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ATTRIBUTION SCIENCE IN TAKINGS LITIGATION

By Daniel J. Metzger

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1. INTRODUCTION

Climate science plays a central role in climate litigation, and cases under the Takings Clause of the United States' and many state constitutions are no exception. In the climate context, takings cases to date have involved claims that challenge the constitutionality of both adaptation and mitigation measures. For instance, real estate developers have claimed that land use and zoning regulations that seek to reduce exposure to climate change impacts constitute regulatory takings.¹ Property owners have claimed that restrictions on the development of fossil fuel infrastructure upset their investment-backed expectations.² And property owners adversely impacted by climate-related flood control measures have sought compensation for their harms.³ In these and other cases, the foreseeability of climate change impacts and the causal connections between local action and global climate change may or may not be explicit elements of a claim, but they remain critical issues for litigants and courts to address.

This paper explicates the role of attribution science in climate-related takings cases. That science factors into plaintiffs' claims, government defenses, and judicial decisions. For the purposes of this analysis, this paper examines how marshalling the best available climate change attribution science could bolster governments' defenses of climate regulations. The next section reviews the legal framework for takings cases and provides a brief primer on attribution science. The paper then turns to three legal themes: (1) linking local mitigation to global impacts, (2) resetting expectations about how land can be used and, (3) relevant to flood control cases, the relative benefits conferred by imperfect flood control measures. As we shall see, attribution science has a clear and important role to play in how courts resolve climate change-related takings claims.

¹ *See, e.g.,* Columbia Venture, LLC v. Richland County, 413 S.C. 423 (S.C. 2015).

² *See, e.g.,* E&B Natural Resource Mgmt. v. Alameda County, 2019 WL 1585637 (N.D. Cal. Apr. 12, 2019).

³ *See, e.g.,* Harris County Flood Control District v. Kerr, 499 S.W.3d 793 (Tex. 2016).

2. BACKGROUND AND CONTEXT

2.1 Legal Framework

Climate litigation is a broad category and commonly cited-definitions capture a variety of cases.⁴ Those cases present recurring issues that include, among others, whether climate impacts can be foreseen and whether it is possible to link climate impacts to anthropogenic causes. Both of these issues factor into adjudication of claims brought under the Takings Clause of the U.S. Constitution, which provides that “private property [shall not] be taken for public use, without just compensation.”⁵ The Takings Clause requires that the government must pay compensation to anyone whose private property was put to “public use” so that the government does not impose the cost of providing a public benefit on an unlucky individual when fairness dictates that those costs should be shared by the whole public.⁶

In practice the Takings Clause raises contested questions about what exactly it means to “take” private property and what compensation is fair.⁷ Where government seizes or occupies property in a way that actually changes title or possession from a private person to the government, or from a private person to another private entity but for a public purpose, a *per se* or *physical* taking

⁴ Definitions vary, but generally seek to capture litigation for which an issue relating to climate change influences the outcome of the case. The cases discussed here are *not* ones where climate change is *explicitly* a central feature of the case. See, e.g., David Markell & J.B. Ruhl, *An Empirical Assessment of Climate Change in the Courts: A New Jurisprudence or Business as Usual?*, 64 FLA. L. REV. 15, 27 (2012) (defining climate change litigation to include “any piece of federal, state, tribal, or local administrative or judicial litigation in which the . . . tribunal decisions directly and expressly raise an issue of fact or law regarding the substance or policy of climate change causes and impacts.”) Rather, the climate takings cases to date involve litigation where climate change *implicitly* guides the case’s outcome in whole or in part. See, e.g., Jacqueline Peel & Hari M. Osofsky, *Climate Change Litigation*, in ANNUAL REVIEW OF LAW AND SOCIAL SCIENCE at 8.2–8.3 (describing climate change litigation “in terms of a series of concentric circles” ranging from core cases where climate change is centrally featured to matters that have “no specific climate change framing but with implications for mitigation or adaptation”).

⁵ U.S. Const. Art. V.

⁶ *Armstrong v. United States*, 364 U.S. 40, 49 (1960) (noting the purpose of the Takings Clause, which is to prevent the government from “forcing some people alone to bear public burdens which, in all fairness and justice, should be borne by the public as a whole.”).

⁷ *Penn Cent. Transp. Co. v. City of New York*, 438 U.S. 104, 123 (1978) (“The question of what constitutes a ‘taking’ for purposes of the Fifth Amendment has proved to be a problem of considerable difficulty.”).

has taken place and the legal question is relatively simple: how much was the property worth? A large body of judicial precedent explores the harder question posed by so-called “regulatory takings”: does government owe compensation to the owner of property where the government does not actually take away the property or physically occupy it, but rather regulates in a way that makes that property less valuable?⁸

While the law of regulatory takings continues to evolve, both in terms of process and substance,⁹ its general contours are well-enough settled to explore how attribution science factors into the litigation. Under the test established in *Penn Central Transportation v. City of New York*,¹⁰ courts assessing when a regulation triggers the government’s duty to compensate affected property owners analyze three factors: the economic effect of a regulation on the property owner, the extent the regulation interferes with reasonable investment-backed expectations, and the character of the government action.¹¹

Courts applying these factors regularly remind litigants that doing so is a complex and fact-dependent process,¹² but over time cases have produced guidance on how to apply each factor. The economic impact on an owner goes to how severely a regulation limits an owner’s use of a particular property; in the climate context, as in many other contexts, where a portion of a whole property is the subject of a regulatory takings challenge, defining the whole for takings analysis is critically important.¹³ The extent to which regulation interferes with reasonable investment-backed

⁸ For an early exposition of the tension between regulation that shapes the way property can be used and regulation that has the effect of devaluing property altogether see *Pennsylvania Coal v. Mahon*. 260 U.S. 393, 415 (1922) (“[Although] property may be regulated to a certain extent, if regulation goes too far it will be recognized as a taking.”).

⁹ For example, in 2019 the Supreme Court decided *Knick v. Township of Scott*, upending precedent that effectively prohibited litigating state violations of the federal Takings Clause in Federal court. 139 S. Ct. 2162, 2167 (2019).

¹⁰ 438 U.S. 104 (1978).

¹¹ *Palazzolo v. Rhode Island*, 533 U.S. 606, 617 (2001).

¹² See, e.g., *Murr v. Wisconsin*, 137 S. Ct. 1933, 1942–43 (2017) (“This area of the law has been characterized by ad hoc, factual inquiries, designed to allow careful examination and weighing of all the relevant circumstances. . . . A central dynamic of the Court’s regulatory takings jurisprudence, then, is its flexibility.”)

