2

Why Cumulative Environmental Problems Are Difficult and Implications for Law

Introducing the CIRCle Framework

2.1 INTRODUCTION

To design effective regulation for cumulative environmental problems, we need to understand why it is challenging to deal with them. We can then design a regulatory regime to anticipate and head off these challenges as much as possible. We can also avoid incorporating regulatory features that might entrench or exacerbate these challenges. While laws cannot single-handedly solve cumulative environmental problems, the core premise of this book is that across a wide range of legal areas related to the environment,[1] rules can supply guiding structures to support governments and others to do so.

As outlined in Chapter 1, key features of cumulative environmental problems are that they (1) are caused by many *heterogeneous actors*, undertaking (2) *diverse activities*; (3) involve *scientific complexity and unpredictability* of the resulting effects, which (4) aggregate over a *long period of time*; and (5) *engage multiple regulatory regimes* that may each deal separately with single issues (such as biodiversity or water pollution). This chapter collects insights from diverse disciplinary and interdisciplinary literatures – cognitive science, complex systems, public administration and policy analysis, science and technology studies, ethics, economics, management of common pool resources, and environmental management – to illuminate the key challenges associated with these features.[2] Synthesizing these challenges produces a

[1] See Chapter 3 for a discussion of potentially relevant areas of law.

[2] The chapter does not address disciplinary insights into cumulative effects that lack one or more important characteristics of cumulative environmental problems as defined earlier. For example, compound/multi-hazard planning deals with the aggregation of risks that accumulate over a shorter time period than is in focus here.

"CIRCle Framework" of four key functions that are needed, and that formal rules can deliver, to support action to address cumulative environmental problems: conceptualization, information, regulatory intervention, and coordination. Section 2.2 discusses the difficulties that lead to each Framework function in turn. Section 2.3 synthesizes why these difficulties make formal rules desirable, and the design features they indicate, and presents the CIRCle Framework that results from the preceding analysis.

First, a quick word about method. Since the terminology associated with cumulative effects (here used interchangeably with "cumulative impacts") varies between disciplines, and relevant knowledge is widely dispersed, finding it is not straightforward. The research for this chapter focused on the five features of cumulative environmental problems set out earlier, as well as the general idea of cumulative impacts or effects and related types of problems, for example, "wicked" and "super wicked" problems, "intractable policy problems," and collective action problems. These ideas engage vast literatures, far beyond what a single chapter could explore in depth. So, rather than delving deeply, this chapter focuses on key principles and research findings that are most relevant to considering how law could and should address cumulative environmental problems. To this end, references in this chapter skew toward review and synthesis articles and articles that deal with multiple jurisdictions, with original research articles cited mainly for illustrative purposes or because they are seminal contributions. Much other research, and many other disciplines, are relevant and helpful but fall outside the scope of this chapter and are reserved for future work refining the CIRCle Framework. The focus here is distilling implications for law from other disciplines; additional discussion and contributions from legal and regulatory scholarship are discussed in later chapters that each focus on a single CIRCle Framework function.

2.2 WHY IS DEALING WITH CUMULATIVE EFFECTS SO HARD? INSIGHTS FROM OUTSIDE LAW

2.2.1 *Conceptualizing the Matter of Concern Threatened by Cumulative Environmental Harm*

We begin by asking the simplest questions related to a cumulative environmental problem: cumulative effects *on what, or whom*? In other words, what do we care about, what is the "matter of concern" to be protected from cumulative environmental harm, or restored, and what do acceptable conditions for it look like? Answering even these initial questions is beset by challenges.

Laws in different jurisdictions legitimately protect diverse things related to the environment – here termed the "matter of concern." This may be, for example, a natural resource like water as the foundation of a human right, the preservation of "wilderness," a particular species, or the relationship between an Indigenous group and a place. Across this diversity, insights from environmental impact assessment ("EIA") literature, cognitive science, economics, political science, and ethics suggest that clearly articulating important dimensions of a matter of concern – conceptualizing it – is not straightforward. Ambiguity, subjectivity, different values held by different actors, and the multiple possible dimensions of a matter of concern all pose challenges. Conceptualization, in turn, affects what information is needed to assess and respond to the problem, which actors are identified as potentially causing harm, and which actors and regulatory regimes are and should be engaged in dealing with the problem.

2.2.1.1 Conceptualizing Key Dimensions of a Matter of Concern: The Roles of Values, Science, and Transparency

EIA literature demonstrates the centrality and also the challenging complexity of conceptualization in terms of the multiple dimensions that are relevant and the subjectivity of decisions about these dimensions, whether decisions occur inside or outside an EIA context. EIA scholars, practitioners, and detailed technical guidelines on EIA generally agree that cumulative effects assessment involves first selecting environmental components as the focus for assessment, defining their boundaries, and defining the baseline conditions against which effects are considered to determine whether they are significant or unacceptable.[3]

These are important insights into the many dimensions of conceptualization that are also relevant outside EIA, but they make selecting these dimensions seem like a purely technical exercise. In reality, these are normative questions involving subjective decisions: Science can guide, but not decide.[4] Different interest groups will have different views, with variation across institutional, cultural and political settings.[5] In relation to thresholds of acceptable change to a matter of concern, policy analysis scholars note that even with

[3] E.g., F. Chris Jones, "Cumulative Effects Assessment: Theoretical Underpinnings and Big Problems" (2016) 24 *Environmental Reviews* 187–204, 191; Larry Canter, *Cumulative Effects Assessment and Management: Principles, Processes and Practices* (EIA Press 2015) 25–77.

[4] Jones, "Cumulative Effects Assessment," 196, 198.

[5] Cary Coglianese and Shana M. Starobin, "Social Science and the Analysis of Environmental Policy" (2020) 37 *Review of Policy Research* 578–604, 581.

fulsome scientific information, deciding "how safe is safe" in relation to pollution depends on normative values and diverse criteria, from economic efficiency to equity.[6] The conflict management literature shows that clarity and transparency about what matters is necessary to understand, recognize, and, if possible, accommodate the different interests involved.[7]

Conceptualizing what we care about raises fundamental questions about links between people and the environment. Variants of EIA have arisen that expressly recognize these links. These variants include cultural impact assessment, health impact assessment, human rights impact assessment, and socio-economic impact assessment.[8] Conceptualizing a matter of concern as having economic value can also engage other concepts and regimes, such as natural capital and environmental economic accounting.[9]

Links between people and the environment are consequential because the amount of change to a matter of concern that is deemed unacceptable will depend on why it matters and who plays a role in deciding. The amount and type of acceptable change to a desert oasis, for example, may well be different if it constitutes cultural heritage, as opposed to habitat for an endangered fish.

