The 1987 Montreal Protocol on Substances that Deplete the Ozone Layer: a Turning Point for Environmental National and Global Cooperation

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Paper

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Process Paper

In order to pour effort into a months-long process of research, synthesis, and writing, there is an undeniable obstacle that only true engagement or interest can overcome. For the 2024 National History Day (NHD) topic "Turning Points in History," I resolved to write about environmental justice. Narrowing down my topic into the Montreal Protocol on Substances that Deplete the Ozone Layer was difficult; however, the protocol's local "hearth" in my city, Irvine, as well as its potential implications for current climate legislation helped me make my topic selection. With this, my thesis evolved to focus on the unprecedented level of national and global cooperation shown through the Montreal Protocol as well as its lessons for environmental policy today. Given the protocol's precedent of cooperation, the topic's direct relevance to this year's NHD theme reflects on not only the past but the present and future in environmental legislation.

Research is the foundation of any history-based project. During this process, I specifically focused on finding various perspectives surrounding the Montreal Protocol, from the scientists to the chemical industries. Providing this balance in perspective was crucial to establish a well-rounded historical narrative that supported my main argument. In order to condense my notes into a format that could then turn into concise, synthesized writing, I created a detailed outline for my project with links to sources and specific statistics that I knew I wanted to include in certain parts of the paper. Throughout the process of collecting information, creating the outline, and writing the paper, an obstacle was ensuring that my analysis was thorough, nuanced, and well-supported by concrete evidence. However, by exploring sources with a critical eye, I was able to overcome this difficulty.

Additionally, my research process was enriched with interviews with Professor Michael J. Prather and Professor Donald R. Blake, both UCI faculty members who directly contributed to

the establishment of the Montreal Protocol. Through the opportunity to interview both professors, I was able to learn about their firsthand accounts and perspectives on the protocol, which added a layer of nuance in my paper.

The main message I hope readers take away from my paper is how the collaborative nature of the Montreal Protocol can bring beneficial and effective change to current climate legislation. Climate change is an imminent threat and the past several years has clearly shown its detrimental impact on Earth, from the unprecedented high temperatures to exacerbated natural disasters. Through my paper, I hope to bring insight to the discussion surrounding environmental legislation especially as climate change continues to test current policies.

"If not us, who? If not now, when?" - Professor F. Sherwood Roland[1]

An Early Discovery Intrigues Research

In the early 1970s, scientist James E. Lovelock discovered that chlorofluorocarbons (CFCs),[2] a compound found in households items from aerosol hair spray to refrigerators,[3] were more widespread with longer lifespans than originally thought.[4] Presented at a 1972 scientific meeting between meteorologists and chemists, his findings piqued interest in University of California, Irvine chemist Sherwood F. Rowland, who in result conducted a full study into CFCs with Mario Molina, his post-doctoral student.[5] Through investigation, Rowland and Molina proposed a correlation between CFCs and stratospheric ozone,[6] a three-oxygen molecule protecting against ultraviolet (UV) radiation.[7] While contentious, demand for anti-CFC action mounted, resulting in the global 1987 Montreal Protocol on Substances that Deplete the Ozone Layer.[8] Despite scientific ambiguity that shrouded the stratospheric ozone layer and its effects at

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[1] "UCI loses the legendary F. Sherwood Rowland." *UCI News*, 11 Mar. 2012, news.uci.edu/2012/03/11/uci-loses-the-legendary-f-sherwood-rowland/. Accessed 12 Jan. 2024.
[2] Anderson, Stephen O., and Marco Gonzalez. *35th Anniversary Protecting the Ozone Layer*. Edited by Sally Rand, 2nd ed., Institute for Governance & Sustainable Development, 2022.
[3] "Back from the brink: how the world rapidly sealed a deal to save the ozone layer." *Rapid Transition Alliance*, 11 June 2019, rapidtransition.org/stories/back-from-the-brink-how-the-world-rapidly-sealed-a-deal-to-save-the-ozone-layer/. Accessed 12 Jan. 2024.
[4] Anderson, Stephen O., and Marco Gonzalez. *35th Anniversary Protecting the Ozone Layer*. Edited by Sally Rand, 2nd ed., Institute for Governance & Sustainable Development, 2022
[5] Gilet, Candace. "Ozone depletion." Edited by Anna Thanukos. *Understanding Science*, https://undsci.berkeley.edu/ozone-depletion-uncovering-the-hidden-hazard-of-hairspray/putting-the-pieces-together/. Accessed 13 Feb. 2024.
[6] The Editors of Encyclopaedia Britannica. "Montreal Protocol." *Britannica*, edited by The Editors of Encyclopaedia Britannica, 21 Dec. 2023, www.britannica.com/event/Montreal-Protocol. Accessed 12 Jan. 2024.
[7] "Basic Ozone Layer Science." *United States Environmental Protection Agency*, National Service Center for Environmental Publications, 7 Oct. 2021, www.epa.gov/ozone-layer-protection/basic-ozone-layer-science#:~:text=Depletion%20of%20this%20layer%20by,organisms%2C%20plants%2C%20and%20plastics. Accessed 13 Feb. 2024.
[8] "About Montreal Protocol." *UN environment programme*, www.unep.org/ozonaction/who-we-are/about-montreal-protocol. Accessed 12 Jan. 2024.

the time, the Montreal Protocol was a turning point to environmental legislation, setting a precedent for environmental cooperation in the U.S. in addition to its global impact of successful collective climate action.

Reacting to the 1974 Hypothesis

Renowned for their affordability, inflammability, and nontoxic quality, CFCs were especially appealing to chemical industries.[9] On June 28 of 1974,[10] Rowland and Molina then published a *Nature* article hypothesizing that CFCs released chlorine monoxide and chlorine atoms upon solar radiation exposure and decomposition. According to their proposal, the reaction's chlorine monoxide and chlorine atoms broke down the stratosphere's ozone molecules.[11] This hypothesis backed a harmful cycling reaction where 100,000 ozone molecules could be destroyed by one chlorine atom.[12] In turn, the UV radiation overexposure could threaten health through skin cancer and cataracts. An ozone-depleting substance (ODS), CFCs' long 50-to-150-year lifespan[13] made the chemical especially harmful compared to methyl chloroform, carbon tetrachloride, bromine-releasing methyl bromide, and halons.[14] With longevity, CFCs

[9] "Back from the brink: how the world rapidly sealed a deal to save the ozone layer." *Rapid Transition Alliance*, 11 June 2019, rapidtransition.org/stories/back-from-the-brink-how-the-world-rapidly-sealed-a-deal-to-save-the-ozone-layer/. Accessed 12 Jan. 2024.

[10] Molina, Mario J., and F. S. Rowland. "Stratospheric sink for chlorofluoromethanes: chlorine atom-catalysed destruction of ozone." *Nature*. Abstract.

[11] The Editors of Encyclopaedia Britannica. "Montreal Protocol." *Britannica*, edited by The Editors of Encyclopaedia Britannica, 21 Dec. 2023, www.britannica.com/event/Montreal-Protocol. Accessed 12 Jan. 2024.

[12] "Basic Ozone Layer Science." *United States Environmental Protection Agency*, National Service Center for Environmental Publications, 7 Oct. 2021, www.epa.gov/ozone-layer-protection/basic-ozone-layer-science#:~:text=Depletion%20of%20this%20layer%20by,organisms%2C%20plants%2C%20and%20plastics. Accessed 13 Feb. 2024.

[13] "Why you don't hear about the ozone layer anymore." *YouTube*, uploaded by Vox, 24 Nov. 2021, www.youtube.com/watch?v=CaLOiGEDPJQ. Accessed 12 Jan. 2024.

[14] "Phaseout of Class I Ozone-Depleting Substances." *United States Environmental Protection Agency*, National Service Center for Environmental Publications, 27 Nov. 2023, www.epa.gov/ods-phaseout/phaseout-class-i-ozone-depleting-substances#:~:text=ODS%20include%20chlorofluorocarbons%20(CFCs)%2C,ultraviolet%20light%20in%20the%20stratosphere. Accessed 12 Jan. 2024.

could bring lasting harm, justifying action against ODS. After the publication, further research in the U.S. brought federal attention to the negatives of CFCs. Once the National Academy of Sciences agreed with Molina and Rowland, the U.S. enacted a 1978 ban on CFC aerosols.[15]

Publishing their own findings in *Nature*, British Antarctic Survey (BAS) scientists provided international corroboration for the 1974 discovery.[16] However, divisions remained within the scientific community. Critics criticized Rowland for threatening to cross the thin line between scientific neutrality and political advocacy given his pronounced public stance on ozone regulation. In fact, the seemingly unrealistic and intangible nature of the 1974 discovery only contributed to Rowland's "'outcast status,'" with an EPA official admitting that the chemist's ideas were relatively dismissed.[17] Moreover, despite requesting meetings with the American Chemical Society and American Physical Society to discuss ozone depletion, both groups declined, citing lack of interest and leaving little hope for effective collaboration.[18]

Further division stemmed from the CFC-producing chemical industries who adamantly opposed the 1974 findings, claiming the research inconclusive. Critics emphasized the measurements' potential errors with geographic and seasonal changes in ozone concentrations challenging data collection processes.[19] Meanwhile, DuPont, a chemical company producing

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[15] The Editors of Encyclopaedia Britannica. "F. Sherwood Rowland." *Britannica*, 24 June 2023, www.britannica.com/biography/Frank-Sherwood-Rowland. Accessed 12 Jan. 2024.
[16] Colwell, Steve, and Jonathan Shanklin. "The Ozone Hole." *British Antarctic Survey Natural Environment Research Council*, 30 June 2022, www.bas.ac.uk/data/our-data/publication/the-ozone-layer/. Accessed 13 Feb. 2024.
[17] Jones, Lanie. "Ozone Warning : He Sounded Alarm, Paid Heavy Price." *Los Angeles Times*, 14 July 1988, www.latimes.com/archives/la-xpm-1988-07-14-mn-8873-story.html. Accessed 12 Jan. 2024.
[18] "Discovery of a Lifetime: F. Sherwood Rowland and the Ozone Layer." *YouTube*, uploaded by UCI Open, 10 Dec. 2012, Discovery of a Lifetime: F. Sherwood Rowland and the Ozone Layer. Accessed 12 Jan. 2024.
[19] American Chemical Society. Chlorofluorocarbons and Ozone Depletion. 2017. www.acs.org/content/dam/acsorg/education/whatischemistry/landmarks/cfcsozone/cfcs-ozone.pdf

approximately one-fourth of the world's CFCs,[20] persistently denied the findings,[21] publicizing ads claiming they would halt CFC production the day concrete evidence surfaced.[22] Chemical industries hesitated especially to accept CFCs as harmful ODS due to the price tag of abandoning the profitable substance: a whopping eight-billion dollars.[23]

Meanwhile, Rowland felt he had the responsibility to inform the world about the discovery and its implications on climate change and public health. His research found that ozone depletion could lead to skin cancer and ultimately contribute to global warming, directly impacting individuals. Testing the undefined frontier between science and political advocacy that was a previous source of criticism, Rowland testified before Congress and informed state legislatures across the U.S., spreading word[24] on what he deemed a "major global environmental problem."[25] Molina created an alliance with other scientists who supported the hypothesis[26] which built momentum on collaboration.