¹³ See, e.g., *Id.* at 1944 (“To the extent that any portion of property is taken, that portion is always taken in its entirety.”). Although these denominator problems are prominent in takings litigation generally, they are issues for which attribution science has no special insight and are already the

expectations is similarly a complex inquiry. As discussed below, cases have held that constructive notice of impending regulatory changes can defeat those expectations; this is one avenue through which attribution science can play a crucial role, by making future climate impacts, and therefore necessary government responses, presently knowable.¹⁴ The character of government action factor serves as a sort of pressure relief valve for some necessary government regulation. A regulation that only restates prohibitions on using property that were already implied by “background principles of the State’s law of property and nuisance” does not trigger any duty to compensate a property owner.¹⁵ But that does not mean that a regulation that totally eliminates a property’s value can always be justified on the basis of nuisance concepts; in some instances, courts have held that holding

subject of significant scholarly attention. *See, e.g.*, Edward L. Rubin, *The Mistaken Idea of General Regulatory Takings*, 2019 MICH. ST. L. REV. 225, 271–72 (2019) (“Assuming that *Lucas* is good law, the crucial issue in the case is the denominator problem: whether the property is regarded as one lot or two. If viewed as two lots, the value of the second lot was in fact entirely eliminated; if viewed as one lot, the limitations on construction and subdivision are standard zoning regulations that have been repeatedly upheld.”); Danaya C. Wright, *A New Time for Denominators: Toward A Dynamic Theory of Property in the Regulatory Takings Relevant Parcel Analysis*, 34 ENVTL. L. 175, 191 (2004) (“If the full ten acres are considered the relevant parcel, then the landowner suffers only a ten percent loss in value of the entire lot. If only the one acre serves as the denominator, the landowner may suffer a complete loss. Not surprisingly, landowners advocate for the smallest possible denominator while the government advocates for the largest denominator.”); Marc R. Lisker, *Regulatory Takings and the Denominator Problem*, 27 RUTGERS L.J. 663, 694–707 (1996); John E. Fee, *Unearthing the Denominator in Regulatory Takings Claims*, 61 U. CHI. L. REV. 1535 (1994).

¹⁴ *Compare* *Connolly v. Pension Ben. Guar. Corp.*, 475 U.S. 211, 227 (1986) (concluding that reasonable investment backed expectations were not upset when ERISA was amended to achieve statutory goals that were well-known before the Act’s passage) *with* *Eastern Enterprises v. Apfel*, 524 U.S. 498, 530, 535–36 (1998) (agreeing that plaintiffs’ reasonable investment-backed expectations would be upset by a requirement to pay benefit contributions for certain employees where plaintiff ceased operations nearly a decade before passage of ERISA and did not participate in negotiations for later agreements where, critically, an industry commitment to the funding of lifetime health benefits for both retirees and their family members was first suggested). *Cf.* *Fed. Housing Admin. v. The Darlington, Inc.*, 358 U.S. 84, 91 (noting in a case resolved on substantive due process grounds that “[t]hose who do business in the regulated field cannot object if the legislative scheme is buttressed by subsequent amendments to achieve the legislative end”).

¹⁵ *Lucas v. S.C. Coastal Council*, 505 U.S. 1003, 1003 (1992).

title to a piece of property must mean the owner is entitled to at least *some* beneficial use of that property.¹⁶

2.2 Scientific Context

Human activities have generated vast quantities of greenhouse gas emissions that are having a dramatic impact on the climate.¹⁷ Atmospheric carbon dioxide, methane, and nitrous oxide reached new record concentrations in 2019, at 148%, 260%, and 123% of pre-industrial levels, respectively.¹⁸ And all of these concentrations are increasing at an accelerating rate.¹⁹

These changes in atmospheric chemistry have triggered a cascade of changes in other parts of the global climate system. 2020 was among the warmest years ever recorded—worldwide, average global temperature was about 1.2°C above pre-industrial levels.²⁰ Each of the five years following the Intergovernmental Panel on Climate Change’s (“IPCC”) Fifth Assessment Report in 2019 saw average temperatures not recorded since 1900.²¹ Arctic sea ice has declined to levels not seen in a thousand years.²² Sea level rise is happening at an accelerating rate, driven in large part by melting glaciers and ice sheets²³ and creating significantly increased risks of coastal flooding, erosion, and salination.²⁴ Globally averaged land surface air temperature has increased even faster

¹⁶ *See id.* at 1028 (“[T]he notion pressed by [defendants] that title is somehow held subject to the “implied limitation” that the State may subsequently eliminate all economically valuable use is inconsistent with the historical compact recorded in the Takings Clause that has become part of our constitutional culture.”).

¹⁷ INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, GLOBAL WARMING OF 1.5C at 53 (2018) [hereinafter *1.5C Report*] , https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_Chapter1_Low_Res.pdf.

¹⁸ WORLD METEOROLOGICAL ORGANIZATION, GREENHOUSE GAS BULLETIN 16 at 1 (2020), https://library.wmo.int/doc_num.php?explnum_id=10437.

¹⁹ *Id.* (“The increase in CO₂ from 2018 to 2019 was larger than that observed from 2017 to 2018 and larger than the average annual growth rate over the last decade.”).

²⁰ *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>.

²¹ INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, SPECIAL REPORT: SPECIAL REPORT ON THE OCEAN AND CRYOSPHERE IN A CHANGING CLIMATE, TECHNICAL SUMMARY 51 (2019), https://www.ipcc.ch/site/assets/uploads/sites/3/2019/11/04_SROCC_TS_FINAL.pdf

²² *Id.* at 52.

²³ *Id.* at 55.

²⁴ *Id.* at 56.

than sea surface temperature, having already increased by about 1.4°C from 1880 to 2018.²⁵ And a host of other impacts have been tied to anthropogenic changes in atmospheric chemistry—to name just a few, longer fire weather seasons,²⁶ increases in the severity and duration of some droughts,²⁷ changes to the hydrologic cycle,²⁸ and increased loss of biodiversity.²⁹

As these changes have become more acute, scientific understanding of the climate system has also improved dramatically. Attribution science, as defined in this paper, refers to research connecting human activity to climate change and connecting changes in climate overall to specific impacts. This paper addresses this work as falling into four research areas: climate change attribution, extreme event attribution, impact attribution, and source attribution.³⁰

2.2.1 Climate Change, Extreme Event, and Impact Attribution

Studies that explore climate change, extreme event, and impact attribution share key sources of data and techniques. First, physical understanding of how elements of the climate system function and interact with one another. The reflective capacity of sea ice, for example, can be tested in

²⁵ INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE AND LAND, TECHNICAL SUMMARY 44 (2019), https://www.ipcc.ch/site/assets/uploads/sites/4/2020/07/03_Technical-Summary-TS_V2.pdf.

²⁶ *Id.* at 45.

²⁷ See 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. Marthens 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.”).

²⁸ Kate Marvel et al., *Twentieth-Century Hydroclimate Changes Consistent with Human Influence*, 569 NATURE 59, 64 (2019) (suggesting that “anthropogenic influences on global hydroclimate were present throughout the twentieth century, albeit in different forms”).

²⁹ Carlos Riquelme et al., *Extinction risk assessment of a Patagonian ungulate using population dynamics models under climate change scenarios*, 64 J. OF BIOMETEOROLOGY 1847 (2020).

