

At NAPCA, Ludwig closely followed the development of SCEP and SMIC. In August 1969, SCEP member (and later SMIC joint secretary) G.D. Robinson of the Center for the Environment and Man, Inc., in Hartford, CT, forwarded the SCEP proposal, which detailed the aims of the study and its intended impact on planning for the 1972 UNCHE. Ludwig read the document closely, annotating it extensively, and then stayed in close contact with the organizers of both studies until their completion.³²⁶ At NOAA, McCormick corresponded with William H. Matthews, SCEP's associate director; Matthews later stressed that the cooperation between NAPCA, NOAA, WMO, and SCEP/SMIC was an "opportunity for 'cross-fertilization' as well as to make a double coordinate and consistent contribution to the conference of our views and recommendations with regard to man's impact on climate."³²⁷

C. Summary

In this section we have shown how the topic of carbon dioxide and climate change was recognized as a global problem. This refutes any potential suggestion that, when scientists spoke of "climate change" in the 1960s, they might have been thinking of local climate, such as the "climate of California." In fact, a global understanding of the character of the "carbon dioxide problem" informed several high-profile academic-governmental reports and figured prominently in international efforts to address global environmental crises. It also reveals the extent to which CO₂ as air pollution figured in those efforts, including the late 1960s preparations for the historic 1972 UN Stockholm Conference on the Human Environment.

V. CULTURAL UPTAKE

One question that arises from the review of scientific research and communication on carbon dioxide in the 1950s and '60s is, how much of the available scientific knowledge was generally known at this time? General cultural uptake does not establish what Congress knew or intended when it wrote the Clean Air Act, but it does help to establish how words and concepts were

324. See archival documents from 1967–1969, including reports from: The Netherlands, Japan, Sweden, the UK, Ottawa, Montreal, Toronto, Belgium, France, West Germany, Israel, and Holland (on file at b. 1, NARA-NAPCA).

325. R.A. MCCORMICK, TRIP REPORT, MEETING OF WMO WORKING GROUP ON ATMOSPHERIC POLLUTION AND ATMOSPHERIC CHEMISTRY, SECOND SESSION, GENEVA, MARCH 5-19, 1969 (1969) (on file at b. 1, f. 3, NARA-NAPCA).

326. Letter from John H. Ludwig, Assistant Commissioner at NAPCA, to William H. Matthews, Associate Director at SCEP (Jan. 22, 1971) (on file at b. 11, f. 22, NARA-NAPCA).

327. Letter from R.A. McCormick, Director of Meteorology at NOAA, to William H. Matthews, Associate Director of SCEP (Jan. 26, 1971) (on file at b. 11, f. 22, NARA-NAPCA).

generally understood at that time, something that rises in significance in light of the Court's major questions doctrine. Because many words have a different sense when used in scientific contexts than in everyday use, popular discussion of the issue can help us to understand what people meant when they used the word "climate" in the context of increased atmospheric carbon dioxide. In this section, we offer selected examples of cultural uptake that show that the scientific message had been broadly communicated in the late 1950s and '60s, and that the word "climate" was being used, in the context of CO₂ pollution, to mean global climate change, in the same sense that we understand it today.

A. *Frank Capra's Unchained Goddess*

Frank Capra was one of America's most famous and successful filmmakers. The three-time Oscar winner's films included *Mr. Smith Goes to Washington* (1939), *Arsenic and Old Lace* (1944), *It's a Wonderful Life* (1946), and *Pocketful of Miracles* (1961). They were some of the most popular films ever made and featured many of Hollywood's most bankable stars.³²⁸ In 1958, he produced a film for the Bell System Science Series, entitled *The Unchained Goddess*.

The film was about weather, weather modification, and climate change. It featured a "Dr. Research" (Frank Baxter, a professor at the University of Southern California) explaining recent advances in weather prediction and modification and including a discussion of pollution and particulates in the atmosphere. At one point, Dr. Research's interlocutor asks whether future scientists would be able to control not just local weather, but even the global climate, such as reversing the jet stream. These were "extremely dangerous questions," Dr. Research explains, because "with our present knowledge we have no idea what would happen." Even a few degrees of temperature rise could melt the polar ice caps, creating a future in which sea level rise was so great that an "inland sea would fill a good portion of the Mississippi Valley [and t]ourists in glass bottom boats would be viewing the drowned towers of Miami through 150 feet of tropical water." This could happen because of industrial CO₂:

