ARTICLES

Cloud Seeding, Wildfire Smoke Emissions, and Solar Geoengineering: Why Is Climate Modification Unregulated?

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ABSTRACT

This Article is the first to identify that companies and agencies systemically modify climatic airspaces through wildfire smoke emissions, weather modification (cloud seeding to cause rain), and solar geoengineering. Climate modification is not a conspiracy theory or a hypothetical: it is happening, and it is changing weather patterns. Yet, climate modification is almost wholly unregulated. Further, it is also not recorded or tracked in systemic ways. That is to say, even government agencies do not have comprehensive records of whether; how often; or how much climate modification is occurring. The data is simply not gathered, aggregated, or stored. As a result, major indicators that rely on climatic conditions—including the Environmental Protection Agency climate accounting—systemically overlook the effects of human-caused climate manipulation when accounting for changes in weather and air quality over time.

This lack of regulation is a serious problem: climate accounting fails to measure virtually unregulated activities undertaken by a mix of public and private actors. Without accurately accounting for these activities, scientists and agencies may be understating the effect of climate change on historical factors, including CO_2 emissions levels and rainfall. Such misinformation may lead to dramatic misstatements about the severity of the climate emergency. Inaccuracies in climate accounting

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** Monika U. Ehrman is Professor at SMU Dedman School of Law and Professor of Engineering (by courtesy) in the Department of Civil & Environmental Engineering, at SMU Lyle School of Engineering. In addition to those thanked above, she is grateful to the SMU Underwood Law Library and the Law Library of the University of North Texas at Dallas College of Law for their research assistance.

stemming from the lack of data about climate modification also blind policymakers to opportunities to slow or reverse anthropocentric climate change through measuring, accounting for, and regulating human manipulation of airspace.

How is it possible that the leading federal agency accounting for climate change is failing to account for changes to airspace? Law as a whole systemically overlooks and underregulates human manipulation of "invisible" natural resources which are diffuse; invisible to the naked eye (and thus difficult to detect); lacking commercial value; and seemingly outside centralized human control.[1] *From pollution to fish populations, underground water sources to oil and gas flares, even the agencies tasked with regulating invisible resources find it nearly impossible to detect, measure, and account for human inputs into natural systems.*

These examples illustrate a broader theoretical point: climate and environmental policy analysis and solutions are hamstrung by the limitations inherent in modern Western conceptions of property. This Article demonstrates how an emerging model of multidimensional property—derived from interdisciplinary discussions of overlapping property rights, mismatched property rights, and landscape-level resources—can improve the framing of climate change and other ecological problems, and thus improve the available outcomes.

This Article makes at least three contributions to environmental law, natural resources law, and property law literatures. First, it identifies the crucial problem of climate manipulation, which is currently unregulated and not included in climate accounting. Second, it develops a theory of invisible resources which are difficult to measure, detect, and regulate but nevertheless affect the human environment in vitally important ways. Finally, it demonstrates how a new model of multidimensional property can extend concepts of property rights and regulation into invisible airspaces, making currently unregulated climate mitigation the subject of oversight and regulation.

The real-world importance of addressing this crucial oversight cannot be overstated: Agencies must use all tools at their disposal to understand and address the climate emergency.

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INTRODUCTION

Pollution is an ancient problem with little modern resolution. Hippocrates wrote of outdoor air pollution in Greece, complaining that inhabitants "are likely to have deep, hoarse voices, because of the atmosphere, because it is usually impure and unhealthy in such places."[2] Over 2,400 years later, pollution continues to be vexing, particularly so in this time of climate crisis.[3] Historically, environmental law regulated pollutants to protect human health.[4] But now, the proliferation of atmospheric and hydrologic particulate matter shifts some priority away from human health impacts due to traditional pollution sources, to the direct and indirect effects related to release of those particulates in the context of anthropocentric climate change.[5] This Article argues that policies and solutions are constrained by an incomplete framing of pollution vis-à-vis property theory, through which law continues to divide interconnected systems in ways that defy scientific understanding. By shedding light on this theoretical issue, we highlight the importance of underexplored governance tools, including localized stakeholder collaborations.

This Article begins with a description of two important, unregulated pollutants with profound effects on human health and climate change: wildfire smoke emissions and weather modification. Regarding wildfire smoke emissions, government agencies establish wildfire policies without considering the known levels of CO_2 in smoke, creating tremendous amounts of unregulated greenhouse gas emissions, which are known to directly affect the rate of anthropocentric climate change. In weather modification, public and private entities (including for-profit companies) are allowed to release chemicals into the air to produce more rain and snow with neither regulation nor centralized recordation of how they are affecting the weather. In both instances, land management agencies, companies, and private individuals are playing fast and loose with America's health and understanding of climate

2. David Fowler et al., *A Chronology of Global Air Quality*, 2183 PHIL. TRANSACTIONS: MATHEMATICAL, PHYSICAL & ENG'G SCI. 378, 5 (2020).

3. *See generally*, E. Donald Elliott & Daniel C. Esty, *The End Environmental Externalities Manifesto: A Rights-Based Foundation for Environmental Law*, 29 NYU ENV'T L.J. 505 (2021); E. DONALD ELLIOTT & DANIEL C. ESTY, *Chapter 11, -OPA90: Why Economic Incentives Only Work Sometimes*, *in* ADVANCED INTRODUCTION TO U.S. ENVIRONMENTAL LAW (London: Elgar, 2021).

4. *Id.*

5. *See* CAL. AIR RES. BD., *Inhalable Particulate Matter and Health (PM2.5 and PM10)*, https://perma.cc/FET6-5DNF (last visited Apr. 16, 2023).

change. Embracing a tech-informed, Wild West ethos of "get ahead of the regulation," unregulated actors are intentionally exposing millions of Americans to air pollutants, rendering meaningless attempts to determine human health effects or climate change effects. As the accounting truism notes, you cannot manage what you do not measure. A near-total lack of emissions accounting and regulatory oversight in these areas allows agencies and private parties to unilaterally make decisions that should be subject to democratic accountability.

This governance gap creates a troubling baseline problem. Several US Environmental Protection Agency (EPA) indicators tracking trends in natural conditions (including droughts and wildfire) do not account for 50 years of prior chemical releases and landscape management policies. Without understanding what human modifications were undertaken—and how they affected key climate markers like precipitation levels and wildfire density, intensity, and size—EPA indicators may inaccurately reflect climate trends over time. Our criticism does not challenge or dismiss climate science; on the contrary, we think that unregulated pollutant use has propped up climatic changes that are far more severe than existing data might suggest. Hidden action by public and private parties has likely long obscured the degree to which the climate has already changed.

We trace this reporting and regulatory problem to its theoretical origins in antiquated property laws. There exists an arbitrary divide between natural resources, property, and environmental law, creating theoretical silos that produce problematic real-world problems.[6] Siloed disciplines divorce the externalities of beneficial land uses from their harms, creating a legal construct that does not represent physical (natural) reality. This theoretical detachment from the physical reality of ecosystems obscures the suite of available solutions to environmental issues, leading to hyperregulation of some pollutants and land management activities and a regulatory void around other (more pressing) contributors to climate-changing activities. Governance gaps exist, with concentrated federal regulation in some areas and little in others. Fortunately, emerging understandings of interchangeable tools to rearrange land and resource rights can address how better to match institutional arrangements to the scientific, economic, and social realities of pollution and climate change. Related governance tools—such as stakeholder collaborations operating in tandem with federal laws—have emerged to fill in the gaps.

This Article discusses how an emerging model of multidimensional property[7]—derived from the work of Karen Bradshaw and Dean Lueck[8] and

6. Monika U. Ehrman, *Application of Natural Resources Property Theory to Hidden Resources*, 14 INT'L J. COMMONS 627 (2020).

7. Karen Bradshaw, Billy Christmas & Dean Lueck, *An Introduction to "Overlapping Resources and Mismatched Property Rights"*, 14 INT'L J. COMMONS 553 (2020).