³⁰ These definitions are articulated in Michael Burger, Jessica Wentz, and Radley Horton, *The Law and Science of Climate Change Attribution*, 45 COLUM. J. ENVTL. L. 57, 67 (2020) [hereinafter *Law and Science of Climate Attribution*].

laboratory conditions.³¹ Understanding how such elements operate individually provides a basis for exploring their interactions with each other and how changes in any variable impact the climate system as a whole. Second, observational data about the climate system in action. Observational data include measurements of atmospheric carbon dioxide concentrations, ocean acidity, rainfall extent and distribution, among many others.³² Third, statistical analyses that aim to quantify the likelihood of an observed change happening either with or without climate forcing in play. Scientists can do so, for example, where enough observational data exist to distinguish an anthropogenic climate effect from natural climate variability.³³ Fourth, these studies commonly rely on climate models that incorporate physical understanding, observational data, statistical analysis, and dynamic analysis into tools to compare observed data to counterfactual models without anthropogenic influence on the climate.

Standardized climate models exist, are available to the public, and are powerful tools to explain the links between human activity and observed climate impacts.³⁴ Models can use various forecasts of climate variables like sea surface temperature and atmospheric carbon dioxide concentrations to shed some light on potential climate impacts under different scenarios, even before those impacts actually occur. Still, climate models have limitations. To name a few: the observational data on which they depend contain some uncertainties, natural climate variability can be difficult to distinguish from human-driven changes, and historical data used to establish baseline conditions may reflect other forms of human influence. The distribution of certain species, for example, may now be shifting as a result of climate change but may already have been altered by land use changes occurring before climate measurements were taking place. But those uncertainties can be acknowledged and mitigated by precise language articulating the strength of the models' results. For example, rather than simply concluding that a climate outcome is or is not the result of human

³¹ See, e.g., Bonnie Light, Regina C. Carns, and Stephen G. Warren, 'Albedo dome': a method for measuring spectral flux-reflectance in a laboratory for media with long optical paths, 54 APPLIED OPTICS 5260 (2015).

³² See, e.g., D.J. Wuebbles, 2017: Observational datasets used in climate studies, in FOURTH NATIONAL CLIMATE ASSESSMENT, VOLUME I 430 (D.J. Wuebbles et al. eds, 2017).

³³ See generally K. Hasselmann, *Optimal Fingerprints for the Detection of Time-Dependent Climate Change*, 6 J. CLIMATE 1957, 1957 (1993).

³⁴ *Law and Science of Climate Attribution*, *supra* note 30 at 71–72.

influence, the IPCC uses language that conveys degrees of certainty (very likely, likely, etc.).³⁵ And individual studies use similar language about the degree of confidence with which conclusions are reached, writing for example that a result is “virtually certain (>99% probability)”³⁶ or a conclusion is reached “with high confidence.”³⁷

2.2.2 Localizing Climate Impacts

Attributing local climate impacts and individual extreme events presents distinct challenges. For example, a climate model may take into account varying temperatures in many different years and confidently demonstrate that, on the whole, extreme weather events are becoming more frequent, even though most individual years see no such events. And a specific event may be explained by natural variability or an overall trend that indicates an anthropogenic climate impact. But in some instances, observed local changes diverge so significantly from what models predict in a hypothetical world with no human influence on climate that the best explanation is anthropogenic climate influence.³⁸ In other cases, scientists are forced to work at disentangling climate change from other variables—in the context of drought for instance, an impact attribution study will have to account for both decreased precipitation and increased temperature as a result of climate change, as well as land use impacts on water retention and the possibility of overextraction from an affected aquifer.

Because non-climate variables are difficult to account for, most studies focus only on a single link in the chain of causation—this is known as single-step attribution.³⁹ Some such studies link a local impact to global trends while acknowledging that other factors play a role in causing the impact. For example, a recent study exploring the impact of climate change on bumble bee populations in North America noted that “agricultural intensification, pesticide use, and pathogens, can also affect occupancy and extirpation risk of bumble bees,” but that “risks of bumble bee

³⁵ See, e.g., INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2014: SYNTHESIS REPORT 4 (2015), https://www.ipcc.ch/site/assets/uploads/2018/02/SYR_AR5_FINAL_full.pdf.

³⁶ 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).

³⁷ Thomas Frölicher, et al., *Marine Heatwaves Under Global Warming*, 560 NATURE 360, 362 (2018).

³⁸ See, e.g., Stuart-Smith et al., *supra* note 36 at 88 (“[T]he rates of observed [glacial] retreat are larger than any of the model output, which indicates that a large-scale climate change is a necessary condition for the glacier’s observed length change to occur.”).

³⁹ *Law and Science of Climate Attribution*, *supra* note 30 at 74.

extirpation rise in areas where local temperatures more frequently exceed species' historical tolerances."⁴⁰ Such studies confidently find climate change to be a driver of a particular impact by identifying observable local changes and inferring their climate cause from larger scale or longer term climate change trends. Other single-step attribution studies focus on the link between human warming and a specific change in the global climate system, such as surface temperature increase. A study examining seasonal near-surface temperatures around the world, for example, found evidence that human influence, rather than natural factors, increased the frequency of warmer seasons in twenty-two regions around the world.⁴¹

2.2.3 Source Attribution

Finally, source attribution—linking specific emissions sources to their role in climate change as a whole—is a separate but partially overlapping field of research subject to different constraints. Observational data to understand the extent of greenhouse gases in the atmosphere play a role in source attribution, as does physical understanding of the chemistry of fossil fuel combustion which allows researchers to translate amounts of coal or oil used into quantities of greenhouse gases in the atmosphere. Documentary evidence buttresses those by providing insight into where fossil fuels are being consumed and have been in the past, where those fuels were extracted in the first place, and the infrastructure that moves those fuels from where they are extracted to where they are used. That evidence includes, among others, publicly available information from securities filings, academic literature, and fossil fuel companies' own production records, all coupled with physical understandings of the carbon content of different fuel types.

Several types of source attribution studies bring those data together to assess the carbon impact of particular projects or companies. Richard Heede's "Carbon Majors Report," for example, assesses the percentage of cumulative greenhouse gas emissions attributable to specific oil, natural gas, coal, and cement producers.⁴² Other studies identify the greenhouse gas impact of certain

⁴⁰ Peter Soroye et al., *Climate change contributes to widespread declines among bumble bees across continents* 367 *SCIENCE* 685 (2020).

⁴¹ Peter A. Stott et al., *Single-Step Attribution of Increasing Frequencies of Very Warm Regional Temperatures to Human Influence*, 12 *ATMOSPHERIC SCI. LETTERS* 220 (2011).