Equally challenging, complexity science shows that environmental systems are dynamic, whereas much environmental law assumes stationarity.[10] This underscores the normative nature of deciding a threshold of unacceptable change, because there is no "natural" equilibrium.[11] In practice, however, time can feature strongly in selecting threshold conditions of acceptable change, and this can have important implications. If conditions of the matter of concern have changed significantly, choosing a temporally earlier set of

[6] Ibid 585–588.

[7] Lisa V. Bardwell, "Problem-Framing: A Perspective on Environmental Problem-Solving" (1991) 15 *Environmental Management* 603–612, 607–608 (giving an example of two children fighting over an orange; without determining their interests in the orange, an intervening parent halved the orange, then one child ate the pulp and discarded the skin, and the other did the reverse).

[8] See generally Riki Therivel and Graham Wood (eds), *Methods of Environmental and Social Impact Assessment* (Routledge 2018).

[9] See, e.g., William E. Rees, "Cumulative Environmental Assessment and Global Change" (1995) 15 *Environmental Impact Assessment Review* 295–309; Murray Patterson, Garry McDonald and Derrylea Hardy, "Is There More in Common Than We Think? Convergence of Ecological Footprinting, Emergy Analysis, Life Cycle Assessment and Other Methods of Environmental Accounting" (2017) 362 *Ecological Modelling* 19–36.

[10] Robin Kundis Craig, "Stationarity Is Dead – Long Live Transformation: Five Principles for Climate Change Adaptation Law" (2010) 34 *Harvard Environmental Law Review* 9–73, 37–38.

[11] See note 64 and accompanying text.

conditions as the threshold of acceptability will make contemporary conditions appear more degraded.

Articulating spatial boundaries is also a key part of conceptualization, and also not straightforward. EIA practitioners recommend that spatial boundaries for assessment and potential intervention reflect the scale of the matter of concern that receives impacts.[12] This might be, for example, the spatial distribution of a species, a local community, a transboundary water resource, or the global climate. But there are also trade-offs to consider. Cognitively, if "[p]resented at too large a scale, the problem seems unapproachable and overwhelming; if too small, it is easily dismissed," whereas a middle way can allow for "small wins."[13] Many criteria may apply to selecting a spatial scale: the complexity and time associated with analysis, the number of actors involved, the scalar fit with legal frameworks, economic relevance, and so on.[14]

Ultimately, the subjective nature of these decisions creates a need for transparency. Conceptualizing spatial boundaries, for example, requires transparently considering the implications of different spatial options and trade-offs between options,[15] given that there may be no natural or objective way to conceptualize them.[16] More generally, transparency about the rationale for conceptualizing the matter of concern in a particular way also helps to untangle problems of incoherence, discussed next. Transparency of decisions about what and who matter intersects with issues of information necessary to support environmental democracy and accountability, discussed more fully later.[17]

2.2.1.2 Coherence, Changing Values, and the Need for Coordination in Conceptualizing a Matter of Concern

Because conceptualizing cumulative environmental problems involves multiple dimensions, multiple actors, and decisions over potentially long time periods, the way a matter of concern is conceptualized may differ

[12] Riki Therivel and Bill Ross, "Cumulative Effects Assessment: Does Scale Matter?" (2007) 27 *Environmental Impact Assessment Review* 365–385, 366.

[13] Bardwell, "Problem-Framing," 609.

[14] Sonja A. M. Karstens, Pieter W. G. Bots and Jill H. Slinger, "Spatial Boundary Choice and the Views of Different Actors" (2007) 27 *Environmental Impact Assessment Review* 386–407, 401.

[15] Ibid 406.

[16] C. J. Walters, *Adaptive Management of Renewable Resources* (Macmillan 1986) 14, 34–38.

[17] See Chapter 5. Note that, as discussed in Section 1.2.4, I do not argue that laws should focus on any specific matter of concern. This book focuses on how formal rules can respond to cumulative change to a matter of concern, rather than on processes for deciding what matters.

problematically between actors and through time unless it is formalized. Policy design literature refers to conflicting goals as lacking "coherence,"[18] a term that I adopt here. For example, even within a single watershed, different governments and stakeholders may agree that "drought" is a problem, but have in mind different types of impacts and care about different human and natural systems that may be affected.[19] Similarly, in the EIA context, practitioners can define the core components of a system differently, including whether sociocultural dimensions of biophysical impacts are even considered.[20]

Incoherent conceptualizations are problematic because they can lead to different methodologies and conclusions about changing conditions and can obstruct effective responses to cumulative environmental problems. At minimum, incoherent conceptualizations can make it "impossible to see the elephant for all of its parts,"[21] reducing the comparability and usefulness of assessments if their insights cannot be aggregated with others. Incomparable assessments can compound challenges of insufficient data availability for responding to cumulative environmental problems (discussed later in the chapter), given that understanding cumulative effects fundamentally means aggregating the effects of multiple activities. If goals are uncertain or ambiguous, this also reduces the success of cooperative interventions to avoid environmental harm.[22]

Avoiding inadvertent incoherence in conceptualization requires "frame reflection" and construction of a shared narrative that either resolves or can accommodate different value preferences.[23] This requires some form of interaction between relevant actors, which here is termed coordination, discussed further later on.[24]

[18] Michael Howlett and Jeremy Rayner, "Coherence, Congruence and Consistency in Policy Mixes" in Michael Howlett and Ishani Mukherjee (eds), *Routledge Handbook of Policy Design* (Routledge 2018) 389–403, 394.

[19] See generally Amanda E. Cravens and others, "Integrating Ecological Impacts: Perspectives on Drought in the Upper Missouri Headwaters, Montana, United States" (2021) 13 *Weather, Climate, and Society* 363–376.

[20] Emma E. Hodgson, Benjamin S. Halpern and Timothy E. Essington, "Moving Beyond Silos in Cumulative Effects Assessment" (2019) 7:211 *Frontiers in Ecology and Evolution* 1–8, 3, 6. See also Peter N. Duinker and others, "Scientific Dimensions of Cumulative Effects Assessment: Toward Improvements in Guidance for Practice" (2013) 21 *Environmental Reviews* 40–52, 42–3; Jones, "Cumulative Effects Assessment," 196.