8. The theory developed by Bradshaw and Lueck was originally presented in a 2015 Iowa Law Review Article. Karen Bradshaw & Dean Lueck, *Contracting for Control of Landscape-Level Resources*, 100 IOWA L. REV. 2507 (2015). The model developed by Bradshaw and Lueck was later the subject of a two-day workshop hosted by New York University Law School and The Ostrom Workshop on Natural Resources at Indiana University.

other emerging interdisciplinary discussions of overlapping property rights,[9] mismatched property rights,[10] and landscape-level resources[11]—can improve the framing of the problem of pollution and thus the available outcomes. Similarly, we extend the idea of hidden resources, introduced by Monika Ehrman in other recent work,[12] to the issue of climate-based pollution to illustrate a hyper focus on landscape management and neglected understanding of human management of airscapes, watersheds, and firescapes.[13] From these observations flow new ways to assess pollution. Specifically, we argue that focusing on the human health effects of pollution without considering its effects on the environment creates intractable problems. This argument is particularly true in the wildfire context, where massive smoke emissions are obliterating climate goals in often-unaccounted-for ways in the name of the environmental benefit of restoring fire to the natural landscape.[14] Thus a multidimensional model of property provides a better understanding of the trade-offs in human influence over air, water, wind, and land.[15]

What to do? We suggest that an overreliance on federal statutory law and the concurrent underreporting of natural and anthropogenic climate modification belies the polycentric model of governance necessary for resource-based issues.[16] This theoretical analysis leads us to suggest bolstering pollution (and therefore climate) governance through increased recognition that natural resources management requires bespoke treatment,[17] along with scholarly recognition of the use of stakeholder groups as a conflict resolution mechanism to balance the many competing interests for natural resource property and reach socially acceptable outcomes in ways that courts, which are limited to picking winners and losers, cannot.[18] Stakeholder collaborations serve to fill governance gaps in current

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9. Richard A. Epstein, *Property Rights: Long and Skinny,* 14 INT'L J. COMMONS 567 (2020); Tara Kathleen Righetti, *Liberating Split Estates*, 14 INT'L J. COMMONS 638 (2020).

10. Tracy Yandle, *Understanding the Consequences of Property Rights Mismatches: A Case Study of New Zealand's Marine Resources*, 12 ECOLOGY AND SOC'Y 27 (2007), https://perma.cc/B85P-XX22; Karen Bradshaw & Bryan Leonard, *Virtual Parceling*, 14 INT'L J. COMMONS 597 (2020); Nick Cowen & Charles Delmotte, *Ostrom, Floods and Mismatched Property Rights*, 14 INT'L J. COMMONS 583 (2020).

11. Robin Kundis Craig & J. B. Ruhl, *Adaptive Management for Ecosystem Services Across the Wildland-Urban Interface*, 14 INT'L J. COMMONS 611 (2020).

12. Ehrman, *supra* note 6.

13. Monika U. Ehrman, *Natural Resource Systems and the Evolution of Environmental Law and Agency*, 40 PACE ENV'T. L. REV. 495 (2023); E. Donald Elliott & Daniel C. Esty, *The End Environmental Externalities Manifesto: A Rights-Based Foundation for Environmental Law*, 29 N.Y.U. ENV'T. L.J. 505 (2021).

14. William Boyd, *Climate Liability for Wildfire Emissions from Federal Forests*, 48 ECOLOGY L.Q. 101 (2022).

15. Carol M. Rose, *Thinking about the Commons*, 14(1) INT'L J. COMMONS 557 (2020).

16. *See infra* Part III.

17. Evolving Concept of Peacebuilding: Natural Resource Management and Conflict Prevention (Fuwa Yoshitaro et al., eds., 2001).

18. Karen Bradshaw, *Stakeholder Collaboration as an Alternative to Cost-Benefit Analysis*, 2019 B.Y.U. L. REV. 665 (2020).

environmental policy within the United States,[19] creating a legal framework that more neatly matches the regulated issues.[20]

I. CLIMATE CHANGE INDICATORS

The EPA's reliance on climate change indicators is somewhat problematic, as the indicators do not account for the associated legal and regulatory effects. Climate change indicators are repeated scientific observances of natural conditions.[21] The EPA uses climate change indicators to track changes to climate over time;[22] and it justifies the use of indicators to communicate "climate science information in a sound, transparent, and easy-to-understand way."[23] The indicators track seemingly neutral metrics and show changes over time, which are attributed to climate change.[24]

Just as humans have long managed the landscape,[25] so too have we managed the climate.[26] Studies demonstrate humans intentionally and successfully "were changing and impacting their environments as far back as 10,000 years ago."[27] These anthropogenic effects of modifying seemingly natural phenomena are largely unnoticed, unregulated,[28] and thus unconsidered by climate accounting.[29] This lack of regulation and accounting renders climate trends unreliable.[30] In essence, the problem with using these indicators is that they do not account for human influence on these measures over time.

Critically, this paper is not one of climate skepticism. As stated above, our questions surrounding the veracity of indicators do not challenge climate change. On the contrary, it is impossible to know in which direction the missing data cuts. But human action to control the physical environment may have obscured for decades the extent to which the climate would have otherwise already have changed. Accurately accounting for presently uncounted policy inputs may show that the climate has changed far more than we presently realize.

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19. Karen Bradshaw, *Agency Engagement with Stakeholder Collaborations, in Wildfire Policy and Beyond*, 51 ARIZ. ST. L.J. 437, 481–82 (2019).

20. Challie Facemire & Karen Bradshaw, *Biodiversity Loss, Viewed Through the Lens of Mismatched Property Rights*, 14(1) INT'L J. COMMONS 650, 659 (2020).

21. *View the Indicators*, U.S. ENV'T PROT. AGENCY: CLIMATE CHANGE INDICATORS, (last visited Apr. 16, 2023) https://perma.cc/A3LS-STW5 [hereinafter *EPA*].

22. *USGCRP Indicator Platform*, U.S. GLOB. CHANGE RSCH. PROGRAM, (last visited Apr. 16, 2023) https://perma.cc/W2VD-WHHZ.

23. *Frequent Questions*, U.S. ENV'T PROT. AGENCY: CLIMATE CHANGE INDICATORS, (last modified Jan. 25, 2023) https://perma.cc/Q424-2KB7.

24. *EPA*, *supra* note 21.

25. *See* Lucas Stephens et al., Research Article, *Archaeological assessment reveals Earth's early transformation through land use*, 365 SCIENCE 897 (2019).

26. *Ancient civilizations were already messing up the planet*, FIELD MUSEUM (last visited Apr. 16, 2023), https://perma.cc/K39F-QPXS.

27. *Id.*

28. *See, e.g.,* Arindom Ghosh, *Report Finds Wildfires Are Hindering California's Climate Commitments To Cut GHG Emissions*, CONSERVE ENERGY FUTURE, https://perma.cc/SDX6-V9Z5 (last visited Apr. 21, 2023).

29. Bob Berwyn, *How Wildfires Can Affect Climate Change (and Vice Versa)*, INSIDE CLIMATE NEWS (Aug. 23, 2018), https://perma.cc/R4VS-3JPP.

30. *Id.*; Ghosh, *supra* note 28.

A. WEATHER MODIFICATION

The EPA uses weather and climate indicators that measure rainfall, snowfall, and the timing of precipitation. The EPA indicator for U.S. and global precipitation patterns are based on measurements, beginning in 1901, from land-based weather stations.[31] Importantly, these measurements do not account for human-caused weather modification, such as cloud seeding.[32]

Cloud seeding is a form of artificial weather modification currently used to increase precipitation from certain cloud systems for drought mitigation, agricultural, and recreational (e.g., increasing snowpack for ski hills) purposes.[33] It involves the release of silver iodide or dry ice from airplanes and weather towers into clouds to cause rainfall and snowfall.[34] Scientists developed cloud seeding technology in the 1950s.[35] Originally used in America's conflicts with Vietnam and Laos as a form of meteorological warfare,[36] it later became the subject of a UN Charter, which restricted weather modification for peaceful purposes.[37] Although the theory of generating precipitation by seeding clouds was generally accepted,[38] data supporting any successful efforts was rare, and is only recently forthcoming.[39]

Cloud seeding occurs when seeding material in aerosolized form is released into certain cloud systems.[40] In the United States, cloud seeding is governed by a single federal law,[41] which allows both public and private entities and individuals to engage in this unregulated practice after first registering with the National Oceanic and Atmospheric Administration (NOAA).[42] Although registration does not involve oversight of cloud seeding,[43] it affords NOAA the opportunity to monitor records maintained by registrants.[44]

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31. *Climate Change Indicators: U.S. and Global Precipitation*, U.S. ENVIRONMENTAL PROTECTION AGENCY, https://perma.cc/74FS-DAB2 (last updated July 17, 2022).

32. Manon Simon, *Enhancing the Weather: Governance of Weather Modification Activities of the United States*, 46 WILLIAM & MARY ENV'T. L. & POL'Y REV. 149 (2021), https://perma.cc/2APK-T7VG.

33. Cloud seeding may also be used as a form of geoengineering for climate change mitigation, whereby precipitation decreases associated rising temperatures and drought.

34. William R. Cotton & Roger A. Pielke, Sr, *The rise of the science of weather modification by cloud seeding*, *in* HUMAN IMPACTS ON WEATHER AND CLIMATE (2d ed.) (Cambridge Univ. Press, 2007).

35. National Science Foundation, *Special Commission on Weather Modification, Weather and Climate Modification*, NATIONAL SCIENCE FOUNDATION (1965), https://perma.cc/67SS-7C6T.

