A NEW CAUSAL PATHWAY FOR RECOVERY IN CLIMATE CHANGE LITIGATION?

by Thomas Burman

Thomas Burman works as project development counsel at Virunga Power, a sustainable energy infrastructure developer in East and Southern Africa. He was previously an attorney in the energy, environmental, mining, and transportation division at Stinson LLP.

SUMMARY

Courts across the globe recognize that human-induced climate change leads to more frequent and severe extreme weather and other events, resulting in significant damages to persons and property. Although courts have therefore ordered countries and corporations to take more aggressive actions to limit their greenhouse gas emissions, no court has yet required any emitter to pay damages for injuries from a climate change-related event. Causation issues remain a significant obstacle to such claims. To overcome this obstacle, this Article proposes using causal and liability standards that have long been applied in tort claims involving diffuse environmental pollution. Specifically, the "necessary element of a sufficient set" approach, when combined with proportional liability, may allow a plaintiff to establish an entity's emissions as a legally relevant cause of a specific climate-related injury. The Article reviews the laws of five key jurisdictions, concluding that the proposed approach may successfully establish a legally relevant causal link in most, if not all, of them, with varying success depending on the climate change-related event in question.

In August 2021, the United Nations (U.N.) Intergovernmental Panel on Climate Change (IPCC) issued Part I of its Sixth Assessment Report,[1] which includes the panel's starkest comments to date on the links between anthropogenic greenhouse gas (GHG) emissions and climate change. According to the report, it is now "*unequivocal* that human influence has warmed the global climate system," and it is "*established fact* that human-induced greenhouse gas emissions have led to an increased frequency and/or intensity of some weather and climate extremes" such as "extreme precipitation, droughts, tropical cyclones, and compound extremes (including dry/hot events and fire weather)."[2] The IPCC also provides a dire outlook, predicting a global surface temperature increase of above 2°C from pre-industrial levels; increased frequency and intensity of extreme weather, drought, and heat waves; increased Arctic ice melt; an intensified global water cycle; and rising sea levels, all of which could occur even under more modest scenarios with relatively low levels of future anthropogenic GHG emissions.[3] As one climate scientist notes, the report is "as close as you're ever going to see to watching the scientists of the world screaming at the top of their lungs from the top of the tallest building."[4]

The numerous extreme weather events witnessed in 2021 alone make the IPCC's warnings difficult to ignore. Extreme heat and enormous forest fires stretched across western North America[5] and throughout Greece and Turkey,[6] while historic flooding inundated western Europe.[7] The impacts of Hurricane Ida in the United

Author's Note: Special thanks to Dr. Romain Mauger at the Groningen Centre of Energy Law—University of Groningen for his review and comments.

1. IPCC, Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change 3-4 (2021), https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Full_Report.pdf [hereinafter IPCC Report].
2. *Id.* at 3-4, 11-6 (emphasis added).
3. *Id.* at SPM-15 to SPM-30.
4. Katherine Dunn, *The World's Scientists Are "Screaming at the Top of Their Lungs." Are We Listening?*, Fortune (Aug. 11, 2021), https://fortune.com/2021/08/11/climate-change-un-ipcc-report-scientists-screaming/.
5. *More Than 60 Wildfires Rage Across U.S. West—Including Blaze Bigger Than Portland*, Guardian (July 13, 2021), https://www.theguardian.com/us-news/2021/jul/13/us-wildfires-california-oregon-washington.
6. Thanassis Stavrakis et al., *Raging Wildfires in Greece, Turkey, Force Thousands to Flee*, AP News (Aug. 6, 2021), https://apnews.com/article/europe-fires-athens-heat-waves-4fca06093b6e4c0c463210dfe7fb4cfb.
7. Frank Kreienkamp et al., World Weather Attribution, Rapid Attribution of Heavy Rainfall Events Leading to the Severe Flooding in Western Europe During July 2021 (2021), https://www.worldweath-

States spanned from Louisiana to Maine, leading to New York City's first "flash flood emergency."[8] Extreme winter storms pummeled Texas, forcing extended blackouts.[9] In September 2021, the editors of more than 200 medical journals issued a joint statement claiming that climate change is the "greatest threat to global public health."[10] And in the same month, a World Meteorological Organization report concluded that the number of disasters related to weather, climate, or water hazards have increased fivefold over the past 50 years, causing 115 deaths and US$202 million in losses each day over that period—with more than 91% of deaths occurring in developing countries.[11] The organization's Secretary General echoed the IPCC, explaining that "[t]he number of weather, climate and water extremes are increasing and will become more frequent and severe in many parts of the world as a result of climate change."[12]

Although the correlation between anthropogenic GHGs, climate change, and losses due to extreme weather and other climate-related events is now an "established fact" per the IPCC, to date no court has required a GHG emitter—whether a country, organization, or company—to pay damages for harms arising from such an event. Recent landmark court decisions have required countries such as France,[13] the Netherlands,[14] and Germany,[15] and private entities such as Royal Dutch Shell,[16] to take more aggressive action to curb future GHG emissions, but these cases do not provide relief for climate-related damages that have already been suffered or that will be suffered imminently due to—at least in part—existing anthropogenic emissions. Such questions could be addressed in international arenas, but the recently concluded COP26 in Glasgow did not lead to dedicated compensation for loss and damage,[17] wealthier nations have admitted to falling short on their climate finance commitments to developing nations,[18] and arbitration procedures that could provide meaningful compensation have not been solidified.[19]

Claimants have certainly attempted to obtain monetary relief in litigation against specific GHG emitters for their contributions to climate change, and courts in these cases have largely accepted as a general matter that increased anthropogenic GHG emissions will lead to more climate-related damages.[20] However, causation issues remain a significant obstacle to establishing liability for damages against the defendants in these cases.[21] In general, the law will only assign liability for damages if there is a causal link between a defendant's act (i.e., its GHG emissions) and the plaintiff's specific injury (i.e., the harm resulting from the extreme weather event or other circumstance made more likely or severe by the defendant's GHG emissions).[22] Common-law and civil-law systems alike require causal *necessity*—that is, that the injury would not have occurred without the defendant's GHG emissions.[23] Given the complex, interdependent, and unpredictable nature of our climate, courts have dismissed these damages claims, skeptical that such necessary causation could ever be established.[24]

However, recent progress in the emerging field of climate attribution science may make it possible to establish a legally relevant causal link between a defendant's specific emissions and a claimant's specific harm. Three areas of attribution science are pertinent to demonstrate this link. First, "event attribution" allows one to determine whether total anthropogenic GHGs increased the likelihood or severity of a specific extreme weather or slow-onset event (e.g., glacial melt or sea-level rise).[25] Second, "impact attribution" enables one to determine the extent to which the climate-related event contributed to a plaintiff's injury, accounting for factors unrelated to climate.[26] Lastly, "source attribution" has credibly apportioned most

erattribution.org/wp-content/uploads/Scientific-report-Western-Europe-floods-2021-attribution.pdf.

8. Jesus Jiménez & Michael Levenson, *Ida's Wind-Driven Remnants Pummel the New York City Region*, N.Y. Times (Sept. 1, 2021), https://www.nytimes.com/2021/09/01/us/northeast-rain-ida-new-york.html.
9. Dan Esposito & Eric Gimon, *The Texas Big Freeze: How a Changing Climate Pushed the State's Power Grid to the Brink*, Util. Dive (June 2, 2021), https://www.utilitydive.com/news/the-texas-big-freeze-how-a-changing-climate-pushed-the-states-power-grid/601098/.
10. Lukoye Atwoli et al., *Call for Emergency Action to Limit Global Temperature Increases, Restore Biodiversity, and Protect Health*, 385 New Eng. J. Med. 1134 (2021), https://www.nejm.org/doi/full/10.1056/NEJMe2113200.
11. Press Release, World Meteorological Organization, Weather-Related Disasters Increase Over Past 50 Years, Causing More Damage but Fewer Deaths (Aug. 31, 2021), https://public.wmo.int/en/media/press-release/weather-related-disasters-increase-over-past-50-years-causing-more-damage-fewer.
12. *Id.*
13. Tribunal Administratif [Administrative Court] Paris, Feb. 3, 2021, Nos. 1904967, 1904968, 1904972, 1904976/4-1 (unofficial English translation of *Notre Affaire à Tous v. France*), http://climatecasechart.com/climate-change-litigation/wp-content/uploads/sites/16/non-us-case-documents/2021/20210203_NA_decision.pdf.
14. HR 20 december 2019, ECLI:NL:HR:2019:2007, 19/001 (De Staat der Nederlanden (Ministerie van Economische Zaken en Klimaat)/Stichting Urgenda) (unofficial English translation), http://climatecasechart.com/climate-change-litigation/wp-content/uploads/sites/16/non-us-case-documents/2020/20200113_2015-HAZA-C0900456689_judgment.pdf.
15. Bundesverfassungsgericht [BVerfG] [Federal Constitutional Court] Mar. 24, 2021, 1 BvR 2656/18, 1 BvR 78/20, 1 BvR 96/20, 1 BvR 288/20 (unofficial English translation of *Neubauer v. Germany*), http://climatecasechart.com/climate-change-litigation/wp-content/uploads/sites/16/non-us-case-documents/2021/20210429_11817_judgment-2.pdf.
16. RBDHA the Hague 26 mei 2021, ECLI:NL:RBDHA:2021:5339, C/09/571932/HA ZA 19-397 (Vereniging Milieudefensie/Royal Dutch Shell PLC) (unofficial English translation), http://climatecasechart.com/climate-change-litigation/wp-content/uploads/sites/16/non-us-case-documents/2021/20210526_8918_judgment-2.pdf.
17. Megan Rowling, *Climate "Loss and Damage" Earns Recognition but Little Action in COP26 Deal*, Reuters (Nov. 13, 2021), https://www.reuters.com/business/cop/climate-loss-damage-earns-recognition-little-action-cop26-deal-2021-11-13/.
18. Simon Evans et al., *COP26: Key Outcomes Agreed at the UN Climate Talks in Glasgow*, Carbon Brief (Nov. 15, 2021), https://www.carbonbrief.org/cop26-key-outcomes-agreed-at-the-un-climate-talks-in-glasgow.
19. Pamela McDonald, *Resolving Climate Change Disputes Through Arbitration*, Pinsent Masons (Mar. 31, 2021), https://www.pinsentmasons.com/out-law/analysis/resolving-climate-change-disputes-through-arbitration.
20. Maria L. Banda, Climate Science in the Courts: A Review of U.S. and International Judicial Pronouncements 2 (Envtl. L. Inst. 2020).
21. See discussion *infra* Section I.D.
22. Michael Burger et al., *The Law and Science of Climate Change Attribution*, 45 Colum. J. Env't L. 57, 201 (2020).
23. Ingeborg Puppe & Richard W. Wright, *Causation in the Law: Philosophy, Doctrine, and Practice*, *in* Causation in European Tort Law 17, 34 (Marta Infantino & Eleni Zervogianni eds., Cambridge Univ. Press 2017).
24. See the cases discussed *infra* Section I.D.
25. *Infra* Section II.A.
26. *Infra* Section II.B.

anthropogenic GHG emissions from the beginning of the industrial revolution to today among a small set of "global carbon majors"—investor- and state-owned hydrocarbon producers and cement manufacturers.[27] Due to the fungible nature of GHGs and the relatively few private entities responsible for most global anthropogenic GHG emissions in history, climate attribution science makes it theoretically possible to establish a causal link between a specific climate-related harm and the specific GHG emissions of a specific global carbon major.[28]

The question thus arises as to whether the law has kept up with the science such that entities may be held liable in damages for their emissions. This has been a matter of recent scholarly debate, focusing generally on two questions. First, there is some disagreement as to whether attribution science has advanced to the point that the law could recognize a defendant's emissions as the necessary cause of a claimant's injury, when examining that injury *in its entirety*—for example, whether a claimant whose property was flooded can recover damages for the complete extent of its loss from a single emitter or group of emitters.[29] Second, scholars debate whether courts could or should relax traditional causation standards that have so far precluded climate damages claims, as they have done in asbestos cases and other contexts.[30]

Both questions are properly answered in the negative. First, even given advances in attribution science, it will never be possible to show that a defendant's specific emissions were a necessary cause of a plaintiff's *entire* injury.[31] Indeed, although attribution science now allows one to discern the specific contribution of a single entity's GHG emissions to a single climate-related injury, this (perhaps counterintuitively) will make it *more* difficult to establish liability. This is because attribution science also makes it more apparent that any one defendant's contribution to an overall climate-related injury will be minuscule in every case, since even the largest emitters on the global carbon majors list have contributed only a small fraction to the total atmospheric GHG mix. Thus, attribution science can frustrate efforts to show legally relevant causation, at least when examining a claimant's *entire* climate-related injury.

As for the second question, progress in attribution science will also likely make it *more* difficult to argue that relaxed causation standards should apply.[32] This is because these relaxed standards are invoked in almost all cases to address issues of causal *uncertainty*—where a claimant cannot show who specifically caused the harm, but where the law recognizes it would be unjust to not afford relief. In contrast, attribution science *mitigates* causal uncertainty, allowing one to discern any one GHG emitter's specific contribution to a specific harm.

It therefore may seem like attribution science places plaintiffs in a dilemma, where they are neither able to meet strict necessary causation requirements nor to rely on a relaxed standard. This, however, does not mean that claimants are left without a remedy. Instead, there is a third avenue for establishing causation that has not been given much attention by the "all-or-nothing" approach of the above scholarly debate, but that may be appropriately suited for damages claims arising from climate-related harms. Courts in both common-law and civil-law systems, while not relaxing necessary causation requirements, are nonetheless increasingly willing to recognize the realities of our multicausal world in which—and especially for situations involving diffuse environmental harm—multiple cumulative conditions cause an injury.[33]

To accommodate this reality, courts are increasingly applying "proportional" (or "several") liability, rather than "joint and several" (or "solidary") liability, in cases with multiple tortfeasors.[34] Specifically, proportional liability is applied when one defendant's contribution to a harm is too small on its own to be a necessary cause of a claimant's *total* injury, but where the contribution is still a "necessary element of a sufficient set" (NESS) of several "concurrent minimum causes" that *together* cause the injury.[35] In other words, the defendant's contribution was a necessary part of the complete set of conditions that, when considered together, causes the harm. In such circumstances, courts have held a defendant proportionally (i.e., severally) liable in damages only for its contribution to the plaintiff's total injury.[36]

At first glance, this NESS approach seems well tailored to climate change harms. After all, any one defendant's GHG emissions will only ever form a small component of the total GHGs in the atmosphere, but they are nonetheless a necessary part of the total GHG mix that intensifies a specific slow-onset or extreme weather event or makes such an event more likely to occur, leading to the plaintiff's injury.[37]

Accordingly, it is worth exploring whether a claimant, armed now with a more robust evidentiary record based on current climate attribution science, can use proportional liability and the NESS test to establish legally relevant causation in tort claims seeking damages from a global carbon major for climate-related harms, in proportion to that global carbon major's contribution to the total atmospheric GHG mix. Specific attention is devoted in this Article to U.S. law and the law of European countries where the top-emitting investor-owned global carbon majors are headquartered and incorporated. German law is also examined due to the ongoing *Lliuya v. RWE AG* case, the first action anywhere in the world to allow

27. *Infra* Section II.C.
28. *Infra* Section II.D.
29. *Infra* Section III.A.
30. *Infra* Section III.B.
31. *Infra* Section III.A.
32. *Infra* Section III.B.
33. *Infra* Section III.C.
34. *Id.*
35. *Id.*
36. *Id.*
37. *Id.*

a tort claim for damages against a global carbon major to proceed to the evidentiary stage.[38]

This Article ultimately concludes that, under this approach, one could establish a legally relevant causal link required to hold a global carbon major liable in damages for climate change-related harms. However, success in demonstrating causation will ultimately depend on the nature of the extreme weather or slow-onset event at issue, and on the jurisdiction in which the claim is brought.[39] There remain significant uncertainties in climate attribution science, and it is less robust for extreme weather events than for slow-onset events.[40] Similarly, although there is a trend toward accepting proportional liability in multiple tortfeasor cases in European and U.S. courts, this is a departure from (until recently) firmly rooted principles of joint and several (i.e., solidary) liability.[41] Thus, courts will vary in their acceptance of these theories.

The Article proceeds in three main parts. After a short introduction analyzing which laws will likely apply to these claims and in which countries they will likely be brought, Part I explains the conventional causation standards that apply to all tort claims in these common-law and civil-law jurisdictions, the incompatibility of these causation standards in climate-related tort claims for damages, and the resulting reluctance by courts to find causation in such claims. Part II explains the progress in event, impact, and source attribution science and how all three may be used to establish a complete legally relevant causal chain, from specific GHG emissions to a specific climate-related injury. Part III discusses the scholarly debate on whether necessary causation can be found in climate-related tort claims for damages and whether relaxed causation standards should apply. It then introduces the NESS test and proportional liability, analyzing whether both can reasonably be applied to such claims in the pertinent courts. Part IV concludes.

The analysis presented here should be valuable to scientists, policymakers, and lawyers alike. By identifying the gaps that persist between the state of the law and of the attribution science when it comes to establishing causation, this Article should help scientists focus their research, policymakers tailor their legislative efforts, and lawyers think more creatively and effectively on behalf of their clients, all with the aim of bridging these gaps. It is important to note, however, that this analysis is limited to *causation* issues. Substantial legal scholarship exists concerning other potential obstacles to climate-related tort claims, such as whether a duty to reduce emissions should even be recognized in tort in the first place,[42] or whether there is a corporate fiduciary duty to disclose climate-related risks.[43] In other words, even if causation can be established in a climate-related tort claim for damages against a GHG emitter, this neither guarantees success nor precludes reliance on other (perhaps more viable) theories.