[21] Hodgson, Halpern and Essington, "Moving Beyond Silos," 1, 3, 6.

[22] Ben R. Newell and others, "The Psychology of Environmental Decisions" (2014) 39 *Annual Review of Environment and Resources* 443–467, 458.

[23] Brian W. Head and John Alford, "Wicked Problems" (2015) 47 *Administration and Society* 711–739, 723.

[24] See Section 2.2.4.

Coordination is also required where a conceptualization of what and who matter needs to change due to social or environmental change. Contemporary societies seek to protect many things that were not protected even fifty years ago.[25] Environmental stressors like climate change may require triage or "directed adaptation" for ecosystems.[26] Such intentional change requires coordination to review objectives that form part of a conceptualization with stakeholders as part of an adaptive management approach.[27]

2.2.2 *Informing Decisions by Understanding Conditions of Matters of Concern, Threats, and Interventions*

Considering cumulative effects requires collecting, sharing, and analyzing information about the matter of concern and its current conditions, which activities have affected it and are likely to affect it, and whether those effects would push conditions to become unacceptable. This is easy to say, and more difficult to do.

2.2.2.1 Information Needed to Perceive Incremental Change, Data Shortages, and the Need for Coordination

Cumulative environmental harm can involve slowly shifting environmental conditions that are difficult to discern, even for experienced experts.[28] This "shifting baseline syndrome" means younger generations may be unaware of past conditions (a sociological phenomenon) and individuals may forget their past experience (a psychological phenomenon).[29] A lack of environmental data, reduced interaction with the natural world, and reduced knowledge of the natural environment also make it difficult to perceive cumulative environmental harm.[30] By contrast, perceiving individually large, sudden-onset

[25] Benjamin J. Richardson, *Time and Environmental Law: Telling Nature's Time* (CUP 2017) 98–107.

[26] Gregor W. Schuurman and others, "Navigating Ecological Transformation: Resist-Accept-Direct as a Path to a New Resource Management Paradigm" (2022) 72 *BioScience* 16–29, 20–22.

[27] Larry Canter and Samuel F. Atkinson, "Adaptive Management with Integrated Decision Making: An Emerging Tool for Cumulative Effects Management" (2010) 28 *Impact Assessment and Project Appraisal* 287–297, 290–291, 292–293.

[28] See generally S. K. Papworth and others, "Evidence for Shifting Baseline Syndrome in Conservation" (2009) 2(2) *Conservation Letters* 93–100.

[29] See generally ibid; Masashi Soga and Kevin J. Gaston, "Shifting Baseline Syndrome: Causes, Consequences, and Implications" (2018) 16 *Frontiers in Ecology and the Environment* 222–230.

[30] Soga and Gaston, "Shifting Baseline Syndrome," 224–225.

environmental changes is relatively easy. Empirically, shifting baseline syndrome has been identified in diverse natural resources and geographic contexts, including in relation to fishers in Indonesia, Mexico, and Tanzania; water availability in Alaska; and wildlife in Bolivia.[31]

Shifting baselines are problematic because they can lead to "increased tolerance for progressive environmental degradation."[32] At the extreme, change that occurs beyond human perception is beyond human control – it does not even arise as an issue for regulatory intervention.[33]

Perceiving and understanding accumulating harm requires aggregating comparable (interoperable) data about conditions of the matter of concern through time. But long-term data collection can be a low political priority, and aggregating information from multiple sources encounters challenges with comparability. As a result, data availability is often a problem for assessing cumulative effects.[34] In practice, different agencies of the same government may collect data differently such that it is not interoperable, agencies may lack a mechanism for obtaining data collected by private actors (even research institutions), and no single institution may have the mandate to assemble and interpret the data.[35]

Conversely, coordinating the data-related activities (e.g., collecting, sharing, analyzing) of multiple actors can reduce unnecessary duplication and cost,[36] making the most of available resources. Environmental management and

[31] Ibid 223.

[32] Papworth and others, "Evidence for Shifting Baseline Syndrome," 95; Soga and Gaston, "Shifting Baseline Syndrome," 222, 225.

[33] Rebecca Nelson, "Breaking Backs and Boiling Frogs: Warnings from a Dialogue between Federal Water Law and Environmental Law" (2019) 42 *University of New South Wales Law Journal* 1179–1214, 1203.

[34] Rebecca Nelson, "Water Data and the Legitimacy Deficit: A Regulatory Review and Nationwide Survey of Challenges Considering Cumulative Environmental Effects of Coal and Coal Seam Gas Developments" (2019) 23 *Australasian Journal of Water Resources* 24–34, 29–30; Bram Noble, Jialang Liu and Paul Hackett, "The Contribution of Project Environmental Assessment to Assessing and Managing Cumulative Effects: Individually and Collectively Insignificant?" (2017) 59 *Environmental Management* 531–545, 540; Zhao Ma, Dennis R. Becker and Michael A. Kilgore, "Barriers to and Opportunities for Effective Cumulative Impact Assessment within State-Level Environmental Review Frameworks in the United States" (2012) 55 *Journal of Environmental Planning and Management* 961–978, 964–965.

[35] François Bregha, "Institutional Barriers to Environmental Information" (1992) 20 *Environmental Monitoring and Assessment* 191–200, 192–193.

[36] Rachel Eberhard, Nathan Johnston and Jo-Anne Everingham, "A Collaborative Approach to Address the Cumulative Impacts of Mine-Water Discharge: Negotiating a Cross-Sectoral Waterway Partnership in the Bowen Basin, Australia" (2013) 38 *Resources Policy* 678–687, 683 (describing 100 duplicated monitoring points discovered through collaboration).

assessment literature emphasizes the importance of coordinating to form a shared understanding of an environmental problem and to share related information,[37] and highlights the need for better intergovernmental coordination in assessing cumulative impacts.[38]

2.2.2.2 Costs and Resistance to Data Collection and Sharing

Collecting data about matters of concern and threats to them may involve high costs. This is especially true where a resource is hidden, as in the case of groundwater, or difficult to reach, as for ocean biodiversity. Cumulative impact assessments require significant time, expertise, and cost,[39] in part, driven by the need for significant data gathering. It can also be more expensive to comprehensively monitor many individually small activities, which may constitute cumulatively significant threats, than a few large ones. Cuts to monitoring budgets, sometimes driven by a short-term focus and misperceptions of wastefulness, can create discontinuities that compromise the value of the data,[40] and make it difficult or impossible to assess incremental change (trends) over time.[41]

Lower-cost monitoring methods can include citizen science, hybrid government–citizen science programs, or high-tech automated initiatives.[42] Crowdsourcing data in a way that involves stakeholders may also increase understanding of a problem, but faces challenges in relation to ethics, data quality, data ownership/sharing, and, potentially, exploitation of unremunerated

[37] E.g., Jens Newig and Oliver Fritsch, "Environmental Governance: Participatory, Multi-Level – and Effective?" (2009) 19 *Environmental Policy and Governance* 197–214, 209.