36. Seymour M. Hersh, *Rainmaking Is Used As Weapon by U.S.*, N.Y. TIMES (July 3, 1972).

37. Convention On The Prohibition Of Military Or Any Other Hostile Use Of Environmental Modification Techniques art. II, Dec. 10, 1976, 1108 U.N.T.S. 151.

38. NATIONAL SCIENCE FOUNDATION, *supra* note 35.

39. CBC Radio, *We've been cloud seeding for decades, but now we finally know it works*, CBC RADIO (Feb. 28, 2020), https://perma.cc/GJ24-5759.

40. Cotton & Pielke, *supra* note 34.

41. 15 U.S.C. § 330 (1971).

42. *See* Melissa Currier, *Rain, Rain, Don't Go Away: Cloud Seeding Governance in the United States and a Proposal for Federal Regulation*, 48 UNIV. PAC. L. REV. 949 (2017).

43. Adriana Vélez-León, *Rain on Demand: Regulating, Weather Modification Throughout the United States*, 8 GEO. WASH. J. ENERGY & ENV'T. LAW 148 (2017).

44. *Id.*

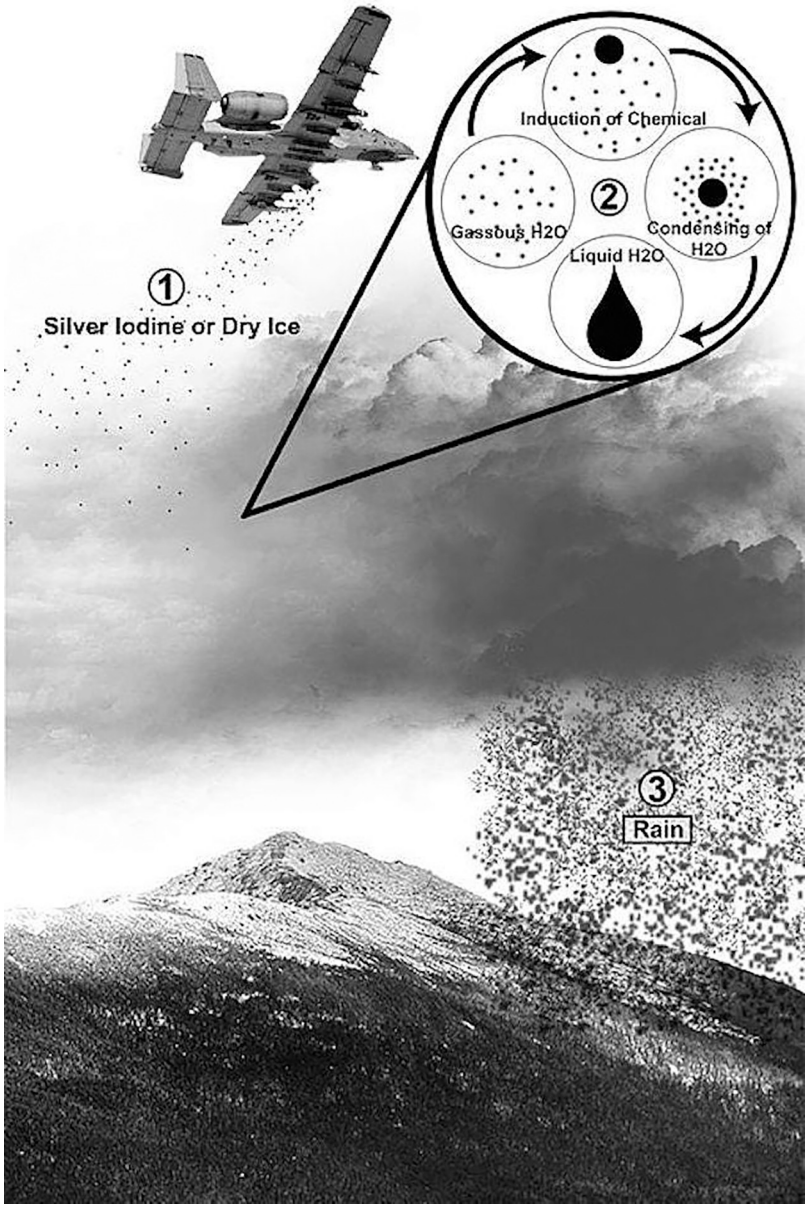

FIGURE 1: Cloud seeding aerial process[45]

45. Spencer McNab, *Cloud Seeding Processes from Plane Seeding*, image, Wikipedia CC 3.0, 2011, https://perma.cc/DY23-MRDS.

The absence of regulatory oversight has not impeded cloud seeding activity.[46] Since the 1970s, states, public utilities, and companies have used cloud seeding to increase snowpack and spring and summer runoff for municipal and agricultural water supplies.[47] For example, in a Division of Water Resources report, Utah noted it had engaged in cloud seeing since 1973,[48] which increased runoff by 59.2 billion gallons. It was estimated that cloud seeding created an average 3–21% increase in precipitation.[49] Although weather modification occurs, there is no centralized record of modification information,[50] including who is doing it and the effects of modification on precipitation.[51] Scattershot pieces of information provide some insights;[52] but incorporating such data may be impossible because it does not appear to exist.[53]

In addition to muddying EPA climate indicators, the use of cloud seeding may have yet-to-be-determined detrimental impacts on environmental and human health.[54] Those who seed with silver iodide claim the silver levels in resulting precipitation remain below EPA secondary maximum containment levels,[55] but there is simply not enough research to conclude silver iodide's use has no or little harmful effects. And as with any incineration or combustion process, amounts of carbon dioxide or other non-combusted products may result.[56] Though these amounts may be de minimis (really, they are unknown), an increase in cloud seeding activity over decades may produce cumulative harmful impacts on environmental wellbeing.[57] The absence of regulatory oversight also means there is a

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46. Susette Horspool, *The Growing Industry of Cloud Seeding*, OWLCATION (July 25, 2022, 4:14 PM), https://perma.cc/V9E4-MWHC.

47. Simon, *supra* note 32.

48. Norman E. Stauffer, Jr., *Cloud Seeding—The Utah Experience,* 33 J. WEATHER MODIFICATION 63 (2001).

49. Don A. Griffith, Mark E. Solak & David P. Yorty, *30+ Winter Seasons of Operational Cloud Seeding in Utah*, 41 J. WEATHER MODIFICATION 23, 32 (2009).

50. Simon, *supra* note 32.

51. We advance a novel observation that the nexus of weather modification and the advent of the relatively new, $10 billion crop insurance industry merits suspicion and further studies. Although this book chapter provides only a preliminary treatment of the topic, we see nothing in the laws regarding weather modification that would preclude insurers from either directly engaging in cloud seeding to cause rain or being alerted in advance of cloud seeding by third parties. Given that crop insurance policy payouts are related to precipitation levels, there appears to be an open question as to whether insurance companies could—or are—using weather modification to manage payouts.

52. *See, e.g.,* Griffith, *supra* note 49 at 35.

53. An attempt to gain this information from the National Oceanic and Atmospheric Administration through a Freedom of Information Act request produced no response.

54. A. Farahat & A. Abuelgasim, *Effect of Cloud Seeding on Aerosol Properties and Particulate Matter Variability in the United Arab Emirates*, 19 INT'L J. ENV'T. SCI. TECH. 951, 951 (2022).

55. Nathan LaCross, *Concerns Regarding Silver Iodide Cloud Seeding*, UTAH DEP'T OF HEALTH (last visited Apr. 11, 2023), https://perma.cc/MCJ4-9H9M.

56. *See generally* Joanne Simpson, et al., *An Airborne Pyrotechnic Cloud Seeding System and Its Use,* 9 J. APPLIED METEOROLOGY 109, 111–12 (1970).

57. *See* James Rodger Fleming, *The Pathological History of Weather and Climate Modification: Three Cycles of Promise and Hype*, 37 HIST. STUD. PHYSICAL & BIOLOGICAL SCIS. 3, 24 (2006) (arguing "we are in danger of entering a new cycle of discourse saturated with hype, the heirs of an impoverished debate" as to "strategies of weather and climate control").

lack of any routine individual project or programmatic environmental assessments, as required under the National Environmental Policy Act (NEPA).[58] Although private and other nonfederal actors may conduct the weather modification activity, applications are submitted to NOAA.[59]

Meanwhile, the technical reports of the EPA indicators and the underlying scientific papers contain no mention of the effects of weather modification on indicators, including snowpack and drought.[60] For example, one technical report notes that variability can include "observation methods, land use, and forest canopy" but do not contemplate human-caused sources.[61] To put it simply, if we have been making rain, it is unsurprising that it is raining more. Counting precipitation levels without accounting for human-created weather modification seemingly creates a faulty comparison of precipitation levels over time. As a result, efforts to attribute changes in precipitation levels to climate change without considering the effects of intentional weather modification paint an inaccurate picture of anthropocentric climate change.