Even now, man may be unwittingly changing the world's climate through the waste products of his civilization. Due to our release through factories and automobiles every year of more than six billion tons of carbon dioxide, which helps air absorb heat from the sun, our atmosphere seems to be getting warmer.³²⁹

The issue was profoundly important, Dr. Research concluded, because when it came to weather and climate, scientists were dealing not only with forces more complex than even the atomic physicists dealt with, but with "life itself."³³⁰

328. See LARY MAY, *THE BIG TOMORROW: HOLLYWOOD AND THE POLITICS OF THE AMERICAN WAY* 87 (2002).

329. *UNCHAINED GODDESS* (Warner Bros. Pictures, 1958), <https://www.youtube.com/watch?v=sqCISPWVnNE>. Discussion of weather modification begins around 47:30.

330. *Id.*

The Bell Science Series has been described as “among the best known and remembered educational films ever made,” and *The Unchained Goddess* was broadcast on television and shown in classrooms around the country.³³¹ Historian James Burkhard Gilbert estimates that by the mid-1960s the series had been watched by almost five million schoolchildren and half a million college students.³³²

B. *Materials for School Children & Teachers*

My Weekly Reader was a pamphlet produced weekly by American Education Publications, based at Wesleyan University, and distributed to millions of children in their classrooms.³³³ Self-described as “The Junior Newspaper,” it often covered scientific topics.³³⁴ The “Science News Supplement” issue for October 5–9, 1959 included a multi-page “science news supplement,” entitled “The Weather Is Changing.” The article covered basic information on weather, the matter of whether weather and climate could be controlled, and the greenhouse effect.³³⁵ It explained,

Carbon dioxide is a gas found in the air. Living things need a little carbon dioxide. Soon, there may be too much.

Every time a car is started, the amount of carbon dioxide in the air is increased. Carbon dioxide forms whenever fuels are burned.

Carbon dioxide is changing our weather. This invisible gas acts like the glass in a greenhouse. It lets sun energy come in, but stops the radiation of heat from the inside out. Carbon dioxide acts like a heat trap. It is making the earth warmer.³³⁶

Another example is a brochure on pollution, written by Thomas G. Aylesworth, a prolific children’s book author who also served as a senior editor at *Current Science* magazine, and at Doubleday. In 1968, he wrote an educational brochure, *Our Polluted World*. The front cover showed white smoke billowing from a set of smokestacks; the inside contained a message from the Surgeon General to “science students” telling them they are about to learn about “one of the most challenging problems of our age.” Much of the brochure focused on what, by that time, were the familiar topics of deadly air pollution, in London, Los Angeles, and Denora, Pennsylvania. But in a section on “Other pollutants,”

331. GEOFF ALEXANDER, *ACADEMIC FILMS FOR THE CLASSROOM; A HISTORY* 66–67, 69 (2010).

332. JAMES GILBERT, *REDEEMING CULTURE: AMERICAN RELIGION IN AN AGE OF SCIENCE* 367, n. 62 (1997).

333. The educational classroom magazine was published weekly from 1928 to 2012. Jason Tomassini, *Longstanding Classroom Magazine, Weekly Reader, Stops Printing*, EDUCATION WEEK (Jul. 25, 2012), https://web.archive.org/web/20160409111730/https://marketbrief.edweek.org/marketplace-k-12/longstanding_classroom_magazine_weekly_reader_stops_printing/.

334. See Janet Raloff, *So Long Weekly Reader...*, SCIENCE NEWS (Jul. 26, 2012), <https://www.sciencenews.org/blog/science-the-public/so-long-weekly-reader>.

335. *The Weather is Changing*, 4 MY WKLY. READER SCI. NEWS SUPPLEMENT 25 (October 5–9, 1959). There is also a note after the last sentence of the quote to “See your Science Supplement on Fish in Issue 1,” so MY WEEKLY READER may have discussed this in more than one issue.