[38] Zhao Ma, Dennis R. Becker and Michael A. Kilgore, "Assessing Cumulative Impacts within State Environmental Review Frameworks in the United States" (2009) 29 *Environmental Impact Assessment Review* 390–398, 392, 397.

[39] Ma, Becker and Kilgore, "Barriers to and Opportunities for Effective Cumulative Impact Assessment," 971 (noting that the evidence on whether this is greater than for EIA without cumulative impact assessment is equivocal).

[40] Eric Biber, "The Problem of Environmental Monitoring" (2011) 83 *University of Colorado Law Review* 1–82, 23–26, 39–41.

[41] E.g., Michael P. Schaubs, Ground Water Levels in the Lost Creek Designated Ground Water Basin (Colorado Division of Water Resources, Department of Natural Resources, 2010) 2, https://dnrweblink.state.co.us/dwr/0/edoc/2753828/DWR_2753828.pdf?searchid=9c553d8a-080a-4fa7-865f-63c663345acd.

[42] See generally M. Hino, E. Benami and N. Brooks, "Machine Learning for Environmental Monitoring" (2018) 1 *Nature Sustainability* 583–588; Susanne Becken and others, "A Hybrid Is Born: Integrating Collective Sensing, Citizen Science and Professional Monitoring of the Environment" (2019) 52 *Ecological Informatics* 35–45.

citizen scientists.[43] Attention to standards for data quality, accessibility, and sharing, and methods for rewarding contributions could help deal with these challenges.[44]

High-tech monitoring methods also raise their own legal issues related to privacy, safety, evidentiary value, and other concerns.[45] Using technology to monitor individually small activities that are potentially cumulatively significant can encounter resistance because of an assumption that their impacts represent "a drop in the ocean" that does not warrant monitoring. Sometimes monitoring is perceived to threaten individual or community privacy, as in community hostility to wildlife monitoring using camera traps in Nepal[46] and drones in Tanzania.[47] Monitoring technology has sometimes legitimized military interventions, such that it can produce an atmosphere of fear.[48]

Participatory approaches to deploying monitoring technology may help address community concerns.[49] Indeed, some argue that with the right safeguards and awareness of "red flags," technology can empower local populations, and environmental monitoring is increasingly participatory in practice.[50] Technology can empower those who experience cumulative impacts to advocate for regulatory intervention, from Indigenous paraecologists in Ecuador advocating for "rights of nature"[51] to community groups in

[43] See generally Kathryn A. Lee, Jonathan R. Lee and Patrick Bell, "A Review of Citizen Science within the Earth Sciences: Potential Benefits and Obstacles" (2020) 131 *Proceedings of the Geologists' Association* 605–617.

[44] Ibid 613.

[45] See generally Chris Sandbrook, "The Social Implications of Using Drones for Biodiversity Conservation" (2015) 44(Suppl 4) *Ambio* 636–647; Jesús Jiménez López and Margarita Mulero-Pázmány, "Drones for Conservation in Protected Areas: Present and Future" (2019) 3 *Drones* 10, 17; Chris Sandbrook, Rogelio Luque-Lora and William M. Adams, "Human Bycatch: Conservation Surveillance and the Social Implications of Camera Traps" (2018) 16 *Conservation and Society* 493–504.

[46] See generally Yashaswi Shrestha and Renaud Lapeyre, "Modern Wildlife Monitoring Technologies: Conservationists versus Communities? A Case Study: The Terai-Arc Landscape, Nepal" (2018) 16 *Conservation and Society* 91–101.

[47] Sandbrook, "The Social Implications of Using Drones for Biodiversity Conservation," 640.

[48] Naomi Millner, "As the Drone Flies: Configuring a Vertical Politics of Contestation within Forest Conservation" (2020) 80:102163 *Political Geography* 1–13, 2–3.

[49] See generally Shrestha and Lapeyre, "Modern Wildlife Monitoring Technologies," 99. Participatory approaches are discussed later as a form of coordination: see Chapter 7.

[50] Nathan Young and others, "Ethical Ecosurveillance: Mitigating the Potential Impacts on Humans of Widespread Environmental Monitoring" (2022) 4 *People and Nature* 830–840, 834–838.

[51] M. R. Peck and others, "The Conflict between Rights of Nature and Mining in Ecuador: Implications of the Los Cedros Cloud Forest Case for Biodiversity Conservation" (2024) 6 *People and Nature* 1096–1115, 1108–1110.

Guatemala using drones in participatory forest monitoring to support community claims against transnational businesses,[52] to citizen science surveillance programs for invasive species that use low-cost smartphones, image recognition, and machine learning.[53] Ultimately, any blanket rejection of technology deserves reexamination in light of cumulative environmental problems and the significant benefits technology offers communities in facilitating the collection of information. Without it, cumulative environmental problems may build, unperceived and unaddressed.

Responding to cumulative environmental problems requires not just collecting, but also sharing and aggregating interoperable data associated with multiple and potentially numerous activities to give useful insights into a cumulative problem.[54] Data for understanding cumulative environmental problems, then, should be "FAIR" – findable, accessible, interoperable (as discussed earlier), and reusable.[55]

Yet, both governments and commercial entities may experience disincentives to sharing information. Regulated entities may also resist sharing information due to concerns that it is commercially sensitive and could give away an advantage to their competitors.[56] Arguments about trade secrets or intellectual property can be prominent in the case of new technology, for example, allegedly environmentally harmful fluids used in hydraulic fracturing,[57] and resource analyses that have commercial value, like in oil and gas.[58] Governments may resist sharing data, preferring to adopt a "what we don't know won't hurt us" attitude, or want to avoid public alarm.[59] Some environmental data may be classified as a state secret (as is soil pollution data in

[52] Millner, "As the Drone Flies: Configuring a Vertical Politics of Contestation within Forest Conservation," 12.