B. WILDFIRE

The EPA also considers wildfire as a climate change indicator.[62] "This indicator tracks wildfire frequency, total burned acreage, burn severity, and the seasonality of wildfire activity in the United States from 1983 to 2021."[63]

Wildfire suppression policy has changed dramatically in the period underlying the indicator.[64] For many decades, federal government firefighting policies followed the "10 am rule," which required firefighters extinguish each fire prior to 10 am the following morning.[65] This total suppression policy focused on putting out fires completely and quickly.[66] As a result, wildfire sizes remained small; they were extinguished quickly; and they burned relatively little area.[67] During the latter part of the twentieth century, fire ecologists began questioning the wisdom of suppression.[68] A narrative of using fire to restore the natural landscape emerged.[69] Critiques of suppression claimed that this policy increased fuel load,

58. Simon, *supra* note 32.
59. *Id.*
60. U.S. EPA, VOL. 7, TECHNICAL DOCUMENTATION: SNOWPACK (2021).
61. EPA, *supra* note 21.
62. EPA, *supra* note 21.
63. U.S. EPA, TECHNICAL DOCUMENTATION: WILDFIRES 1 (2021).
64. *See* Dean Lueck, *Economics and the Organization of Wildfire Suppression*, *in* WILDFIRE POLICY: LAW & ECONOMICS PERSPECTIVES 71, 81 (2012).
65. *Id.*
66. *Id.*
67. *See id.*
68. *See* Jason S. Johnston & Jonathan Klick, *Fire Suppression Policy, Weather, and Western Wildland Fire Trends: An Empirical Analysis*, *in* WILDFIRE POLICY: LAW & ECONOMICS PERSPECTIVES 158, 163 ("Thus the period 1970–2000 was a time of major change in federal wildland fire policy, with the beginning of this period corresponding almost perfectly to the onset of a move to allow at least some natural fires to burn.").
69. *See id.*

resulting in hotter, more intense, more damaging fires.[70] Over time, agencies formally changed wildfire policy, shifting from total suppression to "let burn" policies.[71] These policies are essentially the opposite of the "10 am rule," allowing fires to grow and burn without suppression attempts.[72] Unsurprisingly, letting a fire burn unimpeded results in larger, longer, and more intense fires.[73]

Fire suppression policy underwent a dramatic about-face from the 1980s to the present.[74] Yet, continuing to use the fire indicator without accounting for this policy shift results in a potential false attribution.[75] Simultaneously, land management policies on federal public lands also significantly shifted during this time.[76] Timber harvest dramatically fell on public lands, while pest infestations created diseased trees more susceptible to wildfire.[77] This shift was not accounted for in wildfire policy and thus remains absent from existing climate science.[78]

Because we do not account for these meaningful policy changes, we cannot accurately gauge whether and how much climate change has increased fire risk. The EPA indicator technical documentation notes that wildfires can be influenced by factors other than climate, "particularly changes in fire suppression and fire management practices. . . [and] resources available to fight and manage wildfires. . . ."[79] The report notes, "further analysis is needed before an apparent change in wildfire activity can necessarily be attributed to climate change."[80] So, although countless examples of political statements and media reports attribute the intensity, duration, destructiveness of wildfire to climate change, these accounts crucially overlook policy changes to public land management and fire suppression policies.

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70. *See* Jonathan Yoder, *Fuel for the Fire: Liability and the Economics of Wildfire Risk*, *in* WILDFIRE POLICY: LAW & ECONOMICS PERSPECTIVES 50, 64 (2012).

71. *See* Karen M. Bradshaw, *A Modern Overview of Wildfire Law,* 21 FORDHAM ENV'T L. REV. 445, 453 (2010).

72. *See* Lueck, *supra* note 65, at 76.

73. *See, e.g.*, Sarah E. Anderson & Terry L. Anderson, *The Political Economy of Wildfire Management: Saving Forests, Saving Houses, or Burning Money*, *in* WILDFIRE POLICY: LAW & ECONOMICS PERSPECTIVES 110, 110 (2012) (discussing how "let burn" policies played a part in the "massive fires in Yellowstone National Park that burned over 1 million acres").

74. *See* Johnston & Klick, *supra* note 69.

75. Karen M. Bradshaw, *A Modern Overview of Wildfire Law,* 21 FORDHAM ENV'T L. REV. 445, 452–56, 458–59 (2010).

76. *See* Karen M. Bradshaw, *Norms of Fire Suppression Among Public and Private Landowners*, *in* Wildfire Policy: Law and Economic Perspectives 89, 95–97 (2012).

77. *Id.* at 96–97.

78. *See, e.g.*, *Technical Documentation: Wildfires,* U.S. ENV'T PROT. AGENCY: CLIMATE CHANGE INDICATORS, at 11–12 (last updated July 2022) https://perma.cc/G56U-XGVB (not accounting for pest infestation effects under the "Data Limitations" section).

79. *Id.* at 12.

80. *Id.*

Worsened wildfires have multidimensional effects on issues of environmental justice,[81] greenhouse gas emissions,[82] and human health effects[83] from smoke emissions. For example, in 2018, California wildfire smoke emissions grew so large that it was "on par with the annual emissions produced by generating enough electricity to power the entire state for a year."[84] Against the pressing considerations of climate change effects like sea level rise affecting low-lying island nations and coastal populations,[85] comprehensive policy analysis should weigh the beneficial effects of restoring wildfire to the natural landscape against the harms the US creates for other countries through unremedied smoke emissions.[86] There exist many open, unanswered scientific questions that should inform these policy considerations. But without climate science that accounts for climate change indicator policy changes, much is left on the table.

The remainder of this Article overviews how a new approach to land management and pollution can inform legal and regulatory analysis. Adopting integrated pieces of the larger, interconnected system might produce new solutions to understanding and addressing pressing climate change issues.

II. SILOED APPROACHES IN INTERCONNECTED SYSTEMS

The foundational elements of earth, fire, air, and water constantly change as part of a dynamic and interconnected system.[87] The old, siloed manner of approaching environmental problems in component parts overlooks the fundamental, inescapable interconnectedness of natural systems. Any change to one affects the others. But law and policy generally contemplate human interference with these elements individually.[88] For example, the Clean Air Act considers air quality and the Clean Water Act governs water.[89] Although this individualistic governance appears logical and actionable, it is not sufficiently attuned to the

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81. Savannah M. D'Evelyn, et al., *Wildfire, Smoke Exposure, Human Health, and Environmental Justice Need to be Integrated into Forest Restoration and Management,* 9 CURR. ENV'T HEALTH REP. 366, 370 (2022).

82. THOMAS M. BONNICKSEN, GREENHOUSE GAS EMISSIONS FROM FOUR CALIFORNIA WILDFIRES: OPPORTUNITIES TO PREVENT AND REVERSE ENVIRONMENTAL AND CLIMATE IMPACTS 3 (2008).

83. D'Evelyn, *supra* note 82, at 371–72.

84. U.S. Dep't of Interior, *New Analysis Shows 2018 California Wildfires Emitted As Much Carbon Dioxide As an Entire Year's Worth of Electricity*, https://perma.cc/NMQ8-LUS8 (last visited Apr. 4, 2023).

85. *See, e.g.*, Rachael E. Salcido, *Using International Property Law as a Lever to Evolve Toward Integrative Ocean Governance*, 47 U. PAC. L. REV. 253 (2017).

86. *See generally* Kirsten Engel & Andrew Reeves, *When "Smoke Isn't Smoke": Missteps in Air Quality Regulation of Wildfire Smoke*, *in* WILDFIRE POLICY: LAW AND ECONOMIC PERSPECTIVES 127, 136–38 (2012) (proposing three options "for enhancing the use of prescribed fire and reducing the incidence of smoke from unplanned wildfires").

87. *See generally* Barbara Cosens et al., *Governing Complexity: Integrating Science, Governance, and Law to Manage Accelerating Change in the Globalized Commons*. 118 PROC. NAT'L ACAD. SCI. U.S. no. 36, 2021; FROUKJE MARIA PLATJOUW, ENVIRONMENTAL LAW AND THE ECOSYSTEM APPROACH (2018); Brian Chaffin et al., *Transformative Environmental Governance*, 41, Ann. Rev. Env't Res., 399 Nov. 1, 2016, at 3.

88. Ehrman, *supra* note 8.

89. *Id.*

genuine way in which complex natural systems operate.[90] These elements do not exist in neatly contained silos, but instead interact and influence one another in respects that scientists do not still understand and, most certainly, current environmental laws do not fully contemplate.[91] As research and technology improve and globalization increases, scientists increasingly are finding examples of teleconnection—where apparent anomalies are, in fact, related. But because of this current isolation, federal laws fail to reflect the consequences of changes to essential elements on the larger, interconnected systems.