Public Perspective After the 1974 Discovery

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[20] "Back from the brink: how the world rapidly sealed a deal to save the ozone layer." *Rapid Transition Alliance*, 11 June 2019, rapidtransition.org/stories/back-from-the-brink-how-the-world-rapidly-sealed-a-deal-to-save-the-ozone-layer/. Accessed 12 Jan. 2024.

[21] Schienberg, Jonathan. "Healing the Ozone: First Steps Toward Success." *PBS Learning Media*, 2023, ca.pbslearningmedia.org/resource/healing-the-ozone-first-steps-toward-success-video/retro-report/. Accessed 12 Jan. 2024.

[22] Lee, Mary J., and Donald R. Blake. Videoconference interview with the author. 29 Nov. 2023.

[23] Pedrick, Alexis, and Elisabeth Berry Drago, hosts. "Whatever Happened to the Ozone Hole?" *Distillations Podcast*, produced by Rigoberto Hernandez and Mariel Carr, 17 Apr. 2018. *Science History Institute Museum & Library*, sciencehistory.org/stories/distillations-pod/whatever-happened-to-the-ozone-hole/. Accessed 22 Jan. 2024.

[24] Jones, Lanie. "Ozone Warning : He Sounded Alarm, Paid Heavy Price." *Los Angeles Times*, 14 July 1988, www.latimes.com/archives/la-xpm-1988-07-14-mn-8873-story.html. Accessed 12 Jan. 2024.

[25] Rowland, Sherwood. "F. Sherwood Rowland Interview." Interview by Marika Griehsel. *The Nobel Prize*, June 2005, www.nobelprize.org/prizes/chemistry/1995/rowland/interview/. Accessed 12 Jan. 2024.

[26] Anderson, Stephen O., and Marco Gonzalez. *35th Anniversary Protecting the Ozone Layer*. Edited bySally Rand, 2nd ed., Institute for Governance & Sustainable Development, 2022.

Despite disagreements across environmental, scientific, and business sectors, public consumerism patterns reflected Rowland's endeavors to minimize CFC usage. CFCs were prevalent in U.S. households, with refrigerators contributing 30% CFC usage and cleaning agents or industrial solvents close behind at 19%.[27] Since CFCs were so commonly used, the 1974 hypothesis seemed even more preposterous; as Rowland stated himself, "'it seemed ludicrous that underarm deodorants might have an effect globally.'"[28] But with the help of the media, whose numerous cartoons framed the chemical industries as responsible for ozone depletion, the public supported battling CFCs.[29] This support was demonstrated through "'green consumerism,'" turning away from goods containing CFCs and forcing chemical companies to change marketing.[30] The competition set a collaborative foundation for the 1987 Montreal Protocol since the chemical business sectors had to consider some scientists' and environmentalists' interests. This increased competition corresponded with the number of non-aerosol, non-CFC deodorant and hairspray which more than doubled and quadrupled respectively.[31] In limelight by the late 1970s, ODS incentivized the United Nations Environmental Program (UNEP) to establish the Coordinating Committee on the Ozone Layer, which included a collaborative global research network where countries could advise harm-reduction strategies. Conflicting public demand, industrial perspective, and scientific point of view collectively stirred controversy around ozone depletion. The controversies further

[27] Manzer, L. E. "The CFC-Ozone Issue: Progress on the Development of Alternatives to CFCs." CIESIN. http://www.ciesin.org/docs/011-448/011-448.html. Accessed 13 Feb. 2024.
[28] Rotman, David. "Remembering the Montreal Protocol." *MIT Technology Review*, Elizabeth Bramson-Boudreau, 1 Jan. 2007, www.technologyreview.com/2007/01/01/227161/remembering-the-montreal-protocol/. Accessed 22 Jan. 2024.
[29] "Discovery of a Lifetime: F. Sherwood Rowland and the Ozone Layer." *YouTube*, uploaded by UCI Open, 10 Dec. 2012, Discovery of a Lifetime: F. Sherwood Rowland and the Ozone Layer. Accessed 12 Jan. 2024.
[30] World Resources Institute. *Ozone Protection in the United States: Elements of Success*. Edited by Elizabeth Cook, Nov. 1996.
[31] Ibid.

showed how the Montreal Protocol later became an even larger turning point in environmental legislation as a symbol of unprecedented, unanticipated collaboration across various sectors.

The Ozone Hole

In May 1985, BAS scientists reported proof of ozone depletion above Antarctic research stations. According to their findings, each spring, sunlight exposure broke about 1% of ozone molecules daily, thinning the stratospheric ozone layer. In collaboration with the National Aeronautics and Space Administration (NASA), the scientists discovered that this hole was not only present near the research stations but around Antarctica. As global warming slowed ozone recovery by reducing the layer's temperature, the discovery provided insight on the reasons behind its depletion.[32] The Antarctic discovery incentivized both the U.S. and the world to stand against ODS, contributing to cooperative action in subsequent years. The hole was significant for the Montreal Protocol as a justification that CFCs depleted the stratospheric ozone layer. According to Professor Michael J. Prather of University of California, Irvine, who participated in ozone assessments in the 1970s and 80s,"the ozone hole was like a climate catastrophe…which, suddenly, the earth changed in a way we had not expected."[33]

After the ozone hole discovery, Susan Solomon, a National Oceanic and Atmospheric Administration (NOAA) chemist, led an expedition to Antarctica in 1986 and 1987 where her team confirmed the 1974 findings.[34] Through their 1987 expedition, the scientists found that the concentration of carbon monoxide, a compound source for ozone depletion, significantly

[32] Colwell, Steve, and Jonathan Shanklin. "The Ozone Hole." *British Antarctic Survey Natural Environment Research Council*, 30 June 2022, www.bas.ac.uk/data/our-data/publication/the-ozone-layer/. Accessed 13 Feb. 2024.
[33] Prather, Michael J. Videoconference interview with the author. 21 Dec. 2023.
[34] "Susan Solomon." *Science History Institute Museum & Library*. Accessed 22 Jan. 2024.

increased by more than hundredfold compared to previous years.[35] With the hole, the public demanded anti-ODS action. A 1986 report from the World Meteorological Organization (WMO) and NASA backed this belief:[36] The hole and reported information conveyed the need for successful action against ODS, an ambitious goal requiring collective effort.

A Crucial Frame: Vienna Convention for the Protection of the Ozone Layer

UNEP created the Vienna Convention for the Protection of the Ozone Layer,[37] a structured guideline for ozone protection defined by March 1985.[38] Guiding the Montreal Protocol, the convention encouraged cooperative communication for ozone research[39] and prioritized public health. The Montreal Protocol's inseparable coexistence with the convention[40] reflected the framework's contributions to collective, collaborative environmental legislation on various scales through cooperative communication.

The U.S. evidently supported the convention with President Ronald Reagan referring to stratospheric ozone as a "critical global environmental resource" while underlining the positive impact the framework could have on public health in an August 1985 transmittal letter. The U.S.

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[35] National Science Foundation. *National Science Foundation Annual Report 1987*. Government Publishing Office. *U.S. National Science Foundation*, www.nsf.gov/pubs/1987/1987-NSF-Annual-Report.pdf. Accessed 19 Jan. 2024.
[36] Whitesides, Greg. "Learning from Success: Lessons in Science and Diplomacy from the Montreal Protocol." *AAAS Science & Diplomacy*, edited by Kimberly Montgomery and E. William Colglazier, Center for Science Diplomacy, 10 Aug. 2020, www.sciencediplomacy.org/article/2020/learning-success-lessons-in-science-and-diplomacy-montreal-protocol. Accessed 19 Jan. 2024.
[37] Weiss, Edith Brown. "Vienna Convention for the Protection of the Ozone Layer Vienna, 22 March 1985 Montreal Protocol on Substances that Deplete the Ozone Layer Montreal, 16 September 1987." *Audiovisual Library of International Law*, edited by Codification Division of the UN Office of Legal Affairs, legal.un.org/avl/ha/vcpol/vcpol.html#. Accessed 19 Jan. 2024.
[38] Ibid.
[39] "Treaties." *UN environment programme: ozone secretariat*, ozone.unep.org/treaties/vienna-convention/articles/article-3-research-and-systematic-observations#:~:text=The%20Parties%20undertake%20to%20promote,observation%20of%20the%20state%20of. Accessed 19 Jan. 2024.
[40] Solomon, Susan, and Stephen O. Anderson. "Susan Solomon and Stephen Andersen on Saving the Ozone Layer." Interview by Lucas Perry. *Future of Life Institute*, hosted by Lucas Perry, 16 Sept. 2021. *future of life Institute*, futureoflife.org/podcast/susan-solomon-and-stephen-andersen-on-saving-the-ozone-layer/. Accessed 19 Jan. 2024. Transcript.