⁴² See, e.g., RICHARD HEEDE, *CARBON MAJORS: ACCOUNTING FOR CARBON AND METHANE EMISSIONS 1854–2010: METHODS & RESULTS REPORT* (2014).

political jurisdictions, such as nations⁴³ or cities,⁴⁴ and specific industries, such as tourism or agriculture.⁴⁵ Other studies analyze the relative greenhouse gas intensity of consuming natural gas in different locations, driven by the degree to which transport causes leakage.⁴⁶

3. THE ROLE OF ATTRIBUTION SCIENCE IN TAKINGS LITIGATION

That the sum of global greenhouse gas emissions is driving climate change and its impacts around the world is universally accepted by the scientific community.⁴⁷ Attribution science can be used to support arguments that climate change is causally linked to anthropogenic activity, that climate impacts are foreseeable, and that local climate impacts are at least in part caused by global climate change. Both foreseeability and causation factor prominently in climate cases.

A wide range of impacts that are already occurring can be attributed to climate change. As the number of studies connecting impacts to climate change grows and the confidence of those findings increases, predicting future impacts is made more credible and, in theory, more persuasive to courts.⁴⁸ Predicting precisely what evidence would convince a court that a particular impact is a foreseeable consequence of greenhouse gas emitting activities is beyond the scope of this paper. But the court's determination will likely be guided by the confidence with which researchers can attribute a particular impact of climate change, the reliability of the methods used to determine that

⁴³ See, e.g., Sourish Basu et al., *Estimating US fossil fuel CO₂ emissions from measurements of 14C in atmospheric CO₂*, 24 PROC. NAT'L ACAD. SCI. 117 (2020).

⁴⁴ C40 CITIES CLIMATE LEADERSHIP GROUP, CONSUMPTION-BASED GHG EMISSIONS OF C40 CITIES (2018), <https://www.c40.org/researches/consumption-basedemissions>.

⁴⁵ See, e.g., Emrah Koçak et al., *The impact of tourism developments on CO₂ emissions: An advanced panel data estimation*, 33 TOURISM MGMT. PERSPECTIVES (2020) (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) (production of beef cattle, pork and chickens).

⁴⁶ See, e.g., Diana Burns and Emily Grubert, *Attribution of production-stage methane emissions to assess spatial variability in the climate intensity of US natural gas consumption*, 16 ENV. RES. LETTERS (2021).

⁴⁷ See *supra* Section 2.2.

⁴⁸ *Law and Science of Climate Attribution*, *supra* note 30 at 203.

attribution, the degree of consensus among scientists, and whether studies predate the impact or only seek to explain the event after it occurred.⁴⁹

Takings cases challenging both mitigation and adaptation measures call on government defendants to articulate the best available attribution science. Where a mitigation measure is the subject of a challenge, defendants may be called upon to persuasively articulate how the likelihood or severity of local impacts are lessened by actions taken against global climate change. Despite the availability of attribution science to make that connection, however, most cases still couch local measures in terms of non-climate variables. For example, a zoning plan may ban new fossil fuel extraction activities citing their local air pollution impacts. Such measures have been subject to challenges arguing that the true purpose of the regulation is to address climate change and arguing that, because the link between climate change and local impacts is complex, the measures should be abandoned or invalidated. Where adaptation measures are challenged, defendant governments face the task of demonstrating that local impacts are occurring and, often, that more severe climate change impacts are reasonably foreseeable. For example, an ordinance might require structural changes to coastal developments to prepare for climate driven flooding, and so must justify the cost of shoreline defense or public safety hazard of vulnerable structures.

The sections that follow explore three specific types of actions where attribution science has a crucial role to play in litigation.

3.1 Better understanding the character of government action

Courts in the United States have routinely upheld state and local actions to reduce greenhouse gas emissions and affirmed the legitimacy of state interests in climate mitigation.⁵⁰ At the same time, though, and although the sample size is small, courts reviewing challenges to local measures that would specifically prohibit or limit fossil fuel infrastructure have expressed some

⁴⁹ *Law and Science of Climate Attribution*, *supra* note 30 at 204.

⁵⁰ *See, e.g.*, *Am. Fuel & Petrochemical Manufacturers v. O’Keeffe*, 903 F.3d 903 (9th Cir. 2018) (Oregon measure requiring a regulated party to keep the average carbon intensity of transportation fuels below a limit); *Rocky Mtn. Farmers v. Corey*, 2019 WL 254686 (9th Cir. Jan. 18, 2019) (California’s low-carbon fuel standard); *Rocky Mtn. Farmers v. Corey*, 730 F.3d 1070 (9th Cir. 2013) (same); *Electric Power Supply Association v. Star*, 904 F.3d 518 (7th Cir. 2018) (Illinois zero-emissions credit program); *Coal. for Competitive Elec. v. Zibelman*, 272 F. Supp. 3d 554 (S.D.N.Y. 2017), *aff’d* 906 F.3d 41 (2d Cir. 2018) (New York’s zero-emissions credit program); *Energy and Env’t Legal Inst. v. Epel*, 43 F. Supp. 3d 1171 (D. Colo. 2014).

skepticism that the measures would be justified solely on their climate benefits, and focused instead on more conventional local environmental concerns.

Two examples from outside the takings context are illustrative. In *Oakland Bulk & Oversized Terminal, LLC v. City of Oakland* the city attempted to defend an ordinance banning a port from handling coal, primarily relying on public health effects of coal dust but also noting climate change as another justification for the ban. The court simply concluded that the argument “barely merits a response,” adding that that “[i]t is facially ridiculous to suggest that this one operation resulting in the consumption of coal in other countries will, in the grand scheme of things, pose a substantial global-warming related danger to people in Oakland.”⁵¹ In *Portland Pipe Line Corp. v. City of South Portland* a pipeline company challenged a city ordinance prohibiting any company from loading tar sands oil onto marine vessels in the city.⁵² The city council justified the ordinance as a measure to “protect the public health and welfare from adverse or incompatible land uses,”⁵³ but comments from the public and some city counselors demonstrated their motivation (at least in part) to mitigate climate change impacts.⁵⁴ The court rejected a claim that the ordinance was an invalid attempt to regulate conduct outside the city’s jurisdiction, adding that “while there was an ancillary background motive on the part of some Councilors and citizens, the primary purpose of the Ordinance was not to . . . prevent oil sands extraction in other jurisdictions.”⁵⁵

In the takings context, at least one challenger to local action has argued that because the climate change problem is global in scale, local measures are too small to make a difference and are thus an inappropriate use of local resources. In *Levin Richmond Terminal Corp. v. City of Richmond* the plaintiff has challenged a local ordinance that forbade “the storage and handling of petroleum coke

⁵¹ *Oakland Bulk & Oversized Terminal, LLC v. City of Oakland*, 321 F. Supp. 3d 986, 1008 (N.D. Cal. 2018), *aff'd*, 960 F.3d 603 (9th Cir. 2020).

⁵² 332 F. Supp. 3d 264, 281 (D. Me. 2018).