Siloed thinking within environmental law hampers efforts to address observable issues.[92] One can readily observe that the elements have changed throughout our lifetime. Just as Garrett Hardin observed that water quality varied between his grandfather's lifetime and his own,[93] so too are many people observing that those places they intimately know are noticeably different than they once were—hotter, drier, stormier, more polluted, or worse. These observations of natural conditions are essentially human—we notice the local effect of human influence on earth, fire, air, and water, but are poor at recognizing the causes.[94] Siloed disciplines and their resultant homogenous knowledge may also prevent us from seeing solutions.[95] EPA's climate accounting suffers from the same causal oversights. Namely, it observes changes in natural conditions, but often fails to account for their human causes. Climate science divorced from regulatory and policy inputs may be failing to account for human effects on the climate.

We argue that the conceptualization of the discrete areas of natural resources, property, and environmental law creates arbitrary divisions that divorce the externalities of beneficial land uses from their harms. These divisions create artificial legal constructs that do not represent physical reality. This intentional theoretical detachment from physical (and observable) reality obscures the suite of available solutions to environmental issues and prevents the identification of additional problems. Fortunately, emerging understandings of interchangeable tools to rearrange land and resource rights can address how better to match institutional arrangements to the scientific, economic, and social realities of pollution and climate change.[96]

From these observations emerge new processes to assess pollution. Specifically, we argue that focusing on the human health effects of pollution without considering its other environmental effects (positive and negative) creates intractable problems.

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90. Bradshaw & Leonard, *supra* note 12.

91. *See generally* Cosens et al., *supra* note 89.

92. Norman Eisen et al., *Transforming Natural Resource Governance: Break Silos Sharpen Politics*, BROOKINGS INST. (Feb. 23, 2021) https://perma.cc/E2F6-85F9 (last visited Apr. 11, 2023).

93. Garrett Hardin, *The Tragedy of the Commons*, 162 SCI. 1243, 1245 (1968).

94. *See generally* NATIONAL RESEARCH COUNCIL, GLOBAL ENVIRONMENTAL CHANGE: UNDERSTANDING THE HUMAN DIMENSIONS (1992).

95. Jonathan Adler, IHS and Case Western Workshop comments (Oct. 16 & 24, 2021).

96. *See, e.g.,* Bradshaw & Leonard, *supra* note 12.

A. UNREGULATED POLLUTERS

We often talk about "landscape management"—the concept that humans actively manage the land by planting, fertilization, tilling, harvesting, etc.[97] In this context, property law generally envisions individual landowners managing their land as they please, within the confines set by law. We less often discuss "water management," "atmospheric management," or "firescape management." Yet, public and private parties directly control water, atmosphere, and fire, just as they manage lands. Given the surprising lack of regulation for non-land governance zones, individual humans can create profound effects that affect human health, property value, and environment of related systems. Through the release of chemicals into one system, we (in)directly affect one another. A homeowner using rat poison can decimate a food chain; chemicals in the water turn whales into toxic, polluting sources;[98] emissions from the combustion of gasoline in cars produce acid rain, falling over land and ocean.

Pollution is a complicated problem. In most cases, it is not the substance itself that is inherently hazardous to human health such that it must be regulated, but rather the amount of the substance.[99] Toxicology teaches that substances become injurious in small amounts but hazardous in others. One ice cream cone is not all that bad; five might make you sick; ten a day over a lifetime will contribute to many health conditions. Pollution is similar: a little pollution may be ok, but prolonged pollution exposure at a heightened rate creates detrimental effects on human health.[100]

Most pollutants that pose serious public health risks come from a variety of sources. Famously, methane emissions that contribute to climate change come not only from cars on the road and airplanes in the sky but also the belching of cattle.[101] Governing pollution, then, means sifting through emitting sources and deciding which among them may emit how much.[102] This picking of winners and losers is complex and localized, creating the cooperative federalism model of the Clean Air Act,[103] in which EPA sets the allowable limits of criterion pollutants and states are left with the task of determining who might pollute how much.[104] Alternative mechanisms of allocation include markets, such as carbon, which are

97. *See* Carlos Camacho et al., *Human-induced changes in landscape configuration influence individual movement routines: lessons from a versatile, highly mobile species*, 9 PLOS One, no. 11, 2014, at 1.

98. *See* Sarah Zielinski, *Whales Are Full of Toxic Chemicals*, SCI. NEWS (Jan. 19, 2016) https://perma.cc/6UKN-QR48 (last visited Apr. 11, 2023).

99. *See* E. Donald Elliott & Daniel C. Esty, *Environmental Law for the 21st Century*, 40 PACE ENV'T L. REV. 454, 472 (2023).

100. *Id.*

101. Amy Quinton, *Cows and Climate Change: Making Cattle more Sustainable*, UC DAVIS (June 27, 2019), https://perma.cc/NJ3R-MPBM.

102. *Id.*

103. 42 U.S.C. § 7401.

104. *Id.*

premised on the theory that the highest-value user will purchase credits from the lower-value user.[105]

One unspoken aspect of pollution regulation is unregulated emission sources.[106] Some actors are subject to considerable, costly regulation, while others escape wholly unregulated.[107] In this way, regulated polluters and affected populations bear the costs of unregulated polluters. Regulatory absence forces these groups to either reduce their pollution levels or increase health risks because the government fails to reduce levels of unregulated pollution.

B. POLLUTION'S CONNECTION TO LAND

When we think of pollution, we focus on air and water—not earth (land) or fire. Yet, many laws historically governing pollution derived from English property laws, which developed to manage land and resources.[108] The puzzle of why landlocked rules might cover pollutive air or water emissions may seem archaic; but in fact, regulated pollution largely derives as an externality of production. And production turns a location-based natural resource into a product with human utility. Because the natural resource is tied to the land, pollution therefore begins as a land-based problem.

To consider this long-obscured link, consider lamb fleece becoming wool;[109] cotton plant fibers becoming textiles; or timber becoming lumber. The industrial process of transforming raw agricultural products into usable goods produces pollutants. These pollutant chemicals occur in physical production, air emissions, and effluent.[110] Economic constraints govern how far the harvested good can travel prior to being processed, with transportation costs to centralized processing facilities (mills) being a limiting factor on the viability of production. In other words, the pollution emitted from processing natural objects into usable goods necessarily must take place within a predictable radius of the place from which the goods are grown and harvested.

Consider textiles: textiles may begin as cotton, which is grown on the land, processed, and turned into usable products.[111] Pollutants may begin with the

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105. *What is Carbon Pricing*, S&P GLOBAL (Feb. 25, 2020), https://perma.cc/QB4T-D7LJ.

106. *See, e.g.,* Neel Dhanesha, *The massive, unregulated source of plastic pollution you've probably never heard of*, VOX (May 6, 2022), https://perma.cc/K5RQ-5VWK.

107. Union Electric Co. v. Environmental Protection Agency, 427 U.S. 246 (1976), (Finding that state implementation plans under the Clean Air Act are not subject to findings of economic or technological feasibility requirements by the Environmental Protection Agency).

108. Ben Baack, *The development of exclusive property rights to land in England: An exploratory essay*, 22 ECONOMY & HISTORY 63 (1979).

109. Emma K. Doyle et al., *The science behind the wool industry. The importance and value of wool production from sheep*, 11 ANIMAL FRONTIERS: THE REVIEW MAGAZINE OF ANIMAL AGRICULTURE 15 (2021).

110. *See, e.g.*, Seoyoun Kim, Yoonkyung Cho, and Chung Hee Park, *Effect of Cotton Fabric Properties on Fiber Release and Marine Biodegradation*, 92 TEXTILE RESEARCH JOURNAL 2121 (2022).

111. Salma Katun Sela et al., *Improving the functionality of raw cotton: simultaneous strength increases and additional multi-functional properties*, 6 HELIYON (2020).

agricultural runoff of chemically treated fields; be contributed to by the trucks that carry the unprocessed cotton to the mill; seep into the air and water through the mill processing facility; and again occur through truck transportation.[112] This localizing effect of industrial pollution may appear to be a limiting principle upon its production. Why would a city allow pollution where its children play outside, subject to the known detrimental health effects of high concentrations of harmful emissions on human health?[113]

Moreover, the broader, systemic issues of economic and racial injustice result in historically marginalized communities shouldering a disproportionate pollution burden.[114] Environmental justice concerns abound.[115] Minority and low-income populations are disproportionately located near polluting facilities,[116] which is of heightened concern as new research indicates associations between pollution and health issues, including diabetes, asthma, and cancer.[117]

C. A THEORY OF LANDSCAPE-LEVEL GOVERNANCE

Referring to weather and fire as natural resources may seem peculiar, but they share the same geophysical governance challenges of other landscape-level resources, such as water basins, forests, wildlife habitats, and grazing ranges. Firesheds—landscape-scale areas that face a wildfire threat—operate at a regional scale—smaller than federal resources, larger than localized resources.[118] Fire does not follow jurisdictional boundaries; nor does it respect property boundaries. It encompasses a great deal of land comprised of a mix of underlying landowners: individuals, entities, states, tribes, and the federal government. Effective policy therefore requires cooperation.[119] Firesheds also contain highly variable geographies and resource mixes, such as homes, trees, wildfires, livestock, and

112. *See generally* Kathleen Delate et al., *Organic Cotton Production may Alleviate the Environmental Impacts of Intensive Conventional Cotton Production*, 36 RENEWABLE AGRICULTURE & FOOD SYSTEMS 405 (2021).