also desired being a forefront of ozone protection. Moreover, the U.S. believed the frame would correspond with their foreign economic interests.[41] The convention was enacted by September 22, 1988.[42]

Undertaking the Montreal Protocol on Substances that Deplete the Ozone Layer

Despite accumulating evidence, the science behind ozone depletion and its causes were still unsettled as of 1987.[43] Establishing the Montreal Protocol required more cooperation in order to brainstorm pragmatic, feasible solutions. A major obstacle for the international community was conflicting interests between the European Union (EU), who gained less benefits from CFCs, and the US, who already reaped significant benefits from the substances. Through extensive deliberation, both sides settled on a ten-year delay on CFC phase-outs for the EU.[44] Additionally, UN representative Mostafa Kamal Tolba helped unite professions from various fields, who then convened on potential, effective solutions to abate ozone depletion by ODS.[45] Stephen O. Anderson, U.S. EPA economist and Tolba's ally, directly helped the Montreal Protocol's development by seeking ways for the legislation to be financially feasible.[46] Hailed as

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[41] "UNITED NATIONS: VIENNA CONVENTION FOR THE PROTECTION OF THE OZONE LAYER." *International Legal Materials*, vol. 26, no. 6, 1987, pp. 1516–40. *JSTOR*, http://www.jstor.org/stable/20693168. Accessed 19 Jan. 2024.

[42] Weiss, Edith Brown. "Status." *Audiovisual Library of International Law*, edited by Codification Division of the UN Office of Legal Affairs, legal.un.org/avl/ha/vcpol/vcpol.html#. Accessed 13 Feb. 2024.

[43] Solomon, Susan, and Stephen O. Anderson. "Susan Solomon and Stephen Andersen on Saving the Ozone Layer." Interview by Lucas Perry. *Future of Life Institute*, hosted by Lucas Perry, 16 Sept. 2021. *future of life Institute*, futureoflife.org/podcast/susan-solomon-and-stephen-andersen-on-saving-the-ozone-layer/. Accessed 19 Jan. 2024. Transcript.

[44] Thomas, Lee. "Interview with Lee Thomas, EPA's 6th Administrator." *ThomasFull*, EPA Alumni Association. Interview.

[45] Anderson, Stephen O., and Marco Gonzalez. *35th Anniversary Protecting the Ozone Layer*. Edited by Sally Rand, 2nd ed., Institute for Governance & Sustainable Development, 2022.

[46] Solomon, Susan, and Stephen O. Anderson. "Susan Solomon and Stephen Andersen on Saving the Ozone Layer." Interview by Lucas Perry. *Future of Life Institute*, hosted by Lucas Perry, 16 Sept. 2021. *future of life Institute*, futureoflife.org/podcast/susan-solomon-and-stephen-andersen-on-saving-the-ozone-layer/. Accessed 19 Jan. 2024. Transcript.

"masters of collaborative leadership,"[47] Tolba and Anderson, among many others,[48] helped the Montreal Protocol become a cooperative, collective turning point.

The extensive ratification processes required a minimum of 11 states who were consumers of ⅔ of the global halon or CFC supply.[49] By September 1987, the European Commission and 26 states ratified the Montreal Protocol on Substances that Deplete the Ozone Layer,[50] exemplifying global union and U.S. bipartisanship. The UN finally adopted the protocol on September 16, 1987.[51] Through an 83-0 vote, the U.S. Senate ratified the Montreal Protocol in March 1988.[52] This referendum preceded over three decades of bipartisan cooperation.[53] This national collaboration represented both ends of the political spectrum coming together in a consolidated effort. In fact, in an April 5th Statement on Signing the Montreal Protocol on Ozone-Depleting Substances, President Reagan declared the agreement a "model of cooperation."[54] In 1989, the UN began the protocol implementation process.[55]

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[47] Anderson, Stephen O., and Marco Gonzalez. *35th Anniversary Protecting the Ozone Layer*. Edited by Sally Rand, 2nd ed., Institute for Governance & Sustainable Development, 2022.
[48] Thomas, Lee. "Interview with Lee Thomas, EPA's 6th Administrator." *ThomasFull*, EPA Alumni Association. Interview.
[49] Reagan, Ronald. "Statement on Signing the Montreal Protocol on Ozone-Depleting Substances." 5 Apr. 1988. *National Archives*, www.reaganlibrary.gov/archives/speech/statement-signing-montreal-protocol-ozone-depleting-substances. Accessed 19 Jan. 2024. Speech.
[50] Ibid.
[51] "About Montreal Protocol." *UN environment programme*, www.unep.org/ozonaction/who-we-are/about-montreal-protocol. Accessed 12 Jan. 2024.
[52] ---. "Treaty On Ozone Is Backed In Senate." *The New York Times*, The New York Times Company, 15 Mar. 1988, www.nytimes.com/1988/03/15/science/treaty-on-ozone-is-backed-in-senate.html. Accessed 19 Jan. 2024.
[53] Office of Environmental Quality. "The Montreal Protocol on Substances That Deplete the Ozone Layer." *U.S. Department of State*, www.state.gov/key-topics-office-of-environmental-quality-and-transboundary-issues/the-montreal-protocol-on-substances-that-deplete-the-ozone-layer/#:~:text=The%20Montreal%20Protocol%2C%20finalized%20in,%2Ddepleting%20substances%20(ODS). Accessed 19 Jan. 2024.
[54] Reagan, Ronald. "Statement on Signing the Montreal Protocol on Ozone-Depleting Substances." 5 Apr. 1988. *National Archives*, www.reaganlibrary.gov/archives/speech/statement-signing-montreal-protocol-ozone-depleting-substances.Accessed 19 Jan. 2024. Speech.
[55] Whitney, Craig R. "80 Nations Favor Ban To Help Ozone." *The New York Times*, The New York Times Company, 3 May 1989, www.nytimes.com/1989/05/03/world/80-nations-favor-ban-to-help-ozone.html. Accessed 19 Jan. 2024.

In the unamended 1987 Montreal Protocol, key stipulations included reducing CFC consumption by 20% by 1994 and requiring halons to reach 1986 levels by 1994.[56] Utilizing the Vienna Convention framework, the protocol encouraged open research communication "in a regular and timely fashion" for updated information regarding the stratospheric ozone layer.[57] To assist developing countries in this transition, the protocol allowed 10% annual increases in CFC production for the following decade.[58]

Montreal Protocol Implementation "'[T]o safeguard the earth's protective shield'"[59]

Implementing the protocol and transitioning to alternatives posed obstacles for chemical industries. Researching, finding, and using alternatives to CFCs were challenging, with the EPA estimating that the process would require $36 billion from 1991 to 2075.[60]

Despite the controversies and lack of cooperation immediately following the 1974 discovery, industries, chemists, environmentalists, and the public were able to consolidate their values to develop effective CFC alternatives. This cooperative process showed the U.S.

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[56] Shabecoff, Philip. "Dozens of Nations Reach Agreement to Protect Ozone." *The New York Times*, The New York Times Company, 17 Sept. 1987, www.nytimes.com/1987/09/17/world/dozens-of-nations-reach-agreement-to-protect-ozone.html. Accessed 19 Jan. 2024.

[57] "Treaties." *UN environment programme: ozone secretariat*, ozone.unep.org/treaties/vienna-convention/articles/article-3-research-and-systematic-observations#:~:text=The%20Parties%20undertake%20to%20promote,observation%20of%20the%20state%20of. Accessed 19 Jan. 2024.

[58] Shabecoff, Philip. "Dozens of Nations Reach Agreement to Protect Ozone." *The New York Times*, The New York Times Company, 17 Sept. 1987, www.nytimes.com/1987/09/17/world/dozens-of-nations-reach-agreement-to-protect-ozone.html. Accessed 19 Jan. 2024.

[59] Environmental Protection Agency. "Lee M. Thomas Statement on U.S. Ratification of the Montreal Protocol." *EPA: US Environmental Protection Agency*, National Service Center for Environmental Publications, 11 Aug. 2016, www.epa.gov/archive/epa/aboutepa/lee-m-thomas-statement-us-ratification-montreal-protocol.html. Accessed 10 Feb. 2024. This is a quote from Lee M. Thomas, who was the EPA Administrator during the time the Montreal Protocol was established. It is within an 1988 EPA press release found in an archive, which places the statement in quotation marks already.

[60] Hamilton, Martha M. "The Costly Race to Replace CFCs." *The Washington Post*, Nash Holdings, 29 Sept. 1991, www.washingtonpost.com/archive/business/1991/09/29/the-costly-race-to-replace-cfcs/86e250e5-6031-4b77-88c4-9f9b6963b6b7/. Accessed 19 Jan. 2024.

governmental, industrial willingness to adopt environmentally-friendly production strategies. Given how CFC services and items were annually valued over $28 billion, with 700,000 jobs tied to CFC production,[61] the U.S. was initially hesitant about restrictions from a business standpoint. In fact, the country initially claimed that they would wait until DuPont created effective substitutes by 1986.[62]

DuPont did not announce a CFC production termination until March 1988 following a scientific NASA panel on the 15th, which consolidated the company's beliefs on CFCs' detrimental ozone depletion. Though CFCs constituted only 2% of DuPont's monetary profit in 1987, this showcased a major chemical company's effort to abate ozone depletion despite financial ramifications.[63] By September 1991, vehicle industries also agreed to implement hydrofluorocarbons (HFCs) instead of CFCs,[64] a radical shift in CFC usage as more businesses fought ozone depletion. Non-chemical companies also took action to pursue CFC alternatives. In 1992, Greenpeace, a global environmental advocacy group,[65] created the GreenFreeze fridge, utilizing natural hydrocarbons as a CFC substitute.[66] Both industrial groups and environmental groups pushed the societal boundaries that set limits on the level of collaboration that was expected in the ozone depletion crisis.

