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Climate Science in Adaptation Litigation in the U.S.

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By Jacob Elkin

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I. INTRODUCTION

The most prominent climate litigation to date has primarily focused on mitigation—reducing greenhouse gas emissions—but as climate impacts become more frequent, extreme, and intense, adaptation litigation will increase.[1] Adaptation cases frequently rely on evidence drawn from scientific research into past and future climate change. This research oftentimes consists of one of two types of climate research: attribution studies of climate change to date, and future projections of climate change and its impacts.

Climate change attribution links human activity to climate change, especially changes in the statistics of extreme weather events. Increasingly, it is also beginning to be applied to impacts across sectors such as public health and agriculture development. As one example of climate change attribution, a recent study found that the Summer 2022 United Kingdom heat wave would have been extremely unlikely without human-induced climate change.[2] Climate projections, by contrast, provide a range of plausible future changes in climate and impacts. The magnitude and range of these projections can vary dramatically based on how far into the future they are assessing climate change: predictions for near-term climate change are generally independent of future greenhouse gas emissions, whereas longer-term projections vary dramatically based on the magnitude of future greenhouse gas emissions.[3] The IPCC has noted that "[m]ethods for projecting climate futures have matured since the 1950s and attribution studies since the 1980s," concluding

[1] IPCC, CLIMATE CHANGE 2022: IMPACTS, ADAPTATION AND VULNERABILITY, Chapter 17: Decision Making Options for Managing Risk at 17-56, https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_FinalDraft_Chapter17.pdf ("Litigation on failure of government and business to adapt is becoming more frequent and is expected to increase as climate impact attribution science matures further").

[2] Mariam Zachariah et al., *Without Human-Caused Climate Change Temperatures of 40°C in the UK Would Have Been Extremely Unlikely*, WORLD WEATHER ATTRIBUTION (July 28, 2022), https://www.worldweatherattribution.org/wp-content/uploads/UK-heat-scientific-report.pdf.

[3] IPCC, CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS, Chapter 1: Framing, Context, and Methods at 1-182–183, https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/.

that "understanding of the principal features of the climate system is robust and well established."[4]

This paper examines climate adaptation litigation in two broad categories: (1) cases seeking adaptation measures; and (2) cases challenging planned or existing adaptation actions. For each, the paper describes the key features of the litigation, the role of climate science in the claims and defenses of the parties advocating for or defending adaptation action, and the arguments put forward to limit the role of climate science in the litigation. The paper concludes that climate science is a critical component of climate adaptation cases and that litigants should integrate the best available science into the cases they bring from the outset, but that key legal questions may prevent climate science from playing a determinative role in certain cases.

II. SCIENTIFIC BACKGROUND

The Intergovernmental Panel on Climate Change's (IPCC) latest reports describe the state of climate change in stark, unequivocal terms: anthropogenic climate change is causing impacts in every corner of the world, driven by atmospheric levels of carbon dioxide and other greenhouse gases that have reached their highest levels in almost a million years.[5]

[4] *Id.* at 184 ("In summary, major lines of evidence–observations, paleoclimate, theoretical understanding and natural and human drivers–have been studied and developed for over 150 years. Methods for projecting climate futures have matured since the 1950s and attribution studies since the 1980s. We conclude that understanding of the principal features of the climate system is robust and well established.").

[5] *See* IPCC, CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS, Summary for Policymakers at SPM-10 (2021) [Summary for Policymakers], https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/ ("Human-induced climate change is already affecting many weather and climate extremes in every region across the globe."); *id.* at SPM-8–9 ("In 2019, atmospheric CO2 concentrations were higher than at any time in at least 2 million years (high confidence), and concentrations of CH4 and N2O were higher than at any time in at least 800,000 years (very high confidence)").

The emission of greenhouse gases, helped along by other anthropogenic activities, have caused pronounced changes in the earth's climate.[6] The IPCC has found that global average surface temperature likely increased roughly 1.07 degrees Celsius between the periods of 1850–1900 and 2010–2019; the rate of warming has been faster since the 1970s, with greenhouse gases as the main driver.[7] Average sea surface temperature and ocean heat content have increased over the same period.[8] As warming continues, the Arctic Ocean is expected to become practically sea ice-free during certain months by 2050, and both the Greenland and Antarctic Ice Sheets are expected to continue to lose mass, thus contributing to sea level rise.[9] In the 20th century, global mean sea level rose faster than in any prior century over the last three millennia,[10] with human influence very likely to have been the main driver of these increases since at least 1971.[11]

Those changes are altering weather patterns in ways that have immediate effects on human life, causing more frequent and severe heat waves,[12] driving stronger storms and

[6] *Id.* at SPM-7 ("Observed warming is driven by emissions from human activities, with greenhouse gas warming partly masked by aerosol cooling. . . . Human-induced climate change is already affecting many weather and climate extremes in every region across the globe. Evidence of observed changes in extremes such as heatwaves, heavy precipitation, droughts, and tropical cyclones, and, in particular, their attribution to human influence, has strengthened since AR5.").

[7] Summary for Policymakers at SMP-5; IPCC CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS, Chapter 2: Changing State of the Climate System at 316, https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter02.pdf; *2020 Was One of Three Warmest Years on Record*, WORLD METEOROLOGICAL ORGANIZATION (Jan. 15, 2021), https://public.wmo.int/en/media/press-release/2020-was-one-of-three-warmest-years-record.

[8] Summary for Policymakers at SPM-5.

[9] IPCC CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS, Chapter 9: Ocean, Cryosphere and Sea Level Change at 1214–15, https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter09.pdf.

[10] *Id.* at 1216.

[11] Summary for Policymakers at SPM-5.

[12] Martha M. Vogel et al., *Concurrent 2018 Hot Extremes Across Northern Hemisphere Due to Human-Induced Climate Change*, 7 EARTH'S FUTURE 692 (2019) ("[I]t is *virtually certain* . . . that the 2018 heat event would not have occurred without human-induced greenhouse gas emissions.") (emphasis in original) (internal citation omitted).

precipitation events,[13] worsening droughts,[14] and exacerbating wildfire risk,[15] among other impacts. These climate impacts lead to a wide range of harms to people all over the world, including higher heat-related mortality,[16] loss of biodiversity and changes to species' growth habits and distribution,[17] lower agricultural productivity,[18] and increased human vulnerability to disease.[19] What's more, changing weather patterns impact other human

[13] Paerl, H.W., Hall, N.S., Hounshell, A.G. et al., *Recent Increase in Catastrophic Tropical Cyclone Flooding in Coastal North Carolina, USA: Long-Term Observations Suggest a Regime Shift*, 9 SCI. REP. 10620 (2019) ("Considering . . . extreme precipitation events and their hydrologic and biogeochemical consequences in totality, it is clear that they are unparalleled in the past 120+ years of recorded tropical cyclones in coastal North Carolina.").

[14] Xing Yuan et al., *Anthropogenic Intensification of Southern African Flash Droughts as Exemplified by the 2015/16 Season* 99 BULL. AM. METEOROLOGICAL SOC. S86, S88 (2018) ("Although both the anthropogenic and natural signals are detectable in attributing the flash drought changes, the anthropogenic influence is mainly responsible for the increasing flash drought over [southern Africa]."); *cf.* T. R. Marthews et al., *The 2014 Drought in the Horn of Africa: Attribution of Meteorological Drivers*, 96 BULL. AM. METEOROLOGICAL SOC. S83, S86 (2014) ("Our results suggest that while anthropogenic increases in greenhouse gas concentrations and associated warming of sea surface temperatures did not increase the likelihood of reduced precipitation in the 2014 East African long rains season, human influences did result in higher temperatures and increased net incoming radiation at the surface over the region most affected by the drought.").

[15] van Oldenborgh et al., *Attribution of the Australian Bushfire Risk to Anthropogenic Climate Change*, 21 NAT. HAZARDS EARTH SYST. SCI. 941, 944 (2021) ("[I]t is clear that climate change does play an important role in heat and fire weather risk overall, [but] assessing the magnitude of this risk and the interplay with local factors has been difficult."); Daniel L. Swain, *A Shorter, Sharper Rainy Season Amplifies California Wildfire Risk*, 48 GEOPHYSICAL RSCH. LETTERS e2021GL092843 ("[Precipitation and vegetation stress] shifts increase the overall flammability of California's vegetation at precisely the time of year when it is already at its driest—an effect compounded by California's observed warming trend, which further increases atmospheric water demand and subsequent moisture deficits.").

[16] Ana Maria Vicedo-Cabrera et al., *The Burden of Heat-Related Mortality Attributable to Recent Human-Induced Climate Change*, 11 NAT. CLIMATE CHANGE 492, 498 (2021) ("[H]ealth burdens from anthropogenic climate change are occurring, are geographically widespread and are non-trivial; in many locations, the attributable mortality is already on the order of dozens to hundreds of deaths each year").

[17] Peter Soroye et al., *Climate Change Contributes to Widespread Declines Among Bumble Bees Across Continents*, 367 SCI. 685 (2020) ("[O]verall rates of climate change–related extirpation among species greatly exceed those of colonization, contributing to pronounced bumble bee species declines across both Europe and North America with unknown consequences for the provision of ecosystem services."),

[18] *See, e.g.*, Ariel Ortiz-Bobea et al. *Anthropogenic Climate Change Has Slowed Global Agricultural Productivity Growth*, 11 NAT. CLIMATE CHANGE 306, 309 (2021) ("The cumulative impact of [anthropogenic climate change] on global agricultural [total factor productivity] growth over the 1961–2020 period is about −20.8% with a 90% confidence interval between −39.1% and −10.1%").

[19] *See, e.g.*, Robert M. Beyer et al., *Shifts in Global Bat Diversity Suggest a Possible Role of Climate Change in the Emergence of SARS-CoV-1 and SARS-CoV-2*, 767 SCI. OF THE TOTAL ENVT. 145413 (2021) (describing evidence of "a possible contributing role of climate change in the evolution or interspecies transmission of SARS-CoV-1and SARS-CoV-2, by driving a substantial increase in bat, and therefore bat-borne CoV"); S.-J. Yoon et al.,

systems—including electricity and water distribution systems—in ways that compound risks to humans and the environment. For example, heat waves increase the risk of electricity outages, which in turn increase the risk of heat-related illness and mortality;[20] electricity outages can also increase the risk of wastewater treatment facilities losing power and polluting nearby drinking water and aquatic environments.[21]

A. Attribution Science

Many of the studies that undergird the above summary are examples of detection and attribution research. In this context, *detection* refers to the demonstration that "climate or a system affected by climate has changed in some defined statistical sense," and *attribution* refers to the "process of evaluating the relative contributions of multiple causal factors to a change or event with an assignment of statistical confidence."[22] The field seeks to identify and explain the contributions of entities, sectors, and activities to changes in climate variables like atmospheric carbon dioxide concentrations; describe how changes in specific variables have affected aspects of the global climate system, including global mean temperature, sea level, and the frequency and magnitude of extreme events; and then to detect and study how climatic changes have impacted humans and local environments, along with other potential climate impacts.[23] Following leading work in this area, this

Measuring the Burden of Disease Due to Climate Change and Developing a Forecast Model in South Korea, 128 PUB. HEALTH 725, 731 (2014) ("Among the total burden of disease due to climate change, the main factors were hypertensive heart disease (1.82 [disability-adjusted life years or "DALY"]/1000population), ischaemic heart disease (1.56 DALY/1000 population) and cerebrovascular disease (1.56 DALY/1000 population). Mortality increases rapidly with increasing temperature.").

[20] Brian Stone Jr. et al., *Compound Climate and Infrastructure Events: How Electrical Grid Failure Alters Heat Wave Risk*, 55 ENV'T SCI. TECHNOL. 6957 (2021).

[21] *See*, ENV'T PROTECTION AGENCY, POWER RESILIENCE: GUIDE FOR WATER AND WASTEWATER UTILITIES, EPA 800–R–19–001 (2019), https://www.epa.gov/sites/default/files/2016-03/documents/160212-powerresilienceguide508.pdf; J.D. Morris, 50,*000 Gallons of Sewage Spill into Oakland-Alameda Waters After Power Failure*, SAN FRANCISCO CHRON. (Aug. 16, 2020), https://perma.cc/SBE4-MK2C.

[22] GABRIELE C. HEGERL ET AL., GOOD PRACTICE GUIDANCE PAPER ON DETECTION AND ATTRIBUTION RELATED TO ANTHROPOGENIC CLIMATE CHANGE (2009).

[23] *See* Michael Burger et al., *The Law and Science of Climate Change Attribution*, 45 COLUM. J. ENV'T L. 57, 66 (2020).

paper describes attribution science in four categories: climate change attribution, impact attribution, extreme event attribution, and source attribution.[24]

Climate change attribution refers to research examining how anthropogenic emissions of greenhouse gases and other pollutants have led to increased atmospheric concentrations of those pollutants and to changes to other parts of the global climate system, including global and regional mean temperatures, sea level, and sea ice extent.[25] These studies identify human-caused "fingerprint" patterns in various climate variables, using numerical models of the climate system to estimate both the human influence on a climate variable and the impact of natural climate variability.[26] Paradigmatic climate change attribution studies quantify, for example, the role of burning fossil fuels in increasing concentrations of greenhouse gases in the atmosphere.[27]

Impact attribution refers to studies that explore how a changing climate effects changes that impact the life of humans and other species around the world. The IPCC describes this body of work as focusing on "[t]he attribution of a change in a natural or human system (e.g., wild species, natural ecosystems, crop yields, economic development, infrastructure or human health) to changes in climate-related systems (i.e., climate, and ocean acidification, permafrost thawing or sea level rise)."[28] While impact attribution is

[24] *See id.* at 66–67.