38. See the discussion of this case *infra* Sections I.D and II.E.
39. *Infra* Section III.C.
40. *Infra* Section III.A.
41. *Infra* Section III.C.
42. *See*, *e.g.*, Martin Spitzer & Bernhard Burtscher, *Liability for Climate Change: Cases, Challenges, and Concepts*, 8 J. Eur. Tort L. 137, 162 (2017).
43. *See generally*, *e.g.*, Perry Wallace, *Climate Change, Fiduciary Duty, and Corporate Disclosure: Are Things Heating Up in the Boardroom?*, 26 Va. Env't L.J. 293 (2008).

I. The Conflict Between Traditional Causation Rules and Climate Change

A. *Which Law Will Apply and in Which Forum?*

Before analyzing the causation standards that would apply to a private tort claim for climate change-related damages against a specific emitter, one must first determine which countries would have jurisdiction over these actions and which countries' laws would apply. European Union (EU) regulations (applicable to Germany, the Netherlands, and France),[44] and English[45] and U.S. law,[46] all confer jurisdiction over courts located in a defendant's domicile. As discussed further in Section II.C, the six highest emitting investor-owned entities on the Global Carbon Majors list are domiciled in the United States (ExxonMobil, Chevron, Peabody),[47] England (BP),[48] the Netherlands (Royal Dutch Shell),[49] and France (Total).[50] Germany is also a useful country to examine given the ongoing *Lliuya v. RWE* case, involving a tort claim for damages against German company RWE AG, discussed throughout this Article.[51] Accordingly, climate-related tort claims for damages will likely be brought in these countries.

Courts located in these countries could apply either forum or foreign law to such claims. EU regulations provide that the applicable law for tort claims is generally the

44. European Parliament and Council Regulation 1215/2012 of 12 December 2012 on Jurisdiction and the Recognition and Enforcement of Judgments in Civil and Commercial Matters (Recast), 2012 O.J. (L 351/1), art. 4(1).
45. *See* Alexander Layton, *Alexander Layton on Brexit and Private International Law—What Now?*, Eur. Ass'n Private Int'l L. (Dec. 11, 2020), https://eapil.org/eapil-activities/eapil-virtual-seminar-series/alexander-layton-on-brexit-and-private-international-law-what-now/.
46. Goodyear Dunlop Tires Operations, SA v. Brown, 564 U.S. 915, 924 (2011).
47. Exxon Mobil Corp., Annual Report Pursuant to Section 13 or 15(d) of the Securities Exchange Act of 1934 (Form 10-K) (Jan. 31, 2021), https://ir.exxonmobil.com/static-files/12d442a1-9503-450f-86a5-139512ce2f35; Chevron Corp., Annual Report Pursuant to Section 13 or 15(d) of the Securities Exchange Act of 1934 (Form 10-K) (Feb. 10, 2021), https://chevroncorp.gcs-web.com/static-files/69451f3b-d3c5-4f6f-9a99-22dca3b2410c; Peabody Energy Corp., Annual Report Pursuant to Section 13 or 15(d) of the Securities Exchange Act of 1934 (Form 10-K) (Feb. 24, 2021), https://app.quotemedia.com/data/downloadFiling?webmasterId=101533&ref=115658355&type=PDF&formType=10-K&dateFiled=2021-02-23&cik=0001064728&CK=1064728&symbol=0001064728&companyName=.
48. BP, Performing While Transforming From IOC to IEC: Annual Report and Form 20-F 2020 (2021), https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/investors/bp-annual-report-and-form-20f-2020.pdf.
49. Royal Dutch Shell, Powering Progress: Annual Report and Accounts 2020 (2021), https://reports.shell.com/annual-report/2020/servicepages/downloads/files/shell-annual-report-2020.pdf.
50. Total SA, Universal Registration Document 2020 Including the Annual Financial Report (2021), https://www.total.com/system/files/documents/2021-03/2020-universal-registration-document.pdf.
51. RWE, Powering Ahead. Annual Report 2020 (2021), https://www.rwe.com/-/media/RWE/documents/05-investor-relations/2020-Q4/2021-03-16-rwe-annual-report-2020.pdf?la=en&sc_lang=en&hash=AA578F521D91E8E91A5963091BA383E2.

location where the damage occurs,[52] which in many climate-related cases could be foreign law.[53] However, for any "non-contractual obligation arising out of environmental damage," a claimant can choose "to base his or her claim on the law of the country in which the event giving rise to the damage occurred."[54] Courts would likely interpret this clause to include climate-related damage.[55] Since the "event giving rise to the damage" in this case could very well include all corporate decisions made at the headquarters level, claimants in climate tort suits in France, Germany, and the Netherlands will likely have the freedom to choose whether to apply forum or foreign law, based on which is more favorable to their claim.[56]

English law follows these principles after the United Kingdom's (U.K.'s) withdrawal from the EU.[57] Courts in Texas, California, and Missouri (the states of incorporation for ExxonMobil, Chevron, and Peabody) apply the "most significant relationship" test under the Restatement (Second) of Conflict of Laws.[58] Under this test, the law of the state with the "most significant relationship to the occurrence and the parties" applies, considering, among other things, the place of injury, the place of the event giving rise to the injury, and the domicile of the parties.[59] Thus, courts using the Second Restatement test could also apply forum or foreign law, depending on the circumstances.[60]

For the sake of analytical clarity, this Article will examine causation and liability principles applicable in the foregoing countries in which the top six investor-owned global carbon majors are domiciled. The Article also examines the widely referenced Principles of European Tort Law[61] and Restatement of the Law of Torts[62] treatises, which summarize principles and emerging trends applicable across Europe and the United States, respectively. Examining forum law and the general principles embodied in these treaties will provide a comprehensive overview of the potential causation and liability principles any plaintiff or defendant would confront in a private tort claim seeking climate change-related damages.

52. European Parliament and Council Regulation 864/2007 of 11 July 2007 on the Law Applicable to Non-Contractual Obligations (Rome II), 2007 O.J. (L 199/40), art. 4(1) [hereinafter Rome II Regulation].
53. Spitzer & Burtscher, *supra* note 42, at 151.
54. Rome II Regulation, *supra* note 52, art. 7.
55. Spitzer & Burtscher, *supra* note 42, at 151.
56. *Id.*
57. The Law Applicable to Contractual Obligations and Non-Contractual Obligations (Amendment etc.) (EU Exit) Regulations 2019, SI 2019/834, pt. 4 (noting that the Rome II Regulation retained EU law, without amendments to these pertinent articles).
58. *See* Nedlloyd Lines B.V. v. Superior Court, 3 Cal. 4th 459, 465 (Cal. 1992); Sheehan v. Northwestern Mut. Life Ins. Co., 44 S.W.3d 389, 396 (Mo. Ct. App. 2000); Farmers Ins. Exch. v. Leonard, 125 S.W.3d 55, 62 (Tex. Ct. App. 2003).
59. Restatement (Second) of Conflict of Laws §145 (Am. L. Inst. 1971).
60. Michael Byers et al., *The Internationalization of Climate Damages Litigation*, 7 Wash. J. Env't L. & Pol'y 264, 294 (2017).
61. Principles of European Tort Law: Text and Commentary (European Group on Tort Law eds., 2005) [hereinafter PETL].
62. Restatement (Third) of Torts: Liability for Physical and Emotional Harm (Am. L. Inst. 2012) [hereinafter Third Restatement, Liability for Physical and Emotional Harm]; Restatement (Third) of Torts: Apportionment of Liability (Am. L. Inst. 2000) [hereinafter Third Restatement, Apportionment of Liability].

B. *Factual and Legal Causation—Can and Should Causation Be Found?*

Regardless of the specific tort claim asserted, plaintiffs seeking damages based on a defendant's GHG emissions must establish that those emissions caused their harm. Common-law and civil-law systems apply a two-part test to the causal analysis, requiring both "factual" and "legally relevant" causation.[63] Factual causation asks whether a condition was in fact necessary to cause the harm alleged.[64] If established, courts then apply limiting normative principles to determine whether the law *should* recognize the cause-in-fact as the "legal" cause of the harm.[65]

1. Factual Causation—The Requirement of Necessity

To determine if a condition is a cause-in-fact, courts use an objective counterfactual inquiry, labeled the "but-for" test in common-law systems and the "conditio sine qua non" test in civil-law systems.[66] Under each test, the fact finder will (explicitly or implicitly) create a hypothetical counterfactual scenario in which the condition that is alleged to have caused the claimant's harm is removed from the set of relevant circumstances surrounding the injury. The outcome of that scenario is then compared against the real-world scenario.[67] If removing the alleged cause results in no harm, one can say that the harm would not have resulted "but for" that condition, or that the condition is the conditio sine qua non of the harm.[68] The defendant's act or omission is thus established as the "necessary cause" of the harm.[69]

There are key differences between the causal analysis used by courts and the statistical approaches used in scientific research, such as climate attribution science. Statistical analyses are probabilistic, examining the correlation of two or more conditions to determine the probability of the occurrence of one condition *B* (e.g., the event) given the existence or nonexistence of another condition *A* (i.e., the alleged cause).[70] In contrast, the legal fact finder must make a deterministic conclusion regarding causation.[71] To do so, the fact finder generally must look beyond statistics, for example to personal observations and experience, to conclude that A in fact caused B, rather than was merely correlated with B.[72] Although this adds an element to the causal analysis, the legal fact finder also is not beholden to

63. Petra Minnerop & Friederike Otto, *Climate Change and Causation: Joining Law and Climate Science on the Basis of Formal Logic*, 27 Buff. Env't L.J. 49, 55-56 (2020).
64. *Id.* at 55.
65. *Id.* at 56.
66. Puppe & Wright, *supra* note 23, at 34.
67. *Id.* at 35.
68. *Id.*
69. Minnerop & Otto, *supra* note 63, at 49.
70. Alexis Hannart & Philippe Naveau, *Probabilities of Causation of Climate Changes*, 31 J. Climate 5507, 5508 (2018).
71. Puppe & Wright, *supra* note 23, at 54.
72. Richard W. Wright, *Causation in Tort Law*, 73 Cal. L. Rev. 1735, 1808 (1985).

the same high threshold of certainty typically required to demonstrate statistical significance in scientific studies.[73]

In any event, factual findings in legal proceedings necessarily incorporate probabilities, due to the standard of proof required to establish causation. In common-law systems such as the United States and England, the standard of proof for tort claims is expressed as the "balance of probabilities," in which a claimant must show that the defendant's act or omission "more likely than not" (i.e., more than 50%) caused the claimant's harm.[74]

The standard of proof in civil-law systems is often higher but varies by country. Marta Infantino and Eleni Zervogianni divide the different European approaches regarding standards of proof and causation into three categories.[75] First, "bounded causation" countries like Germany require the fact finder to find causation to a degree of "near certainty."[76] "Overarching causation" countries such as France allow fact finders flexibility to find causation based on, for example, "several precise, and corroborative evidence."[77] Lastly, "pragmatic causation" countries, such as the Netherlands, "are in principle less generous than countries within 'overarching' causation, but are nevertheless open to allowing case-by-case deviations to well-established principles when the circumstances so mandate."[78]

2. Legal Causation

Even if the defendant's act or omission is established as the necessary cause of the harm to the required standard of proof, this does not always mean that the defendant will be liable. Instead, courts in both common-law and civil-law systems will next apply policy norms under the second limb of the causation analysis, to determine whether the defendant is the "legal" cause.[79] These policy norms are largely consistent across common-law and civil-law systems and include, among other things, whether the injury was a foreseeable result of the defendant's conduct, whether the injury fits within the scope of the rule that the defendant infringed, and whether the defendant's conduct was sufficiently close in space and time to the injury.[80]

3. Limitations of the Conventional Causation Analysis

The but-for and conditio sine qua non tests address the classic tort causation situation where one party is the direct and sole cause of harm to another party.[81] This classic situation, however, often does not accurately reflect how cause and effect interrelate in the real world.[82] For example, the tests cannot be applied to "alternative causation" situations in which it is obvious that the claimant suffered an injury due to another party's tortious conduct, but it is unclear which of multiple tortfeasors caused the harm.[83]

This situation is often explained via a scenario in which two hunters negligently fire in the direction of a claimant but the claimant cannot prove which of the two actually struck him.[84] It is therefore also impossible to say that any one defendant's act was the necessary cause of the injury.[85] A more complex situation arises where a plaintiff develops a medical condition after taking defective generic medication manufactured by multiple companies.[86] The plaintiff cannot determine which company manufactured the medication actually taken, but all companies engaged in tortious behavior.[87]

Necessary causation also cannot be met in cases of "multiple sufficient causes."[88] This is often explained by the "twin fires" scenario[89] in which a defendant negligently starts a wildfire that then merges with a separate fire started by natural causes. The combined fire then destroys a claimant's property.[90] Either fire would have been sufficient on its own to cause the harm, and as a result the negligently started fire was not the necessary cause.[91] Necessary causation also cannot be established in cases of "concurrent minimal causation," where multiple tortfeasors contribute to a harm, but each contribution on its own would be insufficient to cause the harm.[92] This is seen in toxic tort cases, for example when many defendants contribute a small amount of pollution to a waterway.[93] Collectively, the pollution exceeds an injurious threshold, but no one contribution is large enough on its own to cause the harm.[94]

73. *See*, *e.g.*, Ministry of Defence v. Wood [2011] EWCA (Civ) 792 [60] (Eng.).
74. Banda, *supra* note 20, at 7 (contrasting this to the more exacting "clear-and-convincing" standard of proof).
75. Marta Infantino & Eleni Zervogianni, *The European Ways to Causation*, *in* Causation in European Tort Law, *supra* note 23, at 85, 87-88.
76. Marta Infantino & Eleni Zervogianni, *Summary and Survey of the Results*, *in* Causation in European Tort Law, *supra* note 23, at 587, 612.
77. *Id.* at 614.
78. Infantino & Zervogianni, *supra* note 75, at 88.
79. Minnerop & Otto, *supra* note 63, at 56 ("The second limb is finding the legally relevant cause.").
80. Infantino & Zervogianni, *supra* note 76, at 603 (listing the "six formulas" used to determine legal causation).
81. Samantha Lawson, *The Conundrum of Climate Change Causation: Using Market Share Liability to Satisfy the Identification Requirement in* Native Village v. ExxonMobil Co., 22 Fordham Env't L. Rev. 433, 448 (2010).
82. R. Henry Weaver & Douglas Kysar, *Courting Disaster: Climate Change and the Adjudication of Catastrophe*, 93 Notre Dame L. Rev. 295, 338 (2017).
83. Wright, *supra* note 72, at 1816-17.
84. *Id.*; *see also* Summers v. Tice, 199 P.2d 1 (Cal. 1948).
85. Wright, *supra* note 72, at 1816.
86. Lawson, *supra* note 81, at 451-52 (discussing Sindell v. Abbott Laboratories, 607 P.2d 924 (Cal. 1980)).
87. *Id.* at 452.
88. Tory Weigand, *Tort Law—The Wrongful Demise of But For Causation*, 41 W. New Eng. L. Rev. 75, 83 (2019).
89. *Id.* (discussing Anderson v. Minneapolis, St. Paul & Sault Ste. Marie Ry. Co., 179 N.W. 45 (Minn. 1920)).
90. *Anderson*, 179 N.W. at 46.
91. *Id.* at 49.
92. Monika Hinteregger, *Civil Liability and the Challenges of Climate Change: A Functional Analysis*, 8 J. Eur. Tort L. 238, 256 (2017).
93. Third Restatement, Liability for Physical and Emotional Harm, *supra* note 62, §27 illus. 4 (noting that contamination from each polluter "is a factual cause" of the injury).
94. *Id.*

C. *Reconciling Necessary Causation With Climate Change*

Anthropogenic GHG emissions can reasonably be identified as the necessary cause of many circumstances ascribed to a changing climate.[95] For example, 97% of actively publishing climate scientists agree that most of the observed increase in global mean surface temperatures since the start of the Industrial Revolution in the 1880s would not have occurred without an increase in anthropogenic GHG emissions.[96] And as the IPCC has made clear, it is an "established fact that human-induced greenhouse gas emissions have led to an increased frequency and/or intensity of some weather and climate extremes, in particular for temperature extremes."[97] Scientists also generally agree that increased temperatures resulting from increased GHG emissions lead to increased glacial melt and sea-level rise.[98] Stated differently, there is a necessary causal connection between increases in anthropogenic GHG emissions and increases in global temperature, and between increases in global temperature and a general increase in the frequency and/or severity of some extreme weather and slow-onset events.

Courts have had little problem accepting these causal links as a general matter, which has led to numerous "climate-friendly" decisions in recent years in which defendants (mostly governments) have been ordered to take actions to reduce emissions. For example, in December 2019, the Netherlands Supreme Court required the Dutch government to reduce countrywide GHG emissions by at least 25% from 1990 levels by the end of 2020, observing "there is a direct, linear connection between the greenhouse gas emissions caused by humans, which are partly caused by the burning of fossil fuels, and the warming of the planet," and that such warming "may result in local areas of extreme heat, extreme drought, extreme precipitation, or other extreme weather."[99] In May 2021, another Dutch court required Royal Dutch Shell to reduce its emissions by 45% compared to 2010 levels by 2030 and to zero by 2050, explaining "that every emission of CO_2 [carbon dioxide] and other greenhouse gases, anywhere in the world and caused in whatever manner, contributes to" damage in the Netherlands.[100]

In April 2021, the German Federal Constitutional Court found that the country's climate legislation was unconstitutional because it did not provide for sufficiently concrete post-2030 measures.[101] The court noted the "almost unanimous scientific opinion" that "global warming is essentially due to the change in the material balance of the atmosphere caused by anthropogenic emissions," and that this can lead to, among other things, "disruption of food production and water supply, damage to infrastructure and settlements, illnesses and deaths, and consequences for people's mental health and well-being."[102] And in February 2021, the Administrative Court of Paris held the French government responsible for failing to take sufficient actions in response to climate change, observing that an increase in anthropogenic GHGs "leads to an increase in extreme climatic phenomena such as heat waves, droughts, forest fires, extreme rainfall, floods, and hurricanes."[103] Accordingly, courts have readily tied anthropogenic GHG emissions to climate change-related harms in general, and they have ordered governments and others to refrain from contributing to such harms through their emissions.