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[61] Manzer, L. E. "The CFC-Ozone Issue: Progress on the Development of Alternatives to CFCs." CIESIN. http://www.ciesin.org/docs/011-448/011-448.html. Accessed 13 Feb. 2024.
[62] "Back from the brink: how the world rapidly sealed a deal to save the ozone layer." *Rapid Transition Alliance*, 11 June 2019, rapidtransition.org/stories/back-from-the-brink-how-the-world-rapidly-sealed-a-deal-to-save-the-ozone-layer/. Accessed 12 Jan. 2024.
[63] Glaberson, William. "Behind Du Pont's Shift On Loss of Ozone Layer." *The New York Times*, The New York Times Company, 26 Mar. 1988, www.nytimes.com/1988/03/26/business/behind-du-pont-s-shift-on-loss-of-ozone-layer.html. Accessed 19 Jan. 2024.
[64] Hamilton, Martha M. "The Costly Race to Replace CFCs." The Washington Post, Nash Holdings, 29 Sept. 1991, www.washingtonpost.com/archive/business/1991/09/29/the-costly-race-to-replace-cfcs/86e250e5-6031-4b77-88c4-9f9b6963b6b7/. Accessed 19 Jan. 2024.
[65] "About." *Greenpeace*, www.greenpeace.org/usa/about/. Accessed 19 Jan. 2024.
[66] "Back from the brink: how the world rapidly sealed a deal to save the ozone layer." *Rapid Transition Alliance*, 11 June 2019, rapidtransition.org/stories/back-from-the-brink-how-the-world-rapidly-sealed-a-deal-to-save-the-ozone-layer/. Accessed 12 Jan. 2024.

Collectively, searching for CFC replacements found hydrochlorofluorocarbons (HCFCs), the less intense version of its predecessor. Then, HCFCs transitioned to HFCs,[67] a strong greenhouse gas.[68] Environmentalists believed that HCFCs should be phased out as soon as possible, ideally right after the CFC phase-out date,[69] emphasizing the need for quick progress in research.[70] On the other hand, chemical industries claimed that HCFCs should be phased out later, citing potential obstacles for business investment and developing states' transition to a CFC-free market.[71]

Changes to the Protocol Over the Decades

The Montreal Protocol could be adjusted with new technological or scientific findings, and the treaty adopted several amendments[72] while bringing forward ODS phaseout dates.[73] One year after the protocol implementation began in 1989, legislators adopted the London Amendment, adding the Multilateral Fund which granted funds to developing countries

[67] UNEP Ozone Secretariat. "Fact Sheet 2: Overview of HFC Market Sectors." *UN environment programme: ozone secretariat*, Oct. 2015, ozone.unep.org/sites/ozone/files/Meeting_Documents/HFCs/FS_2_Overview_of_HFC_Markets_Oct_2015.pdf. Accessed 19 Jan. 2024.
[68] Fahey, David. "33. David Fahey on the Montreal Protocol, ozone depletion and SRM." Interview by Jesse Reynolds and Pete Irvine. *Challenging Climate*, hosted by Jesse Reynolds and Pete Irvine, 4 Apr. 2023. *YouTube*, www.youtube.com/watch?v=7vgT7LfG2YQ. Accessed 13 Feb. 2024.
[69] Holusha, John. "Du Pont to Construct Plants For Ozone-Safe Refrigerant." The New York Times, The New York Times Company, 23 June 1990, www.nytimes.com/1990/06/23/business/du-pont-to-construct-plants-for-ozone-safe-refrigerant.html. Accessed 19 Jan. 2024.
[70] ---. "Ozone Issue: Economics of a Ban." *The New York Times* [New York City], 11 Jan. 1990, p. 1. *The New York Times*, www.nytimes.com/1990/01/11/business/ozone-issue-economics-of-a-ban.html. Accessed 22 Jan. 2024.
[71] Holusha, John. "Du Pont to Construct Plants For Ozone-Safe Refrigerant." The New York Times, The New York Times Company, 23 June 1990, www.nytimes.com/1990/06/23/business/du-pont-to-construct-plants-for-ozone-safe-refrigerant.html. Accessed 19 Jan. 2024.
[72] "Climate Change: Lessons from the Montreal Protocol." *YouTube*, uploaded by Carnegie Council for Ethics in International Affairs, Oct. 2007, www.youtube.com/watch?v=X2HAwuRyzxU. Accessed 19 Jan. 2024.
[73] Environmental Protection Agency. "Accelerated Phaseout of Ozone-Depleting Chemicals." *EPA: US Environmental Protection Agency*, National Service Center for Environmental Publications, 3 Aug. 2016, www.epa.gov/archive/epa/aboutepa/accelerated-phaseout-ozone-depleting-chemicals.html. Accessed 10 Feb. 2024.

struggling to fulfill the agreement's stipulations.[74] Subsequent amendments, from the Copenhagen Amendment[75] to 2016 Kilagi Amendment,[76] encouraged a formal shift from CFCs to HCFCs and HFCs, respectively. HCFCs could not destroy ozone as effectively as CFCs while HFCs did not deplete ozone. While the subsequent ODSs helped preserve ozone, they remained strong greenhouse gases contributing to global warming[77] and were regulated after the 1900s.[78] Through transitions, the Montreal Protocol not only became a turning point by its cooperative nature but also collaboration in climate change, connecting to the broad categorization of environmental legislation. In 1997, a Montreal Amendment mandated a license system for ODS transfers while the 1999 Beijing Amendment exempted regulation for some domestic-use chemicals.[79] Over decades, the list of regulated chemicals grew, naming approximately 100 substances by September 2023.[80]

"[W]e sink or swim together": Consequences of the Montreal Protocol

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[74] "About the Multilateral Fund." *Multilateral Fund for the Implementation of the Montreal Protocol*, www.multilateralfund.org/aboutMLF/default.aspx. Accessed 19 Jan. 2024

[75] Weiss, Edith Brown. "Vienna Convention for the Protection of the Ozone Layer Vienna, 22 March 1985 Montreal Protocol on Substances that Deplete the Ozone Layer Montreal, 16 September 1987." *Audiovisual Library of International Law*, edited by Codification Division of the UN Office of Legal Affairs, legal.un.org/avl/ha/vcpol/vcpol.html#. Accessed 19 Jan. 2024.

[76] United States Environmental Protection Agency. "Frequent Questions on the Phasedown of Hydrofluorocarbons." *United States Environmental Protection Agency*, 21 Dec. 2023, www.epa.gov/climate-hfcs-reduction/frequent-questions-phasedown-hydrofluorocarbons. Accessed 19 Jan. 2024.

[77] Fahey, David. "33. David Fahey on the Montreal Protocol, ozone depletion and SRM." Interview by Jesse Reynolds and Pete Irvine. *Challenging Climate*, hosted by Jesse Reynolds and Pete Irvine, 4 Apr. 2023. *YouTube*, www.youtube.com/watch?v=7vgT7LfG2YQ. Accessed 13 Feb. 2024.

[78] Rogers, Kara. "hydrofluorocarbon." *Britannica*, edited by The Editors of Encyclopaedia Britannica, 13 Oct. 2023, www.britannica.com/science/hydrofluorocarbon. Accessed 19 Jan. 2024.

[79] Weiss, Edith Brown. "Vienna Convention for the Protection of the Ozone Layer Vienna, 22 March 1985 Montreal Protocol on Substances that Deplete the Ozone Layer Montreal, 16 September 1987." *Audiovisual Library of International Law*, edited by Codification Division of the UN Office of Legal Affairs, legal.un.org/avl/ha/vcpol/vcpol.html#. Accessed 19 Jan. 2024.

[80] "Consumption of ozone-depleting substances." *European Environment Agency*, 15 Sept. 2023, www.eea.europa.eu/en/analysis/indicators/consumption-of-ozone-depleting-substances#:~:text=The%20protocol%20covers%20around%20100,and%20methyl%20bromide%20(MB)%2C. Accessed 19 Jan. 2024.

The Montreal Protocol was a turning point in environmental legislation as an epitome of collaboration for the U.S. and beyond. As former Prime Minister of the United Kingdom and chemist[81] Margaret Thatcher said at a 1990 global ozone layer conference, “we sink or swim together… we cannot achieve satisfactory results while major producers and users of these substances remain outside it.”[82]

The Montreal Protocol became the first universally adopted UN treaty.[83] Through collaboration across various sectors and dozens of countries, the protocol radically changed the stratospheric ozone. By 2019, the treaty phased out 98% of ODS, preventing approximately 2 million skin cancer cases annually.[84] From 1986 to 2021, global CFC emissions plunged from 1.08 million tonnes to -848.[85] In the US, consumerism plummeted from 1986’s 100 default to -0.4 in 2021, displaying preference towards environmentally-friendly alternatives.[86] In October 2022,[87] a scientific panel reported that by 2040, the ozone layer will likely meet 1980 levels,[88] demonstrating the protocol’s success.

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[81] *Thatcher, Margaret, Baroness Thatcher of Kesteven.* Encyclopedia Britannica, Chicago, 2015. *ProQuest*, https://www.proquest.com/encyclopedias-reference-works/thatcher-margaret-baroness-kesteven/docview/1941023642/se-2.

[82] Thatcher, Margaret. "Speech to Ozone Layer Conference." 27 June 1990. *Margaret Thatcher Foundation*, www.margaretthatcher.org/document/108133. Accessed 19 Jan. 2024. Speech.

[83] Office of Environmental Quality. "The Montreal Protocol on Substances That Deplete the Ozone Layer." *U.S. Department of State*, www.state.gov/key-topics-office-of-environmental-quality-and-transboundary-issues/the-montreal-protocol-on-substances-that-deplete-the-ozone-layer/#:~:text=The%20Montreal%20Protocol%2C%20finalized%20in,%2Ddepleting%20substances%20(ODS). Accessed 19 Jan. 2024.