[25] *See id.*

[26] Benjamn D. Santer et al., *Human and Natural Influences on the Changing Thermal Structure of the Atmosphere*, 110 PROC. NAT'L ACAD. SCI. 17235 (2013).

[27] *See, e.g.*, Gabriele Hegerl, Francis Zwiers & Claudia Tebaldi, *Patterns of Change: Whose Fingerprint Is Seen in Global Warming?*, 6 ENVTL. RES. LETTERS 044025 (2011) ("Rigorous quantitative analyses of the patterns of change in the temperature of the atmosphere and ocean observed over the past half-century, incorporating all known uncertainties in the observations, in our knowledge of climate variability, and feedbacks, underpin the assessment that most of the warming of the past fifty years is 'very likely' (more than 90% likelihood) due to anthropogenic increases in greenhouse gases.").

[28] IPCC CLIMATE CHANGE 2022: IMPACTS, ADAPTATION AND VULNERABILITY, Chapter 1: Point of Departure and Key Concepts at 1-38, https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_FinalDraft_Chapter01.pdf.

relatively newer than the other fields of attribution science, it too is well-established, with impact attribution studies being conducted since the 1990s.[29]

Extreme event attribution refers to studies that look at specific, observed weather events, aiming to detect and quantify the role (if any) that climate change played in such an event. Examples of these studies increasingly arise where extreme events have major impacts on human life,[30] and they are sometimes available within days after an extreme event occurs.[31]

Each of these three types of attribution studies makes use of similar data sources and analytical techniques. They typically rely on a combination of observational data, physical understanding of how climate processes function and relate to human systems, statistical analyses that are used to measure and understand data, and climate models. Observational data—including, for example, measurements of carbon dioxide concentrations in the atmosphere, surface temperatures, sea levels throughout the world, water vapor, precipitation, sea ice, and wind speed—are used to determine baselines against which to detect and measure changes in the measured variables. Understanding physical properties of the climate system and related processes, like the energy-trapping

[29] *See* IPCC, CLIMATE CHANGE 2001: SYNTHESIS REPORT, Summary for Policymakers at 6–8 https://www.ipcc.ch/site/assets/uploads/2018/05/SYR_TAR_full_report.pdf ("Recent regional changes in climate, particularly increases in temperature, have already affected hydrological systems and terrestrial and marine ecosystems in many parts of the world.").

[30] For example, a collection of studies have assessed the role of climate change in Hurricane Harvey *See e.g.*, Kevin Trenberth et al., *Hurricane Harvey Links to Ocean Heat Content and Climate Change Adaptation*, 6 EARTH'S FUTURE 730 (2018); S-Y Simon Wang et al., *Quantitative Attribution of Climate Effects on Hurricane Harvey's Extreme Rainfall in Texas*, 13 ENVTL. RES. LETTERS 1 (2018); Geert Jan van Oldenborgh et al., *Attribution of Extreme Rainfall from Hurricane Harvey, August 2017*, 12 ENVTL. RES. LETTERS 1 (2017); Mark Risser & Michael Wehner, *Attributable Human-Induced Changes in the Likelihood and Magnitude of the Observed Extreme Precipitation During Hurricane Harvey*, 44 GEOPHYSICAL RES. LETTERS 12457 (2017).

[31] *See, e.g.*, Henry Fountain, *Climate Change Drove Western Heat Wave's Extreme Records, Analysis Finds*, N.Y.T. (July 7, 2021), https://www.nytimes.com/2021/07/07/climate/climate-change-heat-wave.html (describing a study completed in just over a week and done using peer-reviewed techniques found that a heat wave almost certainly would not have occurred without global warming); *Pathways and Pitfalls in Extreme Event Attribution*, WORLD WEATHER ATTRIBUTION (May 13, 2021), https://www.worldweatherattribution.org/pathways-and-pitfalls-in-extreme-event-attribution/; Eric Roston & Jackie Gu, *How Scientists Know that Climate Change Juices Heat Waves*, BLOOMBERG GREEN (Nov. 9, 2021), https://www.bloomberg.com/graphics/2021-extreme-weather-analysis/.

effects of atmospheric carbon dioxide or the reflectivity of ice, provides a way to develop models for how climate variables interact with each other and human activities. Statistical analyses can be used to evaluate—for example— whether observations are consistent with internal variability or indicative of anthropogenic climate change. Modeling, finally, allows scientists to simulate interactions among climate and environmental variables both with and without anthropogenic climate forcing in the simulation. By running a model that reflects actual greenhouse gas concentrations and then re-running the model with the concentrations that would have been expected without human influence, scientists can explore what changes appear and are thus likely a result of human activity.[32]

Source attribution refers to studies that aim to identify the nature and extent of a particular entity, activity, or place's contribution to global climate change.[33] Source attribution is conceptually linked to the other types of attribution science because it

[32] A complete discussion of the precise techniques used in each type of attribution study is beyond the scope of this paper. For more detailed discussions of the methodologies used in particular types of attribution see, for example, IPCC, CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS, Technical Summary at TS-73 (2021), https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/; Elisabeth Lloyd & Naomi Oreskes, *Climate Change Attribution: When Is It Appropriate to Accept New Methods?*, 6 EARTH'S FUTURE 311 (2018); NAT'L ACAD. OF SCI., ENG'G, AND MED., ATTRIBUTION OF EXTREME WEATHER EVENTS IN THE CONTEXT OF CLIMATE CHANGE 51 (2016); Theodore G. Shepherd, *A Common Framework for Approaches to Extreme Event Attribution*, 2 CURRENT CLIMATE CHANGE REPS. 28 (2016); Peter A Stott et al., *Attribution of Extreme Weather and Climate-Related Events* 7 WIREs CLIM CHANGE 23–41 (2016); Kevin E. Trenberth, John T. Fasullo, and Theodore G. Shepherd, *Attribution of Climate Extreme Events* 5 NAT. CLIMATE CHANGE 725 (2015); Gabriele C. Hegerl, Use of Models and Observations in Event Attribution, 10 ENVTL. RES. LETTERS 1 (2015); and Mike Hulme, *Attributing Weather Extremes to 'Climate Change': A Review*, 38 PROGRESS IN PHYSICAL GEOGRAPHY 499, 500 (2014).

[33] *See, e.g.*, RICHARD HEEDE, CARBON MAJORS: ACCOUNTING FOR CARBON AND METHANE EMISSIONS 1854–2010: METHODS & RESULTS REPORT (2014), https://climateaccountability.org/pdf/MRR%209.1%20Apr14R.pdf (assessing specific oil, natural gas, coal, and cement producers); Matthew J. Eckelman and Jodi D. Sherman, *2018: Estimated Global Disease Burden From US Health Care Sector Greenhouse Gas Emissions*, 108 AM. J. OF PUBLIC HEALTH S120_S122 (2021), https://doi.org/10.2105/AJPH.2017.303846 (assessing the United States' healthcare system); Sourish Basu et al., *Estimating US Fossil Fuel CO2 Emissions from Measurements of 14C in Atmospheric CO*, 24 PROC. NAT'L ACAD. SCI. 117 (2020) (assessing the United States itself); C40 CITIES CLIMATE LEADERSHIP GROUP, CONSUMPTION-BASED GHG EMISSIONS OF C40 CITIES (2018), https://www.c40.org/researches/consumption-based-emissions (certain cities); Emrah Koçak et al., *The Impact of Tourism Developments on CO2 Emissions: An Advanced Panel Data Estimation*, 33 TOURISM MGMT. PERSPECTIVES (2020) (assessing tourism in the most visited countries 1995 to 2014); Dario Caro et al., *Greenhouse Gas Emissions Due to Meat Production in the Last Fifty Years, in* QUANTIFICATION OF CLIMATE VARIABILITY, ADAPTATION AND MITIGATION FOR AGRICULTURAL SUSTAINABILITY 27 (Mukhtar Ahmed & Claudio O. Stockle eds., 2017) (assessing the production of beef cattle, pork and chickens).

contributes to an understanding of the full causal chain that links specific activities to climate change impacts in quantifiable ways. It is distinct from the other types of attribution science though, in terms of both technique and data sources. Source attribution studies critically depend on documentary evidence like historical records of fossil fuel producers or consumers showing the amount and type of fossil fuels produced or consumed during the course of an entity, project, or activity. Those records can include national greenhouse gas inventories, fossil fuel extraction and use reports, securities disclosures, and reports prepared by governments and private actors quantifying the emissions or sequestration caused by particular activities. So, for example, by figuring out how much of a fossil fuel was consumed, accounting for all the factors relevant to translating that fuel into greenhouse gases, and comparing that figure to the total concentration of anthropogenic carbon dioxide in the atmosphere, researchers can attribute a specific percentage of total atmospheric carbon to a particular source.[34]

B. Managing Challenges and Limitations in Attribution Science

Attribution science can help illuminate how anthropogenic climate change has affected both natural and human systems, for example through changes in the probability or characteristics of extreme events—but there are limitations on how attribution science can be used and some remaining uncertainties.

One major challenge facing attribution science is the presence of confounding variables; this challenge becomes all the greater when researchers seek to assess the role of climate change in generating discrete, local impacts. Confounding variables—including local contexts and decisions that are relatively removed from anthropogenic climate change, such as local water management decisions, use of impervious surfaces, and tree cutting—make it more difficult to identify climate change impacts such as flooding or

[34] *See, e.g.*, HEEDE, *supra* note 33, at 29 (attributing 3.52% of cumulative global carbon dioxide equivalent emissions to Chevron in particular).

water shortage than if those impacts could be studied without such variables.[35] As a result, many impact attribution studies focus on just a single link in the causal chain of climate change: this approach, referred to as "single-step attribution," seeks to ameliorate the difficulties that arise from assessing many exogenous variables in the same attribution study.[36]

Another concern that may arise from the utilization of attribution science in non-scientific contexts is the varying degrees of confidence attached to different scientific conclusions. These varying degrees of confidence are not unique to climate science. As authors in the Proceedings of the National Academy of Sciences described: "[a]ll science has uncertainty," and "[r]esearch directed at clarifying facts can provide imperfect answers to questions such as how well an oil pipeline will be maintained and monitored, how long the recovery period will be after bariatric surgery, and how much protection bicycle helmets afford."[37] Since "[t]aking full advantage of scientific research requires knowing how much uncertainty surrounds it,"[38] researchers typically convey their conclusions in terms of degrees of confidence, rather than absolute certainty: a study may conclude, for example, that a result is "virtually certain (>99% probability)"[39] or a conclusion is reached "with high confidence."[40] These statements can be misinterpreted to mean that the scientific study itself is an unreliable source of information. However, probabilistic language is common across many fields of scientific study and is used to

[35] *See* Burger et al., *supra* note 23, at 74; IPCC CLIMATE CHANGE 2022: IMPACTS, ADAPTATION AND VULNERABILITY, Chapter 16: Key Risks Across Sectors and Regions at 16-15, https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_FinalDraft_Chapter16.pdf ("for impact attribution [the main challenge] often is the separation of the effects of other external forcings (i.e., direct human influences or natural disturbances) from the impacts of the changes in the climate-related systems.").

[36] Burger et al., *supra* note 23, at 74.

[37] Baruch Fischhoff & Alex L. Davis, *Comunicating Scientific Uncertainty*, 111 PROCS. OF THE NAT'L ACAD. OF SCIS. 13664, 13664 (2014).

[38] *Id.*

[39] *See, e.g.*, R. F. Stuart-Smith et al., *Increased Outburst Flood Hazard from Lake Palcacocha Due to Human-Induced Glacier Retreat*, 14 NATURE GEOSCIENCE 85–90 (2021).

[40] Thomas Frölicher, et al., *Marine Heatwaves Under Global Warming*, 560 NATURE 360, 362 (2018).

manage uncertainties in a systematic way.[41] It should not be taken to mean that the conclusions a study reaches are unreliable.[42]

C. Climate Projections

As discussed above, climate models help support attribution science by simulating interactions among climate and environmental variables both with and without anthropogenic climate forcing. In addition to revealing information pertaining to current and historical climate change and its impacts, climate models can be utilized to predict future changes to the climate and resulting changes to human and environmental systems. By comparing past projections from climate models to actual climate observations, researchers have concluded that climate models have allowed for generally accurate projections of certain climate variables like global temperature, though the same models have underestimated sea level rise.[43]

In order to utilize climate models to predict future climatic changes and impacts, researchers first simulate the historical or present climate over an extended simulation period.[44] Then, one of two types of simulation are most commonly used to make projections of future changes. The first type of simulation is an *equilibrium simulation*, which involves altering the greenhouse gas concentrations in a model and then running the model again until it reaches a new equilibrium.[45] This allows researchers to estimate climatic changes by comparing the altered CO2 concentration simulation with the baseline simulation. In contrast to equilibrium simulations, in which greenhouse gas concentrations are changed all at once, the second type of simulation—*transient*

[41] *See* Fischhoff & Davis, *supra* note 37.
[42] *See* Elisabeth A. Lloyd et al., *Climate Scientists Set the Bar of Proof Too High*, 165 CLIMACTIC CHANGE 55 (2021) ("[C]limate scientists have set themselves a higher level of proof in order to make a scientific claim than law courts ask for in civil litigation in the USA, the UK, and virtually all common law countries.").
[43] *See, e.g.*, Stefan Rahmstorf et al., *Comparing Climate Projections to Observations up to 2011*, 7 ENV'T. RSCH. LETTERS 4 (2012); Zeke Hausfather et al., *Evaluating the Performance of Past Climate Model Projections*, 47 GEOPHYSICAL RSCH. LETTERS 1 (2020).
[44] IPCC, CLIMATE CHANGE 2001: THE SCIENTIFIC BASIS, Chapter 1: The Climate System: An Overview at 9, https://www.ipcc.ch/site/assets/uploads/2018/03/WGI_TAR_full_report.pdf.
[45] *Id.*

simulations—assess scenarios in which greenhouse gas concentrations vary over time, often based on specific emissions scenarios.[46]

The IPCC has utilized transient simulations in its assessment reports to predict future climate change. In the IPCC's Fifth Assessment Report, the IPCC utilized Representative Concentration Pathways ("RCPs")—which estimate changes in radiative forcing based on plausible future events and actions—to simulate future climate change under a low emission, high emission, and two intermediate emission scenarios.[47] In its Sixth Assessment Report, the IPCC has utilized five "Shared Socio-Economic Pathways" to simulate future climate change; these pathways describe possible future emissions scenarios based on various socio-economic factors including population growth and urbanization.[48] These simulations can be paired with statistical and dynamical impacts models to—for example—project changes in future crop yields. The attribution science discussed above can also be combined with climate projections to present an even fuller picture of the impacts of future climate change on human and environmental systems.[49]

D. Managing Challenges and Limitations in Climate Projections

While the climate models discussed above allow for the assessment of many future climate changes and their impacts, these models often have greater skill when assessing global or large-scale regional changes, rather than local changes and impacts. This may present a problem for climate litigation, which frequently centers on claims of specific local climate impacts, but downscaled climate models can help correct for this. *Downscaling* refers to the process of utilizing large-scale climate models to generate

[46] *Id.*

[47] Intergovernmental Panel on Climate Change, Representative Concentration Pathways (RCPs), DATA DISTRIBUTION CENTRE, https://perma.cc/3475-P4JY (last modified Nov. 4, 2019).