336. *Id.*

Aylesworth discussed CO₂: “[t]wo common examples of this type of pollutant are carbon dioxide and aero-allergens. Buildup of CO₂ increases the daytime temperature and may have far-reaching influence on the weather.”³³⁷ A copy of this brochure made it to the offices of Senator Muskie.³³⁸

C. Allen Ginsberg on *The Merv Griffin Show*

In March 1969, a concerned citizen in Seattle named Henry M. Watson wrote to Washington Senator Henry “Scoop” Jackson. Watson explained that, on a February 1969 episode of *The Merv Griffin Show*, Beat poet Allen Ginsberg told an alarming story of planetary demise. Ginsberg claimed that “the current rate of air pollution brought about by the proliferation of automobiles and ‘their excrement’” could cause “the rapid build-up of heat on the earth.” This accretion would then “melt the polar ice caps, causing a flooding of the greater part of the globe.” Ginsberg attributed this information to a presidential science advisor.³³⁹

Mr. Watson had no doubt that the eccentric poet—“one of America’s premier kooks”—was wrong, and he wanted Jackson to do something to stop his spreading disinformation.

I would very much appreciate your efforts to throw light on this and recommend that a public statement by responsible public officials be made in refutation After all, quite a few million people watch this show, people of widely varying degrees of intelligence, and the possibility of this sort of charge—even from an Allen Ginsberg—being accepted even in part, is dangerous.³⁴⁰

The constituent had sought assurances that Ginsberg was merely deranged and wanted Jackson to do something about it.

Jackson forwarded the letter to Presidential Science Advisor Lee DuBridge who replied with a detailed letter describing current knowledge of CO₂ and the

337. THOMAS G. AYLESWORTH, OUR POLLUTED WORLD: APPLIED ECOLOGY OF AIR AND WATER 13–14 (1965) (on file at s. V.A.5, b. 376, f. 1, BC-ESM).

338. *Id.*

339. Letter from Henry M. Watson to Henry Jackson, U.S. Senator of Wash. (Mar. 6, 1969) (on file at b.7, f. Jackson, sen. Henry, Senators and Representatives 1963–1973, Office of Science and Technology, Record Group 359, National Archives and Records Administration, College Park, Maryland, United States [*hereinafter* NARA-OST]). However, in a 1974 interview Ginsberg attributed the information to anthropologist Gregory Bateson, who discussed global climate change explicitly in the question-and-answer discussion following his lecture at the Dialectics of Liberation Congress held in London between July 15 and 30 of 1967. Remembered as a “now legendary” event in the “expression of the politics of dissent,” the Congress was attended by radical intellectuals, activists, and artists such as William S. Burroughs, Thich Nhat Hahn, C.L.R. James, Angela Davis, and Kwame Ture (née Stokely Carmichael). See James McKenzie, *An Interview with Allen Ginsberg*, in *FIRST THOUGHT: CONVERSATIONS WITH ALLEN GINSBERG* 62–91 (Michael Schumacher ed. 2017); Gregory Bateson, *Lecture at Dialectics of Liberation: Consciousness versus Nature* (July 17, 1967) (transcript at Villon Films Archive, https://villonfilms.ca/archive/vf_avtacrbcfbp); *The Dialectics of Liberation*, VERSO <https://www.versobooks.com/products/89-the-dialectics-of-liberation> (last visited Jan. 7, 2024). Muskie and Ginsberg met at least once the year the CAA was passed, at the first Earth Day celebration in Philadelphia on April 22, 1970. See *Earth Day*, THE ALLEN GINSBERG PROJECT (Apr. 22, 2017), <https://allenginsberg.org/2017/04/sat-22-earth-day/>.

340. *Id.*

greenhouse effect. DuBridge affirmed that CO₂ was in fact increasing. The CO₂ “greenhouse effect” was a known fact, and it was also known “[w]e are indeed filling the atmosphere with a great many gases and in very large quantities from our automobiles, from industry, and from the burning of fossil fuels.”³⁴¹

DuBridge was not necessarily ready to sound an alarm on the issue, explaining that “what effect this increased carbon-dioxide is having and will have on our atmosphere and our climate is by no means clear.” More research was needed. But echoing Roger Revelle, he acknowledged that it could be serious:

I do not imply by any of this that the problem is not of considerable importance We are, in a word, performing a gigantic experiment on ourselves. It seems to me of great importance that we know the meaning of this experiment and its possible outcomes before discovering them too late and perhaps to our sorrow³⁴²

A vivid description of the greenhouse effect had reached the powerful U.S. Senator Henry Jackson from the president’s Science Advisor in 1969, prompted by a letter from an ordinary citizen based on something he had heard on television from America’s most famous (or infamous) poet.