[84] "Thirty years on, what is the Montreal Protocol doing to protect the ozone?" *UN environment programme*, 15 Nov. 2019, www.unep.org/news-and-stories/story/thirty-years-what-montreal-protocol-doing-protect-ozone. Accessed 19 Jan. 2024.

[85] Roser, Max, and Hannah Ritchie. "Ozone Layer." *Our World in Data*, Global Change Data Lab, ourworldindata.org/ozone-layer?insight=the-montreal-protocol-is-one-of-the-most-successful-international-agreements-to-date#key-insights-on-the-ozone-layer. Accessed 19 Jan. 2024.

[86] Ibid.

[87] World Meteorological Organization, et al. *Scientific Assessment of Ozone Depletion: 2022 Executive Summary*. Report no. 278.

[88] "Ozone layer recovery is on track, due to success of Montreal Protocol." *United Nations: UN News Global perspective Human stories*, 9 Jan. 2023, news.un.org/en/story/2023/01/1132277. Accessed 19 Jan. 2024.

Regarding scale and feasibility, reducing the ozone depletion's effects differs from mitigating grave climate change.[89] In the 28th Conference of the Parties meeting (COP28), country leaders convened to discuss how to abate the climate crisis; however, while leaders called for decreased fossil fuel production and consumption, they did not decide to phase them out, delaying climate action.[90]

The Montreal Protocol remains a historical asset for climate legislation. Through high-level collaboration across national and global sectors, the protocol successfully upended conflict in the environmental sector. Recalling the legislation that consolidated the world for an environmental cause, the flexibility and cooperation that made the Montreal Protocol successful can be implemented in modern-day policy.

[89] NASA. "NASA Announces Summer 2023 Hottest on Record." *NASA*, 14 Sept. 2023, www.nasa.gov/news-release/nasa-announces-summer-2023-hottest-on-record/. Accessed 19 Jan. 2024.
[90] "COP28 ends with call to 'transition away' from fossil fuels; UN's Guterres says phaseout is inevitable." *United Nations: UN News Global perspective Human stories*, news.un.org/en/story/2023/12/1144742#:~:text=Nations%20at%20COP28%20in%20Dubai,of%20oil%2C%20coal%20and%20gas. Accessed 22 Jan. 2024.

Annotated Bibliography

Primary Sources

Report

National Science Foundation. *National Science Foundation Annual Report 1987*. Government Publishing Office. *U.S. National Science Foundation*, www.nsf.gov/pubs/1987/1987-NSF-Annual-Report.pdf. Accessed 19 Jan. 2024.

This 1987 yearly report from the National Science Foundation has a section titled "Antarctic Ozone Layer: Research Continues" describing the ozone scientific expeditions to the South Pole for two years from 1985. To inform readers about the factors leading up to the Montreal Protocol, this report provides statistics about the prevalence of ODS as well. I used this in my paper in order to smoothly explain the sequence of discoveries that supported the push for effective ozone regulation, which was present both before, during, and after the Montreal Protocol enactment.

Press Releases

Environmental Protection Agency. "Accelerated Phaseout of Ozone-Depleting Chemicals." *EPA: U.S. Environmental Protection Agency*, National Service Center for Environmental Publications, 3 Aug. 2016, www.epa.gov/archive/epa/aboutepa/accelerated-phaseout-ozone-depleting-chemicals.html. Accessed 10 Feb. 2024.

In this 1992 EPA press release, the agency discusses speeding up ozone phase-out processes by making the phase-out dates earlier; in result, I learned of the protocol revisions that brought ODS regulation to quicker speed. Through this knowledge, I was able to further understand the importance of the Montreal Protocol's flexible structure and include the source's context in order to emphasize on this significance. In turn, this overall significance supported my thesis by elaborating on the radical impacts of the protocol that stemmed from global and national cooperation.

Environmental Protection Agency. "Lee M. Thomas Statement on U.S. Ratification of the Montreal Protocol." *EPA: US Environmental Protection Agency*, National Service Center for Environmental Publications, 11 Aug. 2016, www.epa.gov/archive/epa/aboutepa/lee-m-thomas-statement-us-ratification-montreal-protocol.html. Accessed 10 Feb. 2024.

In the form of a 1988 EPA press release, this statement transcript from former EPA administrator Lee M. Thomas recognizes the significance of the U.S. ratification while emphasizing on the necessity of international cooperation for effective progress. By reading this source, I learned about the former EPA leader's stance on the Montreal Protocol, which is a key perspective since his position implies that he is speaking on behalf of the entire agency in this statement. Including his quote in my title along with the additional footnote context helped me convey this point of view in a shorter and concise way.

Interviews

Lee, Mary J., and Donald R. Blake. Videoconference interview with the author. 29 Nov. 2023.

In this interview, UCI Chemistry Professor Donald R. Blake describes his 34-year relationship with Rowland as well as his personal direct involvement in the Montreal Protocol. Through this privilege, I was able to learn more extensively about the obstacles in creating an effective ozone treaty, specifically regarding the chemical industries and their reactions to the 1974 publication. By incorporating these details in my paper, I was able to convey a fuller understanding of the various factors that impacted ozone diplomacy in the 1980s and beyond.

Prather, Michael J. Videoconference interview with the author. 21 Dec. 2023.

In this interview, UCI Earth System Science Professor Michael J. Prather, who was involved in the early ozone assessments throughout the 1970s and 1980s, describes the Montreal Protocol's feasibility. Emphasizing the importance of business in the events that led to the Montreal Protocol, this interview showed the negotiating aspect of the treaty. This opened my understanding of the protocol by broadening my view to a business standpoint.

Rowland, Frank Sherwood. "F. Sherwood Rowland Interview." Interview by Marika Griehsel. *The Nobel Prize*, June 2005, www.nobelprize.org/prizes/chemistry/1995/rowland/interview/. Accessed 12 Jan. 2024.

In this interview, Professor F. Sherwood Rowland provides his account of the 1974 hypothesis. In the interview, Professor Rowland recognizes the importance of the stratospheric ozone hypothesis and the significant ways the Montreal Protocol impacts the modern world (e.g. through environmental movements). Through his perspective, I was able to understand why Rowland relentlessly advocated for action against ODS like CFCs then incorporated this reasoning into my paper.

Solomon, Susan, and Stephen O. Anderson. "Susan Solomon and Stephen Andersen on Saving the Ozone Layer." Interview by Lucas Perry. *Future of Life Institute*, hosted by Lucas Perry, 16 Sept. 2021. *future of life Institute*, futureoflife.org/podcast/susan-solomon-and-stephen-andersen-on-saving-the-ozone-layer/. Accessed 19 Jan. 2024. Transcript.

This podcast interview with Stephen O. Anderson and Susan Solomon discuss firsthand accounts of the process behind the Montreal Protocol. Solomon was involved in the mid-1980s Antarctic ozone expeditions and Anderson was an EPA economist who assisted in the process of making the protocol more financially feasible. By utilizing the information about the varying experimental and economic factors involved in this protocol, I was able to further understand the process behind establishing the Montreal Protocol as a whole.

Thomas, Lee. "Interview with Lee Thomas, EPA's 6th Administrator." *ThomasFull*, EPA Alumni Association. Interview.

In this EPA Alumni Association interview, Lee Thomas, the former EPA administrator who led the federal agency during the Montreal Protocol's establishment, shares his experiences against stratospheric ozone depletion in the 1980s. As he describes the extensive international discussions poured into the ozone protocol, he also provides an example of conflict that resolved into agreement between the EU and the U.S. By including this example in my paper, I was able to further convey the complexities behind protocol discussions due to conflicting interest and historical context between two groups engaged in international diplomacy.

Presentations/Speeches

"Discovery of a Lifetime: F. Sherwood Rowland and the Ozone Layer." *YouTube*, uploaded by UCI Open, 10 Dec. 2012, Discovery of a Lifetime: F. Sherwood Rowland and the Ozone Layer. Accessed 12 Jan. 2024.

This video includes a presentation on F. Sherwood Rowland and the 1974 ozone discovery by former National Academy of Sciences President Ralph J. Cicerone, who brought governmental awareness to the environmental crisis himself. Through this presentation, I learned about Professor Rowland's life and different attitudes toward the 1974 hypothesis. By using the information about how the cartoons helped persuade the public as well as the initial uncollaborative attitude by distinguished science societies, I was able to convey the different perspectives from the initial stages of ozone discoveries.

Reagan, Ronald. "Statement on Signing the Montreal Protocol on Ozone-Depleting Substances." 5 Apr. 1988. *National Archives*, www.reaganlibrary.gov/archives/speech/statement-signing-montreal-protocol-ozone-depleting-substances. Accessed 19 Jan. 2024. Speech.

In this statement about the US' Montreal Protocol ratification, former President Reagan emphasizes the importance of the treaty while urging other states to become member states. To relay its significance, Reagan highlights the benefits of protecting ozone, which he describes as a key resource. The nuances in this speech helped me corroborate the U.S. perspective of the Montreal Protocol; for example, by using the information about the minimum required states for official ratification, I was able to elaborate on the country's stance in my paper.

Thatcher, Margaret. "Speech to Ozone Layer Conference." 27 June 1990. *Margaret Thatcher Foundation*, www.margaretthatcher.org/document/108133. Accessed 19 Jan. 2024.

Speech.

Through her speech at the Second Meeting of Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer, Former United Kingdom Prime Minister Margaret Thatcher lauds ozone-related accomplishments and calls for more action. By this speech, I specifically learned about the UK government's stance on the ozone depletion issue and how Thatcher believed that hard effort was truly necessary in order to pull through successful environmental conclusions. This supported the international angle portion of my thesis as nations were able to come together to reduce stratospheric ozone depletion through this persevering work amid initially scientific uncertainty and contentious discussion.