[53] Petr Pyšek and others, "Scientists' Warning on Invasive Alien Species" (2020) 95 *Biological Reviews* 1511–1534, 1522–1524.

[54] A. John Sinclair, Meinhard Doelle and Peter N. Duinker, "Looking up, Down, and Sideways: Reconceiving Cumulative Effects Assessment as a Mindset" (2017) 62 *Environmental Impact Assessment Review* 183–194, 192.

[55] Mark D. Wilkinson and others, "The FAIR Guiding Principles for Scientific Data Management and Stewardship" (2016) 3:160018 *Scientific Data* 1–9; Hodgson, Halpern and Essington, "Moving Beyond Silos," 3.

[56] Nelson, "Water Data," 30.

[57] See generally Keith B. Hall, "Hydraulic Fracturing: Trade Secrets and the Mandatory Disclosure of Fracturing Water Composition" (2012–2013) 49 *Idaho Law Review* 399–435.

[58] See generally Abbe E. L. Brown, "The Future of Intellectual Property" in Daniel J. Gervais (ed), *Rights to Do, Rights to Prevent, and an Intersected Approach? Lessons from Intellectual Property, Information Control and Oil and Gas* (Edward Elgar 2021) 105–127.

[59] Bregha, "Institutional Barriers to Environmental Information," 194–195.

China).[60] Other reasons include wanting to avoid "arming" opponents to a politically preferred project,[61] or protecting corrupt government officials who benefit from environmental harms.[62]

Finally, to usefully address cumulative environmental problems, data must also be contextualized by reference to specific matters of concern and their thresholds, rather than numerical values about abstracted environmental conditions. For example, reporting aggregate volumes of withdrawals from a river system, without more, says little about cumulative impacts in terms of stress relative to ecological thresholds and acceptable change. A small aggregate volume might be ecologically insignificant if withdrawn from a large river system, or catastrophic if withdrawn from a small stream in an arid zone. Context matters, but contextualizing data requires analysis, which, as described next, takes work and can be complex.

2.2.2.3 Complexity, Dynamism, Modeling, and Uncertainty

Complexity scholars show that predicting how potentially large numbers of activities will interact and aggregate to affect something is complex, involving deep uncertainty, feedback loops, emergent behavior, complex interactions, and nonlinear responses.[63] External drivers such as climate change and global economic shifts can combine with internal local-scale drivers like interactions between species to produce continuous change.[64]

This has several important implications. The psychological difficulty of constructing accurate mental models of dynamic systems[65] means formal scientific modeling is often needed to understand a complex system and its possible futures. Such models can require substantial data and computing capabilities,[66]

[60] Takashi Itakura, "Current Issues with the Regulatory Framework for Managing Soil Contamination in China" (2015) 18 *Asia Pacific Journal of Environmental Law* 119–146, 128–130.

[61] Bregha, "Institutional Barriers to Environmental Information," 195.

[62] Crispin Andrews, "Wildlife Monitoring: Should UAV Drones Be Banned?" (July 14, 2014) (discussing corruption in the context of illegal export of elephant tusks and rhinoceros horns), https://eandt.theiet.org/content/articles/2014/07/wildlife-monitoring-should-uav-drones-be-banned/.

[63] See generally Lael Parrott and Wayne S. Meyer, "Future Landscapes: Managing within Complexity" (2012) 10 *Frontiers in Ecology and the Environment* 382–389.

[64] Ibid 384.

[65] Newell and others, "The Psychology of Environmental Decisions," 450.

[66] Emma E. Hodgson and Benjamin S. Halpern, "Investigating Cumulative Effects across Ecological Scales" (2018) 33 *Conservation Biology* 22–32, 27–28.

and require significant time, expertise, and cost to undertake,[67] as well as multiple disciplines.[68] This is not a new issue. In the 1960s, Colorado lawyers noted the "dramatic possibilities" for efficiently managing large numbers of groundwater withdrawals of "utiliz[ing] the services of a computer," noting with evident envy that Nevada had such a device.[69] With improving computing capabilities, the feasibility of cumulative analysis methods further increases.[70]

Even with sophisticated models, it may be necessary to use significant simplifications and assumptions,[71] and significant uncertainty may be unavoidable due to nonlinearities and indirect effects.[72] Accordingly, information about predicted futures may best be presented as scenarios or "envelopes" rather than precise predictions,[73] and there is a need for ongoing adaptive management to counter uncertainties associated with cumulative effects.[74]

In other words, information about cumulative impacts is often complex and unavoidably uncertain. Uncertain information tends to discourage individuals from voluntarily adopting pro-environmental behavior, undermines cooperative solutions to a problem,[75] and heightens risks that information will not be used to take action.[76] Empirical research suggests that EIA, an important context for cumulative effects analysis, does not necessarily have a significant effect on decision-making.[77] Other risks to high-quality data and analysis for informing decision-making include cost cutting, regulatory capture,

[67] Ma, Becker and Kilgore, "Barriers to and Opportunities for Effective Cumulative Impact Assessment," 971.

[68] Hodgson and Halpern, "Investigating Cumulative Effects across Ecological Scales," 29.

[69] Raphael J. Moses and George Vranesh, "Colorado's New Ground Water Laws" (1966) 38 *University of Colorado Law Review* 295–310, 303.

[70] Hodgson and Halpern, "Investigating Cumulative Effects across Ecological Scales," 28.

[71] Ibid 27.

[72] Hodgson, Halpern and Essington, "Moving Beyond Silos," 1, 4.

[73] Parrott and Meyer, "Future Landscapes," 387.

[74] See generally Canter and Atkinson, "Adaptive Management with Integrated Decision Making."

[75] Newell and others, "The Psychology of Environmental Decisions," 454, 458. See also Section 2.2.3.1.

[76] Ben Orlove and others, "Climate Decision-Making" (2020) 45 *Annual Review of Environment and Resources* 271–303, 286; National Research Council, *Using Science as Evidence in Public Policy* (National Academies Press 2012) 14–15.