A much more precise causal link is required, however, for tort claims that seek damages from one or more emitters for their contribution to a specific harm that a claimant alleges was caused or made more intense or likely by climate change. Instead of showing generally that anthropogenic GHG emissions lead to more frequent or severe extreme weather or other climate-related events, a claimant must establish that a defendant's specific GHG emissions were the necessary cause of the harm that the claimant suffered from a specific event.[104]

Working backwards from the harm suffered by a plaintiff, one can conceptualize four stages in the causal chain for any tort claim seeking climate change-related damages:

1. The plaintiff's harm or some portion thereof was caused by an extreme weather or slow-onset event (e.g., sea-level rise, flooding, hurricane, glacier melt).
2. The specific extreme weather or slow-onset event was made more likely or more severe by a change in the climate system, such as an increase of global mean surface temperatures or increased ocean acidification.
3. The change in the climate system was caused to some specific determinable extent by an increase in anthropogenic GHG emissions.

95. Minnerop & Otto, *supra* note 63, at 76.
96. *Id.*
97. IPCC Report, *supra* note 1, at 11-6.
98. Minnerop & Otto, *supra* note 63, at 76-77.
99. HR 20 december 2019, ECLI:NL:HR:2019:2007, 19/001 (De Staat der Nederlanden (Ministerie van Economische Zaken en Klimaat)/Stichting Urgenda) §§2.1, 4.2 (unofficial English translation), http://climatecasechart.com/climate-change-litigation/wp-content/uploads/sites/16/non-us-case-documents/2020/20200113_2015-HAZA-C0900456689_judgment.pdf.
100. RBDHA the Hague 26 mei 2021, ECLI:NL:RBDHA:2021:5339, C/09/571932/HA ZA 19-397, §4.3.5 (Vereniging Milieudefensie/Royal Dutch Shell PLC) (unofficial English translation), http://climatecasechart.com/climate-change-litigation/wp-content/uploads/sites/16/non-us-case-documents/2021/20210526_8918_judgment-2.pdf.
101. Bundesverfassungsgericht [BVerfG] [Federal Constitutional Court] Mar. 24, 2021, 1 BvR 2656/18, 1 BvR 78/20, 1 BvR 96/20, 1 BvR 288/20 (unofficial English translation of *Neubauer v. Germany*), http://climatecasechart.com/climate-change-litigation/wp-content/uploads/sites/16/non-us-case-documents/2021/20210429_11817_judgment-2.pdf.
102. *Id.* §§2, 4(a).
103. Tribunal Administratif [Administrative Court] Paris, Feb. 3, 2021, Nos. 1904967, 1904968, 1904972, 1904976/4-1, at 26 (unofficial English translation of *Notre Affaire à Tous v. France*), http://climatecasechart.com/climate-change-litigation/wp-content/uploads/sites/16/non-us-case-documents/2021/20210203_NA_decision.pdf.
104. Hinteregger, *supra* note 92, at 240.

4. The defendant contributed some specific portion of the total anthropogenic GHG emissions that caused the specific change in the climate system.[105]

Several obstacles materialize if one attempts to establish this causal chain with respect to a single GHG emitter. First, there is never any single responsible party for harms amplified by climate change—no one source of emissions can be identified as the cause of a specific harm, but instead any harm will result from a confluence of multiple conditions contributed by multiple actors.[106] In other words, climate change is a "collective action problem so pervasive and so complicated as to render at once both all of us and none of us responsible."[107]

The climate and interconnected natural systems are also exceedingly complex, and their multiple components often do not interact on any predictable basis.[108] There is also already a background occurrence of many events often attributed to climate change, such as hurricanes, heat waves, droughts, seasonal allergies, pest invasions, and disease, which makes it difficult to say whether a specific occurrence of such an event would have happened absent anthropogenic forcings.[109] Different types of weather events and slow-onset events also have different susceptibility to natural fluctuations in frequency and severity.[110]

Further, the varying latency and residence periods of different GHGs also mean that one defendant's emissions can persist in the atmosphere for decades or centuries, contributing to an injury long after the emissions occur.[111] There is also a lack of pertinent observational data regarding, for example, precipitation, health, agricultural productivity, and flood history, particularly in the developing world.[112] This reduces the confidence in connecting any one event to climate change.[113]

D. Judicial Reluctance to Find Climate Change Causation

Due in large part to these complexities, courts have yet to find any defendant emitter liable in damages for harms that were allegedly intensified or made more likely by the emitter's contribution to the overall mix of atmospheric GHGs. In *Comer v. Murphy Oil USA*, a U.S. federal court dismissed claims alleging that 34 large emitting companies caused increased sea levels and temperatures in the Gulf of Mexico, which in turn amplified Hurricane Katrina and the resulting property damage.[114] The court dismissed the action while observing that the plaintiffs could not establish legal causation, stating the "assertion that the defendants' emissions combined over a period of decades or centuries with other natural and man-made gases to cause or strengthen a hurricane and damage personal property is precisely the type of remote, improbable, and extraordinary occurrence that is excluded from liability."[115]

Similarly, in *Native Village of Kivalina v. ExxonMobil Corp.*, two coastal communities in Alaska sought damages from 24 oil, energy, and utility companies, arguing that the defendants' emissions caused the sea ice surrounding the plaintiffs' communities to melt, making them more vulnerable to waves, storm surges, and erosion.[116] The plaintiffs alleged that they were therefore forced to relocate, and they sought their relocation costs as damages.[117] In its order, the court stated "there is no realistic possibility of tracing any particular alleged effect of global warming to any particular emissions by any specific person, entity, [or] group at any particular point in time."[118] Instead, the "genesis of global warming is attributable to numerous entities which individually and cumulatively over the span of centuries created the effects [the plaintiffs] now are experiencing."[119]

Notably, the *Comer* and *Kivalina* courts' discussions of causation were in dicta, since each also dismissed the suits because the plaintiffs failed to establish standing under Article III of the U.S. Constitution, which requires a justiciable "case or controversy."[120] This in part requires the court to conduct a preliminary causal analysis based on the plaintiff's allegations, to assess whether the injury is "fairly traceable" to the defendant, and to also analyze whether the controversy presents a "political question" better addressed by the legislature.[121] The *Comer* and *Kivalina* courts dismissed the claims on both traceability and political question grounds.[122] Further, the *Comer* court also held that the federal Clean Air Act (CAA)[123] preempted the claims, since through the CAA Congress entrusted the

105. *See* Minnerop & Otto, *supra* note 63, at 74-75; *see also* Hinteregger, *supra* note 92, at 240.
106. Spitzer & Burtscher, *supra* note 42, at 169 ("A single defendant's isolated emissions can never be a sufficient cause for the victim's harm.").
107. Douglas Kysar, *What Climate Change Can Do About Tort Law*, 42 Env't L. Rev. 1, 4 (2012).
108. Weaver & Kysar, *supra* note 82, at 304.
109. Kysar, *supra* note 107, at 31.
110. Spitzer & Burtscher, *supra* note 42, at 167.
111. *Id.* at 139.
112. Rachel James et al., *Attribution: How Is It Relevant for Loss and Damage Policy and Practice?*, *in* Loss and Damage From Climate Change 113, 123 n.16 (Reinhard Mechler et al. eds., Springer 2019); Friederike Otto et al., *Toward an Inventory of the Impacts of Human-Induced Climate Change*, 101 BAMS E1972, E1977 (2020).
113. Otto et al., *supra* note 112, at E1976.
114. *See* Memorandum Opinion and Order Granting Defendants' Motions to Dismiss, Comer v. Murphy Oil USA, Inc., No. 1:11-cv-00220-LG-RHW, slip op. at 2, 42 ELR 20067 (S.D. Miss. Mar. 20, 2012), http://climatecasechart.com/climate-change-litigation/wp-content/uploads/sites/16/case-documents/2012/20120320_docket-111-cv-00220_memorandum-opinion-and-order-1.pdf.
115. *Id.* at 35.
116. *See* Order Granting Defendants' Motions to Dismiss for Lack of Subject Matter Jurisdiction, Native Vill. of Kivalina v. ExxonMobil Corp., No. C 08-1138 SBA, slip op. at 13, 39 ELR 20236 (N.D. Cal. Sept. 30, 2009), http://climatecasechart.com/climate-change-litigation/wp-content/uploads/sites/16/case-documents/2009/20090930_docket-408-cv-01138-SBA_order.pdf.
117. *Id.* at 4.
118. *Id.* at 20.
119. *Id.*
120. *Comer*, slip op. at 14; *Kivalina*, slip op. at 6.
121. *Comer*, slip op. at 14, 23; *Kivalina*, slip op. at 6, 16.
122. *Comer*, slip op. at 20-21, 29; *Kivalina*, slip op. at 15, 22.
123. 42 U.S.C. §§7401-7671q, ELR Stat. CAA §§101-618.

U.S. Environmental Protection Agency rather than the judicial system to regulate GHG emissions.[124]

These cases demonstrate that, at least in the United States, causation does not present the only obstacle to establishing a colorable tort claim for climate change-related damages. Although the causation theories presented in this Article should help plaintiffs meet the "fair traceability" requirement under Article III, courts may still be inclined to dismiss such claims on political question, preemption, or other grounds. As discussed in Section II.E, a new wave of U.S. climate change cases could cause courts to revisit these issues, meaning the debate regarding the justiciability of such claims is far from over.

Courts outside the United States have also refused tort claims for climate change-related damages, citing causation issues. Although it is not home to a global carbon major, New Zealand's Supreme Court in *Smith v. Fronterra Co-Operative Group* upheld the dismissal of nuisance and negligence claims against industrial and agricultural entities whose emissions allegedly contributed to loss of land, loss of spiritual and cultural sites, and damage to freshwater fisheries.[125] In affirming the dismissal, the court explained that the alleged harms stemmed "from a number of consequential and indirect steps," and were "such an unlikely or distant result of the defendants' emissions that it would not be fair to impose liability on them."[126] The court specifically held that the claimant could not meet the "but-for" test, and that it was "impossible to measure" the "proportion of the damage pleaded that is caused by climate change effects contributed to by each defendant."[127]

The district court in Essen, Germany, was similarly skeptical of causation arguments in *Lliuya v. RWE AG*.[128] In this case, a Peruvian farmer brought a claim against RWE under §1004 of the German Civil Code, which protects landowners from unreasonable disturbance with the use or ownership of their property.[129] Under this law, the landowner may require the disturber to remove the disturbance or pay the costs for such removal.[130]

Saúl Luciano Lliuya asserted that his home village of Huaraz, Peru, is threatened by a potential glacial lake outburst flood due to the melting of the Palcaraju glacier situated above the village.[131] He alleged that the glacial lake has grown, and that anthropogenic GHG emissions are primarily responsible for the increased melt that has led to the flood risk.[132] Lliuya sought damages from RWE equal to RWE's alleged proportionate contribution to the total mix of global anthropogenic GHG emissions, which Lliuya estimated at 0.47%.[133] This translates to 17,000 euros in damages, or 0.47% of the total cost of adaptive measures needed to prevent a flood.[134] Lliuya declined to seek the entire cost of these measures from RWE, instead only asking for damages proportionate to RWE's alleged contribution to his total injury.[135]

The District Court Essen dismissed Lliuya's claim, finding that RWE could not be considered a "disturber" under §1004 "due to the absence of adequate and equivalent causation of the impairment."[136] The court applied the necessary causation test according to its conventional understanding, stating that it could only be met in cases of multiple tortfeasors if removing the defendant's contribution would undo the entire damage alleged.[137] The court found that RWE's emissions "are not so significant in the light of the millions and billions of emitters worldwide that anthropogenic climate change and therefore the supposed flood risk of the glacial lake would not occur if the defendant's particular emissions were not to exist."[138]

II. Developments in Event, Impact, and Source Attribution Science

Courts have therefore been reluctant to find legally relevant causation in tort claims seeking damages from a GHG emitter on the theory that its emissions contributed to a specific harm resulting from a climate change-related event. It is important to note, however, that these courts all dismissed the plaintiffs' causation theories without allowing them to proceed to evidentiary phases.

Should any claim be allowed to proceed, there is a chance that a relatively new scientific discipline—climate attribution science—could be invoked to successfully establish a causal link between a defendant's specific emissions and a specific portion of a claimant's specific climate-related injury. Three fields of attribution science are pertinent to establishing this causal chain—event attribution, impact attribution, and source attribution.

A. *Linking Anthropogenic GHG Emissions to Extreme Weather and Slow-Onset Events*

Event attribution science examines the link between anthropogenic GHG emissions and changes to the likelihood and/or severity of a specific slow-onset or extreme weather event.[139] The term "slow-onset event" is often used to refer to longer-term changes to some aspect of the climate system, such as increases in global mean surface temperature, increased glacier melt, sea-level rise, or ocean

124. *Comer*, slip op. at 29-30.
125. [2020] NZHC 419 at [10], http://climatecasechart.com/climate-change-litigation/wp-content/uploads/sites/16/non-us-case-documents/2020/20200306_2020-NZHC-419_opinion.pdf.
126. *Id.* at [63], [82].
127. *Id.* at [84], [88].
128. Landgericht [LG] Essen [District Court Essen] Dec. 15, 2016, 2 O 285/15 (unofficial English translation of *Lliuya v. RWE AG*), http://climatecasechart.com/climate-change-litigation/wp-content/uploads/sites/16/non-us-case-documents/2016/20161215_Case-No.-2-O-28515-Essen-Regional-Court_decision-1.pdf.
129. *Id.* at 5.
130. *Id.*
131. *Id.* at 3.
132. *Id.*
133. *Id.*
134. *Id.* at 4.
135. *Id.* at 3.
136. *Id.* at 6.
137. *Id.*
138. *Id.*
139. James et al., *supra* note 112, at 129.

acidification.[140] The term "extreme weather event" is in most cases self-explanatory, referring to an individual hurricane, drought, flood, or other similar event.[141]

Each event attribution study generally follows the same approach. The study will use a counterfactual inquiry somewhat like what courts use to find necessary causation, examining the extent to which anthropogenic GHG emissions increased the probability (i.e., the risk) of the examined extreme weather or slow-onset event, with the applicable threshold for the event defined by the researchers.[142] Using climate modeling, researchers create two simulations—one situation reflecting the world "as is" with anthropogenic GHG emissions and other scrutinized forcings, and another counterfactual simulation without these forcings.[143] Ensemble runs are then made of the "factual" and "counterfactual" models.[144] Based on the ensemble runs, the probability of the defined threshold being exceeded for a given event can be determined for both simulations.[145] Researchers will then derive a fraction of attributable risk (FAR) by comparing the probability of the event occurring under the factual and counterfactual scenarios.[146]

Once a FAR is established, the researchers will then provide an "attribution statement" that explains the impact that anthropogenic GHG forcings had on the probability or severity of the examined event.[147] Unlike causal statements in law, event attribution statements are probabilistic rather than deterministic.[148] In other words, instead of asking whether anthropogenic GHGs "caused" an event, event attribution asks whether and how anthropogenic forcings influenced the frequency, likelihood, and/or severity of the event.[149]

Although not deterministic, a high threshold is required to make an attribution statement.[150] The typical null hypothesis is that anthropogenic forcings did not influence the likelihood or severity of a given event, and statistical significance must be shown to reject the hypothesis.[151] This is then accounted for by assigning a confidence level to account for uncertainties (i.e., it is X% likely that global warming (or anthropogenic GHG emissions if the study is focusing specifically on human influence) increased the likelihood of the studied event by X%).[152]

Confidence levels vary significantly based on the slow-onset or extreme weather event at issue, and other factors contributing to uncertainty.[153] Slow-onset events such as sea-level rise, melting permafrost, ocean acidification, and heat waves bear a close linear relationship to increased anthropogenic GHG emissions and rising temperature, and are attributed to anthropogenic forcings with higher confidence.[154] Most extreme weather events such as hurricanes, droughts, and floods are attributed to climate change with low to medium confidence.[155] This is in part because extreme weather events are more local in nature and occur less frequently, and because there are relatively more nonlinear, naturally occurring, and complex interactions that contribute to the event.[156] Further, event attribution studies must rely on long-term observational records to create accurate models, but a robust observational record may be lacking, especially in developing countries.[157] A model's accuracy will depend on the accuracy and availability of the data used, and on the model's ability to accurately capture this data and how the pertinent climate systems interact to create the event.[158]

The first event attribution study was published in 2004, examining the European heat wave of 2003.[159] It found that anthropogenic GHG emissions at least doubled the likelihood of a heat wave like the one that summer.[160] The study assigned a "very likely" confidence level of >90%.[161] Since 2012, the Bulletin of the American Meteorological Society (BAMS) has published an annual report including event attribution studies for the previous year.[162] As of 2019, approximately 70% of attribution studies published in BAMS had found anthropogenic forcings to be a "significant" contributor to the event studied, to varying degrees of significance and confidence.[163]

For example, the 2016 and 2017 reports contained three studies concluding it was "virtually certain" that heat-related events (extreme heat in Asia and marine heat waves off the coasts of Alaska and Australia) would not have happened without (i.e., but for) the contribution of anthropogenic GHG emissions (i.e., FAR = 1).[164] Lower FARs have been assigned in attribution studies concerning