Treaty Document

Vienna Convention. United Nations Environment Programme, https://ozone.unep.org/treaties/vienna-convention/articles/article-3-research-and-systematic-observations#:~:text=The%20Parties%20undertake%20to%20promote,observation%20of%20the%20state%20of. Accessed 13 Feb. 2024.

The Vienna Convention for the Protection of the Ozone Layer lays a foundation for the Montreal Protocol, setting guidelines for responsibilities ranging from data collection to withdrawals. In particular, I focused on Article 3, which states that the convention's member states must cooperate when gathering data on stratospheric ozone depletion and relay that information in a timely, regular way. This context was especially

important in my paper because it helped me attribute the Montreal Protocol's flexibility and success to the Vienna Convention.

Articles

Glaberson, William. "Behind Du Pont's Shift On Loss of Ozone Layer." *The New York Times*, The New York Times Company, 26 Mar. 1988, www.nytimes.com/1988/03/26/business/behind-du-pont-s-shift-on-loss-of-ozone-layer.html. Accessed 19 Jan. 2024.

This 1988 article from The New York Times reports on DuPont, the major chemical industry, and its 1988 decision to halt its CFC production—a decision largely driven by a mid-March National Aeronautics and Space Administration (NASA) panel on stratospheric ozone depletion. I learned about the chemical industry perspective on CFC bans and ozone depletion, which helped me understand why they willingly cooperated in favor of ODS regulations. I also learned about the relatively small impact the halt would have on DuPont's monetary profit, which I directly used in my paper since financial investment was a key factor for the company when they were deciding whether or not to support a CFCs ban.

Holusha, John. "Du Pont to Construct Plants For Ozone-Safe Refrigerant." The New York Times, The New York Times Company, 23 June 1990, www.nytimes.com/1990/06/23/business/du-pont-to-construct-plants-for-ozone-safe-refrigerant.html. Accessed 19 Jan. 2024.

This 1990 article from The New York Times reports on the chemical company DuPont's plans to build plants to create CFC-free refrigerants. Within this report, the writer provides the perspectives on CFC alternatives from industrial and environmental

standpoints. Through this knowledge, I grew aware of the possible ramification of early or late HCFC bans, which helped me understand the high-stakes nature of legislative action.

Jones, Lanie. "Ozone Warning : He Sounded Alarm, Paid Heavy Price." *Los Angeles Times*, 14 July 1988, www.latimes.com/archives/la-xpm-1988-07-14-mn-8873-story.html. Accessed 12 Jan. 2024.

This LA Times article describes the opposition Sherwood F. Rowland and Mario Molina faced after publishing their 1974 discovery on CFCs' impact on stratospheric ozone depletion. Through the forms of opposition detailed in the article I learned about the obstacles that made it so difficult for Rowland to persuade others to act against CFCs. Due to these hardships, I was able to further understand the monumental meaning behind the Montreal Protocol given how the treaty was a landmark for universal collaboration.

Molina, Mario J., and F. S. Rowland. "Stratospheric sink for chlorofluoromethanes: chlorine atom-catalysed destruction of ozone." *Nature*. Abstract.

This article is from Rowland and Molina's 1974 hypothesis. Through the abstract, I learned about the overall process that leads to stratospheric ozone depletion as well as the exact date of the hypothesis. The specific date helped me track the chronological sequence of events from the initial hypothesis to the coming decades.

---. "Ozone Issue: Economics of a Ban." *The New York Times* [New York City], 11 Jan. 1990, p. 1. *The New York Times*, www.nytimes.com/1990/01/11/business/ozone-issue-economics-of-a-ban.html. Accessed 22 Jan. 2024.

Similar to another 1990 article on the ozone-free refrigerant plant plans, this report describes the environmentalists' and industries' stances on the timing of the HCFC ban; however, this source emphasizes the amount of money needed in order to effectively implement the alternative(s). By learning about the large monetary requirement for large-scale HCFC production and its fiscal impact, I was able to understand the economic implications of the Montreal Protocol. Since this article elaborates on the environmentalists' perspective on HCFCs compared to the other 1990 article, I deepened my understanding of research and scientific justification even after the protocol was ratified.

Shabecoff, Philip. "Dozens of Nations Reach Agreement to Protect Ozone." *The New York Times*, The New York Times Company, 17 Sept. 1987, www.nytimes.com/1987/09/17/world/dozens-of-nations-reach-agreement-to-protect-ozone.html. Accessed 19 Jan. 2024.

This 1987 article from The New York Times reports on the global Montreal Protocol ratification and briefly details its main stipulations. I learned that the protocol aims to decrease ODS consumption levels by specific percentage points by certain years (e.g. requiring halons reach 1986 levels by 1994). This source was especially meaningful because it provides information on the conditions made under the initial Montreal Protocol establishment, not that of the amendments. Especially since I later detailed the changes to the Montreal Protocol in a separate section in my paper, I thought it was important to include these initial conditions to clearly establish the alterations over time.

---. "Treaty On Ozone Is Backed In Senate." *The New York Times*, The New YorkTimes Company, 15 Mar. 1988, www.nytimes.com/1988/03/15/science/treaty-on-ozone-is-backed-in-senate.html. Accessed 19 Jan. 2024.

This article from *The New York Times* reports on the Senate ratification of the Montreal Protocol in the spring of 1988. According to the article, the Senate approved the treaty through a landslide 83-0 vote. Through this article, I was able to incorporate the statistic about the Senate vote as evidence to show the level of cooperation on the U.S. national scale.

"UNITED NATIONS: VIENNA CONVENTION FOR THE PROTECTION OF THE OZONE LAYER." *International Legal Materials*, vol. 26, no. 6, 1987, pp. 1516–40. *JSTOR*, http://www.jstor.org/stable/20693168. Accessed 19 Jan. 2024.

This article details the Vienna Convention's stipulations and includes a letter of transmittal from former President Ronald Reagan. In the letter of transmittal, President Reagon discusses U.S. interest in mitigating the ozone depletion crisis, which included potential economic gain and global leadership. By including this information in my paper, I was able to add variety to the different perspectives surrounding the Montreal Protocol and elaborate on the U.S. governmental role in the treaty's establishment.

Whitney, Craig R. "80 Nations Favor Ban To Help Ozone." *The New York Times*, The New York Times Company, 3 May 1989, www.nytimes.com/1989/05/03/world/80-nations-favor-ban-to-help-ozone.html. Accessed 19 Jan. 2024.

This 1989 article from The New York Times reports that 80 countries expressed their inclination to halt certain chemicals' production. Given the accumulating scientific research that points towards CFCs' damage on the stratospheric ozone layer, I learned about the increasing governmental action against the substances that deplete the ozone. While keeping the importance of accumulating scientific evidence in mind, I directly used information about the Montreal Protocol's implementation date in order to provide an accurate, chronological explanation in my paper.

Secondary Sources

Fact Sheet

UNEP Ozone Secretariat. "Fact Sheet 2: Overview of HFC Market Sectors." *UN environment programme: ozone secretariat*, Oct. 2015, ozone.unep.org/sites/ozone/files/Meeting_Documents/HFCs/FS_2_Overview_of_HFC_Markets_Oct_2015.pdf. Accessed 19 Jan. 2024.

From the UNEP Ozone Secretariat, this fact sheet file overviews HFCs, one of the alternatives for CFCs. By learning about the transition from HCFCs to HFCs and the HFC markets across varying sectors, I elaborated on the CFC substitutes that followed the 1987 Montreal Protocol.

Articles

"About the Multilateral Fund." *Multilateral Fund for the Implementation of the Montreal Protocol*, www.multilateralfund.org/aboutMLF/default.aspx. Accessed 19 Jan. 2024

This informational article provides details about the Multilateral Fund, a provision that was added to the Montreal Protocol in 1990 through the London Amendment. I

learned about the significance and weight of the Multilateral Fund, which was implemented in order to help developing countries meet the Montreal Protocol conditions. Including information about the fund's purpose, my paper was able to further elaborate how the protocol was so successful.

"Back from the brink: how the world rapidly sealed a deal to save the ozone layer." *Rapid Transition Alliance*, 11 June 2019, rapidtransition.org/stories/back-from-the-brink-how-the-world-rapidly-sealed-a-deal-to-save-the-ozone-layer/. Accessed 12 Jan. 2024.

From the Rapid Transition Alliance, an organization network that aims to spread hopeful evidence-backed news about the climate, this article provides a history of the Montreal Protocol, DuPont's involvement, and the factors that allowed the agreement to become successful. In particular, I learned about the GreenFreeze fridge, an alternative for CFC refrigerants that was established in 1992 by a global environment advocacy group called Greenpeace. I directly used this example in my paper to show that additional group(s) other than DuPont proactively sought alternatives to find alternatives to CFCs.

"Consumption of ozone-depleting substances." *European Environment Agency*, 15 Sept. 2023, www.eea.europa.eu/en/analysis/indicators/consumption-of-ozone-depleting-substances#:~:text=The%20protocol%20covers%20around%20100,and%20methyl%20bromide%20(MB)%2C. Accessed 19 Jan. 2024.

From the European Environment Agency, this article provides information on EU member states' progress on reducing stratospheric ozone depletion. Along with the data tables showing the EU's ODS consumption levels that helped me perceive the outcomes of Montreal Protocol regulations, I also learned that the list of regulated chemicals expanded since the 1980s. In my paper, context about the expanding list of regulated substances further demonstrated the additive, flexible nature of the protocol.

"COP28 ends with call to 'transition away' from fossil fuels; UN's Guterres says phaseout is inevitable." *United Nations: UN News Global perspective Human stories*, news.un.org/en/story/2023/12/1144742#:~:text=Nations%20at%20COP28%20in%20Dubai,of%20oil%2C%20coal%20and%20gas. Accessed 22 Jan. 2024.

This news article from the United Nations reports on COP28, a global meeting that can impact the world's progress in environmental legislation. By learning about the status quo of the progress behind these meetings, I was able to understand why climate action is especially necessary now.