[77] Urmila Jha-Thakur and Thomas B. Fischer, "25 Years of the UK EIA System: Strengths, Weaknesses, Opportunities and Threats" (2016) 61 *Environmental Impact Assessment Review* 19–26, 21; Ivar Lyhne and others, "Theorising EIA Effectiveness: A Contribution Based on the Danish System" (2017) 62 *Environmental Impact Assessment Review* 240–249, 243; John J. Loomis and Maurício Dziedzic, "Evaluating EIA Systems' Effectiveness: A State of the Art" (2018) 68 *Environmental Impact Assessment Review* 29–37, 31–32.

manipulation by proponents, and political pressure,[78] all of which underscores the importance of transparency.

Research on "actionable" or usable science suggests at least a partial antidote to this disconnect between information and action: Decision-makers are more likely to use information that is credible (scientifically adequate), salient (relevant to decision-makers' needs), and legitimate (fair, unbiased, and respectful of stakeholders).[79] These characteristics can develop through processes to "co-produce" knowledge[80] by meaningfully involving stakeholders in genuine deliberation and social learning, as opposed to one-way consultation.[81] This poses a challenge for cumulative environmental harms, however, which involve many actors. Though not impossible,[82] initiating and maintaining the involvement of many stakeholders in iterative scientific work can be expensive, time-consuming, and complex.[83] That is, it requires attention to coordination about information, discussed further later.[84]

For completeness, it is also important to note that complex, multilayered policy settings can produce a need to collect information about the regulatory landscape itself to determine gaps and weaknesses. Even understanding which interventions are available to address diverse threatening activities, and who the relevant regulators are, may be a significant task. But it is critical to evaluating whether existing mechanisms are adequate to deal with threats, or whether change is needed.[85]

[78] Erin O'Donnell and Rebecca Nelson, "Shield Science for Robust Decisions" (2020) 3 *Nature Sustainability* 675–676, 675.

[79] For a seminal article on this issue, see David W. Cash and others, "Knowledge Systems for Sustainable Development" (2003) 100 *Proceedings of the National Academy of Sciences* 8086–8091. See also Laurenz Langer, Janice Tripney and David Gough, *The Science of Using Science: Researching the Use of Research Evidence in Decision-Making* (University College London 2016) 27.

[80] Orlove and others, "Climate Decision-Making," 17; see generally Aparna Bamzai-Dodson and others, "Engaging with Stakeholders to Produce Actionable Science: A Framework and Guidance" (2021) 13(4) *Weather, Climate, and Society* 1027–1041.

[81] See generally Amanda E. Cravens and Nicole M. Ardoin, "Negotiating Credibility and Legitimacy in the Shadow of an Authoritative Data Source" (2016) 21:30 *Ecology and Society* 1–14; Nicola Ulibarri, "Collaborative Model Development Increases Trust in and Use of Scientific Information in Environmental Decision-Making" (2018) 82 *Environmental Science and Policy* 136–142.

[82] Cravens and Ardoin, "Negotiating Credibility," 10.

[83] Bamzai-Dodson and others, "Engaging with Stakeholders," 1030–1031 (the "inform" or "loading dock" approach).

[84] See Section 2.2.4.

[85] The case studies presented in Chapters 8 to 10 demonstrate approaches to collecting information about regulatory landscapes relevant to specific cumulative environmental problems.

2.2.3 *Intervening to Protect a Matter of Concern from Cumulative Harm*

Even if contributors to cumulative harm, and relevant decision-makers, meaningfully consider information about this harm, it is not a foregone conclusion that they will act to address it. Political factors and a sense of futility can discourage action. Allocating responsibilities to act among many heterogeneous contributors to harm can be ethically ambiguous. Adaptive intervention, needed to deal with uncertainty, strikes diverse challenges. This section addresses each of these issues in turn. Additional issues that arise from legal structures themselves – like the legal silos that produce fragmented, unconnected decision-making, and the cost of interventions – are addressed later in this book.[86]

2.2.3.1 Risk Perception, Futility, and Short-Termism as Barriers to Action

Although they may aggregate to cause serious harm (and putting aside the issue of shifting baselines), individually minor actions are often simply considered less serious than more dramatic single harms, which discourages action to address cumulative harms. People tend to perceive the risks of "acute hazards," that is, individual "high-energy events, which are usually of a short duration, such as cyclones and floods" differently to chronic hazards or "quiet crises," that is, "insidious and/or pervasive [hazards], commonly being of low energy and occurring over [longer] periods."[87] The latter often simply seem less important.[88] Cognitively, appreciating the aggregate risk of minor activities needs to overcome automatic assessments that a small impact caused by a familiar activity is not a threat, and relies on judging the effect of aggregating something – a type of thinking that tends not to be done well automatically.[89] Media reporting can reinforce these cognitive tendencies. While reporters flock to catastrophic environmental accidents (e.g., a supertanker oil spill), individually less dramatic cumulative effects receive little attention (e.g., the cumulatively greater amount of oil discharged annually by ships cleaning their ballast tanks).[90]

[86] See Chapter 6, Section 6.5.3.
[87] Melissa Haw, Chris Cocklin and David Mercer, "A Pinch of Salt: Landowner Perception and Adjustment to the Salinity Hazard in Victoria, Australia" (2000) 16 *Journal of Rural Studies* 155–169, 157.
[88] Ibid 166.
[89] Daniel Kahneman, *Thinking, Fast and Slow* (Penguin Books 2012) 93.
[90] Bregha, "Institutional Barriers to Environmental Information," 196.

A distinct cognitive challenge arises in cases of slowly accumulating harm that will only manifest relatively far in the future. People tend to have "cognitive myopia" and discount future consequences excessively in favor of immediate rewards or avoidance of immediate costs.[91] Indeed, policy responses that "discount the future irrationally" are considered a key feature of problems that are "super wicked."[92]

Even where an actor perceives that their activity, even though relatively minor, causes cumulative harm, a sense of futility ("changing my activity would make no difference") may discourage them from changing course.[93] Countering this sense of futility is possible with structured effort. It might involve, for example, communicating an ethical duty of collective action[94] or emphasizing the symbolic benefits of acting, like "freedom and independence from foreign oil" in the case of adopting lower emission cars.[95]

Decision-making structures that emphasize the short term may reinforce the effects of cognitive myopia and feelings of futility. Decision-makers in democratic political institutions tend to focus on short electoral cycles, though short-termism also varies among nations.[96] Short-term electoral cycles discourage intervention to deal with slowly accumulating threats that impose short-term costs on constituents[97] to create spatially and temporally diffuse benefits. This can affect things such as considering climate change scenarios and long-term planned activities like timber harvesting. Countering short-termism might involve mechanisms to "'lock[] in' long-term preferences" to avoid returning to short-term considerations as time progresses;[98] shortening the

[91] Elke U. Weber, "Breaking Cognitive Barriers to a Sustainable Future" (2017) 1:0013 *Nature Human Behaviour* 1–2, 1.