⁵³ *Id.* at 359; *see also* CITY OF SOUTH PORTLAND CODE § 27-786, https://www.southportland.org/files/5414/8648/6531/CH_27_Zoning_with_New_TOC_format.pdf (“[T]here shall be no installation, construction, reconstruction, modification, or alteration of new or existing facilities, structures, or equipment, *including but not limited to those with the potential to emit air pollutants*, for the purpose of bulk loading of crude oil onto any marine tank vessel”) (emphasis added).

⁵⁴ 332 F. Supp. 3d at 281.

⁵⁵ *Id.* at 299.

at a coal or petroleum coke storage handling facility.”⁵⁶ Levin contends that the terminal is a unique facility limited by market conditions such that the ordinance is likely to put it out of business, and that the ordinance is therefore an impermissible regulatory taking.⁵⁷ The city’s explanation of its ordinance situates it squarely within its traditional police power authority to abate nuisances such as local air pollution from fugitive dust, without triggering the Takings Clause’s compensation requirement.⁵⁸ But Levin contends that the city’s explanation for the ordinance belies a truer motive: “to reduce global climate change affected by the burning of fossil fuels.”⁵⁹

The case raises the question of whether local government action to halt fossil fuel infrastructure could be defended on the basis of global climate change.

Attribution science could address that question in at least two ways. First, impact attribution studies can demonstrate the link between global climate change and local climate impacts. Those studies face challenges—as noted above, disentangling the role of non-climate variables is complex and it may not be possible in every instance to isolate climate change’s role in local effects. But such studies are well-accepted within the limitations they face and can provide a clear basis to argue that climate change has localized impacts within the relevant jurisdiction—here, the city of Richmond—and that taking action to reduce greenhouse gas emissions, including upstream and/or downstream greenhouse gas emissions associated with fossil fuel products, is a means of addressing a key driver of local risk.

Second, source attribution studies can help link local emissions to global climate change as a whole to justify the action.⁶⁰ Although a regulation targeting an individual facility or type of facility within a single sub-national jurisdiction will not stop climate change, source attribution studies and greenhouse gas accounting protocols provide another basis for a government to argue that measures

⁵⁶ Complaint for Declaratory and Injunctive Relief at ¶¶ 117–26, *Levin Richmond Terminal Corporation v. City of Richmond*, No. 20-cv-1609 (N.D. Cal. March 4, 2020).

⁵⁷ *Id.* at ¶ 121.

⁵⁸ *Id.* Exhibit A: City of Richmond Agenda Report dated February 4, 2020.

⁵⁹ *Id.* at ¶ 47.

⁶⁰ See, e.g., Richard Heede, *Tracing Anthropogenic Carbon Dioxide and Methane Emissions from Fossil Fuel and Cement Producers, 1854–2010*, 122 *CLIMATIC CHANGE* 229 (2014); CLIMATE ACCOUNTABILITY INST., *THE CARBON MAJORS DATABASE: CDP CARBON MAJORS REPORT 2017* (2017); B. Ekwurzel et al., *The Rise in Atmospheric CO₂, Surface Temperature, and Sea Level from Emissions Traced to Major Carbon Producers*, 144 *CLIMATIC CHANGE* 579 (2017).

that reduce emissions are linked to mitigating global climate change as a whole. For example, a variety of methodologies exist to quantify both direct and indirect emissions from individual projects, such as the terminal in Richmond.⁶¹ The magnitude of these impacts can be measured by using proxies, such as the Social Cost of Carbon and Methane, or else measured in an absolute sense against a science-based emissions target. Of course, infrastructure challenges are not the only types of projects that may be subject to takings challenges. A local ban on fracking, for example, could generate a takings challenge from producers with mineral leases expecting to develop new wells.⁶²

Using source attribution or greenhouse gas accounting protocols in this way would provide a specific methodology to link the local action to global climate change, which could provide a way for governments to counter arguments that those links are too tenuous to justify local action. Arguments that local action will have a discernable effect on climate change are going to face challenges since, as noted above, there are uncertainties about how natural variability and climate change interact in local contexts. But attribution science provides a scientifically sound means of making the argument that such an effect does exist. Relying on these studies is one way that climate mitigation measures can be defended.

Cases in other contexts provide examples of courts examining the role a particular project plays in climate change as a whole. A large set of NEPA cases have held that Environmental Impact Assessments must consider the extent to which a project will contribute to climate change.⁶³ And in

⁶¹ See, e.g., Environmental Protection Agency, *Greenhouse GAS Reporting Program*, EPA.GOV, <https://www.epa.gov/ghgreporting/ghgrp-reported-data>; K. Dimitriou et al., *Greenhouse gases (CO₂ and CH₄) at an urban background site in Athens, Greece: Levels, sources and impact of atmospheric circulation*, 253 *ATMOSPHERIC ENV'T* (2021); João Gomes et al., *Estimating local greenhouse gas emissions—A case study on a Portuguese municipality* 2 *INT'L J. GREENHOUSE GAS CONTROL* 130 (2008); *Law and Science of Climate Attribution*, *supra* note 30 at 128–39. In addition, a government can assess the relative greenhouse gas intensity of a project in its particular geographic location in light of the physical infrastructure on which the project will rely See, e.g., Burns and Grubert, *supra* note 46.

⁶² Cf. *Union Oil Co. of California v. Morton*, 512 F.2d 743, 750–51 (9th Cir. 1975) (challenging Department of Interior's decision to refuse permission for oil companies to build drilling platforms on already-leased plots where the Secretary determined the platforms would be "inconsistent with protection of the environment").

⁶³ See, e.g., *Ctr. for Biological Diversity v. Nat'l Highway Traffic Safety Admin.*, 538 F.3d 1172 (9th Cir. 2008). For a more complete discussion of climate change litigation in the context of the National Environmental Policy Act, see Michael Burger and Jessica Wentz, *Downstream and Upstream Greenhouse Gas Emissions: The Proper Scope of NEPA Review*, 41 *HARV. ENV'T L. REV.* 110 (2017).

Plan B Earth v. Sec’y of State, an intermediate appellate court in the U.K. held that local officials assessing whether to approve a new runway at Heathrow airport must take into account national commitments under the Paris Agreement and the broader context of mitigating climate change under U.K. law.⁶⁴ The U.K. Supreme Court reversed the intermediate court’s decision, but did agree that officials approving the new runway had to assess its global climate impacts even though that consideration did not dictate a particular substantive outcome.⁶⁵

In *Gloucester Resources Limited v. Minister for Planning*, planning officials in New South Wales, Australia denied a company’s application to construct a new coal mine.⁶⁶ On appeal, the court agreed that one valid reason (among several) to deny the permit was the indirect greenhouse gas emissions that a new coal mine would cause, reasoning that, “[i]t matters not that [the] aggregate of the Project’s GHG emissions may represent a small fraction of the global total of GHG emissions. The global problem of climate change needs to be addressed by multiple local actions to mitigate emissions by sources and remove GHGs by sinks. . . . All emissions are important because cumulatively they constitute the global total of greenhouse gas emissions, which are destabilising the global climate system at a rapid rate”⁶⁷

In sum, takings doctrine as it currently stands does not foreclose a U.S. court from similarly agreeing both that climate change is driving local harms that merit local mitigation measures, and that addressing proportionately small individual sources is an appropriate step to remedying those harms. Few enough climate change cases have been filed under the Takings Clause to fully predict when and how courts will accept these arguments, particularly since courts’ analyses of the character

⁶⁴ *Plan B Earth et al. v. Sec’y of State*, [2020] EWCA Civ 214, ¶ 233.