Gilet, Candace. "Ozone depletion." Edited by Anna Thanukos. *Understanding Science*,undsci.berkeley.edu/ozone-depletion-uncovering-the-hidden-hazard-of-hairspray/the-tip-of-the-iceberg/. Accessed 12 Jan. 2024.

This article from Berkeley explains the sequence of discoveries that drove advocacy for CFC regulations, from James E. Lovelock to Professors Sherwood F. Rowland and Mario Molina. Through this information, I was able to further understand the role of science in the Montreal Protocol and the origins of stratospheric ozone depletion discussions. Since background information is necessary in order to explain the history

of ozone depletion, I specifically used the context about Lovelock's presentation in my paper.

Molina, Mario., and Janda, Kenneth. "Ralph J. Cicerone *(1943–2016)." Nature. 14 Dec. 2016. https://doi.org/10.1038/540342a,* https://www.nature.com/articles/540342a

This article from the *Nature* journal honors Ralph J. Cicerone, an atmospheric scientist who beneficially contributed to environmental policy. Since he directly helped bring stratospheric ozone depletion to the forefront of an environmental cause, his efforts contributed to the Montreal Protocol establishment. Through this source, I was able to learn about Cicerone's direct contributions to the agreement, which helped me understand the various factors involved in the legislative process.

NASA. "NASA Announces Summer 2023 Hottest on Record." *NASA*, 14 Sept. 2023, www.nasa.gov/news-release/nasa-announces-summer-2023-hottest-on-record/. Accessed 19 Jan. 2024.

This NASA article reports 2023 summer as the warmest in recorded history. By learning about this historical landmark, I was able to further understand the dire environmental impacts of climate change. Through this understanding, I was able to truly emphasize the Montreal Protocol's environmental consequences and its connection to modern environmental crises as I wrote this paper.

Office of Environmental Quality. "The Montreal Protocol on Substances That Deplete the Ozone Layer." *U.S. Department of State*, www.state.gov/key-topics-office-of-environmental-quality-and-transboundary-issues/the-montreal-protocol-on-substances-that-deplete-the-ozone-layer/#:~:text=The%20Mont

real%20Protocol%2C%20finalized%20in,%2Ddepleting%20substances%20(ODS). Accessed 19 Jan. 2024.

This article from the U.S. Department of State details the Montreal Protocol with a focus on the Kigali Amendment. By learning that the US referendum for the Montreal Protocol preceded over thirty years of bipartisan cooperation, I was able to support my thesis directly regarding the national scale.

"Ozone layer recovery is on track, due to success of Montreal Protocol." *United Nations: UN News Global perspective Human stories*, 9 Jan. 2023, news.un.org/en/story/2023/01/1132277. Accessed 19 Jan. 2024.

This 2023 UN News article provides insight into the stratospheric ozone layer's current recovery after the Montreal Protocol was ratified in 1987. I learned about the large progress that ozone layer recovery has made so far, as well as statistics about what is anticipated to occur in the future with regards to ozone depletion recovery. In my paper, I specifically included data about the expected ozone levels in 2040 relative to 1980 in order to convey how the Montreal Protocol will continue impacting the world in coming decades, further justifying its legacy as an environmental turning point made possible through legislation.

Rogers, Kara. "hydrofluorocarbon." *Britannica*, edited by The Editors of Encyclopaedia Britannica, 13 Oct. 2023, www.britannica.com/science/hydrofluorocarbon. Accessed 19 Jan. 2024.

From Britannica, the article describes HFCs, one of the CFC alternatives. I learned that despite HFCs' lacking ozone-depleting abilities, they are a strong greenhouse gas that

significantly contribute to global warming. In my paper, I incorporated this information to bring more insight into the reasons for CFC alternatives.

Rotman, David. "Remembering the Montreal Protocol." *MIT Technology Review*, Elizabeth Bramson-Boudreau, 1 Jan. 2007, www.technologyreview.com/2007/01/01/227161/remembering-the-montreal-protocol/. Accessed 22 Jan. 2024.

This article from the MIT Technology Review summarizes the controversy that led to the Montreal Protocol's establishment. As the article sources Professor F. Sherwood Rowland, providing a primary source within a secondary one, I learned about his personal stance on the processes behind the treaty. I used a quote from Professor Rowland about the mundane nature of the items with harmful CFCs to highlight how he himself admitted that the 1974 hypothesis's implications could provoke disbelief.

Science History Institute Museum & Library. "Susan Solomon." Science History Institute Museum & Library, Accessed 13 Feb. 2024.

This article from the Science History Institute Museum & Library provides a biography of Professor Susan Solomon, who directly participated in the 1980s research process that built the science-based foundation justifying the Montreal Protocol establishments. By learning that her 1980s discoveries corroborated with the 1974 hypothesis, I was able to further show the large scale of experimentation that led to the treaty as well as the building credibility of science behind ozone regulation.

Thatcher, Margaret, Baroness Thatcher of Kesteven. Encyclopedia Britannica, Chicago, 2015. *ProQuest*,

https://www.proquest.com/encyclopedias-reference-works/thatcher-margaret-baroness-kesteven/docview/1941023642/se-2.

This article provides a biography of former United Kingdom Prime Minister Margaret Thatcher. By learning that she was a research chemist before becoming prime minister, I was able to justify why I included her quote in my paper since the occupation suggested expertise about the processes behind scientific proofs or experiments as well as the science behind ozone depletion.

The Editors of Encyclopaedia Britannica. "F. Sherwood Rowland." *Britannica*, 24 June 2023, www.britannica.com/biography/Frank-Sherwood-Rowland. Accessed 12 Jan. 2024.

This Britannica article is a biography of Professor F. Sherwood Rowland, whose discovery and environmental-related efforts helped bring stratospheric ozone depletion to the national then international spotlight. In particular, I learned that the National Academy of Sciences conceded with the 1974 discovery and the subsequent 978 aerosol ban that followed. By implementing this information in my paper, I was able to chronologically detail the sequence of events following the initial 1974 discovery, recording the different moments that supported the professors' hypothesis.

The Editors of Encyclopaedia Britannica. "Montreal Protocol." *Britannica*, edited by The Editors of Encyclopaedia Britannica, 21 Dec. 2023, www.britannica.com/event/Montreal-Protocol. Accessed 13 Feb. 2024.

In this Britannica article, writers provide background information on the Montreal Protocol and the fundamental details surrounding the agreement, corroborating on the discoveries that led to the agreement's establishment. Since I found this source in the

beginning stages of my research, I was able to familiarize myself with the general sequence of events that led up to the Montreal Protocol along with why ozone depletion was a particularly important issue at that time. The source also provides a clear explanation for how CFCs contribute to ozone depletion, which enhanced my understanding of the science behind this topic and is implemented in my paper.

Whitesides, Greg. "Learning from Success: Lessons in Science and Diplomacy from the Montreal Protocol." *AAAS Science & Diplomacy*, edited by Kimberly Montgomery and E. William Colglazier, Center for Science Diplomacy, 10 Aug. 2020, www.sciencediplomacy.org/article/2020/learning-success-lessons-in-science-and-diplomacy-montreal-protocol. Accessed 19 Jan. 2024.

This Science Diplomacy article describes key takeaways from the Montreal Protocol. Along with the diplomacy behind combatting stratospheric ozone depletion, I also learned that reports from World Meteorological Organization and National Aeronautics and Space Administration confirmed surfacing scientific findings that supported the 1974 hypothesis. By including the latter half in my paper, I was able to detail the process behind accumulating scientific credibility.

Booklet

American Chemical Society. Chlorofluorocarbons and Ozone Depletion. 2017. www.acs.org/content/dam/acsorg/education/whatischemistry/landmarks/cfcsozone/cfcs-ozone.pdf

This American Chemical Society booklet on stratospheric ozone depletion details the history behind the Montreal Protocol and the different perspectives involved, including information about the challenges that made ozone regulation a difficult topic to discuss.

In particular, I learned that ozone regulation critics claimed that scientific principles such as the accuracy behind the collection of stratospheric data was uncertain. In turn, this information helped me elaborate on a different point of view on the ozone discovery and its regulation.

Graphs

Our World in Data. “Change in the consumption of ozone-depleting substances.” UN Environment Programme, Accessed 13 Feb. 2024.

This Our World in Data map shows the level of ODS consumption from 1986 to 2021 in the US. I observed that the U.S. ODS consumption plunged especially after the Montreal Protocol went into action in the late 1980s. By using this info in my paper, I was able to show how the protocol impacted the U.S. on the national scale.

Our World in Data. “Emissions of ozone-depleting substances, World.” UN Environment Programme, Accessed 13 Feb. 2024.

This map from Our World in Data shows worldwide ODS emissions quantified by tonnes relative to years. Through this visually represented data, I learned about the drastic decreases in ODS emissions around the time of the Montreal Protocol’s implementation in 1989, including CFCs. By implementing this data in my paper, I was able to show how successful the Montreal Protocol was.

Webpages

"About." *Greenpeace*, www.greenpeace.org/usa/about/. Accessed 19 Jan. 2024.

This webpage provides information about Greenpeace, an international campaign organization that was mentioned as an example in the Rapid Transition Alliance article. Learning that Greenpeace is an environmental advocacy group explained why they

proactively invested in creating a CFC-free refrigerator in the first place, which deepened my understanding of their participation.

"About Montreal Protocol." *UN environment programme*, www.unep.org/ozonaction/who-we-are/about-montreal-protocol. Accessed 12 Jan. 2024.

This webpage from the UN Environment Programme (UNEP) provides background information on the Montreal Protocol. Of the background information, the key facts that I mainly used this source for were about the treaty's adoption date and the amendments added to the agreement over time. Since UNEP is an official credible source, directly implementing the adoption date as a chronological anchor helped me organize the order of events in my research outline before I began writing my paper.