[92] Kelly Levin and others,"Overcoming the Tragedy of Super Wicked Problems: Constraining Our Future Selves to Ameliorate Global Climate Change" (2012) 45 *Policy Sciences* 123–152, 128.

[93] Daniel Sperling and Deborah Gordon, *Two Billion Cars: Driving Towards Sustainability* (OUP 2009) 171–172.

[94] See generally Jonathan Crowe, "'It Makes No Difference What We Do': Climate Change and the Ethics of Collective Action" (2021) 40 *University of Queensland Law Journal* 477–490.

[95] Sperling and Gordon, *Two Billion Cars*, 171–172.

[96] Hal E. Hershfield, H. Min Bang and Elke U. Weber, "National Differences in Environmental Concern and Performance Are Predicted by Country Age" (2014) 25 *Psychological Science* 152–160; Johanna Peetz and Michael J. A. Wohl, "Perceiving Time through Group-Based Glasses: Collective Temporal Orientation" (2019) 58 *British Journal of Social Psychology* 609–629, 615.

[97] Sari Graben and Eric Biber, "Presidents, Parliaments, and Legal Change: Quantifying the Effect of Political Systems in Comparative Environmental Law" (2017) 35 *Virginia Environmental Law Journal* 357–419, 410.

[98] Levin and others, "Overcoming the Tragedy of Super Wicked Problems," 128.

perceived temporal distance by describing the cumulative problem as urgent;[99] or expressly considering the interests of future generations.[100]

2.2.3.2 Allocating Responsibility for Action, Ethical Ambiguity, and the Role of Coordination

Effectively intervening to respond to cumulative environmental harm requires comprehensively considering activities that create harm and determining whether and how to allocate responsibility for preventing or responding to harm among multiple, and potentially many, contributors. There is no single "right" answer. Risk-based cost-benefit analyses and different ethical frameworks, for example, may produce different approaches.[101] Risk analysts suggest assessing "the relative importance of each nth risk effect, the potential improvement from addressing it and the costs (including delay) of doing so."[102] Even this apparently simple approach, however, is more difficult than it seems where there is uncertainty about whether a change will lead to an improvement in the matter of concern – and cumulative impacts can involve multiple sources and kinds of uncertainty associated with multiple interacting risks, leading to compounding uncertainty.[103]

To attribute responsibility to someone who contributes to harm, ethicists tend to rely on some combination of causation, coercion (i.e., whether an actor could have acted in a different way), knowledge of consequences, intentionality, and appreciation of the moral implications of the action.[104] These factors can all be problematic for cumulative impacts, especially for individually minor impacts. Causation may be difficult to predict or prove due to complex interacting effects, and the causes of a problem may include "background" natural causes and harms with uncertain origins. Individually, small effects may not be controllable in a meaningful way (e.g., using water for basic household needs or harming the environment to undertake basic economic development) or where reducing harm requires resources that someone lacks. Complex, nonlinear systems may mean a contributor does not appreciate or intend the consequences of their

[99] Orlove and others, "Climate Decision-Making," 15.
[100] See, e.g., Iñigo González-Ricoy and Axel Gosseries (eds), *Institutions for Future Generations* (OUP 2016).
[101] Jonathan B. Wiener, "Learning to Manage the Multirisk World" (2020) 40 *Risk Analysis* 2137–2143, 2139.
[102] Ibid 2140.
[103] See generally James Rising and others, "The Missing Risks of Climate Change" (2022) 610 *Nature* 643–651.
[104] Kelly G. Shaver, *The Attribution of Blame: Causality, Responsibility and Blameworthiness* (Springer 1985) 70; see also Philip Pettit, "Responsibility Incorporated" (2007) 117 *Ethics* 171–201.

action. Cumulative environmental problems can involve the "distributed moral actions" of many individuals, where an individual action is "either not morally charged at all or below a threshold of moral relevance."[105] Though the cumulative impact is morally bad, no individual intended it, so intentionality means that no one can be held responsible.[106]

An alternative "ethics without intentionality" would attribute responsibility for the entire environmental harm to each contributor to that harm in proportion to their ability "to avoid the negative outcome," regardless of their intention, provided the contributors know that they will be held responsible, and are able to learn from, and modify, their behavior.[107] An alternative, potentially more controversial (in Western cultures) ethic of collective responsibility would address cumulative harms by making an agent or non-agential set of actors responsible for distributed morally negative actions.[108]

Public administration scholars suggest a different solution to allocating responsibility: participatory and collaborative governance (a type of coordination; see later on) makes stakeholders more likely to accept the output of a decision-making process and comply with it if their legitimate representatives are involved, especially where this occurs early, transparently, is based on clear and understandable information, and does not exclude important groups.[109] In addition, introducing regulation to address cumulative environmental problems itself is considered ethically relatively unproblematic if one accepts that regulation is justifiable if it deters unwanted behavior.[110]

2.2.3.3 Adapting Interventions, Fairness, Path Dependence, and "Single Action Bias"

To cope with their inherent uncertainty, scholars have long prescribed adaptive management (relevantly here, adaptive interventions) for problems caused by

[105] Luciano Floridi, "Faultless Responsibility: On the Nature and Allocation of Moral Responsibility for Distributed Moral Actions" (2016) 374:20160112 *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 1–13, note 11.

[106] Ibid 4.

[107] Ibid 11.

[108] For a review of the variety of ways this is conceptualized in the philosophical literature, see generally Säde Hormio, "Collective Responsibility for Climate Change" (2023) 14:e830 *WIREs Climate Change* 1–14.

[109] Jens Newig and others, "The Environmental Performance of Participatory and Collaborative Governance: A Framework of Causal Mechanisms" (2018) 46 *Policy Studies Journal* 269–297, 291.