Later that year, DuBridge appeared on the CBS television program *Meet the Press*, where he discussed science and technology in relation to the needs of society. The greatest needs, which he felt “everybody recognizes,” had to do with “solving the problems of the environment.”³⁴³ Air and water pollution could be reduced, he thought, through “regulations, practices and requirements which will reduce the amount of pollution that is being put into the air by automobiles . . . [and] industrial combustion.”³⁴⁴ He also raised the possibility of a “polluter’s tax,”³⁴⁵ and defended scientists who might be accused of overstating their case:

I don’t like to be a calamity howler, but sometimes it takes a few calamity howlers to wake people up to the fact that there are serious problems and to arouse people to the point where they are willing to do something about it. I think we are at that point now.³⁴⁶

Towards the end of the interview, DuBridge was asked if it would ever be possible to build a pollution-free car. He replied, “[c]ertainly not. If by that you mean zero waste material going into the atmosphere. Any combustion process is bound at least to produce carbon dioxide and water, and these may be regarded as pollutants.”³⁴⁷

341. Letter from Lee DuBridge to Henry Jackson, U.S. Sen. of Wash. (Mar. 25, 1969) (on file at b.7, f. Jackson, sen. Henry, NARA-OST).

342. *Id.*

343. Transcript: *NBC’s Meet the Press*, *supra* note 14.

344. *Id.* at 3.

345. *Id.* at 17.

346. *Id.* at 6.

347. *Id.* at 19.

D. Popular Magazines

Numerous popular magazines also covered the carbon dioxide problem. These discussions were being followed by the staff of Senator Edmund Muskie; the Muskie archives include several press clippings and articles documenting public awareness of carbon dioxide and global climate change. Articles found in the Muskie papers include one in the *Rotarian*—the magazine of the Rotary Club—with an attached note saying it was sent to Muskie by fellow Senator Jennings Randolph. The article, entitled “Let’s Clear the Air,” was written by the popular children’s book author, Clifford B. Hicks. Hicks mainly wrote fiction, but in 1965 he wrote a science book for children, *The World Above* (1965), about the atmosphere. The article, presumably intended to promote the book, explained the “worrisome . . . possible long-range effects” of human activity on our planet:

Many scientists believe we may be fouling our own nests beyond the ability of future generations to clean them up. For example, we may be unknowingly tampering with the earth’s climate by altering the delicate balance of the oxygen-CO₂ cycle. Man takes oxygen from the atmosphere, uses it, and gives back carbon dioxide. Plant life takes carbon dioxide, uses it, and gives back oxygen. It’s a balanced swap. Today, though, we are burning fossil fuels in such huge amounts that we are slowly but steadily increasing the level of carbon dioxide in the atmosphere. Meanwhile we are scraping away more and more plant cover to make room for an expanding population—plant cover required to remove the CO₂.

In our delicately tuned atmosphere, carbon dioxide performs the function of passing incoming heat radiation to the earth’s surface, but preventing it from being reflected back out into space; it’s the same function that a pane of glass serves in a greenhouse. If we are increasing the level of carbon dioxide (and according to one estimate the CO₂ level is rising at a rate of about 6 billion tons a year), we may be slowly raising the earth’s temperature as more and more heat is trapped inside the atmospheric greenhouse. Such a rise in temperature probably would not be detectable in a single generation. But a rise of only a few degrees would melt polar ice caps, inundate cities, and alter the natural environment everywhere.³⁴⁸

Another article, also in 1965, “We Can Afford Clean Air,” was published in *Fortune* magazine. The article, which was reprinted by the Department of Health, Education and Welfare in a bound edition, and which Muskie’s staff preserved, presented CO₂ and other greenhouse gases as a substantial threat to clean air, particularly since the problem was likely to grow in the future.³⁴⁹ A third article in 1965, from the *Federal Reserve Bank of Philadelphia Business*

348. Clifford B. Hicks, *Let’s Clear the Air*, 107 THE ROTARIAN 16, 20 (July 1965) (on file at s. V.A.5, b. 375, f. 3, BC-ESM).

349. Edmund K. Faltermayer, *A Fortune Proposition: We Can Afford Clean Air*, FORTUNE, November 1965, at 162 (on file at s. V.A.6, b. 535, f. 5, BC-ESM).