[48] IPCC, CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS, Chapter 1: Framing, Context, and Methods at 230, https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/.

[49] *See etc*. JONATHAN WOETZEL ET AL., MCKINSEY GLOBAL INSTITUTE, CLIMATE RISK AND RESPONSE: PHYSICAL HAZARDS AND SOCIOECONOMIC IMPACTS (2020), https://perma.cc/55NE-TVTU (utilizing projections of climate change under an RCP, along with attribution science pertaining to current climate change, to summarize the current understanding of climate risk).

simulations or statistics pertaining to more local climate changes and impacts.[50] There are two primary types of downscaling. The first type—*dynamical downscaling*—refers to the process of using regional climate models to simulate regional climate changes and the impacts of those changes.[51] The second type—*statistical downscaling*—utilizes large-scale climate models to estimate future local changes through historically-based statistical relationships between large-scale and local climates.[52] Both types of downscaling can generate information on regional climate change and its local impacts that can be utilized in preparing for future climate change.

Despite the general utility of downscaling, downscaling can generate some additional uncertainty when making predictions about future climate change and impacts.[53] Statistical downscaling relies on the assumption that statistical relationships between large-scale and local climates will remain the same under novel future conditions.[54] Dynamical downscaling avoids this concern by relying on representations of physical principles—such as the laws of thermodynamics—that can be expected to remain the same under future conditions.[55] That said, dynamical downscaling typically requires significant computational resources and can be sensitive to systematic errors in the representation of physical processes—referred to as "biases"—in the large-scale model or the downscaling process.[56]

When researchers and scientists do not have access to a relevant downscaled model, they can also make use of large-scale climate models by articulating the nature and

[50] *See* Geophysics Fluid Dynamics Laboratory, Climate Model Downscaling, https://perma.cc/K25U-3UYS (last visited Aug. 16, 2022); IPCC, CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS, Chapter 10: Linking Global to Regional Climate Change at 1366–1367, https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/.
[51] *See* Geophysics Fluid Dynamics Laboratory, *supra* note 50.
[52] *Id.*
[53] *Id.*
[54] *Id.*
[55] *Id.*
[56] *Id.*; *see also* IPCC, CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS, Chapter 10: Linking Global to Regional Climate Change at 1366–1367.

extent to which predictions of local climate impacts may differ from regional predictions modeled at a larger scale. The results of a study of likely future climate impacts on an individual city, for example, may show that while regional modeling suggests that North America will experience increased average surface temperature overall, factors like land use, local aerosol concentrations, and small-scale natural variability may cause that city to experience more or less warming than elsewhere on the continent.

III. CLIMATE SCIENCE IN ADAPTATION CASES

Climate science can answer necessary questions that guide the outcome of litigation. The sections that follow describe key types of adaptation litigation scenarios where climate science has a critical role to play. For each, this paper highlights specific legal questions that have emerged from the attempted or successful utilization of climate science. Key questions that arise from the cases discussed in this section include the following:

- Whether government and corporate defendants have legal discretion to incorporate climate science into their decision-making differently than plaintiffs claim they should, or to ignore certain science altogether.
- Whether the relevant climate impacts are foreseeable enough to justify or mandate adaptation measures that respond to those impacts.
- Whether the relevant climate impacts have already occurred or will occur in a timeframe that is judicially cognizable.
- Whether the judiciary has the expertise to determine questions pertaining to the validity and significance of climate science, or whether those questions should be left to other branches of government.

Beyond this, as litigants continue to explore an expanding range of theories and as more cases advance beyond procedural challenges to the merits of the cases, the scope, and the advantages and limits, of climate science will become increasingly evident.

The sections that follow describe categories of adaptation cases and highlight the core questions that climate science can help answer, providing a few examples along the way to help illustrate those questions. The cases discussed here fall into two broad categories. First, actions that seek adaptation measures. And second, challenges to adaptation measures already implemented or planned.[57]

A. Actions Seeking Adaptation Measures

Currently, there are many more cases seeking adaptation measures than challenging them. These cases generally center on a public or private actor's alleged duty to consider or address climate impacts. Four types of these cases are discussed in the sections that follow. First, cases where plaintiffs are aiming to bring up-to-date climate information into decision making under the National Environmental Policy Act (NEPA). Second, cases where plaintiffs are aiming to do the same under federal environmental statutes other than NEPA. Third, cases aiming to cause a public body to take steps to adapt to impending climate impacts. And fourth, cases that seek to cause a private party to prepare for climate impacts. The first two categories center on the information underlying decision-making, while the latter two center on the adaptation actions (or the lack of those actions) themselves.

[57] A related, emerging set of cases concerns the related concept of liability for failing to adapt business practices in response to past or projected climate change. This litigation has charged that some party that bears responsibility for managing or responding to risks like climate change has failed or is failing to do so properly. Thus far, however, these cases have not turned on climate science. In *York v. Rambo*, for instance, plaintiffs allege that Pacific Gas & Electric recognized the impacts of climate change and wildfire risk in their public disclosures, but failed to recognize the company's own role in exacerbating that risk through its alleged pattern and practice of ignoring wildfire safety regulations. See York County v. Rambo, No. 3:19-cv-00994, Complaint at ¶ 68 (Feb. 22, 2019 N.D. Cal.); *see also* Lynn v. Peabody Energy Corp., 250 F. Supp. 3d 372, 382 (E.D. Mo. 2017) (holding that plaintiffs failed to allege the relevant standard of proof in an action alleging that Employee Retirement Income Security Act (ERISA) plan managers imprudently invested in Peabody Coal despite their actual or constructive knowledge of rapidly deteriorating coal prices and the dim outlook for the industry's future).

i. Climate Information and Adaptation Under NEPA

Numerous cases have held that federal agencies must consider a project's impacts on climate change when conducting NEPA reviews.[58] Courts have also held that agencies must consider how climate change will affect environmental conditions in the project location in order to accurately characterize the affected environment and the environmental effects of the proposal.[59] While courts will take a hard look at environmental reviews to ensure the relevant considerations are analyzed with the requisite level of care, courts reviewing cases brought under NEPA and its state analogs are deferential to agencies' decisions about how much weight to put on climate impacts when assessing a potential project.[60] This means that while these cases may force an agency to conduct a more searching review of climate information and, in the process, perhaps even raise the bar for future reviewers, they do not always change the final outcome of the specific matter.

Assessing how climate change may affect the potential environmental impacts of proposed projects requires linking global climate change to highly local impacts. In NEPA

[58] *See, e.g.*, Ctr. for Biological Diversity v. Nat'l Highway Traffic Safety Admin., 538 F.3d 1172 (9th Cir. 2008); *see also* Michael Burger & Jessica Wentz, *Downstream and Upstream Greenhouse Gas Emissions: The Proper Scope of NEPA Review*, 41 HARV. ENV'T L. REV. 110 (2017); Michael Burger & Jessica Wentz, *Evaluating the Effects of Fossil Fuel Supply Projects on Greenhouse Gas Emissions and Climate Change Under NEPA*, 44 WM. & MARY ENV'T. L. & POL'Y REV. 423 (2020); ROMANY M. WEBB ET AL., EVALUATING CLIMATE RISK IN NEPA REVIEWS: CURRENT PRACTICES AND RECOMMENDATIONS FOR REFORM (2022).

[59] For example, in a NEPA review for a facility that would store hazardous substances, an agency would need to consider whether impacts such as sea level rise or more severe floods may affect the risk of environmental contamination from the facility. *See* Jessica Wentz, *Assessing the Impacts of Climate Change on the Built Environment under NEPA and State EIA Laws: A Survey of Current Practices and Recommendations for Model Protocols* (Sabin Center for Climate Change Law 2015); WEBB ET AL., *supra* note 58, at 24–25.

[60] *See, e.g.*, Idaho Rivers United v. United States Army Corps of Engineers, No. 14-cv-1800 at 40 (W.D. Wash Feb. 9, 2016) (accepting agency's characterization that "accurately predicting how future conditions affect sediment accumulation" [in a river] is not currently realistic or feasible" where plaintiffs argued the Corps should have forecasted how climate change would increase river sedimentation because the court concluded "there is speculation inherent in such an exercise"); Center for Biological Diversity v. U.S. Bureau of Land Management, No. 2:14-cv-00226 (D. Nev. Aug. 23, 2017) at 16 (rejecting plaintiffs challenge that an environmental review was inadequate for failing to include specific climate change data because "BLM concluded in its expertise that the climate change data before it was not reliable enough to feed into its models").

litigation, the question is whether an agency adequately analyzed that linkage. Lawsuits challenging agency reviews in this context typically argue that a project is vulnerable to climate change impacts in a way that was not properly assessed in the planning and environmental review process. These lawsuits typically center on one of three NEPA requirements. First, the requirement to assess the environmental impacts of a proposal.[61] Second, the requirement under NEPA's implementing regulations to "prepare supplements to . . . final environmental impact statements if . . . [t]here are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts."[62] And third, NEPA's requirement that the implementing agency consider and assess reasonable alternatives to the project.[63]

1. Litigation Pertaining to an Agency's Obligation to Evaluate a Project's Impacts

NEPA requires agencies to assess "the environmental impact of the proposed action" and "any adverse environmental effects which cannot be avoided should the proposal be implemented."[64] When climate change threatens to affect a project and the surrounding environment, those climate impacts can also alter the effects of the project itself.[65] As a result, lawsuits have emerged concerning the adequacy of agencies' assessments of climate change's impacts on the environmental effects of certain projects.

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[61] 42 U.S.C. § 4332(C)(i)–(ii).
[62] 40 C.F.R. § 1502.9(c)(1).
[63] 42 U.S.C. § 4332(C)(iii), (e).
[64] 42 U.S.C. § 4332(C)(i)–(ii).
[65] *See* U.S. COUNCIL ON ENV'T QUALITY, FINAL GUIDANCE ON FEDERAL DEPARTMENTS AND AGENCIES ON CONSIDERATION OF GREENHOUSE GAS EMISSIONS AND THE EFFECTS OF CLIMATE CHANGE IN NATIONAL ENVIRONMENTAL POLICY ACT REVIEWS at 24 (2016) ("For example, an agency considering a proposed long-term development of transportation infrastructure on a coastal barrier island should take into account climate change effects on the environment and, as applicable, consequences of rebuilding where sea level rise and more intense storms will shorten the projected life of the project and change its effects on the environment."). In March 2017, President Donald Trump signed an executive order directing the Council on Environmental Quality (CEQ) to rescind this 2016 guidance, which CEQ did in April 2017. E.O. 13783, 82 FED. REG. 16093, 16094 (2017); 82 FED. REG. 16576 (2017). In June 2019, CEQ published new draft guidance pertaining to the consideration of climate change in NEPA reviews. 84 FED. REG. 30097 (2019). Then, in January 2021, President Joseph Biden signed an executive order directing CEQ to rescind the 2019 draft guidance and review, revise,

While courts have held that agencies must consider climate impacts in at least certain scenarios,[66] these lawsuits still run up against the substantial discretion that NEPA affords agencies to determine which impacts are significant. Courts have explicated that an agency's determination as to whether an impact of its proposed action is significant enough to warrant preparation of an environmental impact statement is reviewable only if it was arbitrary, capricious or an abuse of discretion.[67] Likewise, courts have stated that as long as an agency has taken a "hard look" at the relevant environmental impacts, courts should not impose "unreasonable extremes" or interject in an area of agency discretion.[68]

Given that plaintiffs in cases challenging agencies' assessments of climate impacts must overcome such deferential standards, they may turn to climate science to demonstrate that climate change's impacts are more substantial than an agency has stated. *Landwatch v. Connaughton* is an example of such a case. In *Landwatch*, Central Oregon LandWatch and WaterWatch of Oregon challenged the United States Forest Service's approval of a permit to construct a new water supply pipeline allowing continued diversion of water from Tumalo Creek.[69] The plaintiffs claimed that the Forest Service's approval of the project was based on an environmental assessment that violated NEPA by failing to provide a quantitative—rather than purely qualitative—assessment of the impact of climate change on the project and level of stream flows in the creek and, as a result, failing to fully assess the impact of the project's anticipated water withdrawals.[70]

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and update its 2016 guidance. E.O. 13990, 86 FED. REG. 7037, 7042 (2021). In February 2021, CEQ withdrew the 2019 draft guidance and announced it will separately review the 2016 guidance, stating that "[i]n the interim, agencies should consider all available tools and resources in assessing GHG emissions and climate change effects of their proposed actions, including, as appropriate and relevant, the 2016 GHG Guidance." 86 FED. REG. 10252 (2021).