⁶⁵ [2020] UKSC 52.

⁶⁶ [2019] NSWLEC 7.

⁶⁷ *Id.* at ¶¶ 515–16. Although it is not a takings case and is differently situated than the examples discussed here, *Massachusetts v. EPA* does demonstrate how courts might reject arguments that a small step to address climate change is unreasonable where other actors have a greater influence on the overall problem. The court noted that “EPA does not believe that any realistic possibility exists that the relief petitioners seek would mitigate global climate change . . . because predicted increases in greenhouse gas emissions from developing nations, particularly China and India, are likely to offset any marginal domestic decrease.” 549 U.S. 497, 523–24 (2007). But the court concludes that while the relief at issue there “will not by itself reverse global warming, it by no means follows that we lack jurisdiction to decide whether EPA has a duty to take steps to slow or reduce it,” and that “[a] reduction in domestic emissions would slow the pace of global emissions increases, no matter what happens elsewhere.” *Id.* at 526.

of a government action are essentially ad-hoc, fact-dependent inquiries.⁶⁸ But the science justifies linking local action to global change, suggesting local governments have this way of defending measures they take to mitigate global climate change and have, therefore, a greater incentive to take those steps in the first place.

3.2 Resetting the reasonableness of property owners' expectations

A property owner's interrupted plan or hope that they will be able to use their property in a specific way is itself not sufficient to satisfy the expectations prong of the regulatory takings analysis; that expectation must be reasonable.⁶⁹ And the mere fact that a climate regulation was not in place when property was acquired does not mean it was reasonable to expect that no such regulation would ever be imposed.⁷⁰ Attribution science addresses this prong of the *Penn Central* analysis in both mitigation and adaptation cases.

3.2.1 Mitigation

Where governments impose rules designed to limit fossil fuel infrastructure, extraction or use, ultimately hoping to mitigate climate change, opponents may argue that such measures interfere with their reasonable investment-backed expectations. *E&B Natural Resources Management Corp v. County of Alameda* provides an example of the kind of case where these arguments are likely to arise. There, the owners of an oil field challenged their county's decision not to renew necessary permits such that oil production would have to stop.⁷¹ Despite no changes to the actual extractive use since about 1967, and without explicitly acknowledging the use's climate change impacts, the county decided in 2017 that continuing to produce oil at the site was "not required by public need"

⁶⁸ See Thomas W. Merrill, *The Character of the Government Action*, 36 VERMONT L. REV. 649, 661 (2012) ("With minimal guidance from the Supreme Court, lower courts have been left largely to their own devices in exploring the meaning of the character factor under the Penn Central test.").

⁶⁹ *Cienega Gardens v. United States*, 331 F.3d 1319, 1346 (Fed. Cir. 2003) ("[A court's analysis of reasonable investment-baked expectations is an] objective, but fact-specific inquiry into what, under all the circumstances, the Owners should have anticipated.").

⁷⁰ See *Palazzolo*, 533 U.S. at 634–35 (2001) (O'Conner, J., concurring) ("[T]he state of regulatory affairs at the time of acquisition is not the only factor that may determine the extent of investment-backed expectations. . . . Courts instead must attend to those circumstances which are probative of what fairness requires in a given case.").

⁷¹ *E&B Natural Resource Mgmt. v. Alameda County*, 2019 WL 1585637 (N.D. Cal. Apr. 12, 2019).

and that “the use could cause serious detriment to the surrounding properties or the general public.”⁷² The owners have challenged that denial as a regulatory taking.

The regulatory regime in place when the oil field developed is a strong indication of what its investors reasonably expected, but the court’s analysis of whether those expectations continued to be reasonable will take into account the circumstances as of the date the alleged taking occurred. Attribution science could help the county defend its decision against some of the likely arguments the oil producer could raise. To name a few: that the emissions associated with fuels from one (small) facility have no measurable impact on anthropogenic climate change as a whole, since source attribution studies can quantify the impacts specific projects on climate change overall; that nothing has changed since wells were drilled decades ago; and that a small reduction in global climate change has no discernable connection to local impacts, since models are increasingly able to link local weather effects to climate change.

New investments in fossil fuel dependent infrastructure have to be done against the backdrop of state-of-the-art attribution science linking even small emitters’ contributions to climate change as a whole. Arguments that an individually small emitter should be somehow immune from restrictions may fall flat in light of attribution studies that quantify the role of any emitter in global climate change. Similarly, climate change attribution and source attribution studies bolster the huge amount of public and political attention to climate change regulation that has put local emitters on notice that rules designed to limit emissions of greenhouse gases are likely priorities for governments at any scale.⁷³ Knowing that even small emitters can play a role in climate change as a

⁷² Verified Complaint and Petition at ¶ 35, *E&B Natural Resources Management Corp. v. County of Alameda*, No. 4:18-cv-05857 (N.D. Cal. Sept. 24, 2018).

⁷³ ENERGY INFORMATION ADMINISTRATION, *NET ZERO BY 2050* at 14 (2021), <https://www.iea.org/reports/net-zero-by-2050> (“The path to net - zero emissions is narrow: staying on it requires immediate and massive deployment of all available clean and efficient energy technologies. . . . A major worldwide push to increase energy efficiency is an essential part of these efforts, resulting in the annual rate of energy intensity improvements averaging 4% to 2030 - about three-times the average rate achieved over the last two decades.”); *FOURTH NATIONAL CLIMATE ASSESSMENT* 60, 62, (D.J. Wuebbles et al. eds, 2017), <https://nca2018.globalchange.gov/> (“State, local, and tribal government approaches to mitigating greenhouse gas emissions include comprehensive emissions reduction strategies as well as sector- and technology-specific policies . . . [and since 2014] the scale and scope of adaptation implementation has increased, including by federal, state, tribal, and local agencies as well as business, academic, and nonprofit organizations”); *1.5C Report*,

whole, it may not be reasonable to expect that fossil fuel infrastructure and other property uses that directly or indirectly create emissions will avoid restrictions going forward.