Review, discussed CO₂ in the context of the Conservation Foundation's work on the subject.³⁵⁰

Scientists including geophysicist Gordon MacDonald communicated concerns about rising carbon dioxide to broader audiences. For example, in 1969 MacDonald published a paper in *Technology Review* entitled, "The Modification of Planet Earth by Man," with the sub-heading: "Man's technology is changing his physical environment The results could endanger man's future on Earth."³⁵¹ The paper was about climate change, and it began by listing various forms of pollution that could alter the climate, including carbon dioxide from "burning fossil fuels," direct heating of the atmosphere by "burning of fossil and nuclear fuels," changing the albedo, and other factors; of all these, CO₂ was the most concerning, in part because it had "long been recognized as potentially affecting worldwide climate," and new work in climate modeling, "reported in the *Journal of Atmospheric Sciences* (1967), [calculated] that the change in carbon dioxide content of the atmosphere between 1900 and 1940 was sufficient to warm the earth by about 0.1 to 0.2° C."³⁵² MacDonald called for "urgent action" to deal with "the long-term problems of climate alteration," including world-wide programs to monitor carbon dioxide.³⁵³ The article also discussed in detail the competing cooling effects of particulates versus the heating effect of CO₂. The article was republished in *Current* in January 1970 with the title "Caring for our Planet: How Man Endangers the Planet."³⁵⁴ Another paper, published in 1970 in *Environmental Quality: The Forensic Quarterly*, also discussed the countervailing effects of carbon dioxide and particulates, suggesting that with one or the other "probably taking the lead, the danger of the melting of the ice caps or the dangers of a new ice age are not trivial."³⁵⁵ MacDonald made similar arguments in other wider-reaching settings, including, for example, a 1969 public conference on "our disposable world"—sponsored by the Junior League of Los Angeles and The Rand Corporation—and a 1970 address to the Industrial College of the Armed Forces.³⁵⁶ MacDonald did not take

350. Evan B. Alderfer, *Good Air for the Great Society*, 1 FED. RSRV. BANK OF PHILA. BUS. REV. 1, 11 (Dec. 1965) (on file at s. V.A.6, b. 535, f. 5, BC-ESM).

351. Gordon J.F. MacDonald, *The Modification of Planet Earth by Man*, 72 TECH. REV. 27, 27 (1969). The personal papers of MacDonald in which we found this article, and those for notes 114 and 353-357, were generously donated to us by his family. After our research was completed, we donated them, with the family's permission, to the Harvard University Archives where they await processing.

352. *Id.* at 28. MacDonald was undoubtedly referencing the influential paper by Syukuro Manabe & Richard T. Wetherald, *Thermal Equilibrium of the Atmosphere with a given Distribution of Relative Humidity*, 24 JOURNAL OF THE ATMOSPHERIC SCIENCES 241 (1967), which has recently been characterized as "arguably the greatest climate-science paper of all time." Piers Forster, *Half a Century of Robust Climate Models*, 545 NATURE 296, 296 (2017).

353. *Id.* at 31.

354. Gordon J.F. MacDonald, *Caring for our Planet: How Man Endangers the Climate*, 114 CURRENT 17, 17 (1970).

355. Gordon J.F. MacDonald, *How Can we Do a Better Job of Managing the Environment?*, 44 ENV. QUAL.: THE FORENSIC Q. 69, 79 (1970).

356. Gordon J.F. MacDonald, *Man and His Environment*, conference speech for the Junior League of Los Angeles and the Rand Corporation (Dec. 6, 1969), in OUR DISPOSABLE WORLD 2, 2 (1970). John Middleton also spoke about air pollution at the conference. See also MacDonald, *Our Beleaguered*

a position in 1970 on which effect he thought would end up dominating—although he thought that particulate had dominated so far—but rather he stressed the enormity of the changes that both forms of pollution (carbon dioxide and particulates) could effect.³⁵⁷

By 1970, the issue of carbon dioxide and climatic change appeared often in popular publications. In a 1970 issue of the magazine, *Fortune* writer and editor Tom Alexander published an article entitled “Some Burning Questions About Combustion.” The article discussed issues of acid rain, the greenhouse effect, and prospects for cleaning up the internal-combustion engine. “One combustion product that worries some scientists a great deal,” Alexander wrote, “is not usually classified as a pollutant.” CO₂, he noted, was “expected to increase another 25 percent by the year 2000” (no doubt referencing the statistic that was often cited at the time, which was offered in the 1965 PSAC report).³⁵⁸ While it “probably poses no direct threat to health . . . quite a few scientists maintain that in the long run it may prove to be the most important pollutant of them all.”³⁵⁹ Alexander also discussed the impact of particulates, the cooling effects of which could outweigh the warming effects of carbon dioxide. Regardless, he wrote, “[w]hether the climate gets warmer or cooler, the implications are serious. Man and his institutions everywhere are critically adjusted to just the climatological conditions that prevail.” Further, “relatively small perturbations could trigger latent instabilities,” since, as he noted, as water gets warmer, its capacity to absorb CO₂ decreases, which could accelerate the greenhouse effect.³⁶⁰