140. Minnerop & Otto, *supra* note 63, at 54 n.14.
141. Otto et al., *supra* note 112, at E1974.
142. *See* Minnerop & Otto, *supra* note 63, at 68.
143. *See* Daniel L. Swain, *Attributing Extreme Events to Climate Change: A New Frontier in a Warming World*, 2 One Earth 522, 523 (2020).
144. *Id.*
145. *Id.*
146. Burger et al., *supra* note 22, at 92.
147. Swain, *supra* note 143, at 524 (noting this is the last step in the event attribution analysis).
148. Sophie Marjanac et al., *Acts of God, Human Influence, and Litigation*, 10 Nature Geoscience 616, 616 (2017).
149. *See* Swain, *supra* note 143, at 522.
150. *Id.* at 524.
151. *Id.*
152. *Id.*
153. *Id.* at 526 fig.4.
154. *Id.*
155. *Id.*
156. *Id.*
157. James et al., *supra* note 112, at 130.
158. Peter Stott et al., *Attribution of Extreme Weather and Climate-Related Events*, 7 WIREs Climate Change 23, 32 (2016) ("Model evaluation is subject to the availability and quality of observations.").
159. *Id.* at 25 (citing Peter Stott et al., *Human Contribution to the European Heatwave of 2003*, 143 Nature 610 (2004)).
160. *Id.*
161. *Id.*
162. *See* Friederike Otto et al., Environmental Change Institute, The Science of Attributing Extreme Weather Events and Its Potential Contribution to Assessing Loss and Damage Associated With Climate Change Impacts 3 (2015) (discussing the BAMS annual report and its collection of event attribution studies).
163. Burger et al., *supra* note 22, at 101.
164. Yukiko Imada et al., *Climate Change Increased the Likelihood of the 2016 Heat Extremes in Asia*, 99 BAMS S97 (2017); John Walsh et al., *The High Latitude Marine Heat Wave of 2016 and Its Impacts on Alaska*, 99 BAMS S39 (2017); Sarah E. Perkins-Kirkpatrick et al., *The Role of Natural Variability and Anthropogenic Climate Change in the 2017/18 Tasman Sea Marine Heatwave*, 99 BAMS S105 (2017), *discussed in* Burger et al., *supra* note 22, at 103.

tropical cyclones.[165] For example, a 2015 study of tropical cyclone activity in the western North Pacific Ocean examined a threshold of "accumulated cyclone energy" as a proxy for intensity, finding that anthropogenic forcings increased the likelihood of this threshold being reached at a FAR of 0.81.[166]

B. *Linking Climate Change-Related Events to a Specific Injury*

The fact that anthropogenic GHG emissions may increase the likelihood or severity of a climate-related event does not complete the causal chain from a defendant's emissions to a plaintiff's injury. Impact attribution seeks to explain the link between event and injury by separating out "exogenous" variables not related to the extreme weather or slow-onset event.[167] Impact attribution then determines how much of any given impact should be attributed to the climate change-related event and how much should be attributed to other variables.[168]

In many cases, separating out "climate" from "non-climate" impacts is a qualitative exercise.[169] For example, if one wants to attribute anthropogenic climate forcings to a landslide in a certain area, how should the study account for unsustainable farming practices that may have contributed to erosion risk? As one scholar notes, "[i]mpacts from extreme weather hazards are largely moderated by the extent to which humans and assets are exposed to these hazards, and to what extent they are vulnerable or sensitive to these hazards."[170] As a general matter, financial and other losses from natural hazards have increased recently.[171] It would be intuitive to attribute these increased losses at least partially to climate change.

However, several impact studies have normalized these loss increases to account for non-climate variables that have increased exposure and vulnerability to the events causing the loss. These studies reveal little to no remaining increasing loss trend attributable to climate impacts.[172] In other words, at least generally, it remains uncertain how much, or indeed if any, of the general increase in losses should be attributed to anthropogenic climate forcings rather than other factors.[173] On the other hand, impact attribution provides a standard methodology to account for non-climate contributions to a claimant's injury, which in any individual case can still be a useful tool to better define how much of a given injury a claimant can attribute to anthropogenic GHGs.

Indeed, some impact attribution studies have quantified the impact of climate-related events, rather than analyzing the impact qualitatively. For example, one study of the 2003 European heat wave concluded that it caused approximately 570 deaths in Paris and London, after accounting for non-climate-related factors.[174] Another study attributes certain specific monetary losses from 2013 and 2014 winter flooding in the U.K. to anthropogenic GHG emissions.[175] In most cases, however, impact attribution will necessarily involve qualitative and policy-based considerations about what *should* be attributed to the act or omission of the injured party, anthropogenic forcings, or some other condition.[176] Also, for many studies it is impossible to accurately separate out the various ways in which non-climate factors increased a claimant's risk exposure. In these cases, all that can be provided is a general qualitative statement that anthropogenic forcings contributed to the impact to some extent.

C. *Apportioning Anthropogenic GHG Emissions Among Global Carbon Majors*

Event and impact attribution allow researchers to better determine how much of any one extreme weather or slow-onset event, or one resulting climate-related impact, is attributable to the total mix of global anthropogenic GHGs. However, this still does not answer the question of how much any one GHG emitter contributed to that event or impact. Source attribution fills this gap by tracing the total mix of anthropogenic GHGs to specific entities.[177]

The discipline started in 2014, when Richard Heede published a study presenting a quantitative analysis of the fossil fuel and cement production records of investor-owned, state-owned, and nation-state producers of oil, natural gas, coal, and cement, which he used to derive their proportionate contributions to total anthropogenic GHG emissions since 1854.[178] He found that only 90 entities—which he referred to as the "global carbon majors"—were responsible for 63% of the cumulative worldwide industrial CO_2 and methane emissions between 1751 and 2010.[179]

Source attribution studies rely primarily on company-reported data.[180] For example, investor-owned companies headquartered, operating, or selling in the United States must make regular filings to the U.S. Securities and Exchange Commission noting, among other things,

165. *See* Burger et al., *supra* note 22, at 109.
166. Wei Zhang et al., *Influences of Natural Variability and Anthropogenic Forcing on the Extreme 2015 Accumulated Cyclone Energy in the Western North Pacific*, 97 BAMS S133 (2016), *discussed in* Burger et al., *supra* note 22, at 109.
167. Burger et al., *supra* note 22, at 112.
168. *Id.*
169. *Id.* n.213.
170. Laurens M. Bouwer, *Observed and Projected Impacts From Extreme Weather Events: Implications for Loss and Damage*, *in* Loss and Damage From Climate Change, *supra* note 112, at 63, 64.
171. *Id.* at 70.
172. *Id.* at 71.
173. *Id.*
174. *See* Daniel Mitchell et al., *Attributing Human Mortality During Extreme Heat Waves to Anthropogenic Climate Change*, 11 Env't Res. Letters 1 (2016), *discussed in* Burger et al., *supra* note 22, at 125.
175. James et al., *supra* note 112, at 127 (citing Nathalie Schaller et al., *Human Influence on Climate in the 2014 Southern England Winter Floods and Their Impacts*, 6 Nature Climate Change 627 (2016)).
176. *See* Burger et al., *supra* note 22, at 115 n.213.
177. *Id.* at 128.
178. *Id.* at 139 (citing Richard Heede, *Tracing Anthropogenic Carbon Dioxide and Methane Emissions to Fossil Fuel and Cement Producers, 1854-2010*, 122 Climate Change 229, 230 (2014)).
179. Heede, *supra* note 178, at 234.
180. *Id.* at 231.

global production activities.[181] Investor-owned companies without U.S. operations typically also often provide annual reports to their shareholders that include similar information.[182] Self-reported data are corroborated with third-party reporting for state-owned enterprises.[183] In the case of mergers and acquisitions, source attribution studies attribute the historical production of the acquired company to the extant company.[184]

Heede's work was updated most recently in 2020, expanding the list to include 108 global carbon majors accounting for 69.6% of all industrial GHGs emitted from 1751 to 2018.[185] The top 20 emitters on the most recent global carbon majors list, which are responsible for approximately 35% of all such emissions from 1965 to 2018, are listed in Table 1. The table also shows their cumulative and proportionate emissions since 1965.[186]

Like other fields of attribution science, there are uncertainties and normative questions underlying source attribution. Because the studies rely on company statements in securities filings and investor reporting, the data are also biased and erroneous to some extent.[187] Further, there are fairness questions in assigning responsibility for GHG emissions only to hydrocarbon producers, rather than those who burn hydrocarbons to create actual emissions.[188]

D. *Linking the Attribution Sciences to Establish a Complete Causal Chain*

When considered together, event, impact, and source attribution can be used to establish a complete causal chain between any one global carbon major's GHG emissions and at least a portion of a claimant's injury. Using the causal chain presented in Section I.C, the three fields of attribution science can address each link as follows:

1. **Impact attribution**. The claimant's harm or some portion thereof was caused by an extreme weather or slow-onset event (e.g., sea-level rise, flooding, hurricane, glacier melt).
2. **Event attribution part I**. The specific extreme weather or slow-onset event was made more likely or more severe by a change in the climate system, such as an increase of global mean surface temperatures or increased ocean acidification.

Table 1. Top 20 Global Carbon Majors and Their Cumulative Emissions, 1965 to 2018

No.	Company	$MtCO_2e$*	% of Global
1	Saudi Aramco (Saudi Arabia)	61,143	4.33%
2	Gazprom (Russia)	44,757	3.17%
3	Chevron (USA)	43,787	3.10%
4	ExxonMobil (USA)	42,484	3.01%
5	National Iranian Oil Co. (Iran)	36,924	2.62%
6	BP (U.K.)	34,564	2.45%
7	Royal Dutch Shell (Netherlands)	32,498	2.30%
8	Coal India (India)	24,341	1.73%
9	Pemex (Mexico)	23,025	1.63%
10	PetroChina/China National Petroleum (China)	16,515	1.17%
11	Petróleos de Venezuela (Venezuela)	16,029	1.14%
12	Peabody Energy (USA)	15,783	1.12%
13	ConocoPhillips (USA)	15,422	1.09%
14	Abu Dhabi (UAE)	14,532	1.03%
15	Kuwait Petroleum Corp. (Kuwait)	13,923	0.99%
16	Iraq National Petroleum Co. (Iraq)	13,162	0.93%
17	Total SA (France)	12,755	0.90%
18	Sonatrach (Algeria)	12,700	0.90%
19	BHP (Australia)	10,068	0.71%
20	Petrobras (Brazil)	9,061	0.64%
Top 20		493,473	34.98%
Global		1,410,737	100%

*$MtCO_2e$ is metric tons of carbon dioxide equivalent.
Source: Climate Accountability Institute, *supra* note 185.

181. Richard Heede, Climate Accountability Institute, Carbon Majors: Updating Activity Data, Adding Entities, & Calculating Emissions: A Training Manual 8 (2019), https://climateaccountability.org/pdf/TrainingManual%20CAI%2030Sep19lores.pdf.
182. *Id.*
183. *Id.* at 9.
184. *Id.* at 10.
185. Press Release, Climate Accountability Institute, Update of Carbon Majors 1965-2018, at 2 (Dec. 9, 2020), https://climateaccountability.org/pdf/CAI%20PressRelease%20Dec20.pdf.
186. *Id.* at 1.
187. Burger et al., *supra* note 22, at 75-76.
188. Spitzer & Burtscher, *supra* note 42, at 161.

3. **Event attribution part 2**. The change in the climate system was likely caused to some specific determinable extent by an increase in anthropogenic GHG emissions.

4. **Source attribution**. The defendant contributed some specific portion of the total anthropogenic GHG emissions that likely caused the specific change in the climate system.

The degree of certainty for each link in the causal chain could vary greatly depending on the confidence levels of studies establishing these links, and each new step examined creates additional "cascading" uncertainties that reduces overall confidence.[189]

There has not been a published study completing this entire chain to date. However, studies have combined different types of attribution science to create a longer chain. The 2016 BAMS included three studies finding that anthropogenic GHG emissions increased sea surface and ocean temperatures (*event attribution*), which in turn harmed ocean ecosystems through impacts such as coral reef bleaching and reduced fish stocks (*impact attribution*).[190] A 2017 study determined that anthropogenic GHG emissions made the 2013-2014 Argentina heat wave five times more likely (*event attribution*).[191] The study then attributed 37% of that probabilistic increase to the EU, 34% to the United States, 21% to China, and 18% to India (*source attribution*).[192]

Another study found that anthropogenic GHG emissions made an extreme rainfall event in the U.K. in January 2014 40% more likely (*event attribution*), attributing 3% of that increase to the EU (*source attribution*).[193] A 2017 study examined the impact that anthropogenic GHG emissions had on temperatures and sea levels (*event attribution*). It then determined the proportionate responsibility of the 20 emitters who most significantly contributed to those impacts (*source attribution*).[194] Similarly, a 2019 study apportioned responsibility for ocean acidification from anthropogenic GHG emissions (*event attribution*) among the top 20 emitters on the global carbon majors list (*source attribution*), noting the responsibility of each.[195]

A study from February 2021 demonstrates perhaps the most complete attribution chain developed between anthropogenic GHG emissions and, in this case, the risk of damage to Lliuya and the village of Huaraz presented by a glacial lake outburst flood, the harm at issue in *Lliuya v. RWE AG*.[196] The researchers combine event and impact attribution to show that anthropogenic GHG emissions are almost entirely responsible for the additional melting of the Palcaraju glacier that has created the outburst flood risk.[197] First, they found that anthropogenic forcings were 95% responsible for local temperature increases from 1989 to 2018.[198] They then determined that the retreat of the Palcaraju glacier from 1940 to the present was 100% attributable to the temperature trend.[199] Accordingly, they concluded:

> [I]t is virtually certain (>99% probability) that the observed retreat of Palcaraju glacier could not have occurred due to natural variability alone and therefore that the observed large-scale climate warming that we attribute to human influence is a "necessary cause" of the observed retreat, both to 1940 and to the present.[200]

The study then linked this retreat and the glacial lake outburst flood hazard with an impact attribution statement.[201] Using qualitative language, they concluded that the retreat increased the risk of a glacial lake outburst flood from "medium" in the 19th century to "very high" today—posing "a serious threat to Huaraz, which compels the local authorities to implement hazard mitigation measures."[202]

Thus, by linking anthropogenic GHG emissions to temperature increases, temperature increases to glacial retreat, and glacial retreat to a flood risk that in turn necessitates mitigation actions, this study enables a fact finder to conclude that anthropogenic GHG emissions are the conditio sine qua non of the risk of a glacial lake outburst flood and the cost of the required mitigation measures. This study did not incorporate source attribution. However, given the strong linear correlation between anthropogenic GHG emissions and temperature increases, and between temperature increases and glacial retreat, and because the risk at issue here warranting action is almost entirely attributable to anthropogenic GHG emissions, one could also close the causal link for a global carbon major by calculating the specific GHGs contributed by that global carbon major to the total anthropogenic GHG mix.

The Palcaraju glacier study benefits from strong linear relationships along the entire causal chain. However, attribution is also possible for events that do not respond linearly to GHG emissions, and attribution science can also account for the varying latency and residency periods of different GHGs. Specifically, Luke Harrington and Friederike Otto have developed a methodology that

189. Burger et al., *supra* note 22, at 115.
190. Sophie Lewis & Jennie Mallela, *A Multifactor Risk Analysis of the Record 2016 Great Barrier Reef Bleaching*, 99 BAMS S144 (2017); Michael Jacox et al., *Forcing of Multiyear Extreme Ocean Temperatures That Impacted California Current Living Marine Resources in 2016*, 99 BAMS S27 (2017); Russell E. Brainard et al., *Ecological Impacts of the 2015/16 El Niño in the Central Equatorial Pacific*, 99 BAMS S21 (2017), *discussed in* Burger et al., *supra* note 22, at 117.
191. Friederike Otto, *Assigning Historic Responsibility for Extreme Weather Events*, 7 Nature Climate Change 757, 758 (2017).
192. *Id.*
193. *See* Minnerop & Otto, *supra* note 63, at 69-70.
194. Brenda Ekwurzel et al., *The Rise in Global Atmospheric CO_2 Surface Temperature, and Sea Level From Emissions Traced to Major Carbon Producers*, 144 Climate Change 579, 588 (2017).
195. Rachel Licker et al., *Attributing Ocean Acidification to Major Carbon Producers*, 14 Env't Res. Letters 1, 7 fig.3 (2019).
196. Rupert Stuart-Smith et al., *Increased Outburst Flood Hazard From Lake Palcacocha Due to Human-Induced Glacier Retreat*, 14 Nature Geoscience 85 (2021).
197. *See generally id.*
198. *Id.* at 88.
199. *Id.* at 86.
200. *Id.*
201. *Id.*
202. *Id.*

accounts for the fact that many climate-related events do not relate on a linear, one-for-one basis to anthropogenic GHG emissions.[203] They explain that these relationships generally fall into three categories: linear, sigmoidal, or quasi-exponential.[204]

For linear relationships, the marginal rate of impact of each GHG remains constant as additional GHGs are emitted.[205] For sigmoidal relationships, the marginal rate of impact will increase until overall emissions reach a threshold, at which point rates decrease and eventually reach zero.[206] For quasi-exponential relationships, marginal rates of impact will increase with each unit of GHG added.[207]

Harrington and Otto then examine how these patterns would relate to a hypothetical emitter with varying emissions patterns.[208] For example, if an impact results from a climate-related event bearing a sigmoidal relationship to GHGs, an entity's proportionate responsibility for that impact would be less the later in time it adds emissions to the total mix of GHGs, because the marginal impact of new GHGs decreases over time.[209] If the event bears a quasi-exponential relationship to GHGs, the same entity's proportionate responsibility for the event would increase the later in time its emissions are added, because of increasing marginal impacts over time.[210] They apply these methodologies to six different emissions profiles based on different hypothetical times at which the emissions occurred and different hypothetical emission rates.[211]

E. Are Courts Warming to the Climate Science?

As discussed, courts nearly universally reject causation arguments in tort claims seeking damages from an emitter for climate-related injuries. However, a new wave of cases in Europe and the United States could lead courts to revisit this issue, at least if they let the claimants argue causation on the merits, equipped with the foregoing attribution science tools. The most advanced case in this regard is *Lliuya v. RWE AG*, discussed above.

Following the District Court Essen's dismissal of his claims, Lliuya appealed to the Higher Regional Court Hamm, which in November 2017 reversed the district court's causation analysis and ordered the case to proceed to evidence gathering.[212] The higher regional court rejected the district court's all-or-nothing reasoning that legally relevant causation could not be found because eliminating RWE's emissions would not mitigate the glacial flood risk to Lliuya.[213] Instead, the court explained that "in the case of multiple 'disturbers,' each participant must eliminate its own contribution, and joint and several liability is considered only if the contributions cannot be separated and there is equal importance."[214] Assuming Lliuya could establish causation to the required standard of proof, the higher regional court's order suggests that RWE may be held liable in damages for its proportionate contribution to Lliuya's costs of mitigating the flood risk. Responsibility for the entire harm does not need to be established.