3.2.2 Adaptation

Impact attribution studies are able to link climate change as a whole to local effects. The public availability of this kind of science suggests that in some cases it will not be reasonable, for example, to expect to develop coastal property in ways that are highly vulnerable to climate-driven flooding and extreme precipitation events. Local governments that act to prevent such development can point to numerous studies that highlight well-known risks of such development, of which a reasonable investor ought to be aware. These might include the National Climate Assessment, which

supra note 17 at 15 (“Pathways limiting global warming to 1.5°C with no or limited overshoot would require rapid and far-reaching transitions in energy, land, urban and infrastructure (including transport and buildings), and industrial systems (high confidence). These systems transitions are unprecedented in terms of scale, but not necessarily in terms of speed, and imply deep emissions reductions in all sectors, a wide portfolio of mitigation options and a significant upscaling of investments in those options (medium confidence.”); *cf.* CHRISTINA GOLDFUSS, COUNCIL ON ENVIRONMENTAL QUALITY, FINAL GUIDANCE FOR FEDERAL DEPARTMENTS AND AGENCIES ON CONSIDERATION OF GREENHOUSE GAS EMISSIONS AND THE EFFECTS OF CLIMATE CHANGE IN NATIONAL ENVIRONMENTAL POLICY ACT REVIEWS 10 (2016), https://ceq.doe.gov/docs/ceq-regulations-and-guidance/nepa_final_ghg_guidance.pdf (“In light of the global scope of the impacts of GHG emissions, and the incremental contribution of each single action to global concentrations, CEQ recommends agencies use the projected GHG emissions associated with proposed actions as a proxy for assessing proposed actions’ potential effects on climate change in NEPA analysis.”). This 2016 guidance was rescinded under the Trump administration, but President Biden has directed agencies to make use of it “as appropriate and relevant” while his administration considers new guidance on NEPA and climate change. Rachel Franzin, *White House rescinds Trump proposal to limit greenhouse gas consideration in infrastructure decisions*, THE HILL (Feb. 18, 2021 11:34 AM), <https://thehill.com/policy/energy-environment/539397-white-house-rescinds-trump-proposal-aiming-to-limit-greenhouse-gas>.

details impacts at the regional level;⁷⁴ more localized assessments undertaken by state and local governments;⁷⁵ or even studies published by scientific researchers.⁷⁶

Knowing that a regulatory change is likely can prove fatal to a takings claim. For example, in *Columbia Venture, LLC v. Richland County*, a developer purchased a tract of land subject to a preliminary FEMA designation as a regulatory floodway.⁷⁷ The new owners negotiated a non-binding memorandum of understanding with the County, agreeing to “work with the development group on issues that are critical to the proposed development” but existing local rules prevented any development in a FEMA-designated floodway.⁷⁸ After FEMA’s floodway determinations became final, the property owner brought a takings claim against the county. The court found the property owner’s expectations that it could somehow either change County rules, alter FEMA’s

⁷⁴ FOURTH NATIONAL CLIMATE ASSESSMENT, *supra* note 73.

⁷⁵ See, e.g., CONSOLIDATED EDISON, CLIMATE CHANGE VULNERABILITY STUDY at 16 (2019), [https://www.coned.com/-/media/files/coned/documents/our-energy-future/our-energy-projects/climate-change-resiliency-plan/climate-change-vulnerability-study.pdf?la=en%23::~text=Con%20Edison%20recognizes%20the%20global,occurring%20at%20an%20accelerating%20rate.&text=This%20Study%20evaluates%20present%2Dday,vulnerability%20to%20climate%2Ddriven%20risks](https://www.coned.com/-/media/files/coned/documents/our-energy-future/our-energy-projects/climate-change-resiliency-plan/climate-change-vulnerability-study.pdf?la=en%23::~text=Con%20Edison%20recognizes%20the%20global,occurring%20at%20an%20accelerating%20rate.&text=This%20Study%20evaluates%20present%2Dday,vulnerability%20to%20climate%2Ddriven%20risks;); (“[C]hanges in the global climate system affect local climatology and weather in Con Edison’s service territory . . . [including] both long-term mean changes, such as gradual increases in temperature and sea level, and changes in extreme events, such as heat waves, hurricanes, and storm surge.”); CALIFORNIA’S FOURTH CLIMATE CHANGE ASSESSMENT 38 (2018) (“Available science indicates that because of climate change, many people will endure more illness and be at greater risk of early death in California.”), https://www.energy.ca.gov/sites/default/files/2019-11/Statewide_Reports-SUM-CCCA4-2018-013_Statewide_Summary_Report_ADA.pdf; CITY OF NORFOLK, VIRGINIA, VISION 2100 at 5 (2016) (“[B]y 2100, Norfolk could be expected to experience an inundation of 3-5% of its currently-dry land – meaning that about 1,500 acres would be under water – for at least some portion of the day – on a daily basis.”), <https://www.norfolk.gov/DocumentCenter/View/27768/Vision-2100---FINAL?bidId=>; DOUGLAS AND IRON COUNTIES [WISCONSIN], LAKE SUPERIOR SOUTH SHORE BLUFF RECESSION RATE STUDY 13 (2012) (“Most early [climate change] predictions are that the level of Lake Superior will fall in general. However, storminess is likely to increase and there will still be periods of high water.”), <http://www.nwrpc.com/DocumentCenter/View/1177/Final-Report?bidId=>.

⁷⁶ See, e.g., C. Izaguirre et al., *Climate change risk to global port operations*, 11 NATURE CLIMATE CHANGE 14 (2021); William V. Sweet et al., *In Tide’s Way: Southeast Florida’s September 2005 Sunny-Day Flood* 97 BULL. AM. METEOROLOGICAL SOC. S25 (2016); Pardeep Pall et al., *Anthropogenic Greenhouse Gas Contribution to Flood Risk in England and Wales in Autumn 2000*, 470 NATURE 382 (2011).

⁷⁷ *Id.* at 8.

⁷⁸ *Id.* at 8.

determination, or otherwise work out a regulatory change to develop the property were unreasonable.⁷⁹

As attribution science continues bringing the link between climate change and local climate impacts into sharper focus, the reasonableness of expecting regulatory regimes to ignore those impacts is cast into serious doubt. The interaction of the reasonable expectations prong of the takings analysis with sea-level rise, for example, has already been the subject of considerable scholarly attention.⁸⁰ Governments can argue that measures designed to address sea-level rise and other climate impacts—increased risk of wildfires, intensified extreme weather events, coastal flooding, and others—are reasonably foreseeable for the owners of property likely to be affected by those impacts.