[66] *See* WEBB ET AL., *supra* note 58, at 21.

[67] Sierra Club v. U.S. Dep't of Transp., 753 F.2d 120, 126 (D.C. Cir. 1985).

[68] Nat. Res. Def. Council, Inc. v. Morton, 458 F.2d 827, 838 (D.C. Cir. 1972).

[69] Landwatch v. Connaughton, No. 6:13-CV-02027-AA, 2014 WL 6893695, at *1 (D. Or. Dec. 5, 2014), *aff'd sub nom*. Cent. Oregon Landwatch v. Connaughton, 696 F. App'x 816 (9th Cir. 2017).

[70] Landwatch v. Connaughton, 696 F. App'x 816, 819 (9th Cir. 2017); *see also* Report or Affidavit of Edward Salminen, Hydrologist, BS, MS, Landwatch v. Connaughton, 2013 WL 12315137 (D.Or. Sept. 7, 2013) ("Available quantitative tools for addressing possible climate change impacts (and dispelling some of the

In support of their claim, plaintiffs provided a report and testimony of a hydrologist who outlined an approach that the Forest Service could have taken to "quantitatively address the cumulative effect of climate change on streamflow in Tumalo Creek."[71] In his report, the hydrologist cited to previous studies that combined groundwater models with climate change data sets to "quantitatively evaluate likely changes in groundwater recharge and surface runoff basin wide, and changes to groundwater discharge to selected streams within the basin."[72] In a separate declaration, the hydrologist asserted that "[t]he best available science and actual data from the last three decades underscores that climate change is having a direct, indirect and cumulative effect on water volumes, the timing and delivery of water and, therefore, on water temperature," referring to a Forest Service blog summarizing the current state of knowledge concerning climate change's effects on aquatic resources.[73] The hydrologist explained that a quantitative assessment of climate change impacts is "relevant because reductions in streamflow due to climate change would reduce the baseline water yield, thereby intensifying the impacts of the City of Bend's water withdrawals."[74] This would in turn conflict with the Forest Service's claim that climate change would impact the proposed action and the No Action Alternative equally.[75]

In response, the Forest Service provided a declaration from a research ecologist who testified that "projections of climate change impacts . . . have a very large uncertainty about the extent to which any particular site will be impacted."[76] After explaining certain

uncertainty as to their likelihood) are not incorporated into the assessment. This error carries through to the Forest Service Decision Notice, which concludes at pages 15-16 that 'positive quantitative predictions are not attainable with respect to climate change.' This conclusion is wrong.").

[71] Report or Affidavit of Edward Salminen, Hydrologist, BS, MS, Landwatch v. Connaughton, 2013 WL 12315137.

[72] *Id*.

[73] Second Declaration of Edward Salminen, Landwatch v. Connaughton, 2014 WL 12781365 (D.Or. Jan. 13, 2014); Declaration of Edward Salminen, Landwatch v. Connaughton, 2013 WL 12315138 (D. Or. Nov. 21, 2013).

[74] Second Declaration of Edward Salminen, Landwatch v. Connaughton, 2014 WL 12781365.

[75] Declaration of Edward Salminen, Landwatch v. Connaughton, 2013 WL 12315138

[76] Declaration of Dr. Sherri L. Johnson, Landwatch v. Connaughton, 2013 WL 12315140 (D. Or. Dec. 18, 2013).

factors impacting site-to-site variability of climate impacts, the ecologist asserted that "[i]n light of the current understanding regarding the effects of climate change on any particular site-specific stream and available methodological tools available to seek to model or evaluate the magnitude of such effects," she did "not see the relevance of modeling climate change impacts for the [project]."[77]

The Ninth Circuit upheld a summary judgement order dismissing plaintiffs' claims.[78] The court held that, since the Forest Service had determined that climate change was not a significant issue because it would have the same impact on the stream flows under any project alternative, the Forest Service was not required to conduct a quantitative analysis of climate impacts, as NEPA requires only brief discussion of less-than-significant issues.[79] Furthermore, the court held that agencies can describe environmental impacts in qualitative terms when they provide a reason for doing so and for why they cannot provide objective data; the court then referred to defendants' arguments that "precise quantification was unreliable" as the reason for allowing a purely quantitative description of climate impacts.[80]

Idaho Rivers United v. United States Army Corps of Engineers provides another example of a court rejecting plaintiffs' claims that an agency's analysis of climate change impacts was inadequate under NEPA.[81] In *Idaho Rivers*, a collection of environmental and fishing industry organizations challenged the Army Corps' environmental review of a Snake River Programmatic Sediment Management Plan. Plaintiffs argued that the Army Corps had failed to take a hard look at the impacts of climate change on sediment deposition in the Lower Snake River and had proceeded as if there would be no increase in sediment reaching the navigation channel due to climate change.[82] In their complaint,

[77] *Id.*
[78] Landwatch v. Connaughton, 696 F. App'x 816, 817 (9th Cir. 2017).
[79] *Id.* at 819.
[80] *Id.*
[81] Idaho Rivers United v. United States Army Corps of Engineers, No. C14-1800JLR, 2016 WL 498911, at *17 (W.D. Wash. Feb. 9, 2016).
[82] *Id.*

plaintiffs pointed to a study in the administrative record predicting that increased forest fires associated with climate change could increase sediment yields ten-fold, which they claimed the Corps had failed to adequately incorporate into its analysis.[83]

In response, the Corps argued that it did consider studies on sediment yield, loading, accumulation, and erosion, including in relation to climate change, and that it had acknowledged that climate change could affect sediment management.[84] However, the Corps argued that current science did not allow it to "assume that an increase in sediment *loading* will directly relate to an increase in sediment *accumulation* that would interfere with navigation or other Corps project purposes when considered in the context of other climatic changes."[85] The Corps further argued that no method currently exists for accurately predicting how future conditions affect sediment accumulation in the Lower Snake River, and that plaintiffs were asking them to engage in an inherently speculative forecasting exercise.[86] Plaintiffs did not present any method of predicting sediment accumulation in the area, and the court thus rejected plaintiffs' NEPA claim and deferred to the agency's environmental assessment.[87]

In contrast with the two preceding cases, the Eastern District of California's opinion in *AquAlliance v. U.S. Bureau of Reclamation* provides an example of a court finding an agency's analysis of climate impacts to be inadequate under NEPA. In *AquAlliance*, water resource management and conservation organizations challenged a Bureau of Reclamation-approved water transfer program as violating NEPA, the California Environmental Quality Act (CEQA), and the Endangered Species Act.[88] In their NEPA review, the Bureau of Reclamation and a local water authority had relied on only historical data when assessing the project's impact on water supplies; plaintiffs alleged that this sole

[83] Complaint for Declaratory and Injunctive Relief, Idaho Rivers United v. United States Army Corps of Engineers, 2014 WL 6982898 (W.D.Wash. Nov. 24, 2014).
[84] *Idaho Rivers United*, 2016 WL 498911, at *17.
[85] *Id*.
[86] *Id*.
[87] *Id*.
[88] AquAlliance v. U.S. Bureau of Reclamation, 287 F. Supp. 3d 969, 984 (E.D. Cal. 2018).

reliance on historical data was unlawful when a climate model demonstrated that climate change would diminish the snow water equivalent—the amount of water held in a volume of snow—by 2035.[89] Plaintiffs supplemented this argument with evidence that climate change has caused and will likely continue to cause snowpack in California to decrease.[90]

In defense of their analysis, defendants pointed to previous analysis that showed that future inflow to key California reservoirs would not substantially diverge from historic patterns.[91] In response, plaintiffs argued—and the court agreed—that the previous modeling was inadequate because it was based solely upon predictions of *annual* inflows to reservoirs and did not assess changes in the timing of precipitation. Plaintiffs then pointed to a climate model that showed that "[r]educed snowpack and earlier snow melt will alter the timing and amount of water supplies, posing significant challenges for water resource management in the West." [92]

Defendants also argued that plaintiffs' arguments were unavailing because they were based on a "worst case scenario" climate model.[93] The court disagreed, noting that the administrative record reflects that recent carbon dioxide emissions have been higher than those predicted in the model.[94]

The court likewise rejected defendants' argument that the effects of climate change on the project are expected to be minimal because California's greenhouse gas emissions are reducing and because "the global dispersion of greenhouse gases means that localized environmental impacts cannot be traced to California's particular emissions."[95] The court

[89] *Id.* at 1028.
[90] *Id.* at 1028 n.32 ("The Court agrees with Plaintiffs that this is not, as Federal Defendants suggest, based on an outlier study. Other evidence in the record corroborates the assertion that snowpack in California has and likely will continue to decrease as a result of climate change.").
[91] *Id.* at 1029.
[92] *Id.*
[93] *Id.*
[94] *Id.* at 1030.
[95] *Id.*

called this argument "simply illogical," noting that California's greenhouse gas emissions will not control the overall trajectory of climate change or its local impacts.[96]

Finally, the *AquAlliance* defendants argued that "[a]ny climate change effects that may have occurred in the most recent ten-year period are difficult to discern in context and would be too small to be outside the range of modeling variability," and that it would be would be speculative to develop hydrology based on potential climate change over the project timespan.[97] The court likewise rejected this argument, pointing to plaintiffs' proffered climate model as directly contradicting defendants' claims as to the speculative nature of climate impacts.[98]

After rejecting the defendants' specific defenses of their climate analysis, the court held that their failure to assess climate change's impacts on the project amounted to a "failure to consider an important aspect of the problem" and thus violated NEPA.[99]

Together, these three cases demonstrate the importance of climate science in cases concerning how climate chance will exacerbate a project's impacts. In *AquAlliance*, a climate model served as key evidence that an agency could have more accurately forecasted climate impacts on a project; furthermore, information on global emissions trajectories helped the *AquAlliance* court reject spurious arguments that plaintiffs were relying on "worst case" models and that California's greenhouse gas emissions would control the overall trajectory of climate change. By contrast, the absence of any relevant climate model in *Idaho Rivers United* led the court to reject plaintiffs' argument that defendants should have more fully assessed future climate impacts. *Landwatch*, then, serves as a reminder than the existence of relevant modeling tools will not always convince a court to require further environmental analysis, especially when the agency can put forward an expert casting doubt on a plaintiff's proffered model.

[96] *Id.*
[97] *Id.*
[98] *Id.*
[99] *Id.* at 1032

2. *Litigation Pertaining to Supplemental Environmental Impact Statements*

Like with the requirement to assess a project's impacts in the first instance, courts have explicated a deferential standard of judicial review for the requirement to prepare a supplement environmental impact statement upon the production of significant new circumstances or information relevant to environmental concerns and bearing on the proposed action. The Supreme Court and lower courts have held that supplemental review is only necessary when new information shows that future federal action will affect the human environment in a significant manner or to a significant extent not already considered,[100] or when new circumstances present a seriously different picture of the project's environmental impact than was previously envisioned.[101] The Supreme Court has also held that an agency's decision not be prepare a supplemental environmental impact statement should be assessed under the Administrative Procedure Act's "arbitrary and capricious" standard, because such a decision is a "factual" one, "the resolution of which implicates substantial agency expertise."[102] The Court further explained that a reviewing court must conduct a searching and careful review to determine whether an agency based its decision on a consideration of the relevant factors and whether it committed a clear error of judgment, while still providing the agency discretion to rely on its qualified experts when presented with conflicting views.[103] This standard of review reflects the courts' hesitancy to disrupt agency determinations under NEPA on highly technical matters as long as the agency has demonstrated reasoned decision-making, which proves a key issue in the climate adaptation cases discussed below.