The higher regional court found that five factual contentions were relevant for Lliuya to establish causation, and it ordered evidence and expert opinions to be taken to establish or refute each. These contentions largely track the causal chain listed in Section I.C, and are quoted verbatim (from the unofficial English translation) as follows:

1. As a result of the significant increase of the expansion and volume of water of the Palcacocha lagoon, there is a serious threat to the defendant's property, which lies beneath the glacier lagoon in the city of Huaraz in the region of Ancash in Peru, due to a flood and/or a mudslide;
2.

a. The CO_2 emissions released by the defendant's power plants ascend into the atmosphere and due to physical laws result in a higher density of GHGs throughout the entire earth atmosphere.

b. The compression of the GHG molecules results in a reduction of the global heat radiation and an increase in the global temperature.

c. As a consequence of the caused, also local, increase in average temperatures, the melting of the Palcaraju glacier accelerates; the glacier loses size and retreats, the water volume of the Palcacocha lagoon increases to a level that cannot be constrained by the natural moraines.

d. The defendant's co-causation share to the causal chain shown in the items above can be measured and calculated. It currently amounts to 0.47%. A possible determination of the causation share shall be quantified accordingly by the expert.[215]

The evidentiary phase is ongoing at the time of publication.

A relatively new slate of cases in the United States may end up relying on similar causation and several liability theories as those presented in *Lliuya*. Between 2017 and 2021, U.S. municipalities filed various tort claims under state

203. Luke Harrington & Friederike Otto, *Attributable Damage Liability in a Non-Linear Climate*, 153 Climate Change 15, 16 (2019).
204. *Id.*
205. *Id.*
206. *Id.*
207. *Id.*
208. *Id.* at 16-17.
209. *Id.* at 18; *see also id.* at 17 fig.1c.
210. *Id.* at 18; *see also id.* at 17 fig.1c.
211. *See generally id.* at 17 fig.1.
212. *See* Oberlandesgericht [OLG] Hamm [Higher Regional Court Hamm] Feb. 1, 2018 (unofficial English translation of *Lliuya v. RWE AG*), http://climatecasechart.com/climate-change-litigation/wp-content/uploads/sites/16/non-us-case-documents/2018/20180207_Case-No.-2-O-28515-Essen-Regional-Court_order.pdf.
213. *Id.* at [4].
214. *Id.*
215. Oberlandesgericht [OLG] Hamm [Higher Regional Court Hamm] Nov. 30, 2017, at [2] (unofficial English translation of *Lliuya v. RWE AG*), http://climatecasechart.com/wp-content/uploads/sites/16/non-us-case-documents/2017/20171211_Case-No.-2-O-28515-Essen-Regional-Court_order.pdf.

laws against several global carbon majors.[216] As in *Lliuya*, the municipalities in part seek damages for adaptive and restorative measures that they allege are necessary to either remedy existing harms or prevent future injuries caused by the defendants' GHG emissions.[217] Causation issues have not yet played a meaningful role. Instead, the current focus is on preliminary procedural questions regarding the grounds on which federal appellate courts may review the removal of cases from state to federal court.[218]

In May 2021, the U.S. Supreme Court gave direction on this issue, returning the cases to lower federal courts for further analysis.[219] The Court's order did not state whether these claims belong in federal or state court, and briefing on this issue is ongoing in most federal dockets as of publication. If the cases remain in federal rather than state court, the chances are likely higher that the claims would be dismissed on the same political question, preemption, or other issues of federal subject matter jurisdiction that led the *Comer* and *Kivalina* courts to dismiss those actions. Indeed, that was what happened in some of these cases before the Supreme Court's May 2021 order.[220] In contrast, one action has been remanded back to state court since the May 2021 order.[221] Accordingly, a split among the federal courts could remain for quite some time, perhaps until the Supreme Court hears the cases again on appeal.

If these cases proceed to the merits stage, statements made thus far by some courts suggest that they may at least entertain evidence that could establish a legally relevant causal link. For example, in *City of Oakland v. BP P.L.C.*,[222] the court initially dismissed the case on federal preemption and political question grounds, but it nonetheless "accept[ed] the vast scientific consensus that the combustion of fossil fuels has materially increased atmospheric carbon dioxide levels, which in turn has increased the median temperature of the planet and accelerated sea level rise."[223] The court also accepted that "[a]s our globe warms and the seas rise, coastal lands in Oakland and San Francisco will, without erection of seawalls and other infrastructure, eventually become submerged by the navigable waters of the United States."[224] If this case now moves forward, it seems the court may be willing to accept a causal argument that links the defendants' GHG emissions to a specific portion of the plaintiffs' harm. If so, attribution science will be needed to establish that chain.

The question then becomes whether the science has advanced to the point to meet the traditional, strict necessary causation standards that apply to these claims, or whether courts could or should relax these strict standards for policy reasons, as they have done in other tort contexts. As will be discussed next, either scenario seems unlikely, notwithstanding advances in attribution science. However, a third avenue could apply, which requires neither the traditional application of strict necessary causation nor a relaxation of such standards, and which courts have long been willing to entertain in cases involving diffuse environmental harm.

III. Finding the Right Tool for the Job

A. *Can a Plaintiff Establish Necessary Causation?*

Notwithstanding advances in attribution science, scholars are divided on whether it is possible to establish necessary causation under the but-for and conditio sine qua non tests in tort cases seeking damages from specific emitters for climate-related harms. Some "optimistic" arguments posit that climate change-related damages are not significantly different in kind from other types of damages that have been compensated in tort cases.[225] For example, three studies from the BAMS report on 2016 extreme events showed that the events would not have occurred without human influence.[226] Since these conclusions are deterministic rather than probabilistic in nature (i.e., concluding that human influence caused the events in question), such findings could in theory "be equated with the legal test of 'but for' causation, meaning that the event could never have occurred without the presence of the causal factor."[227]

There are more arguments that can be labeled "pessimistic," which contend for various reasons that necessary causation cannot be established despite advances in attribution science. It is generally acknowledged that one can demonstrate general causation; namely, that anthropogenic GHG emissions tend to increase the severity and frequency of extreme weather and slow-onset events in *general*, which in

216. *See* City of Annapolis v. BP P.L.C., No. 02-CV-21-000250 (Cir. Ct. Arundel County filed Feb. 22, 2021); City of Hoboken v. Exxon Mobil Corp., No. HUD-L-003179-20 (N.J. Super. Ct. Law Div. filed Sept. 2, 2020); Mayor & City Council of Balt. v. BP P.L.C., No. 24-C-18-004219 (Cir. Ct. Balt. City filed July 20, 2018); State v. Chevron Corp., No. PC-2018-4716 (Providence/Bristol County Super. Ct. filed July 2, 2018); City of New York v. BP P.L.C., No. 18 cv 182 (S.D.N.Y. filed Jan. 9, 2018); City of Oakland v. BP P.L.C., No. RG17875889 (Cal. Super. Ct. Alameda County filed Sept. 19, 2017); City of Imperial Beach v. BP P.L.C., No. C17-01227 (Cal. Super. Ct. Contra Costa County filed July 17, 2017); County of Marin v. Chevron Corp., No. CIV1702586 (Cal. Super. Ct. Marin County filed July 17, 2017); County of San Mateo v. Chevron Corp., No. 17-civ-03222 (Cal. Super. Ct. San Mateo County filed July 17, 2017).

217. *See*, *e.g.*, Mayor & City Council of Balt. v. BP P.L.C., No. 24-C-18-004219, ¶¶ 193-217, 228, 236, 248, 260, 269, 281, 290 (Cir. Ct. Balt. City filed July 20, 2018).

218. *See* BP P.L.C. v. Mayor & City of Balt., 141 S. Ct. 1532, 1535, 51 ELR 20086 (2021).

219. *Id.* at 1543.

220. *See*, *e.g.*, City of Oakland v. BP P.L.C., 325 F. Supp. 3d 1017, 48 ELR 20105 (N.D. Cal. 2018), *vacated and remanded by* City of Oakland v. BP P.L.C., 960 F.3d 570, 50 ELR 20124 (9th Cir. 2020).

221. *See* City of Hoboken v. Exxon Mobil Corp., No. 20-cv-14243, 2021 WL 4077541, 51 ELR 20173 (D.N.J. Sept. 8, 2021).

222. 325 F. Supp. 3d 1017.

223. *Id.* at 1026.

224. *Id.* at 1021.

225. Byers et al., *supra* note 60, at 270-71:

> At one end of the spectrum, commentators who are optimistic about the prospects for climate damages litigation argue that climate damages are not fundamentally different from other types of common-law damages that already give rise to liability, and that climate damages are very much in keeping with the purposes of tort law.

226. Sophie Marjanac & Lindene Patton, *Extreme Weather Event Attribution Science and Climate Change Litigation: An Essential Step in the Causal Chain?*, 36 J. Energy & Nat. Res. L. 265, 269 (2018).

227. *Id.* at 272 & n.40.

turn contributes to the *general* types of injuries underlying many climate change-related tort claims.[228] However, "pessimistic" arguments maintain that it still is not possible to show *specific* causation; namely, that a defendant's specific emissions caused the specific injury alleged.[229]

The limitations are due to the same complexities underlying the climate system discussed in Section I.C. These include, among other things, the nontrivial background rate of occurrence and natural fluctuation of extreme weather events such as hurricanes,[230] a lack of long-term observational and other records and data from which to construct reliable models and infer counterfactual scenarios,[231] the multiplicity of emitters contributing relatively small amounts each to the total mix of emissions,[232] and the varying latency periods of certain impacts and varying residence periods of different GHGs.[233] Impact attribution, the final link in the attribution chain, also remains mostly qualitative, making it difficult in many cases to quantify how much of a claimant's injury should be attributed to climate- versus non-climate-related factors.[234]

Accordingly, there are several credible reasons to doubt that attribution science can be used to show necessary causation. However, some arguments also ignore the established capabilities of the science. For example, Martin Olszynski claims that the exact contributions of any one emitter "are impossible to ascertain,"[235] while Martin Spitzer and Bernhard Burtscher argue that the fact that climate-related events often do not relate linearly to GHG emissions is fatal to a claim.[236] Neither contention seems to be true.

Contrary to Olszynski's argument, Heede's source attribution work provides a credible method of apportioning the contributions of specific major emitters to a degree of certainty that may very well meet applicable standards of proof.[237] Contrary to Spitzer and Burtscher's argument, Harrington and Otto have developed a standard methodology to account for the nonlinear (e.g., sigmoidal and quasi-exponential) relationships between GHG emissions and certain climate-related events, and to determine an emitter's proportionate contribution to those events based on different hypothetical emissions profiles.[238] These methodologies could be applied to a specific nonlinear climate-related event and injury to determine a specific emitter's proportionate responsibility to the required standard of proof.

However, borrowing a term from toxic tort cases, even those scholars who argue against finding a necessary causal relationship in climate-tort cases acknowledge that it may be possible to do so in "signature disease" cases in which the claimant's *entire* harm can be attributed to anthropogenic GHG emissions.[239] For example, notwithstanding the district court's dismissal of the claims in *Kivalina*, one scholar notes that removing all anthropogenic GHGs in a counterfactual scenario would likely have meant that the sea ice protecting the coastal communities would not have melted to the point requiring relocation—in other words, the costs would not have been incurred but for anthropogenic GHG emissions.[240] Others invoke the "signature disease" concept to note that the first-ever attribution study, which found that anthropogenic GHG emissions made the 2003 European heat wave two to six times more likely, could be sufficient to establish but-for causation.[241]

Similar reasoning could apply to other slow-onset events like the glacial lake outburst flood threat in *Lliuya* because, at least according to the attribution study from February 2021, there would be no risk of a flood but for the additional glacial melt that is attributable to anthropogenic GHG emissions.[242] However, the cause in these scenarios is the total mix of anthropogenic GHG emissions, not the specific emissions of any one (or several) defendants named in a suit for climate change-related damages. Thus, necessary causation with respect to those specific defendants remains elusive.

It is likely correct that necessary causation cannot be established in claims seeking damages from specific GHG emitters for their proportionate contribution to an injury stemming from a climate change-related event. However, in many cases this would not be due to the complexities of the climate system, which scholars argue are fatal to these claims. Instead, attribution science has established credible methods of solving for these complexities. This means that a plaintiff could likely—at least in cases where the harm

228. *See* Lawson, *supra* note 81, at 449 n.126 ("In climate change litigation, plaintiffs must first show that anthropogenic greenhouse gas emissions are capable of causing climate change, which they should have little difficulty meeting.").
229. *See id.* at 449 n.127 ("Proving specific causation seems to be more problematic for plaintiffs in the climate change litigation context than general causation. In the climate change context the harm most likely will be the result of an intensified climatic behavior that exists independent of defendant's actions.").
230. Kysar, *supra* note 107, at 31; Spitzer & Burtscher, *supra* note 42, at 167 ("Heavy rainfalls, heat waves or hurricanes (like in *Comer v Murphy Oil*) are subject to natural fluctuations in frequency and severity and can even less be attributed to a particular defendant.").
231. James et al., *supra* note 112, at 123 ("Interviewees were concerned that uncertainties in the science could . . . inhibit efforts in regions with limited data availability and limited ability to provide evidence of the influence of climate change.").
232. Kysar, *supra* note 107, at 35 (noting that the "numerosity" of emitters has "profound implications for causation"); Spitzer & Burtscher, *supra* note 42, at 169 ("[E]ven large-scale emitters' contributions to global warming are only minimal.").
233. Spitzer & Burtscher, *supra* note 42, at 139.
234. Burger et al., *supra* note 22, at 115 ("[T]he qualitative approach would not be as effective at supporting certain applications, such as liability claims, precisely because it does not generate quantitative data.").
235. Martin Olszynski et al., *From Smokes to Smokestacks: Lessons From Tobacco for the Future of Climate Change Liability*, 30 Geo. Env't L. Rev. 1, 21 (2019).
236. Spitzer & Burtscher, *supra* note 42, at 167 ("Moreover, the effects of greenhouse gas emissions are not linear. On the contrary, if the stock of greenhouse gases in the atmosphere exceeds a certain threshold, the probability of fatal climate related events is suddenly increased. Therefore, every emission above this threshold no longer contributes to the harm.").
237. *See supra* Section II.C.
238. *See supra* Section II.D.
239. Kysar, *supra* note 107, at 32.
240. *Id.* ("The harm alleged in *Kivalina* may well fit this characterization.").
241. Weaver & Kysar, *supra* note 82, at 337 & n.298.
242. Stuart-Smith et al., *supra* note 196, at 11 (concluding "that the observed large-scale climate warming that we attribute to human influence is a 'necessary cause' of the observed retreat" of the Palcaraju glacier).

alleged is attributed to anthropogenic GHG emissions with relatively "high" confidence—conclude that at least *part* of the harm suffered by the claimant is attributable to a specific defendant's GHG emissions.

Nevertheless, even though attribution science could very well solve all the complexities of the climate system to a degree required by a court, it will still be impossible for a plaintiff to establish that the emissions from any one defendant, or even a large group of defendants, is the conditio sine qua non or but-for cause of the plaintiff's *entire* harm. Using the District Court Essen's reasoning in *Lliuya*, it simply cannot be said that, if the emissions of any one or several global carbon majors are removed in a counterfactual scenario, the claimant would not suffer the *total* climate-related harm alleged. Removing only RWE's emissions from the total anthropogenic GHG mix would not prevent a glacial lake outburst flood above Huaraz, since the flood risk is created by many complementary conditions, including the total mix of anthropogenic GHG emissions.

In other words, attribution science may be able to establish necessary causation when considering the relationship between *total* anthropogenic GHG emissions and *part* of an injury, but it cannot establish necessary causation for a *single* emitter and an *entire* harm. Indeed, attribution science makes this even harder to establish, because it enables a more precise determination of a single emitter's contribution to an injury. This in turn makes it apparent that no one entity can ever be said to have contributed enough GHG emissions to amount to the conditio sine qua non of a claimant's *entire* harm.

Accordingly, establishing necessary causation in tort cases seeking damages from GHG emitters is not an issue over the science but an issue of the law. Advances in attribution science reveal that it will never be possible to show that any one defendant's emissions are the necessary cause of a claimant's total injury. But does the law nonetheless offer a chance to recover from that defendant? One solution could be that courts relax their strict necessary causation requirements, recognizing that it is unfair as a policy matter for claimants to not be compensated even when defendant emitters have engaged in harmful behavior. Courts relax causation standards in other contexts, but as discussed below they likely would not do so here.

B. Can the Necessary Causation Requirements Be Relaxed?

Legal scholars have proposed and discussed various alternative causation standards that could apply in tort cases seeking climate-related damages, drawing on other situations in which courts have deemed it appropriate as a policy matter to relax strict necessary causation requirements. Although different labels are used to refer to these standards, they generally fall into three categories: alternative causation, market-share liability, and material contribution.

The following section discusses each, and their application in the jurisdictions in which tort claims for climate-related damages would likely be brought (England, France, Germany, the Netherlands, and the United States). It then discusses the scholarly debate regarding the application of these relaxed standards to climate-related torts, and forms a conclusion as to whether such standards would likely apply.