"Basic Ozone Layer Science." *United States Environmental Protection Agency*, National Service Center for Environmental Publications, 7 Oct. 2021, www.epa.gov/ozone-layer-protection/basic-ozone-layer-science#:~:text=Depletion%20of%20this%20layer%20by,organisms%2C%20plants%2C%20and%20plastics. Accessed 13 Feb. 2024.

This EPA webpage details the science behind stratospheric ozone. Of the sciences, one key learned fact was how the ozone depletion process is a chain reaction where 100,000 ozone molecules can be broken apart through one chlorine atom, which highlighted the destructive nature of CFCs. By learning the "how" behind this ozone depletion, I was able to understand the wide scope of the Montreal Protocol more thoroughly, and gear that knowledge towards my research and writing process.

Colwell, Steve, and Jonathan Shanklin. "The Ozone Hole." *British Antarctic Survey Natural Environment Research Council*, 30 June 2022, www.bas.ac.uk/data/our-data/publication/the-ozone-layer/. Accessed 12 Jan. 2024.

This webpage from the British Antarctic Survey, a group that actively participated in the 1980s ozone assessments, explains how the Antarctic ozone hole was discovered. I also learned about the ozone hole's implications, connection to global warming, and its 2016 status quo. Moreover, I learned about how the ozone layer faces slower recovery from global warming, which helped me understand why the Montreal Protocol and climate change are connected scientifically as well.

"Ground-level Ozone Basics." *United States Environmental Protection Agency*, National Service Center for Environmental Publications, 2 June 2023, www.epa.gov/ground-level-ozone-pollution/ground-level-ozone-basics. Accessed 13 Feb. 2024.

This EPA webpage explains the difference between stratospheric ozone and ground-level ozone, emphasizing on the latter's effects and scientific implications. In particular, I learned that stratospheric ozone is helpful as it protects against UV radiation while ground-level ozone is a harmful pollutant. Through this crucial differentiation, I was able to research more accurately and effectively since I could ensure that I was looking at the correct sources that were referring to stratospheric ozone instead of ground-level ozone.

Manzer, L. E. "The CFC-Ozone Issue: Progress on the Development of Alternatives to CFCs." CIESIN. http://www.ciesin.org/docs/011-448/011-448.html. Accessed 13 Feb. 2024.

This article details the process and progress behind the look for CFC alternatives, and it taught me the specific items that contributed significant CFC use. This helped me provide a more tangible picture of how prevalent CFC usage was in day-to-day life. In particular, I learned statistic(s) on the value of CFC services in terms of money and jobs, which helped me understand why the U.S. was eager to produce alternatives.

"Phaseout of Class I Ozone-Depleting Substances." *United States Environmental Protection Agency*, National Service Center for Environmental Publications, 27 Nov. 2023, www.epa.gov/ods-phaseout/phaseout-class-i-ozone-depleting-substances#:~:text=ODS%20include%20chlorofluorocarbons%20(CFCs)%2C,ultraviolet%20light%20in%20the%20stratosphere. Accessed 12 Jan. 2024.

This article from the EPA provides information specifying the qualifications for a substance to be labeled an ODS and a table with anticipated phase-out dates for these ozone-depleting substances. I learned about the different types of ODS, which helped deepen my understanding of the Montreal Protocol since I was able to realize that CFCs were not the only problematic ozone-depleting substances in the world. By including the names of various ODS in my paper, I was able to display a fuller picture of the substances related to the Montreal Protocol and demonstrate this knowledge to readers.

Weiss, Edith Brown. "Status." *Audiovisual Library of International Law*, edited by Codification Division of the UN Office of Legal Affairs, legal.un.org/avl/ha/vcpol/vcpol.html#. Accessed 13 Feb. 2024.

This webpage provides key dates for the Vienna Convention and Montreal Protocol. Under the tab “Status”, I learned the specific dates that the Vienna Convention and Montreal Protocol enactments. By including the date the convention was enacted, I was

able to convey the relatively short time between the enactment date and the ratification date.

Weiss, Edith Brown. "Vienna Convention for the Protection of the Ozone Layer Vienna, 22 March 1985 Montreal Protocol on Substances that Deplete the Ozone Layer Montreal, 16 September 1987." *Audiovisual Library of International Law*, edited by Codification Division of the UN Office of Legal Affairs, legal.un.org/avl/ha/vcpol/vcpol.html#. Accessed 19 Jan. 2024.

From the Audiovisual Library of International Law, this webpage details the Vienna Convention's contributions to the Montreal Protocol then provides a general history of the treaty and the amendments thereafter. By gaining knowledge about the convention's great influence over the protocol as a crucial framework, I learned about the importance of the previous legislation.

Reports

World Meteorological Organization, et al. *Scientific Assessment of Ozone Depletion: 2022 Executive Summary*. Report no. 278.

From multiple global organizations, this report provides a detailed, large overview of the stratospheric ozone layer as of 2022. Specifically, I also learned about when the organizations reported the 2040 statistic which helped my writing flow more chronologically and smoothly.

World Resources Institute. *Ozone Protection in the United States: Elements of Success*. Edited by Elizabeth Cook, Nov. 1996.

This report from the World Resources Institute provides a thorough history of the Montreal Protocol and the progress behind developing CFC alternatives, as of 1996.

Learning about "'green consumerism'" was a major takeaway from this source since it helped me understand the scope of the public's influence over ozone depletion regulations by companies. By incorporating this context in my paper, I was able to convey the substantial public impact on the transition from products containing CFCs to CFC-free ones.

Interview

"Thirty years on, what is the Montreal Protocol doing to protect the ozone?" *UN environment programme*, 15 Nov. 2019, www.unep.org/news-and-stories/story/thirty-years-what-montreal-protocol-doing-protect-ozone. Accessed 19 Jan. 2024.

This introduction preceding this interview transcript with Ozone Secretariat communications officer Stephanie Haysmith provides information about the state of the ozone depletion crisis as of 2019. The introduction includes meaningful statistics about how much ODS was phased out as of 2019 as well as the number of avoided skin cancer cases. By incorporating the statistics about avoided skin cancer cases in my paper, I was able to quantify the Montreal Protocol's radical and beneficial impact on public health.

Podcasts

Fahey, David. "33. David Fahey on the Montreal Protocol, ozone depletion and SRM." Interview by Jesse Reynolds and Pete Irvine. *Challenging Climate*, hosted by Jesse Reynolds and Pete Irvine, 4 Apr. 2023. *YouTube*, www.youtube.com/watch?v=7vgT7LfG2YQ. Accessed 13 Feb. 2024.

In this podcast, climate researchers Dr. Pete Irvine and Dr. Jesse Reynolds interview Dr. David Fahey, Director of the National Oceanic and Atmospheric Administration's Chemical Sciences Laboratory and the Montreal Protocol Scientific Assessment Panel, on the significance of the agreement and stratospheric ozone as well as the transition from CFCs to HCFCs and HFCs. By focusing on the discussion about the transition to CFC-free alternatives, I was able to learn about the consequential global warming from HCFC usage. Through this information, I was able to emphasize on stratospheric ozone depletion's connection to climate change and further highlight the far-reaching consequences of the Montreal Protocol.

Pedrick, Alexis, and Elisabeth Berry Drago, hosts. "Whatever Happened to the Ozone Hole?" *Distillations Podcast*, produced by Rigoberto Hernandez and Mariel Carr, 17 Apr. 2018. *Science History Institute Museum & Library*, sciencehistory.org/stories/distillations-pod/whatever-happened-to-the-ozone-hole/. Accessed 22 Jan. 2024.

This episode of the Distillations Podcast from the Science History Institute Museum & Library discusses the Montreal Protocol as an environmental success. Including clips from primary source news reports that provide info on the status quo on the Montreal Protocol at the time, the source displays the industries' stance on the economic implications of a CFC ban. To show the different factors that impacted the negotiations between scientists, legislators, environmentalists, and industrial corporations, this source was especially helpful.

Videos

"Climate Change: Lessons from the Montreal Protocol." *YouTube*, uploaded by Carnegie Council for Ethics in International Affairs, Oct. 2007, www.youtube.com/watch?v=X2HAwuRyzxU. Accessed 19 Jan. 2024.

This short documentary from the Carnegie Council for Ethics in International Affairs includes a collection of interview clips from stratospheric ozone experts and key figures involved in the 1987 Montreal Protocol, from Dr. Susan Solomon to Dr. Robert Watson, the chair of the International Atmospheric Ozone Assessments from 1980 to 1987. Through this source, I learned about the Montreal Protocol's connection to climate change as a whole as well as why the treaty became so successful. Collectively, the lasting significance of this protocol as conveyed through this source only emphasizes the scope of cooperation necessary to resolve the stratospheric ozone depletion issue.

Schienberg, Jonathan. "Healing the Ozone: First Steps Toward Success." *PBS Learning Media*, 2023, ca.pbslearningmedia.org/resource/healing-the-ozone-first-steps-toward-success-video/retro-report/. Accessed 12 Jan. 2024.

From PBS, this Retro Report documentary overviews the Montreal Protocol and the perspectives involved in the discussion around stratospheric ozone depletion. One of the crucial parts from this source was information about the industry's unwillingness to accept scientific findings pointing towards CFCs as the source of stratospheric ozone depletion, which was shown through an archival CBS clip from 1975 reporting the representatives' unwillingness to accept. By emphasizing on the conflicting perspectives, I was able to highlight the difficulty of coming to a consensus for ozone depletion regulations.

"Why you don't hear about the ozone layer anymore." *YouTube*, uploaded by Vox, 24 Nov. 2021, www.youtube.com/watch?v=CaLOiGEDPJQ. Accessed 12 Jan. 2024.

This Vox documentary provides a general overview of the Montreal Protocol, including the science that led up to the 1987 ratifications and its modern impact. The video also contains an interview with Dr. Susan Solomon, from which I learned why the long CFC lifetime significantly impacted ozone depletion rates. In addition to using this fact in my paper to show why CFCs were especially threatening in the long-term, this source helped me corroborate on the sequential events surrounding the Montreal Protocol.