Concerning the NEPA requirement to supplement environmental impact statements, plaintiffs in several cases have argued that new climate change data or modeling render older environmental assessments outdated, requiring new or

[100] Marsh v. Oregon Nat. Res. Council, 490 U.S. 360, 374 (1989).
[101] Hughes River Watershed Conservancy v. Glickman, 81 F.3d 437, 443 (4th Cir. 1996).
[102] Marsh v. Oregon Nat. Res. Council, 490 U.S. 360, 376 (1989).
[103] *Id.* at 378 (internal citations removed).

supplemental assessments. For example, in *North Carolina Wildlife Federation v. North Carolina Department of Transportation*, plaintiffs argued that a new toll bridge should not be approved because the project's environmental review failed to assess the latest science describing the impacts that sea level rise, storm surge, and other climate impacts will have on the durability of the bridge.[104] Plaintiffs alleged that "the science behind sea level rise, storm surge, and climate change models has significantly advanced [since the project's 2012 environmental impact statement]—with implications for the durability of the Toll Bridge, its utility as a hurricane evacuation route, and its financial viability as a toll revenue generating facility."[105] Plaintiffs pointed to a 2015 Update to the 2010 North Carolina Sea Level Rise Assessment Report, the 2017 Fourth National Climate Assessment, and the 2018 United Nations Environmental Emissions Gap Report as new predictions of future sea level rise in the region.[106] The court found that "while plaintiffs may contend that the updated forecasts on the rising sea level undermines the viability of a Mid-Currituck Bridge, the National Environmental Policy Act's procedural requirement, by regulation, regarding supplements to environmental impact statements is not implicated," as sea level rise "is not a new circumstance that presents a seriously different picture of the environmental impact of the proposed project from what was previously envisioned."[107] The court distinguished between new data pertaining to the environmental impacts of a project and new data pertaining to the project's viability in the face of climate impacts; since the plaintiffs argued that the new sea level rise data was relevant to the project's

[104] Complaint, N. Carolina Wildlife Fed'n v. N. Carolina Dep't of Transportation, No. 2:19-cv-00014-FL (E.D.N.C. Apr. 23, 2019).
[105] *Id.* at *2.
[106] *Id.* at *177–189.
[107] N. Carolina Wildlife Fed'n v. N. Carolina Dep't of Transportation, 575 F. Supp. 3d 584, 619 (E.D.N.C. 2021).

viability rather than its environmental impacts, the court found that the agency was not required to prepare a supplemental environmental impact statement.[108]

Similarly, in *United Sugar v. Semonite*, a plaintiff argued that a 2007 environmental review was inadequate to assess the environmental impact of altering a lake's water level in 2018 because the earlier review could not have included the Army Corps recently-developed climate science on risks from saltwater intrusion, climate change, more extreme drought, and rainfall events.[109] Plaintiffs' complaint cited the Corps' 2016 *Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs and Projects* as one example of recent science that they argued the Corps should analyze with respect to the project.[110] Defendants argued that plaintiffs' claims were moot and that plaintiffs lacked standing, but did not address the plaintiffs' climate science-related claims.[111] The court, in turn, dismissed the case as moot without addressing the merits of plaintiffs' claims, concluding that since the plaintiffs were challenging 2018 and 2019 actions that was no longer ongoing, there was no longer any "live" controversy.[112]

In *Save the Colorado v. Department of the Interior*, conservation groups have challenged an environmental review as inadequate, alleging, among other claims, that the review must be supplemented in light of scientific studies developed in the three years since the original review was completed.[113] Plaintiffs' complaint describes climate impacts

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[108] *Id*; *see also id.* at 615 ("Plaintiffs' argument regarding a supplemental environmental impact statement focuses primarily on how these changes impact the need and feasibility of the project, addressed above, rather than changes in how the project impacts the environment."). The court did not discuss, and plaintiffs did not put forward, an argument that impacts to the durability of the project could in turn exacerbate the project's environmental impacts through increased erosion or the impacts or repeated repair and reconstruction. *See id*. ("'However, as a preliminary matter, none of plaintiffs' asserted bases of new information relate to "environmental concerns' as *caused* by the proposed action") (emphasis in original").

[109] Complaint, United States Sugar Corp. v. Semonite, No. 9:19-cv-81086, at ¶¶ 97–98 (S.D. Fla Aug. 1, 2019).

[110] *Id*. at 97.

[111] Defendant's Motion to Dismiss and Memorandum of Law in Support, United States Sugar Corp. v. Semonite, No. 9:19-cv-81086, at *10–19, (S.D. Fla Oct. 21, 2019).

[112] United States Sugar Corp. v. Semonite, No. 19-CV-81086, 2019 WL 10966205, at *3–6 (S.D. Fla. Dec. 19, 2019).

[113] Complaint, Save the Colorado v. U.S. Department of the Interior, No. 3:19-cv-08285, at ¶¶ 146–50 (D. Ariz. Oct. 1, 2019).

on the Colorado River, citing attribution and predictive science including Bradley Udall & Jonathan Overpeck's 2017 study, *The Twenty-First Century Colorado River Hot Drought and Implications for the Future*; George Rhee and Jimmy Salazar's 2018 study, *How Long Does a 15-Year Drought Last? On the Correlation of Rare Events*; Gregory J. McCabe et al.'s 2017 study, *Evidence that Recent Warming is Reducing Upper Colorado River Flows*, Bibi S. Naz et al.'s 2018 study, *Effects of Climate Change on Streamflow Extremes and Implications for Reservoir Inflow in the United States*; and Mu Xiao et al.'s 2018 study, *On the Causes of Declining Colorado River Streamflows*.[114] Plaintiffs have also argued that

> [i]n light of the climate change projections, detailed throughout the Plan FEIS and extensively highlighted within the Bureau of Reclamation's 2012 Study, the project's purpose and need statement should have included measures to "adaptively mana[ge]" the Dam under climate change conditions, such as times of water scarcity or drought, in order to be a truly comprehensive framework for the facility's management.[115]

The court has not reached a decision in the case.

Courts have addressed similar issues in cases involving state environmental impact assessment laws. For example, in *Citizens Committee to Complete the Refuge v. City of Newark* litigants challenged a California city's approval of a coastal development, arguing that the project's 2015 environmental review was rendered inadequate under CEQA in part by newly-available information on sea level rise.[116] Plaintiffs alleged that new information revealed how sea level rise, combined with the project, will prevent wetlands in the area from migrating and thus effectively eliminate those wetlands.[117] The court rejected this argument on the basis of defendant's previous analysis of sea level rise information, stating that the potential impacts on sea level rise "are not new in relation to this project, so the City did not need to address them [further]."[118] In support of that point, the court

[114] *Id.* at ¶¶ 75–77.
[115] *Id*. at ¶ 101.
[116] Citizens' Comm. to Complete the Refuge v. City of Newark, 289 Cal. Rptr. 3d 223, 236–38 (Cal. Ct. App. 2021).
[117] *Id.*
[118] *Id*. at 237.

pointed to discussion of wetland migration and elimination in the original environmental review of the project.[119] Further, the court found that arguments pertaining to "new scientific studies showing an increased rate of sea level rise" were unconvincing for two reasons.[120] First, an earlier environmental review had "noted that the rate of sea level rise was uncertain and might be accelerating," thus "anticipat[ing] the new information that appellants rel[ied] on."[121] Second,

> while the increased rate of sea level rise might *expedite* the effects of thwarted wetland migration and make it harder to mitigate those effects, the overall impact on the wetlands is the same: Wetlands will be lost because the specific plan did not provide for any mitigation of thwarted wetland migration, so it is immaterial for CEQA purposes that sea level rise may occur faster and make such mitigation more difficult.[122]

The court accordingly found that no supplemental review was necessary.

These examples demonstrate that the bar for using climate science to mandate supplemental agency review of a project's environmental impacts is a high one. As in *Citizens Committee to Complete the Refuge*, a court may decide that the agency already satisfactorily assessed a specific impact—such as sea level rise—and that new climate science does present a sufficiently different picture of that impact to warrant new analysis. Furthermore, courts will not disrupt an agency's decision not to supplement its environmental review with updated climate information as long as the agency has demonstrated a good-faith, non-arbitrary or capricious basis for the decision. Thus, while impact and extreme event attribution science, along with climate modeling, can identify climate risks that an agency overlooked in a project's environmental assessment and demonstrate the need for additional environmental review in certain circumstances, the availability of new science does not necessarily mean that an agency will be required to supplement its review of a project. Of course, better utilization of available science could

[119] *Id.* at 238.
[120] *Id.*
[121] *Id.*
[122] *Id.*

yield different results in at least certain cases. For example, the *North Carolina Wildlife Federation* rejected plaintiffs' argument for a supplemental assessment because plaintiffs had not connected new sea level rise data with new environmental impacts from the project, but plaintiffs could have attempted to argue that sea level rise's anticipated impacts on project viability would in turn create new harms to the local environment.

3. Litigation Pertaining to Agencies' Assessment of Project Alternatives

As with judicial review of decisions not to supplement an agency's environmental review, courts have implemented constraints in their review of agencies' alternatives analyses. Courts evaluate an agency's assessment of project alternatives under a "rule of reason" standard of review.[123] In other words, "the discussion of environmental effects of alternatives need not be exhaustive. What is required is information sufficient to permit a reasoned choice of alternatives so far as environmental aspects are concerned."[124] Furthermore, courts do not require agencies to consider the effects of project alternatives when the "effects cannot be readily ascertained and if the alternatives are deemed remote and only speculative possibilities."[125]

Several of the above cases related to supplemental environmental impact statements also concerned NEPA's mandate to assess project alternatives. *North Carolina Wildlife Federation*, for instance, included the issue of whether defendant's analysis of project alternatives adequately discussed the impact of sea level rise on the financial feasibility of project alternatives. Again, the court rejected the claim, stating that "[p]laintiffs' contention that defendants failed to provide detailed calculations as to future toll-revenue over the next half-century in light of rising sea levels and changing traffic forecasts does not obviate defendant's reasonably discernable and rational path from the fact that one alternative generates revenue to the conclusion that it will likely be more

[123] All Indian Pueblo Council v. United States, 975 F.2d 1437, 1445 (10th Cir. 1992).
[124] Nat. Res. Def. Council, Inc. v. Morton, 458 F.2d 827, 836 (D.C. Cir. 1972)
[125] Env't Def. Fund, Inc. v. Andrus, 619 F.2d 1368, 1375 (10th Cir. 1980).

easily financed."[126] In a footnote, the court stated that "t]o the extent plaintiffs attack defendants' use of a different, older set of updated sea level rise projections, plaintiffs have not shown that, with due deference to the agency's choice of methodology, the decision was so unreasonable to constitute arbitrary or capricious decisionmaking."[127]

In *Save the Colorado*, Plaintiffs argued that defendants' alternatives analysis improperly relied on historically-derived data that defendants admitted "led to the underestimation of drier years in climate change modeling."[128] Plaintiffs have also alleged that defendants should have studied an alternative to the project that "primarily focuse[d] on the adaptive management of operations at the Glen Canyon Dam in light of forecasted climate change effects."[129] As described above, plaintiffs petitioned the court to mandate defendants to develop a supplemental environmental impact statement to address these issues, but the court has not reached a decision in the case.

Finally, in *Norwalk Harbor Keeper v. Department of Transportation*, a conservation group challenged the review done for a railroad bridge, arguing, among other points, that the review failed to consider an alternative that would have been better adapted to heatwaves and other climate change impacts.[130] The group's complaint cited the United States Environmental Protection Agency's 2016 report *Climate Impacts on Transportation* for the claim that "climate change is projected to cause extreme weather events to occur at increasing frequencies, including more severe heat waves, sea level rise, storm surges, and more intense precipitation."[131] The complaint also referenced a Superstorm Sandy grant program notice that recognized that "[b]oth scientific evidence and recent history indicate

[126] N. Carolina Wildlife Fed'n v. N. Carolina Dep't of Transportation, No. 2:19-CV-14-FL, 2021 WL 5893973, at *16 (E.D.N.C. Dec. 13, 2021).
[127] *Id*. at *16 n.6.
[128] Complaint, Save the Colorado v. U.S. Department of the Interior, No. 3:19-cv-08285, at ¶ 115 (D. Ariz. Oct. 1, 2019).
[129] *Id*. at ¶ 106.
[130] Complaint for Declaratory and Injunctive Relief, Norwalk Harbor Keeper v. U.S. Dep't of Transportation, No. 3:18-CV-0091 (SRU), 2018 WL 503522, at ¶¶ 65–93 (D. Conn. Jan. 17, 2018).
[131] *Id*. at ¶ 67.

that weather and climate-related disasters are a continuing threat," though the complaint did not directly cite any such evidence other than the aforementioned EPA report.[132] Plaintiffs argued that the allegedly-ignored alternative would have suffered fewer negative impacts.[133] In response, defendants argued that they had in fact considered the specific alternative in earlier stages of their environmental review and had reasonably concluded not to move forward with the option.[134] In a summary judgement order, the court found that "[d]efendants' decision not to move forward with the [requested alternative] options were reasonable," and that "resiliency considerations did not create a requirement that Defendants further consider the [requested alternative]."[135]

As these examples can be taken to suggest, while attribution science and climate modeling can be the basis and backbone of impact assessment cases, agencies have discretion in how to conduct their environmental impact assessments in light of such science, and courts will defer to an agency's analysis of project alternatives as long as they deem the analysis reasonable. As a result, while climate science can demonstrate how global climate change may impact a project and its alternatives, courts have proven hesitant to rely on such science to overturn agencies' environmental review when the challenged agency has explained its decision to give such science less weight than plaintiffs would argue is warranted.

ii. Climate Information and Adaptation in Other Statutory Contexts

Climate science's role in agency analysis has been brought to the forefront in statutory contexts outside of NEPA, as well. Several different cases have turned on whether agencies should incorporate specific climate-related information when making statutorily-mandated determinations. These cases are linked by the plaintiffs' efforts to

[132] *Id.* at ¶ 70.
[133] *Id*. at ¶¶ 65–93.
[134] Norwalk Harbor Keeper v. U.S. Dep't of Transportation, No. 3:18-CV-0091 (SRU), 2019 WL 2931641, at *10 (D. Conn. July 8, 2019).
[135] *Id*. at *11.

demonstrate that current climate science merits a place in guiding present decision-making, and by defendants' claims of discretion to base their decision-making on other factors.[136]

In *New York v. Raimondo*, for example, the State of New York has challenged the level at which the U.S. Department of Commerce set New York's quota for summer flounder under the Magnuson-Stevens Act, which requires Commerce to base its quotas on the best scientific information available.[137] The state has alleged, among other changes, that ocean warming has shifted the flounder population northward, justifying giving New York a greater share of the total quota than it historically shared with southern states—this historical share was based on a 1993 allocation formula that relied on landings data that New York has claimed is now out of date.[138] To support this argument, the state has pointed to recent data showing that the center of biomass of the summer flounder stock has shifted northeast since the 1980s, along with research that partially attributes the shift to ocean warming.[139]

In response, Commerce has argued that the "best available science" standard is a "practical" one "requiring only that fishery regulations be diligently researched and based on sound science."[140] The Department has further argued that it adequately justified its choice to rely on historical data, rather than New York's proffered data, throughout the

[136] A significant amount of litigation has already arisen from agencies' consideration of climate science under the Endangered Species Act. See Jessica Wentz, *Climate Attribution Science and the Endangered Species Act*, 39 YALE J. ON REGUL. 1042 (2022) for a thorough review of these cases. Litigation has also centered on the assessment of climate impacts in water management decisions, though the role of climate science in those cases requires further analysis. *See, etc.*, Fla. v. Georgia, 141 S. Ct. 1175 (2021); Fla. v. Georgia, 138 S. Ct. 2502 (2018); Natalie J. Reid et al., *When Water Rights Evaporate*, NAT. L. R. (Dec. 18, 2020), https://www.natlawreview.com/article/when-water-rights-evaporate (discussing Texas v. New Mexico, 141 S. Ct. 509 (2020)).