113. The choice of "children" here is not incidental. Children—because of their developing bodies and small size—are particularly vulnerable to human health effects from high level of exposure to certain pollutants. Childhood exposure to pollutions can lead to life-long health problems.

114. *See, e.g.,* Julia Jacobo, *Communities with Large Black, Asian and Hispanic or Latino Populations more likely To Be Exposed to Air Pollution, New Research Suggests*, ABC NEWS (Jan. 12, 2022), https://perma.cc/J2U9-LSDY.

115. *See* Sarah Krakoff, *Environmental Justice and the Possibilities for Environmental Law*, 49 ENV'T. LAW 229 (2019); Richard L. Revesz, *Air Pollution and Environmental Justice*, 49 ECOLOGY LAW QUARTERLY 187 (2022).

116. ROBERT V. PERCIVAL ET AL., ENVIRONMENTAL REGULATION: LAW, SCIENCE, AND POLICY 20 (8th ed. 2018) (citing UNITED CHURCH OF CHRIST, TOXIC WASTE AND RACE AT TWENTY: 1987–2007 (R. Bullard et al. eds., 2007)).

117. Ikenna C. Eze et al., *Association Between Ambient Air Pollution and Diabetes Mellitus in Europe and North America: Systematic Review and Meta-Analysis*, 123 ENV'T HEALTH PERSP. 381 (2015).

118. U.S. Forest Service, *Confronting the Wildfire Crisis, A Strategy for Protecting Communities and Improving Resilience in America's Forests* (Jan. 2022), https://perma.cc/L5UA-ES84.

119. *Id.*

watersheds.[120] Population density, resource access, and land values also vary widely. Laws designed to protect hillside homes in California differ from those that should manage grassfires in Texas or tundra fires in Alaska.

Natural resource governance is complicated because it must encompass multiple jurisdictions and property classifications—e.g., federal and local, public and private. For these reasons, we believe that Congress's historic hands-off approach to wildfire was correct. Congress tasked land management agencies with administering public lands and then left them alone to do so. Agencies subsequently created highly decentralized systems in which the career progression of employees was dependent upon satisfying supervisors and residents. This balance was complicated. Sometimes problems resulted in litigation; but mainly federal land management agencies handled problems at a local level.

During a fire, law consolidates firefighting authority into a single source—the government.[121] The emergency doctrine hands unilateral decision-making power to the government,[122] because efficient disaster response requires a single party making decisions to mitigate harm during the disaster, rather than compensating parties afterwards.[123]

Coordinating fire prevention efforts is far more difficult. In nonemergency situations, property rights generally trump environmental regulation.[124] Landowners possess diverse preferences for cutting trees, creating defensible space, and building homes in wildland-urban interface areas. In this regard, maximizing the value of an individual's property may conflict with sensible landscape-level management.[125]

Absent government condemnation of fire-prone private property, ex ante mitigation of wildfire risk requires landowners to voluntarily cooperate to create landscape-level risk management structures.[126] In most Western states, this cooperation involves public-private arrangements and may include multiple owners and managers because of historical land policies.[127] Thus land within the same fireshed can be managed by individual homeowners, states, tribes, and federal agencies.[128] Wildfire management is paradoxically both highly localized and necessarily federal—whether the fire burns on public or private land.

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120. *Id.*

121. *See* Karen M. Bradshaw, *Norms of Fire Suppression Among Public and Private Landowners*, *in* WILDFIRE POLICY: LAW AND ECONOMIC PERSPECTIVES 89, 90 (Dean Lueck & Karen M. Bradshaw eds., 2012) [hereinafter WILDFIRE POLICY] ("GFAs [government land management and fire agencies] retain absolute authority to fight wildfires; they unilaterally decide which methods to use, how to allocate resources among various fires burning simultaneously, and whether to pursue cost recovery for suppression efforts.").

122. Thomas Merrill, *Property and Fire*, *in* WILDFIRE POLICY, *supra* note 124.

123. *Id.*

124. WILDFIRE POLICY, *supra* note 124.

125. Craig & Ruhl, *supra* note 13.

126. WILDFIRE POLICY, *supra* note 124.

127. *Id.*

128. *Id.*

Wildfire mitigation and ex post restoration strategies are highly localized. Yet, federal land management agencies alone have the resources, expertise, and land management authorities to implement solutions. About 30% of the United States is composed of lands managed by federal agencies. Because the federal government is the largest landowner in the US, it follows that federal land management agencies are best positioned to influence mitigation policy. But the often administratively unwieldy size and overexpansive agenda of the federal government are not desirable characteristics of a land manager. For example, the White Mountain Apache Tribe has employed successful wildfire mitigation strategies. In 2011, the Wallow Fire burned about half a million acres, which is still Arizona's worst fire. Without the Tribe's forest management practices, which mimic the natural burn-and-growth cycle, the fire would have been much more severe.[129]

Reflecting on the stark contrast between tribal and federally managed lands, Jonathan Brooks, the Tribal Forest Manager for the White Mountain Apache Tribe, hinted as to why. "The forests for the White Mountain Apache Tribe, they're very important for livelihood, for economics, cultural aspects, recreation. There [are] so many benefits that the land and that the forests provide for the tribe, and it's very important for us to actively manage it to keep the forest healthy so that everything kind of maintains its balance," he said. Key to that success is the Tribe's being "unhindered by environmental litigation and drawn-out federal government processes," he added. [130]

Successful wildfire solutions, therefore, must be a hybrid governance strategy, both federal-local and public-private in nature.

D. STAKEHOLDER COLLABORATIONS

Stakeholder groups, which manage landscape-level resources, may provide a long-overlooked piece of the solution to pollution and managing non-land resources (such as watersheds and airsheds). Stakeholder collaborations allow iterative, responsive policymaking with flexibility unavailable through other means—a crucial tool in responding to ever-changing land and resource conditions.[131] The existence of groups that can tackle any number of problems within a defined geographic space helps reintegrate discrete, siloed topics (such as "air" and "water") by allowing a single governance body to flexibly, responsively address these resources in interconnected ways and systems—overcoming one of the major shortcomings of environmental law.

Interestingly, federal land management agencies have largely privileged local concerns since inception.[132] Long before Elinor Ostrom won a Nobel Prize for

129. Katie Tubb, *How Federalism Is Making a Difference on Western Lands*, THE HERITAGE FOUND. (Aug. 21, 2019), https://perma.cc/J2HX-HXHH.

130. *Id.*

131. Bradshaw, *supra* note 21, at 446.

132. Karen M. Bradshaw, *Norms of Fire Suppression Among Public and Private Landowners*, *in* WILDFIRE POLICY *supra* note 125, at 91–92 (describing the U.S. Forest Service training agencies to fit into local norms).

describing the benefits of resource users engaging in the governance of natural resources,[133] agencies like the Forest Service, Bureau of Land Management, and National Park Service were crafting innovative partnerships with stakeholders to retain the benefits of federal control governed with local knowledge.

Over the past several decades, a local-first view of federal land management became anathema to environmental activists. Through top-down federal policies, environmentalists were able to achieve tremendously valuable gains in vital issues like air and water pollution. Yet, federal laws centered on natural resources—such as the Endangered Species Act and National Environmental Policy Act—are not as obviously successful. Policymakers did then what they are dangerously poised to do now: They failed to understand that natural resources cannot be governed under a primarily top-down, federalist model. Any environmental problem that has a land-based component cannot be resolved through federal law alone, but instead requires polycentric governance. One-size-fits-all federal policies are problematic and prone to failure.

In the natural resource context, hierarchical federal law certainly achieved valuable outcomes from an environmental preservation perspective. But they also created a tremendous backlash among rural populations and landowners. Federalized policies can overlook important localized knowledge, such as traditional ecological knowledge of Indigenous groups.[134] "While many of the changes associated with increasing state and market integration have established more resilient infrastructures in some regions of the world, they have also frequently undermined traditional adaptations of rural populations to natural hazards."[135]

Win-win solutions are, in some ways, less satisfying because they require compromise, unlike win-loss outcomes. There is less to advertise to constituents and fewer clear-cut gains. Pragmatically, small wins may be the most realistic. Achieving these outcomes is entirely possible. Indeed, over a dozen federal land management agencies have over a thousand stakeholder groups managing public lands and natural resources. But, until now, this invaluable tool for capturing the benefits of federal public land and the need for localized resource governance has gone wholly unnoticed by legal scholars.[136] It exists in the interstices of

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133. *See* ELINOR OSTROM, GOVERNING THE COMMONS: THE EVOLUTION OF INSTITUTIONS FOR COLLECTIVE ACTION 2 (1st ed. 2009) ("Using an institutional mode of analysis, I then attempt to explain how communities of individuals fashion different ways of governing the commons.").