1. Alternative Causation

❑ *Different treatment of alternative causation theories*. Alternative causation was developed to address situations where a plaintiff is injured by tortious conduct of two or more actors but cannot, due to the circumstances underlying the injury, identify which specific tortfeasor(s) caused the harm.[243] The California Supreme Court was the first to apply a relaxed causation standard in this scenario in its 1948 decision in *Summers v. Tice*.[244]

In that case, two hunters negligently discharged their firearms in the direction of the plaintiff.[245] The plaintiff was struck, but it was impossible to determine which defendant fired the injuring shot.[246] Noting that both defendants acted tortiously, the court observed that the plaintiff was "in the unfair position of pointing to which defendant caused the harm."[247] Thus, "[i]f one can escape then the other may also and the plaintiff is remediless."[248] The court therefore found that both defendants should be jointly and severally liable (or solidarily, as phrased in most European systems[249]) for the harm.[250] The court shifted the causal burden to the defendants, who could try to recover from each other.[251]

Most U.S. courts hold that the burden should be shifted in alternative cause scenarios.[252] The U.K.'s House of Lords also expressly endorsed burden-shifting in alternative cause scenarios in *Fairchild v. Glenhaven Funeral Services Ltd*.[253] In *Fairchild*, three claimants contracted mesothelioma after being negligently exposed to asbestos at work.[254] The claimants worked for multiple successive employers and were exposed to asbestos dust at each.[255] Because mesothelioma could be contracted through exposure to a single asbestos fiber, any one defendant could have caused the

243. Wright, *supra* note 72, at 1816.
244. *See id.* (discussing Summers v. Tice, 199 P.2d 1 (Cal. 1948)).
245. *Summers*, 199 P.2d at 2.
246. *Id.*
247. *Id.* at 4.
248. *Id.*
249. Ioannis Lianos, *Causal Uncertainty and Damages Claims for the Infringement of Competition Law in Europe*, 34 Y.B. Eur. L. 170, 188 (2015) (explaining this is the terminology used in the Principles of European Tort Law).
250. *Summers*, 199 P.2d at 4.
251. *Id.* at 5.
252. Third Restatement, Liability for Physical and Emotional Harm, *supra* note 62, §28(b):
> When the plaintiff sues all of multiple actors and proves that each engaged in tortious conduct that exposed the plaintiff to a risk of harm and that the tortious conduct of one or more of them caused the plaintiff's harm but the plaintiff cannot reasonably be expected to prove which actor or actors caused the harm, the burden of proof . . . on factual causation is shifted to the defendants.

253. [2002] UKHL 22, [2003] 1 AC (HL) (appeal taken from Eng.).
254. *Id.* at [3].
255. *Id.* at [7].

harm.[256] The lower court dismissed the cases because the claimants could not establish necessary causation.[257] The House of Lords, however, allowed the claims to proceed on the grounds that each defendant materially contributed to the claimants' risk of contracting cancer.[258]

The House of Lords did not determine whether the defendants should be held jointly and severally liable or only proportionately liable based on their contribution to the claimants' exposure,[259] but it revisited this question in *Barker v. Corus UK Ltd.*,[260] finding that "liability should be divided according to the probability that one or other caused the harm."[261] It is important to note that the House of Lords placed limitations on *Fairchild*'s application. The standard only applies in "situations of scientific, as opposed to merely evidential, uncertainty, as to the cause of the condition," and where the "condition resulted from the same (or at least similar) risks to which the plaintiff was exposed."[262]

There may be an emerging trend elsewhere in Europe where, in cases of alternative causation, multiple tortfeasors are held proportionally (severally) liable according to the probability that each caused the harm. The Principles of European Tort Law provide:

> In cases of multiple activities, where each of them alone would have been sufficient to cause the damage, but it remains uncertain which one in fact caused it, each activity is regarded as a cause to the extent corresponding to the likelihood that it may have caused the victim's damage.[263]

However, courts in Germany, the Netherlands, and France would all still likely shift the burden in cases of alternative causation and hold the defendants jointly and severally (solidarily) liable. For "causal uncertainty arising out of several tortfeasors causing the same damage, German law prefers the solution of solidary liability of all defendants, as 'it is thought that it should not be the victim's risk to prove who caused which part of the damage.'"[264] For example, §830(1) of Germany's Civil Code provides "[i]f more than one person has caused damage by a jointly committed tort, then each of them is responsible for the damage. The same applies if it cannot be established which of several persons involved caused the damage by his act."[265]

Similarly, Article 6:99 of the Netherlands Civil Code states:

> Where the damage is caused by two or more events, for each of which another person is liable, and it is ascertained that the damage originates from at least one of these events, then each of these liable persons is jointly and severally liable for that damage, unless a liable person proves that this specific damage is not caused by the event for which he himself is liable.[266]

However, Dutch courts have expressed a willingness to apply proportional liability in cases of causal uncertainty. In 2006, the Dutch Supreme Court applied Article 6:99 to an asbestos case in which an employee sought damages from his former employer, but it was uncertain to which extent the claimant's cancer was caused by exposure to asbestos dust, the claimant's smoking, or other causes.[267] The claimant's expert estimated that the probability the cancer was caused by asbestos dust was 55%.[268] The court held the employer liable, but it ordered that the liability be reduced consistent with the claimant's own exposure.[269] Accordingly, the court endorsed proportional liability in cases of causal uncertainty, at least between claimant and defendant.[270]

Lastly, French courts do not expressly recognize proportional liability in cases of alternative causation, but one scholar notes that it could apply via the concept of loss of chance (*perte de chance*).[271] The scholar notes that joint and several liability remains the norm in cases of evidentiary uncertainty.[272] However, French courts treat loss of chance as a separate head of damage and apply the doctrine when a defendant has deprived the victim of an opportunity to realize a favorable event.[273] Thus, it can allow for a type of reverse engineering of proportional liability in cases of causal uncertainty, with damages apportioned according to the likelihood that the defendant caused the deprivation.[274]

❑ *Would alternative causation apply to climate-related damages claims?* There is disagreement among scholars as to whether alternative causation standards can or should apply to a climate-related tort claim seeking damages for a de-

256. *Id.*
257. *Id.* at [2].
258. *Id.* at [14].
259. *Id.*
260. [2006] UKHL 20, [2006] 2 AC (HL) (appeal taken from Eng.).
261. *Id.* at [43].
262. Lianos, *supra* note 249, at 24.
263. PETL, *supra* note 61, art. 3:103(1).
264. Lianos, *supra* note 249, at 202 (quoting Ulrich Magnus, *Causal Uncertainty and Proportional Liability in Germany*, *in* Proportional Liability: Analytical and Comparative Perspectives 153, 154 (Israel Gilead et al. eds., de Gruyter 2013)).
265. Bürgerliches Gesetzbuch [BGB] [Civil Code], §830, para. 1 (unofficial English translation), https://www.gesetze-im-internet.de/englisch_bgb/.
266. Art. 6:99 BW (unofficial English translation), http://www.dutchcivillaw.com/civilcodegeneral.htm.
267. HR 31 maart 2006, ECLI:NL:HR:2006:AU6092 (Nefalit/Karamus). This case and the court's approach to proportional liability adopted therein are explained in Anne L.M. Keirse, *Going Dutch: How to Address Cases of Causal Uncertainty*, *in* Proportional Liability: Analytical and Comparative Perspectives, *supra* note 264, at 227, 235-39.
268. Keirse, *supra* note 267, at 235.
269. *Id.* at 236.
270. *Id.* at 238.
271. Lianos, *supra* note 249, at 207 (noting this "has allowed French courts to express the causal impact of the defendant's conduct in probabilistic terms").
272. *Id.* ("Responsibility *in solidum* [is] mostly used for evidential uncertainty with regard to multiple tortfeasors.").
273. *Id.* ("Loss of chance enables French courts to conceal scientific uncertainty, as loss of a chance is defined as a specific head of damage, which is certain, as far as this concerns the loss of a favourable opportunity for the claimant.").
274. *Id.* ("The compensation 'must correspond to a share of the victim's various heads of damage' and 'lower courts must to that effect assess each head of damage and decide the proportion to which it constitutes a reparable loss of chance.'") (quoting Olivier Moréteau, *Causal Uncertainty and Proportional Liability in France*, *in* Proportional Liability: Analytical and Comparative Perspectives, *supra* note 264, at 141, 143).

fendant's GHG emissions. Some argue that there are many policy similarities between these claims and the asbestos cases in which these relaxed standards have applied.[275] For example, liability is tied to the production or use of a product that was initially considered harmless but now is known to be dangerous.[276] And both scenarios also involve significant public costs in remediating the harmful impacts of the product.[277]

On the other hand, unlike an employer negligently exposing its employee to asbestos, it is less apparent that a large emitter can be said to have acted in a particularly dangerous way toward a claimant.[278] Further, the asbestos cases involved a small subset of identifiable defendants who could have caused the claimant's harm, while climate change "is a complex global process triggered by multiple 'innocent' causes like the growth of the world's population, deforestation, natural weather phenomena or 'innocent' greenhouse gas emissions."[279] Further, alternative causation theories address situations involving uncertainty about which of several activities caused the claimant's *loss in full*.[280] In contrast, "[a] single defendant's isolated emissions can never be a sufficient cause for the victim's harm."[281]

Ultimately, relaxed alternative causation standards likely cannot apply to tort claims seeking damages for climate-related harms. This is in part due to the foregoing reasons. However, even if one accepts that the policy circumstances that led to alternative causation being applied in asbestos cases are equally applicable to climate-related torts, the standard still likely cannot be invoked. This is because the standard would not be used to serve the purpose for which it was developed; namely, to address causal uncertainty.

As discussed above, progress in attribution science has largely *removed* uncertainties in attributing specific climate-related injuries to specific GHG emissions. Although the science may not be as robust in certain areas, it would be difficult to argue that the defendant should bear the burden of proof attached to uncertainties in the science, since these generally pertain to matters outside a defendant's control. For example, impact attribution remains largely qualitative, but the link in the causal attribution chain addressed by impact attribution usually pertains to circumstances that by their nature are not attributable to a GHG emitter, such as the plaintiff's own actions or innocent environmental circumstances that increased the plaintiff's exposure to the injury.

2. Market-Share Liability

❑ *Different treatment of market-share liability*. Scholars also debate whether market-share liability could apply to climate-related tort claims for damages. The California Supreme Court was the first to apply this relaxed causation standard as well, in claims arising out of the manufacture and sale of diethylstilbestrol (DES), a synthetic form of estrogen that caused cancer in women exposed to the drug during their mothers' pregnancies.[282] Due to the long latency period between exposure and development of the cancer, and because DES was a generic medication manufactured by multiple drug companies, it was impossible for the women to identify which specific drug company, or group of companies, manufactured the specific DES that their mothers ingested, causing their injury.[283]

In *Sindell v. Abbott Laboratories*, the California Supreme Court determined that it would be unfair to hold any one defendant jointly and severally liable for a plaintiff's entire harm under an alternative causation theory, noting the large number of manufacturers on the market who could have caused the harm and that the manufacturers were acting consistent with industry practice and regulatory requirements when they manufactured the medication.[284] At the same time, however, the court found that policy reasons warranted some relaxation of the necessary causation standard, since the defendants' conduct created a risk of harm to innocent victims, and these defendants were in a better position to both absorb the costs of such harm and to guard against defects.[285] The court held that, where there is a fungible product and it is impossible for the claimant to ascertain which defendant manufactured the specific product causing the injury, the claimant could recover damages from the defendant manufacturer proportionate to the percentage of the product that the defendant sold on the market.[286]

Not all courts in the United States recognize market-share liability, with some applying permutations of the standard while others reject it entirely.[287] European courts and legislatures have generally not accepted the theory, although some apply the more claimant-friendly theory of alternative causation in such situations, resulting in the defendant being jointly and severally liable for the claimant's entire injury. For example, the Principles of European Tort Law do not have a rule addressing this specific scenario, but they explain that it may be covered under Article 3:103(2), which provides:

> If, in case of multiple victims, it remains uncertain whether a particular victim's damage has been caused by an activity, while it is likely that it did not cause the damage of all

275. Geetanjali Ganguly et al., *If at First You Don't Succeed: Suing Corporations for Climate Change*, 38 Oxford J. Legal Stud. 841, 856 (2018) ("The challenges surrounding private climate litigation have a number of similarities with those affecting asbestos and tobacco litigation.").
276. *Id.* at 856-57.
277. *Id.* at 857.
278. Spitzer & Burtscher, *supra* note 42, at 169 (explaining this is because it "could not be established that the defendant materially increased the risk of the particular harm occurring").
279. *Id.*
280. PETL, *supra* note 61, art. 3:103 cmt. ¶ 2 ("Art. 3:103 [addressing alternative causation] is about uncertainty which of several activities has caused the victim's loss in full.").
281. Spitzer & Burtscher, *supra* note 42, at 169.
282. Sindell v. Abbott Laboratories, 607 P.2d 924, 925 (Cal. 1980); *see also* Lawson, *supra* note 81, at 452-56 (providing an overview of *Sindell* and its introduction of market-share liability).
283. *Sindell*, 607 P.2d at 926, 936.
284. *Id.* at 935.
285. *Id.* at 936.
286. *Id.* at 936-37.
287. Lawson, *supra* note 81, at 459-60 (discussing cases).

> victims, the activity is regarded as a cause of the damage suffered by all victims in proportion to the likelihood that it may have caused the damage of a particular victim.[288]

Although this does not exactly match the circumstances in *Sindell*, the commentary explains that this section could apply to a situation in which several drug companies negligently manufacture a drug that injures 25,000 consumers.[289] The commentary assumes that the likelihood of any one defendant causing any one claimant's injury corresponds with the defendant's market share, and accordingly as in *Sindell*, any one defendant's liability to any one injured victim would be proportionate to that market share.[290]

English courts have not considered a claim for market-share liability, but at least one scholar doubts that it would be recognized.[291] Similarly, another scholar explains that market-share liability would not apply in Germany, arguing that under a DES-type case the claimant would need to show which specific defendants manufactured the drugs that the claimant's mother in fact ingested which, by the nature of such claims, would be impossible.[292] In contrast, courts in the Netherlands and France have applied pure alternative causation theories rather than market-share liability in DES cases, holding manufacturers jointly and severally liable even if they composed a small share of the market at the time of manufacture. For example, in 1992, the Dutch Supreme Court awarded full compensation to a DES claimant under the same Article 6:99 of the Dutch Civil Code discussed above, holding one defendant responsible for the claimant's entire harm.[293] The French Court of Cassation ordered joint and several liability among two DES manufacturers in 2009, even though during the relevant period one defendant held an 80% to 90% market share while the other held only a 10% to 20% market share.[294]

❑ *Would market-share liability apply to climate-related damages claims?* Market-share liability seems to be the most discussed relaxed causation standard in the context of climate-related tort claims for damages. Arguments in favor of its application include that, like generic DES medication, GHGs are fungible, at least when considering their contribution to climate change, since the impact of each GHG can be reduced and compared to others via its CO_2 equivalency.[295] Similar policy concerns also arguably apply to climate-related tort claims as to the DES cases, since it can be said that GHG emissions create risks to "innocent" victims and that defendants are in a superior position to absorb the cost of those risks.[296] Further, plaintiffs arguably cannot identify the defendants that caused their specific injury[297]

On the other hand, courts have been reluctant to extend market-share liability beyond the DES context,[298] and they may be especially hesitant to do so where the activity has a high social utility, such as the production of fossil fuels.[299] And while market share may be a useful proxy for harm in some cases, the same perhaps cannot be said for climate-related harms. As one scholar explains, "the simple equation between emissions and harm is erroneous because a 20% contribution to global emissions does not equal a 20% contribution to the harm."[300] Further, while an injury in a DES case can be attributed entirely to a single defective product, "there is a large number of potential 'innocent' causes in the climate change scenario."[301]

Each of the foregoing reasons could lead a court to reject market-share liability in tort claims seeking damages for climate-related harms. However, as was the case with alternative causation, another reason for rejecting the theory is that it was meant to address causal uncertainty, which attribution science specifically mitigates. Accordingly, as attribution science progresses, it will likely become more difficult for a plaintiff to invoke market-share liability theories to recover in climate change-related tort claims for damages.

288. PETL, *supra* note 61, art. 3:103(2).
289. *Id.* art. 3:103 cmt. ¶ 11.
290. *Id.*
291. Ken Oliphant, *Causal Uncertainty and Proportional Liability in England and Wales*, *in* Proportional Liability: Analytical and Comparative Perspectives, *supra* note 264, at 121, 128-29 (explaining that the "theory of market share liability has yet to be ruled upon by English courts" and that its application under English law has not "been much discussed by legal commentators," but doubting that a relaxed causation standard would apply in similar pollution and drug scenarios because "it will generally be difficult to satisfy the requirement . . . that all the risks to which [the claimant] was exposed are the same or similar").
292. Magnus, *supra* note 264, at 161 ("In cases like the DES case, German courts would deny liability of the producers because the claimant cannot prove that a certain producer caused the claimant's damage. Market-share liability has not yet been accepted in Germany.").
293. *See* Keirse, *supra* note 267, at 228 (discussing HR 31 maart 2006, ECLI:NL:HR:2006:AU6092 (Nefalit/Karamus)).
294. *See* Moréteau, *supra* note 274, at 145 (discussing Cour de Cassation [Cass.] [Supreme Court for judicial matters] 1e civ., Sept. 24, 2009, Bull. civ. I, No. 187, D 2010, 49).
295. Lawson, *supra* note 81, at 484 (explaining GHGs are both interchangeable and they present a common risk of injury); Kysar, *supra* note 107, at 37 ("Perhaps because greenhouse gas emissions *do* seem to have that elusive quality of fungibility, commentators advocate application of market share liability for climate-related harms") (citing Daniel J. Grimm, *Global Warming and Market Share Liability: A Proposed Model for Allocating Tort Damages Among CO_2 Producers*, 32 Colum. J. Env't L. 209, 219-21 (2007)); Marjanac & Patton, *supra* note 226, at 286 (noting that the application of market share theory to climate change liability "is an open question that will depend on the degree to which greenhouse gas emissions are accepted as fungible by law").
296. Lawson, *supra* note 81, at 481 (noting the claimants in *Kivalina* "are innocent because their contribution to global warming is negligible in volume compared to the twenty-four named defendants" and that these "defendants are in a superior position to absorb the costs of the harm").
297. *Id.* at 483 ("No amount of due diligence would allow the *Kivalina* plaintiffs to discover the particular defendant that caused their harm. Therefore, MSL [market-share liability] is appropriate in this context.").
298. Kysar, *supra* note 107, at 37 ("Nonetheless, very few courts have applied the market share theory outside of the DES context . . . ."); Marjanac & Patton, *supra* note 226, at 286 ("US courts have been hesitant to extend this doctrine beyond medical negligence cases").
299. Marjanac & Patton, *supra* note 226, at 286 ("Attempting to bring market share cases regarding climate change would likely raise public policy concerns, including questions regarding the . . . social usefulness of emitting activities.").
300. Spitzer & Burtscher, *supra* note 42, at 171.
301. *Id.* at 172.