3.3 Flood control

Finally, attribution science is critical in cases that require governments to defend against claims that flood control efforts effected an unconstitutional taking. With coastal and riverine

⁷⁹ *Id.*

⁸⁰ See, e.g., Thomas Ruppert, *Castles—and Roads—in the Sand: Do All Roads Lead to A “Taking”?*, 48 ENVTL. L. REP. NEWS & ANALYSIS 10914, 10932 (2018) (“[L]ocal governments should begin to pass policies and disseminate information that helps to appropriately shape the long-term expectations of property owners about which infrastructure in which areas will likely be able to be maintained.”); Megan M. Herzog & Sean B. Hecht, *Combatting Sea Level Rise in Southern California: How Local Governments Can Seize Adaptation Opportunities While Minimizing Legal Risk*, 19 HASTINGS W.-N.W. J. ENVTL. L. & POL’Y 463, 516 (2013) (“A local government should emphasize to the court that a property owner can never reasonably expect to use her property in a way that interferes with public trust lands. Certainly, this argument will have the strongest force against owners who purchased their property . . . after sea level rise became a matter of local public acknowledgement.”); Michael Allan Wolf, *Strategies for Making Sea-Level Rise Adaptation Tools “Takings-Proof”*, 28 J. LAND USE & ENVTL. L. 157, 168 (2013) (“Once government regimes have begun the process of sharply curtailing development in coastal regions, all existing and potential landowners should be on notice that further refinements are quite likely in the offing.”); Thomas Ruppert, *Reasonable Investment-Backed Expectations: Should Notice of Rising Seas Lead to Falling Expectations for Coastal Property Purchasers?*, 26 J. LAND USE & ENVTL. L. 239, 275 (2011) (“While no one part of the Penn Central analysis necessarily trumps, ensuring that coastal property owners have full understanding of the nature of the hazards, the dynamic coastal environment, and existing and potential regulatory limitations should demonstrate that owners’ expectations which are drastically out of line with these realities and information are not reasonable.”).

flooding becoming far more frequent, efforts to defend against these floods will increase.⁸¹ Where flood control efforts require intentionally flooding some areas to preserve others or to prevent catastrophic flooding a court can find that a taking has occurred.⁸² The factors a court will apply to an analysis of whether temporary flooding is a taking are similar to those that would apply to regulatory takings,⁸³ and the defense discussed above with respect to the reasonableness of expectations and causation should apply. Courts have also considered, however, the relative benefits of a flood-related project as a defense to a takings claim where a flood control project causes some harm but arguably prevents more. The relevant benefits doctrine compares “the overall benefits of the government action with respect to the particular property as compared to the detriment that was suffered.”⁸⁴

Thus, for example, in *In re Downstream Addicks* the Federal Court of Claims refused to find liability when the Army Corps intentionally released water from a reservoir causing flooding, since the flooding was still less severe than would have occurred with no intervention at all.⁸⁵ Similarly, in *Alford v. United States*, the Federal Circuit held that the Army Corps was not liable for a taking where the Army Corps chose to raise the level of a lake, flooding and damaging lakefront property, but by doing so preventing a levee from breaching and causing even more severe flooding.⁸⁶

⁸¹ See ENVTL. PROT. AGENCY, *Climate Change Indicators: Coastal Flooding*, <https://www.epa.gov/climate-indicators/climate-change-indicators-coastal-flooding> (charting frequency of coastal flooding events in twenty-seven sites along U.S. coasts and finding sharp increases in 2010-2015 relative to previous decades in virtually every site examined).

⁸² See *Arkansas Game & Fish Comm’n v. United States*, 568 U.S. 23, 38 (2012) (“Government-induced flooding temporary in duration gains no automatic exemption from Takings Clause inspection.”).

⁸³ *St. Bernard Par. Gov’t v. United States*, 121 Fed. Cl. 687, 719 (2015) (“In *Arkansas Game & Fish*, the United States Supreme Court held that [in the context of a takings claim premised on government-induced flooding] . . . plaintiffs must establish: (1) a protectable property interest under state law; (2) the character of the property and the owners’ “reasonable-investment backed expectations”; (3) foreseeability; (4) causation; and (5) substantiality.”).

⁸⁴ *Alford v. United States*, 961 F.3d 1380, 1384 (Fed. Cir. 2020); see also *U.S. v. Sponenbarger* 308 U.S. 256, 266 (1939) (government activity effecting property must be “measured in the whole”).

⁸⁵ *In re Downstream Addicks*, 147 Fed. Cl. 566, 580 (2020) (“[E]ven an intentional release of water does not give rise to a takings claim unless the flood control structure releases more water than is entering the reservoir.”).

⁸⁶ 961 F.3d at 1381–82 (“[T]he Army Corps of Engineers raised the water level of Eagle Lake to prevent a nearby levee from breaching[, and the] plaintiffs’ properties were damaged as a result . . . but the damages sustained were less than the damages to the plaintiffs’ properties that would have resulted from a levee breach. . . . [Here] the relative benefits doctrine bars liability.”).

The relative benefits doctrine is well suited to justifying climate adaptation measures. Where zoning restrictions prohibit development in flood prone areas but thereby prevent severe losses that would occur with unchecked development, or where dams and other pieces of flood control infrastructure partially displace property owners but protect the remainder of the property, the connection between those measures and being prepared for climate impacts is fairly close. Adapting to climate impacts will directly mitigate the damages that property owners would otherwise face from extreme weather events.

Attribution science can justify such measures. Studies that localize the impacts of global climate change can quantify the degree to which increases in the intensity and frequency of riverine flooding, providing a basis to justify the cost of adaptation measures that address flooding.⁸⁷ And comparable studies that can quantify the degree to which sea level rise is already affecting particular communities⁸⁸ provide a basis to directly compare the impact of sea level rise to the impact of an adaptation measure. That comparison can ground an argument that even if building flood control infrastructure reduces the value of some property, that reduction is more than offset by the overall benefit the infrastructure creates.⁸⁹

⁸⁷ See, e.g., Lukas Gudmundsson et al., *Globally observed trends in mean and extreme river flow attributed to climate change*, 371 SCI. 1159 (2021).

⁸⁸ See, e.g., Chetan Sharma et al., *Climate change detection and attribution in the Ganga-Brahmaputra Meghna River basins*, 12 *Geoscience Frontiers* (2021); C. Izaguirre et al., *supra* note 76; B. Ekwurzel et al., *supra* note 60.

⁸⁹ The focus of this paper is on claims under the Takings Clause, but the federal government also enjoys broad statutory immunity of negligence claims arising from flood waters. Despite the Federal Tort Claims Act's waiver of sovereign immunity, the federal government is immune to tort "liability of any kind . . . from any damage from or by floods or flood water" under the Flood Control Act of 1928 ("FCA"). 33 U.S.C. § 702c. Cases interpreting this section have clarified that the immunity it affords extends to injuries caused by flood waters, whether or not the flooding was caused by negligence or by flood control measures. See *Nat'l Mfg. Co. v. United States*, 210 F.2d 263, 271 (8th Cir. 1954) ("[A]ny place where there is damage 'from' or 'by' a flood or flood waters in spite of and notwithstanding federal flood control works no liability of any kind may attach to or rest upon the United States therefor.").

4. CONCLUSION

When local governments get to work addressing climate change they run the risk that opponents of those measures will file challenges. Several of the measures governments may adopt—land use and zoning restrictions, rules that block fossil fuel extraction and infrastructure, and flood control measures—can burden property owners’ use of their property. The Takings Clause is a natural fit for those challenges. But as this paper explicates, attribution science provides clear and previously underutilized bases to defend local climate change adaptation and mitigation measures. The existence and clarity of attribution science should bolster governments’ willingness to take steps, even small local ones, to address climate change.