[137] Complaint, New York v. Raimondo, No. 21-CV-0304 (S.D.N.Y. Jan. 31, 2021).

[138] *Id.* at ¶¶ 47, 65,

[139] *Id.* at ¶ 47.

[140] Defendants' Memorandum of Law in Opposition to Plaintiffs' Motion for Summary Judgement and in Support of Defentants' Cross-Motion for Summary Judgement, New York v. Raimondo, No. 21-CV-0304, at *16 (S.D.N.Y. Apr. 2, 2021).

administrative process.[141] The Department's justification for its reliance on historical data is twofold: first, the Department has claimed that it weighed the data New York put forward against "preexisting infrastructure and community reliance, which was in turn based upon historical landings data and the resulting 1993 Allocation formula that had grown around the historical quotas."[142] Second, the Department has claimed that it "did not disregard a superior version of the same data, but rather made a choice between prioritizing historical landings data and current fishery location data," as "[l]andings since 1993 have been constrained by the allocation formulas, so more recent data would simply reflect the same percentages as the [historical] data."[143]

In a 2022 Order granting Commerce's Motion for Summary Judgement, the court deferred to the Department's "expertise and discretion" to weigh the evidence as it deemed appropriate through the administrative process.[144] The court further stated that it "may not champion a competing interpretation of the data over an agency's conclusion that finds support in the record," nor "pretend to have an expertise in scientific matters greater than the challenged agency."[145]

In *Sound Action v. U.S. Army Corps of Engineers*, a group challenged the Corps' failure to use the best available high tide information in determining the scope of its jurisdiction over shoreline armoring projects near Puget Sound under the Clean Water Act.[146] According to plaintiffs, the Corps determined the limit of its jurisdiction using a high tide proxy significantly lower than the actual maximum height of tides in the area; plaintiffs alleged that shoreline armoring projects between the proxy and actual high tide were thus immunized from review under federal law, and could exacerbate climate-

[141] *Id.* at 16–18.
[142] *Id.* at 17–18.
[143] *Id.* "Landings data" pertains to the number of catches of marine fish landed in foreign or domestics ports. *Fish Landings*, OECD, https://data.oecd.org/fish/fish-landings.htm (last visited Aug. 8, 2022).
[144] New York v. Raimondo, No. 1:21-CV-00304 (MKV), 2022 WL 912682, at *9 (S.D.N.Y. Mar. 29, 2022).
[145] *Id.* at *10.
[146] Complaint, Sound Action v. U.S. Army Corps of Engineers, 2:18-cv-00733, ¶ 2, 36 (W.D. Wash May 21, 2018).

driven pressure on the local ecosystem.[147] In a prior memorandum that was central to the litigation, the Commander of the Corp' Northwestern Division had justified its decision not to undertake the process of redefining the scope of its jurisdiction based on limited administrative resources and higher priorities within the agency.[148] In a motion to dismiss, the Corps argued that its memorandum and the underlying decision not to update its jurisdictional scope was not a "final agency action," and that the court should also dismiss the case due to the plaintiff's lack of standing.[149] The court denied the motion to dismiss, after which the Corps offered to rescind both the 2018 memorandum and the allegedly unlawful interpretation on the condition that the court remand the case to the Corps for further action, which the court did.[150] Following the court's remand, the Corps published a Special Public Notice announcing that it had rescinded the challenged policy and extended its Clean Water Act jurisdiction consistent with the court's order.[151]

These cases demonstrate that the tension between climate science and agency discretion extends beyond the NEPA context. While the case did not result in a final decision on the merits, the Corps' action in rescinding its allegedly unlawful interpretation of its jurisdiction in *Sound Action* may suggest that limited administrative resources and divergent priorities are insufficient reasons to ignore up-to-date climate science in at least certain contexts. In contrast, the *Raimondo* court's general deference to Commerce's interpretation of relevant data suggests a limit to the efficacy of up-to-date climate information in convincing some courts to overturn agency analysis.

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[147] *Id.*

[148] Sound Action v. U.S. Army Corps of Engineers, No. C18-0733JLR, 2019 WL 446614, at *3 (W.D. Wash. Feb. 5, 2019).

[149] Corps' Motion to Dismiss Claim 1 for Lack of Jurisdiction, 2:18-cv-00733, at *14–24 (W.D. Wash Sept. 28, 2018).

[150] Sound Action v. United States Army Corps of Engineers, No. C18-0733JLR, 2019 WL 5617571 (W.D. Wash. Oct. 30, 2019).

[151] U.S. Army Corps of Engineers Seattle District, Special Public Notice (Feb. 21, 2020), https://www.nws.usace.army.mil/Portals/27/docs/regulatory2/Public%20Notices/SPNs/20200221-HTL-SPN.pdf.

iii. Breaching a Public Duty by Misapprehending Climate Risk

Another set of cases centers on whether a public or quasi-public entity has undertaken adequate preparations for predictable climate impacts. These are cases that aim to cause a public body to take steps to adapt to impending climate impacts.

Governmental responses to sea level rise can provide the basis for this sort of claim. In *Turek v. Zoning Board of Appeals for the City of Milford*, the Superior Court of Connecticut for the Judicial District of Hartford held that a zoning authority's decision to deny variances that would have allowed homeowners to rebuild their hurricane-destroyed home at a higher level overlooked "the nuances and immediacy of flood hazard or sea level rise . . . contrary to law and logic."[152] After Hurricane Sandy destroyed a home constructed in a flood zone, the property owners proposed to construct a new home on the vacant property further set back from the Long Island Sound.[153] However, due to FEMA and state regulations that require property in the flood zone to be elevated a total of fourteen feet, the proposed residence would have exceeded local aesthetic building height restrictions.[154] The court cited a study that predicted sea level rise based on Connecticut's unique location, oceanography, weather, and geology,[155] along with New York judicial precedent, in asserting that an "aesthetic height regulation should not outweigh consideration of the elevation requirement based upon public safety."[156] The seriousness with which the court took the threat of sea level rise thus directly impacted its decision to overturn the zoning authority's decision. The Appellate Court of Connecticut reversed the lower court's decision, however, finding that plaintiffs had failed to establish a genuine

[152] Turek v. Zoning Bd. of Appeals for City of Milford, No. LNDCV156063404S, 2018 WL 2048566, at *9 (Conn. Super. Ct. Apr. 4, 2018), *judgment entered sub nom.* Turek v. Zoning Bd. of Appeals for the City of Milford (Conn. Super. Ct. 2018), and *rev'd and remanded sub nom.* Turek v. Zoning Bd. of Appeals of City of Milford, 196 Conn. App. 122, 229 A.3d 737 (2020).
[153] Turek v. Zoning Bd. of Appeals of City of Milford, 229 A.3d 737, 739 (Conn. App. Ct. 2020), *cert. denied* 229 A.3d 729 (2020).
[154] *Id*.
[155] Turek, 2018 WL 2048566 at *7 n.20.
[156] *Id.* at *8.

legal hardship from being denied a variance, but had instead merely been denied "their desire to build a certain type of home . . . which is appropriately characterized as personal disappointment."[157]

In addition to sea level rise, cases in this category can center on other climate impacts such as extreme heat. *Cole v. Collier*, for example, turned on whether a Texas prison's alleged pattern and practice of exposing prisoners to extreme heat violated prisoners' Eighth Amendment rights to be free from cruel and unusual punishment and disabled prisoners' rights to reasonable accommodations.[158] In presenting their case, plaintiffs provided expert testimony from a Senior Scientist in the National Center for Atmospheric Research and from a senior health epidemiologist, both of whom testified to current heat impacts and future climate-driven temperature trends.[159] In a memorandum opinion setting out the court's findings of facts, the court summarized the evidence pertaining to the impacts of extreme heat and noted that "[t]here is little dispute that the heat in the housing areas of the Pack Unit during the summer months could violate Plaintiffs' constitutional right to conditions of confinement that are free from a substantial risk of serious harm or injury."[160] Furthermore, the court took judicial notice of a report stating that "climate scientists forecast with a high degree of confidence that average temperatures in the U.S. will rise throughout this century and that heat waves will become more frequent, more severe, and more prolonged."[161] The case was eventually settled, with defendants agreeing to a variety of measures to protect prisoners from exposure to extreme heat.[162]

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[157] Turek, A.3d 737 at 739.
[158] Cole v. Collier, No. 4:14-CV-1698, 2018 WL 2766028, at *1 (S.D. Tex. June 8, 2018)
[159] Amended Expert Report of Dr. Linda O. Mearns, Senior Scientist, National Center for Atmospheric Research, Cole v. Collier, No. 4:14-CV-1698 (S.D. Tex. October 22, 2015); Amended Report of Michael A. McGeehin, Ph.D., M.S.P.H., Cole v. Collier, No. 4:14-CV-1698 (S.D. Tex. January 12, 2016).
[160] Memorandum and Opinion Setting Out Findings of Fact and Conclusions of Law, Cole v. Collier, No. 4:14-CV-1698, at *20 (S.D. Tex. July 19, 2017).
[161] *Id.* at *67 n.27 (citing Daniel W. E. Holt, Heat in U.S. Prisons and Jails: Corrections and the Challenge of Climate Change, Columbia Law School Sabin Center for Climate Change Law, i (August 2015)).
[162] *Cole*, 2018 WL 2766028 at *2–3.

These two cases demonstrate that studies and expert testimony analyzing climate change's impacts on a specific region can help support claims challenging defendants' failures to protect against such impacts. Plaintiffs in both cases relied on specific studies or expert testimony to demonstrate predictable harm. Of course, as *Turek* shows, adequate climate science is not always enough to win a case, and other legal issues—like local aesthetic land use regulations—may prevent certain claims from being successful in court.

iv. Breaching a Private Duty by Misapprehending Climate Risk

Some cases seek to cause a private party to prepare for climate impacts by, as with the cases against public entities, arguing that a defendant is failing to appropriately respond to predicted climate impacts and seeking to cause the defendant to take action to adapt. The theories raised in these cases are similar to the ones raised in lawsuits targeting public bodies, and these cases are likewise often premised on failing to prepare for the effects of sea level rise. In addition to the sea level rise and extreme weather event cases discussed below, future cases of this sort may center on risks related to wildfires, riverine flooding, drought and limited access to water, along with other extreme events and impacts caused or made more likely by climate change.[163]

As with the category of cases discussed above, failure to prepare for sea level rise is a regular basis for claims of this sort. For example, in *Public Watchdogs v. Southern California Edison Co.*, plaintiffs have alleged that a nuclear power plant operator's plan for decommissioning the plant contains provisions for spent fuel—storing the fuel in canisters just three feet above the underground water table and eighteen feet above sea level—that are inadequate because sea level will rise and inundate the facility by 2035.[164] The plaintiffs' complaint cited several predictions of local sea level rise to support their

[163] *Cf.* York County v. Rambo, No. 3:19-cv-00994, Complaint at ¶ 68 (Feb. 22, 2019 N.D. Cal.) (alleging that Pacific Gas & Electric misled investors by failing to disclose "the heightened [wildfire] risk caused by PG&E's own conduct and failure to comply with applicable regulations governing the maintenance of electrical lines, and the hundreds of fires that were already being ignited annually by the Company's equipment.").
[164] First Amended Complaint, Public Watchdogs v. Southern California Edison Co., No. 3:19-cv-01635, at ¶¶ 48-51 (S.D. Cal. Sept. 24, 2019).

allegations.[165] The court found that the plaintiffs pled sufficient facts to establish a "credible threat that a probabilistic harm will materialize," which was enough to survive a challenge to the plaintiffs' standing.[166] Separately, the court dismissed the case on preemption and subject matter jurisdiction grounds.[167] The Ninth Circuit similarly found that the district court lacked subject matter jurisdiction over plaintiffs' claims, since the Administrative Orders Review Act vested the circuit courts with exclusive jurisdiction over decisions arising from Nuclear Regulatory Commission licensing proceedings, so it did not reach any climate-related questions.[168]

In addition to *Public Watchdogs*, several lawsuits filed by the Conservation Law Foundation (CLF) are paradigmatic cases of this kind. The lawsuits allege that fossil fuel companies have failed to adapt certain port facilities to withstand the effects of rising sea levels and intensifying extreme weather events, arguing that this failure violates hazardous waste prevention planning and stormwater pollution prevention planning requirements in permits issued under the Resource Conservation and Recovery Act and the Clean Water Act, respectively.[169] CLF has filed lawsuits concerning an Exxon terminal on the Mystic River in Massachusetts[170]; a Shell terminal in the Port of Providence, in

[165] *Id.* at ¶ 51 n.25 (citing Anne C. Mulken, Sea Level Rise Will Threaten Thousands of California Homes, Sci. Amer. (June 18, 2018), www.scientificamerican.com/article/sea-level-rise-will-threaten-thousands-of-california-homes; Sea Level Rise Could Double Erosion Rates of Southern California Cliffs, U.S. Geol. Sur. (July 9, 2018), https://www.usgs.gov/news/sea-level-rise-could-double-erosion-rates- southern-california-coastal-cliffs)).