Concern about carbon dioxide could even be found in *Sports Illustrated*. In February 1970, *Sports Illustrated* picked up an article which first appeared in *Foreign Affairs* the prior month. Two days after the article was published in *Sports Illustrated*, the article was cited in a congressional hearing convened by the House Committee on Government Operations, Conservation and Natural Resources Subcommittee. There, Dr. Spencer Smith (secretary of the Citizens Committee on Natural Resources, a national conservation organization) asked for the article to be included in the record.³⁶¹ Addressing CO₂ and climate, the

Environment, speech for the Industrial College of the Armed Forces (Sep. 30, 1970), in PERSPECTIVES IN DEFENSE MANAGEMENT 11 (Autumn 1971).

357. At the time, he thought that particulates were dominating, but that would change as early air pollution laws got particulates and other visible pollutants under control but did not address CO₂. Personal communications with the first author, 2001–2002 (on file with Naomi Oreskes).

358. Tom Alexander, *Some Burning Questions about Combustion*, FORTUNE, Feb. 1970, at 130, 131.

359. *Id.*

360. *Id.* at 167.

361. *The Environmental Decade (Action Proposals for the 1970's): Hearing before a Subcomm. of the H. Comm. on Gov't. Op.*, 91st Cong., 99, 104 (1970) (statement of Dr. Spencer Smith, Jr., secretary, Citizens Committee on Natural Resources). It was cited in the record as having been published on Jan 30, 1970. However, the publication date for the copy in SPORTS ILLUSTRATED was Feb 2, 1970. *See generally* Lord Ritchie-Calder, *Mortgaging the Old Homestead*, SPORTS ILLUSTRATED, Feb. 2, 1970, 44. It was first published in January 1970 in FOREIGN AFFAIRS. *See generally* Lord Ritchie-Calder, *Mortgaging the Old Homestead*, 48 FOREIGN AFFAIRS 207 (1970). It is the latter version that was entered into the Cong. Rec. In SPORTS ILLUSTRATED it was highlighted in that issue's letter from the publisher. The same version of

article recommended against taking out ninety-nine-year leases on sea-level properties. Several paragraphs from the article were excerpted and entered into the Congressional Record. They stated in part,

[F]ossil fuels, locked away for eons of time, are extracted by man and put back into the atmosphere from the chimney stacks and the exhaust pipes of modern engineering. About six billion tons of carbon are mixed with the atmosphere annually. During the past century, in the process of industrialization, with its release of carbon by the burning of fossil fuels, more than 400 billion tons of carbon have been artificially introduced into the atmosphere. The concentration in the air we breathe has been increased by approximately 10% . . . This is something more than a public health problem, more than a question of what goes into the lungs of an individual, more than a question of smog. . . Carbon dioxide . . . can seriously disturb the heat balance of the earth because of what is known as the “greenhouse effect.”

. . . [A]t the present rate of increase, the mean annual temperature all over the world might increase by 3.6 ° centigrade in the next 40 to 50 years. The experts may argue about the time factor and even about the effects, but certain things are apparent . . . The north-polar ice cap is thinning and shrinking. The seas, with their blanket of carbon dioxide, are changing their temperature, with the result that marine plant life is increasing and is transpiring more carbon dioxide. As a result of the combination, fish are migrating, changing even their latitudes. On land the snow line is retreating and glaciers are melting . . . [and] the melting of ice caps or glaciers, in which the water is locked up, will introduce additional water to the sea and raise the level. Rivers originating in glaciers and permanent snow fields will increase their flow; and if ice dams, such as those in the Himalayas, break, the results in flooding may be catastrophic. In this process the patterns of rainfall will change, with increased precipitation in some areas and the possibility of aridity in now fertile regions. One would be well advised not to take 99-year leases on properties at present sea level.³⁶²