3. Material Contribution

❑ *Different treatment of material contribution*. Like the alternative causation and market-share liability theories, the "material contribution" standard was developed in situations where a claimant cannot identify a single defendant responsible for its injury, "but can identify a group of individuals or entities responsible for the acts or operations which ultimately caused the damage or loss."[302] This standard "allows an injured party to avoid the need to prove 'but for' causation and only requires proof that the negligent act materially contributed to the claimant's injury."[303] Like the other theories, material contribution will also become less applicable to climate change-related tort claims as attribution science becomes better able to precisely identify a GHG emitter's contribution to an injury.

The House of Lords adopted the standard in 1956 in *Bonnington Castings Ltd. v. Wardlaw*, where a claimant developed pneumoconiosis through long-term exposure to silica dust at his place of employment.[304] The employer failed to comply with its statutory obligation to take certain measures that would have lessened the claimant's exposure to the silica dust, but even if these measures were taken the claimant would still have faced significant exposure.[305] It was established that the employer's breach of its statutory duty contributed only a small, albeit uncertain, amount of the total silica dust exposure that caused the injury.[306] Nevertheless, the House of Lords held that the employer "materially contributed" to the harm and thus required the employer to compensate the claimant's entire injury.[307] "Material contribution" was defined as an exposure that exceeds a de minimis threshold.[308]

Since *Bonnington*, courts in the U.K. have developed two permutations of the material contribution standard—"material contribution to the risk" and the "doubling of the risk."[309] These provide that each defendant who has contributed to the risk of injury to a specific extent can be held liable as a cause.[310] In other words, a claimant need not show that a defendant contributed to the injury, just to an *increase in the risk* of the injury occurring.[311] For example, in *McGhee v. National Coal Board*,[312] the court held that an employer's negligent exposure of its employee to coal dust materially increased the employee's risk of developing dermatitis, even though the dermatitis could have been caused entirely by other exposures.[313] The court in *Heneghan v. Manchester Dry Docks Ltd*.[314] equated the "doubling of the risk" test to a balance of probabilities standard of proof, stating simply that "[i]f statistical evidence shows that a tortfeasor more than doubled the risk that the victim would suffer the injury, it follows that it is more likely than not that the tortfeasor caused the injury."[315]

Courts in France, Germany, and the Netherlands appear to not have expressly dealt with material contribution, material contribution to the risk, or doubling of the risk theories[316]; therefore, it remains uncertain whether these jurisdictions would recognize them. Courts in the United States, however, have addressed similar arguments under the "substantial factor" test. This test was originally developed to address situations of "multiple sufficient causation," where two or more conditions that combined to cause an injury would have each been an independently sufficient cause of the injury.[317]

It was first adopted by the Minnesota Supreme Court in the 1920 "twin fires" case.[318] In that case, the plaintiff alleged that a spark from the defendant's train started a wildfire that destroyed his home.[319] The defendant, however, argued that the fire it ignited had been subsumed by another fire started by natural causes, before consuming the property.[320] Because each fire would have been sufficient on its own to cause the damage, the plaintiff could not establish that his property would not have been destroyed but for the defendant's negligence.[321] But the court held that the plaintiff could recover in full if he established that the negligently caused fire would have been sufficient on its own to damage the property.[322] If so, the negligent fire would be a "substantial factor" to the injury.[323]

Accordingly, the substantial factor test initially was not designed to replace "but-for" causation, since the plaintiff was still required to show that the defendant's actions would have been a necessary cause of the injury on its own.[324] However, courts in the United States have

302. Marjanac & Patton, *supra* note 226, at 280.
303. *Id.* at 280 n.83.
304. [1956] UKHL 1, [1956] 2 WLR 615 (HL) (appeal taken from Eng.).
305. *Id.* at 615-16.
306. *Id.*
307. *Id.* at 621.
308. *Id.*
309. *See* Marjanac & Patton, *supra* note 226, at 280-81 & n.83.
310. *Id.* (explaining that the material contribution to the risk test requires the claimant to "prove that the defendant's negligence materially contributed to the risk of injury (i.e., more than de minimis) to recover damages in full," while the doubling of the risk test requires the claimant to show "that his or her tortious exposure to a disease-causing agent doubled the risk that he or she would otherwise have had of contracting the disease").
311. *Id.*
312. [1973] UKHL 7, [1973] 1 WLR 1 (HL) (appeal taken from Eng.).
313. *Id.* at 4.
314. [2016] EWCA (Civ) 86, [2016] 1 WLR 2036 (HL) (appeal taken from Eng.).
315. *Id.* at 2040.
316. For example, in a treatise on comparative liability theories between France, Germany, the Netherlands, the U.K., the United States, and other jurisdictions, these standards were discussed by the English contributor but not raised by the contributors from France, Germany, and the Netherlands. *See generally* Oliphant, *supra* note 291, at 130; Moréteau, *supra* note 274; Magnus, *supra* note 264; Keirse, *supra* note 267.
317. Weigand, *supra* note 88, at 82 ("The 'material factor' or 'substantial factor' notion thus arose to allow the finding of causation where any one of the possible causes would have been sufficient to cause the injury" such as the "'twin fire' or multiple sufficient causes scenario.").
318. *Id.* at 83 (discussing Anderson v. Minneapolis, St. Paul & Sault Ste. Marie Ry. Co., 179 N.W. 45 (Minn. 1920), *overruled in part on other grounds by* Borsheim v. Great N. Ry. Co., 183 N.W. 519 (Minn. 1921)).
319. *Anderson*, 179 N.W. at 46.
320. *Id.* at 49.
321. *Id.*
322. *Id.*
323. *Id.*
324. Weigand, *supra* note 88, at 107 (explaining that the substantial factor test "is not meant to replace but for causation in multiple defendant or multiple cause cases or otherwise eliminate the independently sufficient causal showing absent concurrence or concert").

long applied this test inconsistent with its original purpose, interpreting it as a relaxation of the but-for test and treating it as a material contribution test.[325] This is largely due to the vague phrasing that U.S. courts and treatises have used when expounding the standard, which resulted in the test becoming "little more than a jurisprudential Rorschach blot—in one circumstance justifying a relaxed standard of causation, in another supporting a heightened standard."[326] Due to its confusion in application, in 2010, the concept was removed in the Restatement (Third) of Torts, but it remains in common and inconsistent use across the United States.[327]

❑ *Would material contribution apply to climate-related damages claims?* Scholars disagree on whether a claimant can credibly argue that a defendant's emissions amount to a "material contribution" toward a claimant's climate change-related injury. Those who argue for its application note that event attribution studies are similar in nature to the statistical evidence that U.K. courts in the above cases have accepted to show that an employer increased the risk of its employee developing a certain health condition.[328] They note that attribution studies have similarly shown that anthropogenic GHG emissions have made certain specific weather and slow-onset events more likely to occur, at times over 100 times more likely.[329] This could be used to establish causation under a "doubling of the risk" standard.[330]

However, this argument can only apply if a court considers *total* anthropogenic GHG emissions in the atmosphere as the cause of the claimant's harm, since "even large-scale emitters' contributions to global warming are only minimal."[331] If anything, attribution science makes it more apparent that no one emitter, or even several global carbon majors, could ever emit enough GHGs to constitute a "material contribution" to a claimant's injury. Thus, as attribution science increasingly allows one to establish any defendant's emissions with greater certainty, it becomes less likely that the material contribution test would apply.

Further, given the lack of a clear and consistent use of the "substantial factor" test in the United States, it is impossible to state as a general matter whether U.S. courts would apply this concept to allow for recovery in a tort case seeking damages for climate-related harms. Perhaps for this reason, scholars appear to have not analyzed in depth whether this standard could apply to U.S. climate litigation. Ultimately, like the other standards discussed above, the fact that attribution science provides greater certainty around any one defendant's emissions also means that it would not be a workable tool to establish causation in a tort claim seeking climate-related damages.

C. *Refocusing the Debate—The NESS Test and Proportional Liability*

The preceding sections have shown that, as attribution science progresses, claimants will be able to attribute any one global carbon major's emissions to a climate-related event and resulting injury with greater certainty. This will make it more difficult to establish necessary causation in an action seeking damages from the global carbon major, as greater certainty makes apparent the relatively insignificant contribution of any one emitter to the total anthropogenic GHG mix. At the same time, greater certainty may also make it less likely that claimants can successfully invoke relaxed causation standards or the material contribution test.

However, this does not mean that claimants are without a path forward in tort claims seeking climate-related damages from specific emitters. Instead, another avenue may be available to establish causation in such claims, one that courts seem increasingly willing to accept (and have long accepted in certain contexts). Specifically, courts may be willing to recognize that any one global carbon major's GHG emissions, though relatively insignificant on their own, constitute a "necessary element of a sufficient set" of several conditions (or "concurrent minimum causes") that, when considered together, cause a climate-related injury. If causation is established under this standard, the defendant could then be held proportionally (or severally) liable, allowing the claimant to recover damages in proportion to the defendant's contribution to the harm. Attribution science enables the claimant to establish this contribution with greater certainty, which, assuming the standard is accepted by a court, would increase the claimant's chances of success in establishing causation regarding that specific defendant.

1. Necessary Element of a Sufficient Set

Courts in Europe and the United States have implicitly applied the NESS concept in cases with circumstances arguably like those underlying climate-related tort claims that seek damages. Richard Wright adapted the NESS approach to the law as a logically sound way to establish causation, addressing nearly all potential causal scenarios

325. *Id.* at 103:
> Although there are instructions and cases indicating that substantial . . . factor is defined in terms of 'but for' consistent with the Second Restatement, there are cases and instances where it is not, with the ever present concern that but for causation no longer has a seat at the head of the causation table.

326. Third Restatement, Liability for Physical and Emotional Harm, *supra* note 62, §26 cmt. j.

327. Weigand, *supra* note 88, at 76:
> The ascendancy of substantial factor causation and the corresponding perceived or actual demise of but for causation in any multiple cause case is troubling. Such use is inconsistent with the humble origins of 'substantial factor' [and] threatens to impermissibly dilute the requisite degree of causal nexus imperative for imposition of responsibility.

328. Marjanac & Patton, *supra* note 226, at 283 ("[E]vent attribution science is theoretically capable of proving a sufficient 'causal' connection between human greenhouse gas emissions and an extreme weather event in the law (if the doubling of the risk test . . . were to be adopted).").

329. *Id.* at 284 (discussing a 2016 study that "found that anthropogenic climate change made temperature anomalies in the Coral Sea (which led to widespread bleaching of coral in the Great Barrier Reef) 175 times more likely to occur").

330. *Id.* ("This study may therefore satisfy the 'doubling of the risk' test with such damage having been clearly 'caused' by anthropogenic emissions."). *See also* Marjanac et al., *supra* note 148, at 617.

331. Spitzer & Burtscher, *supra* note 42, at 169.

without sacrificing the requirement of necessity.[332] According to Wright's phrasing, "a particular condition was a cause of (condition contributing to) a specific consequence if and only if it was a necessary element of a set of antecedent actual conditions that was sufficient for the occurrence of the consequence."[333]

This language addresses the inability of the but-for test to account for causally overdetermined situations where, like the twin fires scenario, an event has multiple causes, each of which would have been independently sufficient to cause the effect.[334] This is because, in all scenarios involving multiple contributing conditions to an event, the two key questions are, first, whether there was a causal set that was sufficient to cause the harm, and second, whether the examined condition formed a necessary part of that causal set.[335] The NESS test can also provide a more precise alternative to the vague material contribution and substantial factor standards. Ultimately, the NESS test is a logically sound approach to causation that encapsulates existing legal standards while recognizing that, in the real world, events are almost always caused by multiple underlying conditions.

As mentioned above, in 2010 the Restatement (Third) of Torts discarded the vague "substantial factor" standard because courts had applied it in disparate and conflicting ways.[336] It instead adopted the NESS test. Section 26 of the Restatement reasserts the primacy of necessary causation, stating that "[c]onduct is a factual cause of harm when the harm would not have occurred absent the conduct."[337] Section 27 then addresses the "twin fire" or "causally overdetermined" scenario, providing that "[i]f multiple acts occur, each of which under §26 alone would have been a factual cause of the physical harm at the same time in the absence of the other act(s), each act is regarded as a factual cause of the harm."[338]

Although the primary purpose of this section is to address causal overdetermination, comment f to §27 explains that it also is meant to incorporate the NESS test and the causal set approach more generally. Specifically, comment f explains:

> In some cases, tortious conduct by one actor is insufficient, even with other background causes, to cause the plaintiff's harm. Nevertheless, when combined with conduct by other persons, the conduct . . . is more than sufficient to cause the harm. The fact that an actor's conduct requires other conduct to be sufficient to cause another's harm does not obviate the applicability of this Section.[339]

Accordingly, even a trivial contribution can be established as a legally relevant factual cause under §27 if it is a necessary part of a set of conditions that together are sufficient to cause the plaintiff's harm.

The Third Restatement provides a few scenarios to further explain how the NESS test should apply. One involves two defendants who each contribute pollution to a waterway, with each contribution being insufficient on its own to cause injury.[340] However, when both defendants' pollution is combined with a naturally occurring pollutant, the total pollution is sufficient to cause the injury.[341] In this example, the Third Restatement provides that both defendants would be considered a factual cause of the injury.[342] In another illustration, a defendant is considered the factual cause of a flood where it contributed a small amount of water to a more significant amount of naturally occurring runoff, because the defendant's incremental contribution resulted in a dam being breached.[343] Even though the contribution was small, the commentary explains that "the actor who negligently provides the straw that breaks the camel's back is subject to liability for the broken back."[344]

2. Applying the NESS Standard in the United States

Some have argued that the NESS test is too significant a departure from traditional necessary causation requirements, and therefore it does not represent the current status of the law.[345] The Third Restatement's phrasing of the test has, however, seen some recent judicial endorsements, including in pollution cases.[346] And long before these courts expressly used the phrasing "necessary element of a sufficient set," others applied the logic underlying the test, primarily in cases involving diffuse environmental pollution and other toxic torts.

For example, as far back as the 1904 case *Warren v. Parkhurst*, the New York Supreme Court considered whether any one of 26 companies, each of whom contributed only a small amount of pollution to a stream, should be held liable in damages to a plaintiff injured by that pol-

332. Wright, *supra* note 72, at 1788 (stating the NESS test "is applicable to the entire spectrum of causation cases," and "incorporates the indispensable notion of necessity, but subordinates it to the notion of sufficiency").
333. *Id.* at 1790.
334. Puppe & Wright, *supra* note 23, at 50 (noting Wright's claim that the "NESS account" captures "the essence of the concept of causation" including in situations "involving overdetermined negative causation"); *see also* Wright, *supra* note 72, at 1793.
335. Wright, *supra* note 72, at 1790 (formulating the NESS test).
336. Weigand, *supra* note 88, at 87:
> According to the drafters, '[t]he substantial-factor test has not . . . withstood the test of time, as it has proved confusing and been misused.' The problem is the perception that the term 'substantial' permits either a more rigorous or more lenient standard for factual cause resulting from the term's evaluative character.

(quoting Third Restatement, Liability for Physical and Emotional Harm, *supra* note 62, §26 cmt. j).
337. Third Restatement, Liability for Physical and Emotional Harm, *supra* note 62, §26.
338. *Id.* §27.
339. *Id.* §27 cmt. f.
340. *Id.* §27 illus. 4.
341. *Id.*
342. *Id.*
343. *Id.* §36 illus. 2.
344. *Id.*
345. *See* Weigand, *supra* note 88, at 109 ("As to the causal set, or NESS approach, identified in the comments of the Third Restatement, it is not remotely the law of Massachusetts or of most other jurisdictions.").
346. *See* June v. Union Carbide Corp., 577 F.3d 1234, 1242-44, 39 ELR 20196 (10th Cir. 2009); *see also* Wilcox v. Homestake Mining Co., 619 F.3d 1165, 1168, 40 ELR 20250 (10th Cir. 2010) (citing *June*, 577 F.3d at 1243).

lution.[347] No one company's pollution alone was sufficient to cause the injury, but the combined pollution exceeded a harmful threshold.[348] The court held that each defendant's pollution was a factual cause of the injury.[349] Stated a different way, each defendant's pollution was a necessary element of a causal set (the total pollution) that was sufficient to cause the injury.

Indeed, it is a generally applied principle of nuisance law in the United States that a plaintiff need only show that a defendant *contributed* to the nuisance, not that the defendant on its own *created* the nuisance.[350] As stated by one federal court:

> Even if the amount of pollution caused by each party would be too slight to warrant a finding that any one of them had created a nuisance . . . pollution of a stream to even a slight extent becomes unreasonable . . . when similar pollution by others makes the condition of the stream approach the danger point.[351]

Indeed, before endorsing the NESS test for all tort claims in its 2010 edition, the earlier Restatement (Second) of Torts explained that defendants who contribute to a nuisance "to a relatively slight extent" may be held liable if "the contribution of all is a substantial interference, which becomes an unreasonable one."[352] Further, "the fact that other persons contribute to a nuisance is not a bar to the defendant's liability for his own contribution."[353] As this language demonstrates, courts in the United States have long implicitly applied the NESS test and causal set approach to nuisance cases, finding any one defendant liable as long as its contribution constitutes a necessary element of the entire causal set (i.e., the entire pollution or other nuisance) that when considered together was sufficient to cause the injury.