134. Laurence Du Sault, *The Karuk Tribe Fights a Growing Wildfire Threat and a Lack of Funding,* HIGH COUNTRY NEWS (Mar. 12, 2019), https://perma.cc/LK78-78GU (describing how western law and policy displaced Karuk cultural practices surrounding wildfire landscape management and created disastrous results).

135. Gregory Button & Anthony Oliver-Smith, *Disaster, Displacement, and Employment: Distortion of Labor Markets During Post-Katrina Reconstruction*, *in* CAPITALIZING ON CATASTROPHE, NEOLIBERAL STRATEGIES IN DISASTER RECONSTRUCTION (Nandini Gunewardena & Mark Schuller eds., 2008).

136. Certainly, scholars have widely recognized the use of public-private partnerships in other areas of Administrative Law. But such partnerships are generally cast as new. In the natural resources

administrative law and the study of natural resources, a seldom-explored area that is only recently emerging as a model of collaborative analysis that presents a more-inclusive alternative to cost benefit analysis.[137]

Weather modification and wildfire policy operate within blind spots within administrative and environmental law. Administrative law scholars tend to focus on the Environmental Protection Agency, disregarding the thirteen administrative agencies that govern public lands and natural resources (water, wildlife, forests, etc.). But EPA primarily focuses on pollution, largely from industrial emitters, with command-and-control regulation. Natural resource governance is different from pollution in a critical, fundamental way.[138] Scientific and sociological understandings suggest that land-based problems operate within ever-changing socio-ecological structures with complex biological interactions. They are subject to pressures absent in the governance of resources untethered from geographic space.

The foundational misunderstanding undergirding Western conceptions of property that the "land" should be treated separately from the ecological system. Unlike a first year Property class, the reality of true natural resources management disallows a discrete parceling of rights and sticks or neat severance of surface from the subsurface. All living and nonliving organisms interact within the physical environment. Modern agency practice and the above-mentioned academic study overlook this integrated dynamic. Additionally, there remains general ignorance to past deliberate resource management efforts by Indigenous populations and wildlife, which have interacted and managed natural resources for tens of thousands of years and through geologic time respectively.

E. NEGATIVE-VALUE RESOURCES

In introducing "negative-value property" to the property law lexicon, Bruce Huber described land with so much toxic material that the cost of remediating is more than the value of the underlying property.[139] In this section, we extend Huber's concept to natural resources, noting that there are many natural features (some of which are not even called resources) that run adjacent to the land and resources in physical space. Where we might talk about oil and gas reserves, airspace, and water as resources that run with the land, we are less likely to talk about pest areas, firesheds, predators, and fuel load.[140] But maximizing the

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contexts, they have been operating for hundreds of years because collaboration is the only way to effectively manage a landscape.

137. *See* Bradshaw, *supra* note 21, at 501-502; Bradshaw, *supra* note 20; Karen Bradshaw, *Stakeholder Dynamics in Land Development*, 50(2) J. LEGAL STUDIES (2021).

138. One way to read Elinor Ostrom's prize-winning is that natural resource governance differs from pollution control. Legal scholars have yet to link that to Administrative Law, but we do so here.

139. Bruce R. Huber, *Negative-Value Property*, 98 WASHINGTON U. L. REV. 1461, 1463 (2021).

140. *See* Tara Kathleen Righetti, *Liberating Split Estates*, 14(1) INT'L J. COMMONS 638, 638–39 (2020) (noting the historical dominance of "the mineral estate").

commercial value of some resources on the land (timber and cattle, for example) requires suppressing other negative-value resources (wildfire and pests).

Putting the land to "beneficial use" or "best and highest use" requires a landowner to decide which resource to maximize and then allocate resources differently. These are subjective decisions. A forester might choose to suppress wildfire to maximize timber harvest. A conservationist might choose to allow a wildfire to restore the natural landscape. A cattle rancher might choose to kill predators to maximize beef values. A wildlife advocate might introduce wolves onto the landscape to increase the population. At times, differing land management policies sharply collide. Gates of the Arctic National Park in Alaska cultivated a wolf population, building on the values of conservation and preservation. Alaskan state officials waited in helicopters outside the park and gunned down the entire wolf pack as it crossed the federal-state border, prioritizing values of hunting caribou over wolf conservation.[141] Negative-value attributes receive less attention.

This analysis shows how divisions between land management and natural resources (such as restoring fire to the natural landscape to benefit forest health) and the pollution control focus of environmental law create gaps between the cause of pollution and its effects. It follows that analysis of risk management developed in the pollution context may not extend to the context of the natural resources. This conclusion renders conventional risk management strategies inappropriate in land management and natural resource contexts. Thus, scholarly analysis of risk management that does not specifically inform land management agencies cannot be readily applied to wildfire risk reduction. Although most scholars suggest that the EPA should use cost-benefit analysis to govern pollution, it does not follow that the Forest Service should not use the same risk management tool to govern wildfire.

III. WILDFIRE EMISSIONS, A CASE STUDY IN MULTIDIMENSIONAL PROPERTY

We use wildfire as an example of how an integrated analysis of pollution reveals factors obscured from a siloed view which considers only atmospheric emissions. Fire itself is a natural process, at once destructive and regenerative. Yet it undeniably causes devastating effects, with dozens killed and hundreds of thousands of people made homeless. Wildfire is an environmental justice disaster, with rural, socioeconomically disadvantaged, and Indigenous persons disproportionally affected. Weeks after a wildfire burned Paradise, California, vulnerable residents were forced to live in camping tents in the parking lot of a nearby Walmart.[142]

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141. *See, e.g.*, Elise Schmelzer, *Storied Alaska Wolf Pack Beloved for Decades has Vanished, Thanks to Hunting*, WASH. POST (Aug. 9, 2016), https://perma.cc/757L-XFEE.

142. Dani Anguiano, *Anxious Wildlife Refugees Camped in Parking Lot Wonder: Where Now?*, THE GUARDIAN (Nov. 19, 2018), https://perma.cc/9EQN-NXAB.

Although it is less visible, the emissions from wildfires are also devastating to vulnerable communities worldwide. In 2018, the wildfire emissions in California obviated all of the CO_2 emission reductions the state had obtained through other measures. As outlined above, state and federal agencies managing wildfire emissions are unregulated polluters. This section considers how we might consider that through the lens of multidimensional property.

For the first two hundred years of American history, the federal government did not provide a comprehensive policy for wildfire.[143] In his excellent, comprehensive overview of wildfire law, Robert Keiter noted that "the most striking fact about fire management on the public lands was the relative dearth of law on it."[144] Federal agencies that manage public lands had the authority to develop wildfire policies.[145] Agencies, in turn, were highly responsive to state and local considerations.[146]

Congress began "fixing" wildfire in 2013. Since then, the incidence of wildfire has dramatically increased. What if our new approach to wildfire is causing the crisis? Indeed, the sharp uptick in disastrous wildfires correlates with increasing federal control and an increased reliance on data-driven fire modeling. When other national disasters occur, we discuss commonly understood solutions. When it comes to wildfire, there is no soundbite solution. Wildfire is inherently local: what works for an Alaskan tundra fire may fail for a Texas prairie wildfire. Yet, human choices always affect the size, duration, direction, and intensity, of a wildfire. The local interests most affected by wildfire should drive the policies that manage it.

Everyone respects firefighters who perform heroic work under extreme conditions. But the agency governing them is rife with perverse incentives. When the conservation movement pushed the Forest Service to stop cutting down trees, it pivoted towards fighting fire. For decades, the Forest Service had a blank check for wildfire spending—it could outspend its budget, then ask Congress for reimbursement. Even today, the agency (i) pays employees dramatically increased overtime the longer a fire burns; (ii) premises career advancement, in part, on active fire days; and (iii) omits wildfire smoke from its emissions limits. Sovereign immunity prevents courts from second-guessing agency firefighting decisions. Under these conditions, the Forest Service has dramatically shifted from fighting fires to managing them, thereby moving away from immediate suppression.

Historically, government firefighters attempted to suppress wildfires as quickly as possible. Federal government firefighting efforts effectively subsidized private

143. Readers interested in the historical development of wildfire in the United States should review the work of historian Stephen Pyne, the preeminent wildfire historian in the United States. He has written countless books and articles on the topic. For a good general overview, see STEPHEN J. PYNE, FIRE: A BRIEF HISTORY (2d ed. 2019).