E. Summary

These examples, while by no means exhaustive, suffice to make the point: scientists working in the 1950s and 1960s on climate change were not isolated in ivory towers, their work unbeknownst to others. On the contrary, by the late 1960s concern about CO₂ and climate change had been communicated to school children and teachers, to conservationists, and to ordinary Americans through film, television, and articles in popular magazines such as *Fortune* and *Sports Illustrated*. Furthermore, historical evidence shows that the staff of the principal congressional architect of the Clean Air Act, Senator Edmund Muskie, was keeping track of this conversation.

the article was also entered into the Senate Cong. Rec. on Feb. 26, 1970 by Maryland Senator Joseph Tydings, 116 Cong. Rec. S4,993–96 (daily ed. Feb. 26, 1970).

362. Lord Ritchie-Calder, *Mortgaging the Old Homestead*, SPORTS ILLUSTRATED, *supra* note 361, at 48–49.

CONCLUSION

The Clean Air Act remains at the center of U.S. climate policy. Until the Act is replaced by superseding legislation, the precise scope of its provisions will continue to shape the nature and ambition of EPA's regulatory program. *West Virginia* is unlikely to be the Supreme Court's final word on the Clean Air Act and climate change; future cases will define the limits of the American climate response as courts address the compatibility of each newly promulgated regulation with statutory language from the 1970s. Historical analysis will be critical to that inquiry.

Under the new major questions doctrine, "context"³⁶³ and "history"³⁶⁴ will guide the Court's interpretation of the most significant provisions of the Act. In this Article, we have shown that this context and history demonstrate that influential members of the science policy establishment engaged broadly with the effects of air pollution on global climate change in the years leading up to 1970. They also demonstrate that Congress recognized that its amendments to the Clean Air Act would have "vast economic and political significance,"³⁶⁵ and understood far more about the potential threat of anthropogenic climate change than either the Court or most commentators have recognized.

This Article has continued the process of exhuming the history of climate change and the 1970 Clean Air Act by analyzing sources beyond the confines of the Congressional Record. In a follow-up paper, we will document how extensively scientists and administrators conveyed their climate knowledge to Congress, including in specific testimony during the lead-up to the 1970 Clean Air Act. We also demonstrate how the word "climate" in the Clean Air Act's definition of welfare can be traced to a June 1970 draft of the bill that provided for research on "climatic modification."³⁶⁶ Understanding both the scientific and original public meaning of "climate," as used in section 302 of the Act,³⁶⁷ and the nature of broader governmental contemplation of global climate change in the 1960s and into 1970, provides the textual and contextual underpinnings for debate over the meaning of the Act's terms. The Court underestimated this history in *Massachusetts* and largely ignored it in *West Virginia*.

If the major questions doctrine is to have doctrinal heft in future climate cases, the Court will need to engage with the full scope of the history presented in this Article and elsewhere. Without sustained historical inquiry, the major questions analysis is grounded in little more than judicial intuition. In some cases, history will support that intuition. In other cases, like *West Virginia*, it will

363. *West Virginia v. EPA*, 142 S. Ct. 2587, 2607 (quoting *Davis v. Michigan Dept. of Treasury*, 489 U.S. 803, 809 (1989)).

364. *Id.* at 2608 (quoting *FDA v. Brown & Williamson Tobacco Corp.*, 529 U.S. 120, 159 (2000)).

365. *Id.* at 2605 (quoting *Utility Air Regulatory Grp. v. EPA*, 573 U.S. 302, 324 (2014)).

366. S. SUBCOMM. ON ENV'T POLLUTION OF THE S. COMM. ON PUB. WORKS, 91ST CONG., DRAFT OF "AIR POLLUTION: A BILL" 5 (Comm. Print. 1970) (on file at Box No. 13, Legislative/Oversight Files, Congressional Sessions: 91-96, Subgroup Undefined: Location 12E3/20/30/2, Records of the US Senate, 1789-2022, Record Group 46, National Archives Building, Washington, DC).

367. 42 U.S.C. § 7602(h).

not. We do not suggest that this history of climate science in the 1960s—or any form of historical evidence—can definitively resolve judicial disputes. In major questions cases involving older statutes and questions of legislative intent, however, history should set the terms of the debate.

We welcome responses to this Article. If you are interested in submitting a response for our online journal, *Ecology Law Currents*, please contact cse.elq@law.berkeley.edu. Responses to articles may be viewed at our website, <http://www.ecologylawquarterly.org>.