It is less clear whether U.S. courts applying a NESS test would also apply proportional rather than joint and several liability to such claims. As a practical matter, courts may be less inclined to hold defendants jointly and severally liable for a harm even if the defendant could be seen as causing some portion of it under the NESS test, if the defendant's contribution is small. Thus, proportional liability would be required to overcome this hurdle. Until recently, the majority rule in the United States was joint and several liability for claims against multiple tortfeasors, at least as a general matter.[354] However, "[t]he clear trend over the past several decades has been a move away from pure joint and several liability."[355]

Further, in cases involving a significant number of tortfeasors, U.S. courts have historically applied proportional liability, especially if each tortfeasor made a relatively small contribution to the total harm.[356] For example, the court in the *Warren* case held that each defendant should be liable in damages only for their proportionate contribution to the pollution that caused the injury.[357] Similarly, a federal district court in New York more recently held that joint and several liability would be "fundamentally unfair" in a toxic tort case brought against 50 manufacturers of the pollutant methyl tert-butyl ether (MTBE), where the MTBE from each defendant commingled with the contributions of others to reach a harmful threshold and pollute private wells.[358]

Accordingly, U.S. courts appear to routinely invoke proportional liability in claims against multiple tortfeasors who each contribute a relatively insignificant amount to a harm, especially in nuisance cases and cases involving diffuse environmental pollution.

3. Applying the NESS Standard in Europe

It is less clear whether European courts would accept the NESS test, including for nuisance claims. Like the Third Restatement, the Principles of European Tort Law envision this test applying to claims involving multiple tortfeasors who each contributed only some portion toward a given harm. Article 3:105 provides: "In the case of multiple activities, when it is certain that none of them has caused the entire damage or any determinable part thereof, those that are likely to have [minimally] contributed to the damage are presumed to have caused equal shares thereof."[359] However, the presumption of equal liability is negated if a defendant's contribution is clear, in which case the defendant will have caused only its specific contribution.[360] Thus, the Principles of European Tort Law contemplate that defendants can be held liable on the basis of their minimal contribution to a harm. Like much of U.S. nuisance case law, this follows a causal set approach, but it is not uniformly recognized

347. 45 Misc. 466, 467 (N.Y. Sup. Ct. 1904).
348. *Id.*
349. *Id.* at 470 ("All of the defendants may be enjoined, and if the question of damages is urged a reference may be had to determine what damage has been caused by each defendant."). *See also* Wright, *supra* note 72, at 1793.
350. *See* Cox v. City of Dallas, 256 F.3d 281, 293 n.19, 31 ELR 20767 (5th Cir. 2001) (collecting U.S. authorities confirming the point that "nuisance liability at common law has been based on actions which 'contribute' to the creation of a nuisance").
351. Boim v. Holy Land Found. for Relief & Dev., 549 F.3d 685, 696-97 (7th Cir. 2008) (quoting W. Page Keeton et al., Prosser and Keeton on the Law of Torts §52, at 354 (5th ed. 1984)).
352. Restatement (Second) of Torts §840E (Am. L. Inst. 1965) [hereinafter Second Restatement].
353. *Id.*
354. *See*, *e.g.*, *id.* §875 ("Each of two or more persons whose tortious conduct is a legal cause of a single and indivisible harm to the injured party is subject to liability to the injured party for the entire harm.").
355. Third Restatement, Apportionment of Liability, *supra* note 62, §17 cmt. a (discussing the varying rules applied across U.S. jurisdictions).
356. Second Restatement, *supra* note 352, §433B cmt. E:
> The possibility arises that there may be so large a number of actors, each of whom contributes a relatively small and insignificant part to the total harm, that the application of the rule [of joint and several liability] may cause disproportionate hardship to defendants. Thus, if a hundred factories each contribute a small, but still uncertain, amount of pollution to a stream, to hold each of them liable for the entire damage because he cannot show the amount of his contribution may perhaps be unjust.

357. Warren v. Parkhurst, 45 Misc. 466, 466 (N.Y. Sup. Ct. 1904).
358. In re Methyl Tertiary Butyl Ether ("MTBE") Prods., 447 F. Supp. 2d 289, 303, 305 (S.D.N.Y. 2006).
359. PETL, *supra* note 61, art. 3:105.
360. *Id.* art. 3:105 cmt. ¶ 2 ("It only comes into play—of course—if the contributions are unclear.").

by European courts, as demonstrated by their treatment of joint and several (solidary) liability versus proportional (several) liability for tort claims.

Although proportional liability may align more with notions of fairness to defendants, "[s]olidary liability is so deeply embedded in the European systems that to abandon it would amount to a profound shift in the balance of the law."[361] Nonetheless, the Principles of European Tort Law opt for several liability where there are multiple tortfeasors contributing to a single injury and there is a "reasonable basis for attributing only part of [the injury] to each of a number of persons liable to the victim."[362] A reasonable basis for apportionment could exist if, for example, several defendants each contribute a specific volume of water to a flood.[363]

Solidary liability in the case of multiple tortfeasors causing a single harm has been the general rule in England,[364] Germany,[365] France,[366] and the Netherlands,[367] at least where the injury is indivisible. Courts in each country have, however, recognized several liability where there is a reasonable basis to apportion liability among defendants. In *Holtby v. Brigham & Cowan (Hull) Ltd.*, the Court of Appeal of England and Wales held each defendant employer severally liable for an employee's asbestosis injury, proportionate to the intensity and duration of exposure to asbestos that the employee experienced at each.[368] As for Germany, the Higher Regional Court Hamm expressly stated that it will accept several liability in the *Lliuya* case, noting that solidary liability for claims arising under §1004 of the German Civil Code "is only considered if the contributions cannot be separated and there is equal importance."[369]

In contrast, as shown in their rulings in the DES cases that opted for joint and several rather than market-share liability,[370] courts in the Netherlands and France may be less inclined than their English and German counterparts to accept several liability. However, in its *Urgenda* decision, the Dutch Supreme Court also cited in dicta to Article 3:105 of the Principles of European Tort Law to support its finding that the Dutch government was required to take action to address its partial contribution to climate change, noting "each country is responsible for its part and can therefore be called to account in that respect."[371] Similarly, the Paris Administrative Court relied on Article 1246 of the Civil Code when holding the French government responsible for climate-related harms, which provides that "[a]ny person responsible for ecological damage is obliged to remedy it," finding the French government must act in proportion to its contribution to the harm.[372] Thus, the opportunity for Dutch and French courts to apply proportional liability in damages claims against multiple tortfeasors has not closed, and both countries may be trending in that direction.

4. Applying the NESS Test in Climate-Related Tort Claims for Damages

The NESS test, when combined with proportional liability, seems well-suited for tort claims seeking damages from a global carbon major in proportion to its contribution to a given climate change-related injury. Unlike the alternative and relaxed standards discussed above, causal uncertainty is not required to invoke the NESS test. Indeed, the test benefits from causal *certainty*, as it requires one to establish the specific amount a defendant contributed to the total set that caused the claimant's harm. Advances in attribution science can provide this precision. Precision should also increase a claimant's chances of invoking proportional liability, since the fairness concerns that may lead a court to reject joint and several liability can be mitigated, allowing the court to ascribe specific responsibility to the defendant.

The NESS test also offers a framework that can apply to any type of climate-related harm, so long as attribution science supports the claim. As discussed, scientists have developed frameworks to discern an individual GHG emitter's contribution to an extreme weather or other climate-related event, regardless of whether there is a linear or other type of correlation between the specific emissions and event in question.[373] Although there are many uncertainties underlying the science, progress to date has at least established

361. *Id.* art. 9:101 cmt. ¶ 4.
362. *Id.*
363. *Id.*:

> For example, where P's land is flooded with ten million litres of water contributed in the proportions of six million and four million by D1 and D2 it may be (we express no final opinion) that it is proper to regard D1 and D2 as liable to P in proportion to their contribution.

364. *See* Oliphant, *supra* note 291, at 122 (explaining that proportional liability was recognized as an "exception" in cases of causal uncertainty through, inter alia, the "material contribution to the risk" test).
365. *See* Magnus, *supra* note 264, at 155 ("Generally, with respect to tortious liability German law follows an all-or-nothing approach.").
366. *See* Moréteau, *supra* note 274, at 141 ("Civil code provisions regarding civil liability (art 1382 and following) provide for full compensation of damage, wherever the basic conditions are met.").
367. Keirse notes that there has been a trend toward proportional liability in recent years, although joint and several liability has been the traditional rule. *See* Keirse, *supra* note 267, at 227.
368. [2003] EWCA (Civ) 111 [20] (Eng.) (Stuart-Smith LJ) ("[The claimant] will be entitled to succeed if he can prove that the defendants' tortious conduct made a material contribution to his injury. But strictly speaking the defendant is liable only to the extent of that contribution.").
369. Oberlandesgericht [OLG] Hamm [Higher Regional Court Hamm] Feb. 1, 2018, at [4] (unofficial English translation of *Lliuya v. RWE AG*), http://climatecasechart.com/climate-change-litigation/wp-content/uploads/sites/16/non-us-case-documents/2018/20180207_Case-No.-2-O-28515-Essen-Regional-Court_order.pdf; *see also* Magnus, *supra* note 264, at 155.
370. *See supra* Section III.B.2 (discussing HR 31 maart 2006, ECLI:NL:HR:2006:AU6092 (Nefalit/Karamus), and Cour de Cassation [Cass.] [Supreme Court for judicial matters] 1e civ., Sept. 24, 2009, Bull. civ. I, No. 187, D 2010, 49).
371. HR 20 december 2019, ECLI:NL:HR:2019:2007, 19/001 (De Staat der Nederlanden (Ministerie van Economische Zaken en Klimaat)/Stichting Urgenda) §5.7.5 (unofficial English translation), http://climatecasechart.com/climate-change-litigation/wp-content/uploads/sites/16/non-us-case-documents/2020/20200113_2015-HAZA-C0900456689_judgment.pdf; *see also* Keirse, *supra* note 267, at 227.
372. Tribunal Administratif [Administrative Court] Paris, Feb. 3, 2021, Nos. 1904967, 1904968, 1904972, 1904976/4-1, at 24 (unofficial English translation of *Notre Affaire à Tous v. France*), http://climatecasechart.com/climate-change-litigation/wp-content/uploads/sites/16/non-us-case-documents/2021/20210203_NA_decision.pdf; *see also* Moréteau, *supra* note 274, at 141.
373. *See supra* Section II.D (discussing Harrington & Otto, *supra* note 203).

a workable framework to attribute proportionate responsibility for many climate-related events to a global carbon major. The question then becomes whether the scientific conclusions in any given case are sufficiently certain to meet the standard of proof imposed by the court hearing the case. Since uncertainties remain in attribution science, some claims will more likely succeed than others.

For example, a claim based on a harm resulting from an extreme weather event (e.g., hurricane) will still be less likely to succeed on the merits than one based on a slow-onset event (e.g., sea-level rise), due to the relatively greater number of uncertainties underlying the former. But as attribution science and our understanding of climate systems continue to strengthen, attribution statements can be made with greater certainty for a greater number of events, which will in turn expand the scope of climate change-related events and injuries forming the basis of credible tort claims for damages. In other words, the combined use of the NESS test and proportional liability can form a workable avenue for establishing legally relevant causation for many types of climate change-related harms that are already occurring, and the application of this avenue should expand in scope as attribution science continues to develop.

Although the NESS test and proportional liability provide a logically suitable framework to establish legally relevant causation, the framework of course must be accepted by a court in a tort claim for damages against a GHG emitter. Courts and treatises have endorsed this framework in analogous cases, suggesting they would at least be open to applying it in this context.

For example, the causal circumstances underlying climate-related tort claims for damages largely mirror several hypothetical scenarios in the Third Restatement.[374] The Third Restatement applies the NESS test to situations in which a defendant contributes a small amount of water to a flood or contributes a small number of pollutants to a total mix of harm-inducing pollution.[375] The treatise also applies the test where a defendant's contribution is minuscule but still amounts to the "straw that breaks the camels' back"[376] and to events where natural or non-tortious conditions contribute to the same harm.[377] Article 3:105 of the Principles of European Tort Law echoes this, stating that proportional liability based on a defendant's specific contribution to the harm is warranted where there are multiple activities contributing to the harm and the defendant's contribution can be discerned.[378]

These situations are closely analogous to harms that result from extreme weather or slow-onset events that anthropogenic GHG emissions have made more frequent, intense, or likely to occur. Just as one factory may contribute an incremental amount of pollution to a waterway, one global carbon major contributes an incremental amount of GHGs to the total atmospheric mix. Depending on whether the relationship between the emissions and the climate-related event is linear, sigmoidal, or exponential, the defendant's responsibility for that specific event may be less than or equal to other emitters, or it could even be the "straw that breaks the camel's back." In any case, the defendant's specific GHG emissions are a necessary element in a set of multiple conditions that, when considered together, is sufficient to cause an injury. Accordingly, a court that ascribes to the standards in either the Third Restatement or Principles of European Tort Law should be willing to entertain the NESS test and proportional liability approach in a tort claim against an emitter seeking climate change-related damages.

Courts in the jurisdictions under review do in fact seem willing to accept this framework, to varying degrees. The Higher Regional Court Hamm allowed a causation and liability argument based on RWE's proportionate contribution to a claimant's alleged climate-related harm to proceed, effectively applying the NESS test and proportional liability approaches directly to a climate-related tort claim for damages.[379] The *Warren* court and other U.S. courts have also endorsed this approach in nuisance and other cases involving diffuse environmental damages, which are closely analogous.[380]

The municipality plaintiffs in the new wave of U.S. climate litigation discussed in Section II.E seek joint and several liability rather than proportional liability,[381] which, given their all-or-nothing approach, could prove fatal to their claims. However, their briefing on causation thus far has relied on U.S. cases recognizing proportional liability in nuisance and related claims.[382] Therefore, there is a chance that, if the courts allow the claims to proceed, the plaintiffs may argue that they are at least entitled to proportional liability if the courts do not grant joint and several liability.

Courts in England also have not examined this approach, either expressly or implicitly, but cases such as *Holtby* demonstrate a willingness to apply several liability in claims involving multiple tortfeasors who each make a small contribution to a claimant's harm. And lastly, French and Dutch courts seem the least likely to apply proportional liability as a general matter in cases with multiple tortfeasors, but in dicta statements in recent climate-related cases suggest they may be open to applying the NESS test and proportional liability in the future. It seems that the like-

374. *See supra* Section III.C.1 (discussing Third Restatement, Liability for Physical and Emotional Harm, *supra* note 62, §27 illus. 4, §36 illus. 2).
375. Third Restatement, Liability for Physical and Emotional Harm, *supra* note 62, §27 illus. 4.
376. *Id.* §26 illus. 2.
377. *Id.* §27 illus. 4.
378. PETL, *supra* note 61, art. 3:105 & cmt. ¶ 2.
379. *See supra* Section II.E.
380. *See id.*
381. *See, e.g.*, City of Oakland v. BP P.L.C., No. RG17875889, ¶ 98 (Cal. Super. Ct. Alameda County filed Sept. 19, 2017) ("Defendants are jointly and severally liable to the People for committing a public nuisance."); Mayor & City Council of Balt. v. BP P.L.C., No. 24-C-18-004219, ¶ 235 (Cir. Ct. Balt. City filed July 20, 2018).
382. *See, e.g.*, Brief for Plaintiff in Opposition to Defendants' Motion to Dismiss at 19, City of Oakland v. BP P.L.C., No. 3:17-cv-06011-WHA (N.D. Cal. filed May 3, 2018) (citing, inter alia, Boim v. Holy Land Found. for Relief & Dev., 546 F.2d 685, 696-97 (7th Cir. 2008)).

lihood of the NESS test and proportional liability being adopted in each country exists on a spectrum—courts in Germany and the United States may be the most willing to apply this approach to climate-related tort claims for damages, while decisions from the U.K. suggest a perhaps greater likelihood of application than those from France and the Netherlands.

IV. Conclusion

There is no credible doubt that anthropogenic GHG emissions contribute significantly to climate change, which in turn has increased the severity and likelihood of slow-onset and extreme weather events. While it is therefore possible to establish necessary causation concerning the connection between total anthropogenic GHGs in the atmosphere and a general increase in damages resulting from these slow-onset and extreme weather events, courts have yet to recognize a legally relevant causal link between a specific entity's GHG emissions and a specific climate change-related injury.

The three fields of attribution science—event attribution, impact attribution, and source attribution—have progressed to the point where this link can be established with increasing confidence, and perhaps with sufficient certainty to meet standards of proof in both common-law and civil-law systems. However, as these links become clearer, it also becomes apparent that no single global carbon major could ever be considered the but-for cause or conditio sine qua non of any claimant's total climate-related injury. This greater causal certainty also means that courts will be less inclined to apply a relaxed causation standard to allow a claimant to recover damages in these cases.

The NESS test, when coupled with proportional liability, could provide an alternative theory of causation for claimants seeking climate-related damages in tort, one that appears to not be invoked in climate litigation to date or discussed much in the scholarly literature on climate-related torts. Advances in attribution science allow a claimant to define, with increasing certainty, the specific contribution of any one defendant's GHG emissions to a climate-related injury. Thus, the science allows a plaintiff to specifically show how these GHG emissions fit within the overall set of multiple contributing conditions that, when considered together, cause a climate change-related injury.

Accordingly, the NESS test and proportional liability provide a useful framework through which claimants can apply attribution science to recover climate-related damages from a global carbon major, in proportion to that entity's historical GHG emissions. It remains unclear, however, whether and to what extent this framework would be accepted in those U.S. and European courts that would likely hear such claims. The theory seems consistent with well-established nuisance law in the United States, and at least the German court in the *Lliuya* case may agree. Its application is less certain in England, and even less so in France and the Netherlands. The theory is yet to be tested to completion in any court; thus, it remains to be seen whether such cases will suffer a fate like all other climate change-related claims for damages to date, or if they will succeed and unlock a new viable theory of recovery in climate change litigation.