[166] Pub. Watchdogs v. S. California Edison Co., No. 19-CV-1635 JLS (MSB), 2019 WL 6497886, at *7 (S.D. Cal. Dec. 3, 2019), *aff'd*, 984 F.3d 744 (9th Cir. 2020)

[167] *Id.* at *19 (S.D. Cal. Dec. 3, 2019).

[168] Pub. Watchdogs v. S. California Edison Co., 984 F.3d 744, 767 (9th Cir. 2020), *cert. denied*, 142 S. Ct. 627, 211 L. Ed. 2d 387 (2021).

[169] *See* Complaint, Conservation Law Foundation v. ExxonMobil Corp., No. 1:16-cv-11950, at ¶¶171–294 (D. Mass. Sept. 29, 2016); Complaint, Conservation Law Foundation v. Shell Oil Products, US, No. 1:17-cv-00396, at ¶¶202–306 (D.R.I. Aug. 28, 2017); Complaint, Conservation Law Foundation v. Gulf Oil LP, No. 3:21-cv-00932, at ¶¶314–465 (D. Conn. July 7, 2021); Complaint, Conservation Law Foundation v. Shell Oil Co., No. 3:21-cv-00933, at ¶¶338–463 (D. Conn. July 7, 2021).

[170] Complaint, Conservation Law Foundation v. ExxonMobil Corp.

Rhode Island[171]; a Gulf Oil terminal in Connecticut;[172] and a Shell terminal in Connecticut.[173] The cases all argue that because the defendants are failing to prepare for future climate impacts, they are placing the public at risk from unintended pollution into waterways. The cases seek, among other forms of relief, injunctions designed to prevent future releases from the facilities.[174]

Of the categories of cases discussed in this paper, the CLF cases contain the most detailed scientific record and present particularly helpful insights into the role that climate science may play in adaptation litigation. The complaints draw on FEMA flood maps, National Climate Assessments, IPCC reports, state climate assessments, and individual peer-reviewed studies to illustrate the past and future impacts of climate change on the relevant region and each facility's specific location;[175] the complaints also point to climate science developed by the defendants to argue that the defendants knew of and knowingly disregarded climate risks to their facilities.[176] CLF's complaints rely on both attribution and predictive science: for example, CLF cites to the IPCC's claim that "[s]ome extreme weather and climate events have increased in recent decades, and new and stronger evidence confirms that some of these increases are related to human activities," along with the U.S. Global Change Research Program's claim that "[i]nfrastructure will be increasingly compromised by climate-related hazards, including sea level rise, coastal flooding, and intense precipitation events."[177] For more local impacts, CLF has cited

[171] Complaint, Conservation Law Foundation v. Shell Oil Products.
[172] Complaint, Conservation Law Foundation v. Gulf Oil LP.
[173] Complaint, Conservation Law Foundation v. Shell Oil Co.
[174] Complaint, Conservation Law Foundation v. ExxonMobil Corp., at ¶295; Complaint, Conservation Law Foundation v. Shell Oil Products, at ¶307; Complaint, Conservation Law Foundation v. Gulf Oil LP., at *86–87; Complaint, Conservation Law Foundation v. Shell Oil Co., at *91–92.
[175] Complaint, Conservation Law Foundation v. ExxonMobil Corp., at ¶¶70–170; Complaint, Conservation Law Foundation v. Shell Oil Products, at ¶¶106–201; Complaint, Conservation Law Foundation v. Gulf Oil LP., at ¶¶158–313; Complaint, Conservation Law Foundation v. Shell Oil Co., at ¶¶170–337.
[176] Complaint, Conservation Law Foundation v. ExxonMobil Corp., at ¶¶97–170; Complaint, Conservation Law Foundation v. Shell Oil Products, at ¶¶151–201; Complaint, Conservation Law Foundation v. Gulf Oil LP., at ¶¶163–170; Complaint, Conservation Law Foundation v. Shell Oil Co., at ¶¶173–188.
[177] *See* Amended Complaint, Conservation Law Foundation v. ExxonMobil Corp., No. 1:16-cv-11950, at ¶140.

studies that assess increased flooding and storm surge near the terminal sites and connect those increases to climate change.[178]

CLF has employed these scientific resources to allege that precipitation and flooding, both increasing as a result of global climate change and exacerbated by storms, storm surge, sea level rise, and increasing sea surface temperatures, substantially threaten pollutant discharges from the terminals and resulting injury to CLF's members; CLF has further alleged that defendants have failed to employ good engineering practices to prepare for these impacts.[179] In addition to claims centered on alleged past discharges, CLF has relied on the aforementioned climate science to allege that defendants have created imminent and substantial endangerment to human health and the environment; have established the conditions for near-inevitable open dumping of solid waste; and have failed to develop and maintain Storm Water Pollution Prevention Plans to reduce or prevent future discharges through good engineering practices, failed to identify sources of pollution reasonably expected to affect future discharges, failed to describe and implement practices to assure future permit compliance, failed to eliminate non-stormwater discharges, failed to eliminate adverse impacts on coastal resources, failed to minimize the potential for leaks and spills, and failed to implement adequate spill prevention and response procedures.[180]

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[178] *See, etc.*, Amended Complaint, Conservation Law Foundation v. ExxonMobil Corp., No. 1:16-cv-11950, at ¶¶163–205 (citing, for example, IPCC, Climate Change 2014: Synthesis Report, Contribution of Working Groups I, II, and III to the Fifth Assessment Report of the IPCC, at 378 (2014), http://www.ipcc.ch/pdf/assessmentreport/ar5/syr/SYR_AR5_FINAL_full_wcover.pdf; *Increasing Hurricane-Generated Wave Heights along the U.S. East Coast and Their Climate Controls*, 24 J. COASTAL RSCH. 479, 487 (2008); Complaint, Conservation Law Foundation v. Gulf Oil LP, No. 3:21-cv-00932, at ¶¶176–272 (D. Conn. July 7, 2021) (citing, for example, Adaptation Subcommittee to the Governor's Steering Committee on Climate Change, The Impacts of Climate Change on Connecticut Agriculture, Infrastructure, Natural Resources and Public Health 103 (April 2010), https://portal.ct.gov/-/media/DEEP/climatechange/ImpactsofClimateChangepdf.pdf; Lauren Morello, *Hurricane Sandy, Scientists See Extent of Storm's Damage Linked to Climate Change*, E&E NEWS (Oct. 31, 2012), https://www.eenews.net/stories/1059971867).

[179] *See, etc.*, Amended Complaint, Conservation Law Foundation v. ExxonMobil Corp., No. 1:16-cv-11950, at ¶14, ¶¶111–233.

[180] *See, etc., id.* at ¶¶234–356; Complaint, Conservation Law Foundation v. Gulf Oil LP, No. 3:21-cv-00932, at ¶¶314–465 (D. Conn. July 7, 2021).

The defendants have used the same science as CLF to cast doubt on the legitimacy of the lawsuits. ExxonMobil's filings in the Everett Terminal case in Massachusetts are illustrative. In motioning the courts to dismiss these actions, Exxon has argued that CLF's claims are based on "speculative allegations of potential injuries that might be suffered decades from now due to rising seas."[181] To that same end, Exxon has argued that CLF's "[c]omplaint relies upon projections which predict that, at its current rate, sea level is expected to rise by no more than 'another one foot' by the end of the century."[182] Furthermore, Exxon has argued that "the rate and extent of alleged climate change are shrouded in uncertainty," emphasizing language in climate assessments that address remaining uncertainties or inquiries that require better data.[183]

Exxon's arguments focus on two points. First, Exxon has argued that "speculative" risks cannot "satisfy the Article III requirement that future risks be 'certainly impending,'" and that the plaintiffs therefore lack Article III standing.[184] Second, Exxon has argued that the alleged climate risks do not satisfy the Resource Conservation and Recovery Act's requirement of an "imminent and substantial endangerment to health or the environment."[185]

The District Court of Massachusetts addressed these issues a 2017 Order denying in part and granting in part Exxon's motion to dismiss. The court held that plaintiffs "state[d] a plausible claim that there is a 'substantial risk' that severe weather events, such as storm surge, heavy rainfall, or flooding, will cause the terminal to discharge pollutants into those areas in the near future and while the Permit is in effect."[186] However, the court also found that plaintiffs lacked standing "for injuries that allegedly will result from rises in sea level,

[181] Memorandum of Law in Support of Defendants' Motion to Dismiss, Conservation Law Foundation v. ExxonMobil Corp., No. 1:16-cv-11950, at *2 (D. Mass. Dec. 16, 2016).
[182] *Id.* at *5–6.
[183] *Id.* at *6.
[184] *Id.* at *2.
[185] *Id.* at *3.
[186] Order, Conservation Law Foundation v. ExxonMobil Corp., No. 1:16-cv-11950, at *2 (D. Mass. Sept. 13, 2017).

or increases in the severity and frequency of storms and flooding, that will occur in the far future, such as in 2050 or 2100," as the court found that "[s]uch potential harms are not 'imminent' the claims concerning them are not ripe for decision because, among other reasons, the Environmental Protection Agency may require changes to the Permit that will prevent the harms from occurring."[187]

Following the court's decision on Exxon's motion to dismiss, Exxon motioned for the court to stay the case until EPA took further action on its permits. The district court granted the stay, stating that "in order to decide whether to grant the Conservation Law Foundation's requested injunctive relief, the court would have to determine whether and to what extent climatologists believe weather patterns in Boston are changing," and "which climate models best predict weather events in the near future."[188] The district court stated that these decisions were best left to EPA. The First Circuit disagreed, however, and in a 2021 decision reversed the district court's stay order, stating that "it is wholly speculative whether the issuance of the permit will illuminate EPA's beliefs as to the best climate change models or how good engineers would respond to them."[189]

Like Exxon, Shell has argued in court in Rhode Island that the alleged climate risks are not imminent,[190] and has further argued that the claimed injuries are not traceable to the company's conduct as they "flow[] from severe precipitation and flooding events that are, again, on the face of the [complaint], wholly unrelated to any Defendant."[191] Shell has used these arguments to allege that CLF lacks standing and that its claims are not ripe.[192] Shell has also argued that the complexity of the science warrants dismissal of the claims under the doctrines of abstention and primary jurisdiction, claiming that the "suit will

[187] *Id.* at *2–3.
[188] Conservation L. Found., Inc. v. ExxonMobil Corp., 448 F. Supp. 3d 7, 22 (D. Mass. 2020), *vacated and remanded sub nom.* Conservation L. Found., Inc. v. Exxon Mobil Corp., 3 F.4th 61 (1st Cir. 2021).
[189] Conservation L. Found., Inc. v. Exxon Mobil Corp., 3 F.4th 61, 74 (1st Cir. 2021).
[190] Motion to Dismiss, Conservation Law Foundation v. Shell Oil Products, US, No. 1:17-cv-00396, at *13–18, *32–34 (D.R.I. Oct. 11, 2019).
[191] *Id.* at *14.
[192] *Id.* at *13–19.

short-circuit the now-underway process to create a framework to address any changes in stormwater discharges potentially resulting from climate change."[193]

The Rhode Island District Court addressed these arguments in much the same way as the Massachusetts District Court did before it. The court stated that the Conservation Law Foundation pled "facts which, taken as true, plausibly establish an injury in fact, traceable to the challenged conduct and likely redressable with a favorable decision."[194] That said, the court differentiated "near-term harms from foreseeable weather events," which survived Shell's motion to dismiss, and "harms in the far future," which did not.[195] The court also found that the Conservation Law Foundation pled facts sufficient to satisfy Resource Conservation and Recovery Act's requirement of an "imminent and substantial endangerment to health or the environment,"[196] and declined to dismiss the case under abstention or primary jurisdiction grounds.[197] The case is currently in discovery, and climate science will continue to play a significant role as it moves forward.