144. Robert B. Keiter, *The Law of Fire: Reshaping Public Land Policy in an Era of Ecology and Litigation*, 36 ENVIRONMENTAL LAW 301, 322 (2006).

145. *Id.*

146. Karen Bradshaw Schulz, *New Governance and Industry Culture*, 88 NOTRE DAME L. REV. 2515, 2545–46 (2013).

forestry. Gifford Pinchot's model of renewable forestry is only commercially viable with wildfire suppression. Foresters transformed many natural forests with large, widely spaced trees into densely packed, monoculture tree farms, which ecologists argue increased the risk and intensity of wildfire. In the 1970s, environmentalists and fire scientists began questioning the wisdom of suppressing fires. They noted that fires have occurred in forests since time immemorial; they are an integral part of the natural landscape. Plants like the Lodge Pole Pine rely on fire to open their cones and reproduce. Big wildfires also serve less direct ecological goals. President Obama once stated that fires are hotter and larger than they were in the past as evidence of climate change, without accounting for agencies' dramatically changed wildfire suppression and forest management strategies. Larger wildfires decrease the likelihood that people will build homes in forests, limiting urban sprawl. And the viability of commercial timber operations depends on reduced wildfire risk. Letting wildfires burn has far broader socio-ecological effects than opening pinecones.

People who build homes in forests have an ever-increasing stake in wildfire management. Local municipalities grow their property tax base by allowing homeowners to build in desirable natural areas known as the wildland-urban interface areas. These homes increase the likelihood that humans will be at risk during a wildfire, which in turn prompts firefighters to engage in riskier techniques to save lives. Homes also distract from protecting timber and, by extension, watersheds, and wildlife. Insurance laws in California mandate that homes in forests—just like those on coastlines—must be insurable, providing a bar on the market response that might otherwise keep people from building there.

Are the terrible losses in California attributable to policy choices made to satisfy a romantic ideal of a landscape that no longer exists? Or is the real problem government subsidies putting commercial forestry and wildland-urban interface users in a natural environment where they do not belong? These questions are too complicated and nuanced to be distilled into a soundbite or tweet. National policy cannot resolve these conflicts. Empowering the stakeholders who bear the costs and benefits of the forests to generate better approaches may be our best step forward.

A. RESTORING FIRE TO THE NATURAL LANDSCAPE

The conversation around restoring wildfire to the national landscape contains some objectionable premises. What, exactly, does "natural" mean? If it implies pre-Colonial landscape management practices, that blindly ignores Indigenous peoples and their widespread historical landscape management practices (which sometimes included intentional prescribed burning).[147] History aside, it is difficult to imagine most North American forests today as "natural." Commercial timber harvest depends upon a process of cutting trees, replanting seedlings, allowing them to grow, then planting them again.

147. *See generally* ROXANNE DUNBAR-ORTIZ, AN INDIGENOUS PEOPLES' HISTORY OF THE UNITED STATES (Beacon Press, 2014).

Foresters replant seedlings designed to grow quickly to maximize revenue. As a result, the timber stands in many forests are monocultures or comprised of a limited mix of commercially valuable trees. As such, the wildfire regime appropriate in a "natural" context is distinctly inappropriate for forests that are no longer "natural." To imagine the difference between a natural forest and a modern forest that was subject to decades of commercial timer practices, imagine a raw swath of wild prairie and a cornfield. In one, there are several plants. In the second, even-age management of selected seeds of the same plant variety grows. To suggest that a landscape management practice suited towards the wild prairie would be appropriate to treat the cornfields without accounting for the differences between the underlying landscapes would be poor advice. Similarly, historic wildfire practices applied to modern landscapes without updating to accommodate the reality of commercially managed lands does not make sense.

Similarly, the "natural" model of forests on which the restoration of wildfire is advocated does not have homes on them. Real forests, however, increasingly do. The expansion of homes into traditional-forested areas—sometimes called the wildland urban interface ("WUI") area—represents the largest risk of restoring fire to the natural landscape. Although the public might be complacent as forestry diminishes, few are comfortable watching homes burn. The WUI of homes in forests can include wealthy landowners. And it is here that federal firefighting agencies have drawn the line—quite literally—with firefighting. Although federal firefighters might allow fire in sparsely populated areas, they are statutorily required to protect human life and homes.

In non-obvious ways, wildfire mitigation and management directly impact whether forests are used for commercial timber production or left in their natural states. For decades, federal agencies managed risk as private foresters continue to do—by cutting trees. Agencies also followed stringent rules to suppress fire as quickly as possible. Over time, however, agencies reflected an increased environmental focus. When goals extended beyond timber harvest, ecologists argued that there were benefits to the plant and animal life in an ecosystem accrued by wildfire. Who can argue with science?

Yet, ostensibly neutral science has a normative edge. This argument implicitly challenges the domestic forestry industry—without adequate wildfire protection, commercial forestry is not viable in the United States. In this sense, supporting wildfire as a natural part of the ecosystem was a mechanism for promoting conservation. Certainly, forest landowners have pushed back—hard—against federal policies to allow fires to burn, understanding that such policies affect their economic interests.

With respect to reform, solutions fall into one of three categories: (1) ex ante land management policies to prevent or mitigate harms created by wildfire; (2) fire suppression strategies to save human lives and satisfy other objectives while the fire is burning; and (3) ex post fire recovery rules to lessen the negative effects, such as mudslides.

"Managing" wildfire risk requires controlling human action on a natural physical landscape. Consider a few examples: insurance companies requiring homeowners to replace wooden shingles with metal roofs to reduce the likelihood that a burning ember will light a house on fire; local governments advocating for defensible space around a home, clearing brush, and other flammable vegetation near a home; and foresters suggesting that cutting trees reduces the fuel load, which reduces the incidence and severity of wildfires.

A mix of groups governs wildfire risk. Insurer and timber landowner coordinated policies represent private governance. Local, state, and federal governments manage adjacent lands. Yet, wildfire does not respect property lines. It operates at a much larger scale than an individual parcel of land. One neighbor's risk management strategy affects the others. Thus, any strategy must be cooperative. The sensible way to manage a landscape is to group ownership at varying levels to reflect different scales of efficient management. Defense, airspace, and radio waves are most sensibly organized at the national level. Multiple layers of governance simultaneously exist on, above, under, and appurtenant to the same piece of land.[148]

This overlapping, multiple-owner land system is complicated. Some argue that divestiture of federal land results in best use and prioritization of rights, while others contemplate government-owned resources as a representative democratic form of ownership. There is not a "correct" option—conflicts abound on federal land, as they do on fee. The reality of overlapping property ownership and management is likely a best case, especially if ownership composition is not a binary choice (i.e., individual or government). Jonathan Adler theorizes that large landowners could also be composed of trusts and various other collective entities, which simultaneously encompasses a broad value spectrum, while retaining key characteristics of private property ownership. Other public-private and cooperative partnerships may also be more useful structures for subnational resources, such as water and wildfire, which cannot be managed efficiently at either a federal or individual level. Encouraging structured decision-making with landowners can encourage effective management, while balancing multiple objectives, including use, development, conservation, and recreation. Federal decision-making with inputs of stakeholders directly interacting with the resource may provide a path forward.

CONCLUSION

In this Article, we add to emergent literature analyzing how natural resource property contains a multitude of rights, interests, and systems and the institutional mechanisms devoted to managing such complexity. We conclude that this intricate problem demands a variety of institutional tools, which may change in

148. *See* Karen Bradshaw & Bryan Leonard, *Mismatched Property Rights: Virtual Parceling*, 14 INT'L J. COMMONS 597, 597–98 (2020) ("In practice, the many overlapping resources on a landscape require varied ownership and governance structures, meaning that virtually all landscapes contain both public and private elements, subject in varying ways to local, state, federal, tribal, and private governance.").

response to shifts in social values, resource dynamics, or economic conditions over time. This analysis yields a new way of looking at pollution and climate change through the lens of multifaceted property.

These novel methods to understand pollution and climate change will be critical as arid climates induce more plentiful and strong wildfires and larger populations affected by climate change hasten the urgency to provide geoengineering solutions. Not only will cloud seeding activity increase to provide water to parched or prosperous groups, but other climate engineering solutions such as solar radiation management and carbon dioxide removal are poised to modify our climate without governance or oversight. These climate geoengineering methods range from dispersing chemicals into the atmosphere to deflect sunlight to pumping a saltwater mist into clouds to increase their reflectivity.[149] Without governance, the sky is the literal limit.

149. Oliver Millman, *Can Geoengineering Fix the Climate? Hundreds of scientists say not so fast*, THE GUARDIAN (Dec. 25, 2022).