The Conservation Law Foundation's Connecticut cases against Gulf Oil and Shell are more recent, and the courts have yet to address the role of climate science in them. That said, Gulf Oil has followed Shell and Exxon in arguing that the Conservation Law Foundation's alleged injuries due to future sea level rise are too speculative to support Article III standing.[198]

Unlike many of the cases discussed in Sections III(A)(1) and III(A)(2), which largely focused on the tension between plaintiffs' proffered climate science and governmental defendants' claims of discretion, this set of cases puts the adequacy of attribution science at the forefront. The Conservation Law Foundation litigation raises several key issues that

[193] *Id.* at *55.
[194] Conservation L. Found., Inc. v. Shell Oil Prod. US, No. CV 17-396 WES, 2020 WL 5775874, at *1 (D.R.I. Sept. 28, 2020).
[195] *Id.*at *1–2
[196] *Id.* at *2–3.
[197] *Id.* at *4.
[198] Defendant Gulf Oil Limited Partnership's Memorandum of Law in Support of Its Motion to Dismiss, Conservation Law Foundation v. Gulf Oil LP, No. 3:21-cv-00932, *7–12 (D. Conn. Oct. 20, 2021).

will likely prove relevant in future litigation, as well. First, the cases draw temporal limits on how far into the future plaintiffs may allege climate change-driven harm. The Massachusetts and Rhode Island courts both distinguished between near-term, judicially-cognizable climate impacts, and impacts that were not expected to occur until the latter half of the century. This emphasis on imminent harm may suggest that attribution science and near-term climate projections will play a larger role in adaptation litigation than long-term projections. The Massachusetts and Rhode Island cases also centered on whether the judiciary is the right forum for determining the best climate science in the first instance, or whether that question should be left to agencies like the EPA. The First Circuit's decision suggests that the judiciary can in fact be an appropriate forum for such questions, and that courts should not refuse to decide questions that turn on the adequacy of climate science.

v. Climate Science in Actions Seeking Adaptation Measures

As the above categories of cases demonstrate, climate science plays a key role in litigation centered on public and private bodies' alleged failure to account for or respond to climate change impacts. One factual question that runs through these cases is whether plaintiffs can show that the actions a defendant is taking (or failing to take) today are likely to have negative consequences in the future, either by identifying risks that a defendant has missed or chosen to ignore, by demonstrating that a known risk is more severe or imminent than a defendant asserts, or through other means. Attribution and predictive science has been pivotally important in the evidence that both plaintiffs and defendants have put forward to answer that question. In these cases, to help assess whether climate change poses current and future threats that should be presently addressed, attribution science can be employed to demonstrate climate change's local impacts, and climate models can be employed to predict future impacts in the near- and long-term. Furthermore, to help assess whether the data underlying present-day decision-making is out of date, climate projections can forecast future departures from historical

climatic baselines, and observational data and attribution studies can show that departures from those baselines are already occurring.

Despite the potential applicability of climate science in these cases, defendants have several potential arguments that may limit plaintiffs' success in court. As in the NEPA cases discussed above, defendants may claim that they *did* consider climate change impacts, but that they have discretion to do so differently than plaintiffs would hope. Defendants may also follow in Exxon and Shell's footsteps in directly challenging the sufficiency of proffered climate science. Such a defense can come in several forms. Defendants may attempt to challenge current attribution science and climate modeling as inherently indeterminate, pointing to statements of uncertainty in the relevant science. Defendants may also argue that impacts past a specific point in the future are too speculative to give rise to legal standing, an argument that the courts accepted in the CLF cases; in rebuttal, attribution science can help demonstrate that many climate impacts are *already* happening, and near-term climate projections can show that additional impacts will occur in a judicially-cognizable timespan. Finally, defendants may argue that the courts should wait until the relevant administrative agency has provided its view on technical, scientific questions before deciding a case, though *Conservation Law Foundation v. ExxonMobil Corp*. suggests that there is a limit on the judiciary's ability to wait for agencies to answer scientific questions before deciding adaptation cases themselves.

B. Challenges to Adaptation Measures

The four categories of cases described above center on lawsuits seeking additional adaptation actions or the more comprehensive use of climate science in agency and corporate decision-making. Climate science has also played a role in litigation challenging adaptation measures that have already been adopted. While few cases challenging adaptation measures have been brought so far, such cases are likely to arise more frequently as local, state, and federal governments seek to address more widespread and severe climate impacts. Governmental adaptation planning invites challenges of several

kinds, and climate science is implicated in important ways, particularly in defense of the challenged adaptation actions.

Several cases have centered on the criteria that undergird land use decisions designed to protect against the effects of sea level rise. For example, in *Argos Properties II, LLC v. City Council for Virginia Beach*, a developer challenged a city council's decision to deny a rezoning that would have allowed a residential development in a location threatened by sea level rise.[199] The developer argued that the city council denied the rezoning on the basis of ad hoc criteria that arbitrarily and capriciously diverged from local ordinances and state regulatory requirements by requiring applicants to account for more extreme predictions of sea level rise and storm intensity.[200] The developer's complaint provides two main examples of this divergence:

> [A]lthough the City's "Public Works Standards and Specifications," by which the City implemented local and state stormwater criterion (the "City Standards"), define a "10-year storm" as depositing 5.98 inches of rain, the Ad Hoc Criteria define this same storm as depositing 6.77 inches of rain. . . . Another of the Ad Hoc Criteria required analysis of stormwater system performance assuming a 1.5 foot rise in the starting tailwater to account for sea level rise. . . . Related to the latter, the letter noted that Argos had "declined to provide" an analysis of its stormwater performance accounting for a 1.5 foot sea level rise, i.e., had declined to provide an analysis not required by law.[201]

In response to these claims, the city council argued that its concerns over stormwater management and future flooding were reasonable and that it had the authority to account for those factors in its land use decision-making.[202] The court agreed, affirming the city council's power to account for sea level rise and flooding projections through criteria not contained in local ordinances or state regulations.[203]

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[199] Petition for Review and Complaint, Argos Properties II v. City Council for Virginia Beach, CL18002289-00 (Va. Cir. Ct. May 17, 2018).

[200] *Id*.

[201] *Id.* at ¶¶ 40–50.

[202] *See* Peter Coutu, *Developer's Lawsuit Against Virginia Beach, City Council Moves Forward*, VIRGINIA-PILOT (Oct. 19, 2018), https://bit.ly/36SFTjO.

[203] *See* Peter Coutu, *Judge Rules Virginia Beach Council Can Factor in Sea Level Rise When Deciding on New Developments*, VIRGINIA-PILOT (Apr. 24, 2019), https://perma.cc/QUW5-RM3K.

The case of *Lindstrom v. California Coastal Commission* follows a similar pattern. In *Lindstrom*, plaintiffs challenged a series of conditions that the California Coastal Commission imposed on construction of a new home on the oceanside.[204] Of particular note, the plaintiffs challenged a condition requiring the home to be set back sixty to sixty-two feet from the edge of a bluff to account for projected sea level rise, exceeding a local government-mandated setback of 40 feet.[205] The court upheld the condition in an opinion that emphasized the science behind the increased setback requirement, which the Commission's staff geologist chose based on a 1999 peer-reviewed FEMA study showing the highest long-term erosion rate in the area.[206] Specifically, the Commission geologist "explained that because of expected sea-level rise the predicted future erosion rate . . . is based on the highest historic erosion rate shown in the 1999 study."[207] Together with *Argos Properties II*, *Lindstrom* demonstrates that science linking global climate change with local sea level rise can play a significant role in land use litigation, establishing a bulwark against claims that adaptation-oriented actions are arbitrary and capricious. Crucially, even the limited science at play in *Lindstrom*—a 1999 study—provided the Coastal Commission with an important defense of their adaptation action.

Climate science has also played a role in the defense of climate resilience construction projects. In *East River Park Action v. City of New York*, local community groups challenged New York City's plan to elevate East River Park to make it serve as a barrier to coastal storms and flooding.[208] In response, the city submitted an affidavit from the Deputy Director for Waterfront Resiliency at the New York City Mayor's Office of Resiliency that detailed the city's work to develop climate change projections for New York City, the impact of Hurricane Sandy on the Lower East Side of Manhattan, and the role of the contested project in protecting the park from worsening sea level rise and

[204] Lindstrom v. California Coastal Com., 252 Cal. Rptr. 3d 817, 822 (Cal. Ct. App. 2019).
[205] *Id.*
[206] *Id.* at 827.
[207] *Id.* at 827 n.13.
[208] Verified Petition, East River Park Action v. City of New York, No. 151491/2020 (N.Y. Sup. Ct. Feb. 6, 2020).

coastal flooding.[209] The court relied on this record in rejecting the challenge to the resilience project, stating that "the record supports that without this plan we will likely not even have a park at all."[210] Plaintiffs appealed that decision, and the appellate court likewise upheld the adaptation action, pointing to the science undergirding New York's resilience plan:

> The City warns that Superstorm Sandy was a wakeup call, and a harbinger of things to come, because the Park's bulkhead is degraded, and that with continued degradation it may altogether collapse. Relying in part on the Federal Emergency Management Agency's (FEMA) 100-year floodplain elevation map, which incorporates wave height assumptions and predictions of elevated sea levels, the City argues that without flood protection, future storm surges will destroy the Park.[211]

The court further stated that

> Notwithstanding petitioner's arguments, the record is clear that coastal flooding protection will greatly benefit the Park. Located immediately next to the East River, the Park is vulnerable to coastal flooding, even more so than the communities lying inland to the west. This project is made with the intention of saving the Park from degradation due to surging salt water from the East River during storms that, over time, have increased in ferocity.[212]

As these statements make clear, much like the land use cases described above, the defendant's introduction of climate science into the evidentiary record played a crucial role in upholding New York's adaptation action in the face of legal challenge.

Adaptation measures incorporated into land use, zoning, and building codes, could also draw challenges under the Takings Clause.[213] Regulatory measures of this kind can include, for example, rules limiting the permissible uses of coastal property, as well as those that require landowners to deal with shoreline defenses. The South Carolina

[209] Affidavit of Carrie Grassie, East River Park Action v. City of New York, No. 151491/2020 (N.Y. Sup. Ct. Mar. 16, 2020).
[210] Transcript of Decision, East River Park Action v. City of New York, No. 151491/2020, at *39 (N.Y. Sup. Ct. Aug. 24, 2020).
[211] E. River Park Action v. City of New York, 160 N.Y.S.3d 195, 197, *leave to appeal denied*, 37 N.Y.3d 1130 (2021).
[212] *Id*. at 200.
[213] U.S. CONST. amend. V; *see* DANIEL J. METZGER, ATTRIBUTION SCIENCE IN TAKINGS LITIGATION (2021).

Supreme Court's 2015 opinion in *Columbia Venture v. Richland County* demonstrates how climate science may impact future takings cases. In *Columbia Venture*, a developer challenged as unconstitutional county land use regulations that effectively prohibited construction in floodways.[214] The developer had purchased land subject to a preliminary FEMA designation of the land as a floodway and brought suit against the county after FEMA's floodway determinations became final.[215] The court analyzed the takings claim under the balancing test developed in *Penn Central Transportation Co. v. City of New York*, 438 U.S. 104 (1978), considering the following three factors: "(1) the extent to which the regulation has interfered with the property owner's reasonable investment-backed expectations; (2) the economic impact of the regulation on the claimant; and (3) the character of the governmental action at issue."[216] The case demonstrates how climate science could prove relevant to both the first and third *Penn Central* factors in future cases. Discussing the first factor, the court found that, under the existing regulatory regime, the company could not reasonably have expected to be able to build on the land at issue.[217] As climate science continues to proliferate and inform land use policy, the availability of such science to "sophisticated . . . real estate development compan[ies]" and other similarly-situated parties may undercut claims that they expected to be able to use property in certain ways.[218] Discussing the third factor, the court "[f]ound] the important public purposes of mitigating the social and economic costs of flooding that are served by the County's ordinances [to be] substantial and legitimate."[219] The court also determined that "the County's regulations further[ed] the important federal purposes served by the NFIP, namely to reduce the losses caused by flood damage."[220] In future cases, science linking global climate change to local impacts may serve to legitimize government action in

[214] Columbia Venture, LLC v. Richland Cty., 776 S.E.2d 900, 903 (S.C. 2015).
[215] *Id.* at 909.
[216] *Id.* at 913 (citing Norman v. United States, 63 Fed. Cl. 231, 261 (2004)).
[217] *Id.* at 914–15.
[218] *Id.* at 914; *see also* Metzger, *supra* note 213, at 16–20.
[219] *Id.* at 915.
[220] *Id.* at 915–16.

similar ways. That said, like the defendants in the CLF cases addressed above, plaintiffs in takings actions may attempt to argue that current climate science is simply too speculative to support governmental action, especially when governments are relying on that science to justify actions with significant economic impacts.

These cases show that climate science provides defendants tools for defending adaptation measures. Those tools include means of demonstrating that local climate impacts already occurring are traceable to climate change as a whole, and that, even though the causal chain is long, future changes in the global climate system will make necessary new local adaptation measures in the future. In an inversion of the cases discussed in Sections III(A)(1) and (2), scientific studies can help governmental defendants claim discretion *to* consider up-to-date climate science in cases like *Lindstrom*, even when that science diverges from codified standards. And even when disconnected from a particular legal standard, climate science may help courts grasp the stakes of a particular matter or the weight of the governmental interest in protecting against climate impacts, as in *East River Park Action* and *Columbia Venture*, respectively. As more challenges to adaptation actions reach the court, the role of climate science in those actions will likely be further illuminated.

IV. CONCLUSION

This paper describes several kinds of climate adaptation cases and details the possibilities and limitations of climate science's role in such litigation. As the cases described above show, climate science can play a critical component in arguing for increased adaptation action and in defending adaptation action already underway. Plaintiffs and defendants alike should thus integrate the best available science into the cases they bring and defend. But even when the science is clear as to global climate change's role in precipitating local impacts, proponents of climate adaptation action may run up against barriers that limit climate science's role in litigation. In a variety of

contexts, cases will continue to turn on whether the relevant public or private party has a legal mandate to incorporate up-to-date science in the way that the litigants suggest should be done, and whether the courts should adjudicate issues pertaining to climate science rather than defer to the administrative agencies that may have greater expertise. Furthermore, as the suite of cases brought by CLF demonstrates, questions will likely continue to arise as to whether the science is in fact clear; plaintiffs in these cases should anticipate arguments centered on remaining uncertainties in climate science and the inherently speculative nature of long-term scientific predictions. While these potential arguments may not be relevant in all climate adaptation action, they will likely continue to inform parties' legal and evidentiary strategies for incorporating climate science into their litigation going forward.