[110] Pettit, "Responsibility Incorporated," 175–176.

diverse and dispersed sources that interact in complex ways,[111] with the exception of problems involving "extreme existential risks" that are too rare and devastating to learn from.[112] However, this is confounded by ethical, economic, and psychological barriers to adapting the duties imposed on contributors to harm. Jurisdictions that seek to improve their laws to better deal with cumulative environmental problems are also adapting those laws and will strike similar barriers.

Countering adaptation, fairness can be perceived as requiring finality of decisions, certainty, and respect for settled expectations.[113] If new information or ideas about what matters or the effectiveness of existing interventions produces new responsibilities or restrictions, and possibly new costs, this can be perceived as unfair and support political obstruction on this basis. On the other hand, shared decision-making (i.e., coordination), transparency, and forms of popular accountability and conflict resolution can help increase legitimacy.[114]

Other factors can also make it difficult to adapt interventions. Path dependence means that past choices constrain future change due to experience, sunk costs, and vested interests.[115] Adaptive management requires iterative decision-making, but "single action bias" means that psychologically, decision-makers feel less worried after they take an initial action, even where "a portfolio of protective actions might have been advisable."[116] Risk aversion in decision-makers and other bureaucratic factors within and between government agencies further discourage adaptive management.[117]

2.2.4 *Coordinating among Governments and with Stakeholders*

The foregoing discussion has already alluded to the critical role of interactions between governments and stakeholders – those affected by and contributing to

[111] E.g., Walters, *Adaptive Management*, 333–354; Jones, "Cumulative Effects Assessment," 192, 196; Canter and Atkinson, "Adaptive Management with Integrated Decision Making"; J. B. Ruhl, "Regulation by Adaptive Management – Is It Possible?" (2005–2006) 7 *Minnesota Journal of Law Science and Technology* 21–57, 22–23.

[112] Wiener, "Learning to Manage the Multirisk World," 2140.

[113] Jonathan H. Adler, "Dynamic Environmentalism and Adaptive Management: Legal Obstacles and Opportunities" (2015) 11 *Journal of Law Economics and Policy* 133–162, 154.

[114] Robin Kundis Craig and others, "Balancing Stability and Flexibility in Adaptive Governance: An Analysis of Tools Available in U.S. Environmental Law" (2017) 22(2):3 *Ecology and Society* 1–15, 7.

[115] Daniel Rosenbloom, James Meadowcroft and Benjamin Cashore, "Stability and Climate Policy? Harnessing Insights on Path Dependence, Policy Feedback, and Transition Pathways" (2019) 50 *Energy Research and Social Science* 168–178, 170–171.

[116] Elke U. Weber, "Experience-Based and Description-Based Perceptions of Long-Term Risk: Why Global Warming Does Not Scare Us (Yet)" (2006) 77 *Climatic Change* 103–120, 116.

[117] Walters, *Adaptive Management*, 23, 30–32.

a cumulative environmental problem – and between governments engaged in a cumulative environmental problem. I use the generic term "coordination" to describe this interaction, intending it to flexibly embrace interactions of various types, from willing partnerships to dispute resolution among antagonists. Chapter 7 expands on this to cover links between laws that may not involve the direct interaction of actors; hence, I do not use the overarching term "collaboration," used in some other fields. This section expands on these rationales for coordination and explores barriers to coordination that stem from the inherent nature of cumulative environmental problems.

2.2.4.1 Coordination Is Needed to Respond to Cumulative Environmental Problems

As discussed earlier, the need for coordination arises in relation to conceptualizing the matter of concern because it involves value-rich decisions that often inherently affect people as part of the matter of concern and because coordination is needed to avoid incoherence in subjective decisions about what and who matter. The need for coordination with stakeholders and governments arises in relation to information because they hold knowledge and data that are important to understand the problem, because monitoring small activities can raise concerns that coordination can address, and because involving them creates opportunities for deliberation and learning that can make decisions more likely to be accepted. And the need for coordination arises in relation to intervention to address and head off ethical quandaries, enhance the legitimacy of decisions, and deal with the lack of a clear way to allocate and adapt responsibilities to act to address cumulative harms.

Coordination is also required for wider reasons related to these functions. Theories in the fields of public policy, public administration, and economics that analyze the distribution of regulatory authority in space show that environmental regulatory authority is often layered, overlapping, controversial, and dynamic between levels of government.[118] This means that intergovernmental coordination is required for sustainable management in general.[119]

Even where relevant regulatory competencies are not formally shared, cumulative environmental problems involve "unavoidable interdependencies" – they

[118] It is beyond the scope of this chapter to review the theories and numerous analytical concepts developed by the relevant disciplines in detail. For a useful review, see: Philipp Trein, Iris Meyer and Martino Maggetti, "The Integration and Coordination of Public Policies: A Systematic Comparative Review" (2019) 21 *Journal of Comparative Policy Analysis: Research and Practice* 332–349.

[119] E.g., Levin and others, "Overcoming the Tragedy of Super Wicked Problems," 127–128.

concern multiple levels of government simultaneously[120] as well as multiple actors at a single level. This produces a need for coordination. Government actors may be relevant to addressing a cumulative environmental problem because they perform a function that relates to an activity or impact that creates a harm or a benefit to a matter of concern. The cumulative harm may also extend horizontally or vertically across the geographic jurisdiction of multiple governments or governing arrangements, for example, air pollution extending across local, subnational, or national boundaries.

Multilevel governance scholars note that "cumulative outcomes of local phenomena create global problems" and "serious global trends," such as proliferating infrastructure, pollution, and resource use and their environmental effects.[121] They argue that cumulative effects counsel higher-level governance "to enhance understanding of a problem" and access scientific information; but, in addition, ensuring finer-grained local understanding of a problem and using legitimate, trusted, and effective local "problem-solving institutions" requires lower-level governance.[122] In other words, coordination between levels can harness "problem solving synergy" between "the unique governance capacities of local and national actors."[123]

Conversely, failing to coordinate carries risks: Overlapping regulatory actors may take different approaches to conceptualization, information, and intervention that are mutually undermining or, at minimum, fail to take advantage of potential synergies.[124] Without attention, concurrent regulatory competencies

[120] Johanna Schnabel, *Managing Interdependencies in Federal Systems: Intergovernmental Councils and the Making of Public Policy* (Palgrave Macmillan 2020) 1.

[121] Joyeeta Gupta and Claudia Pahl-Wostl, "Global Water Governance in the Context of Global and Multilevel Governance – Its Need, Form, and Challenges" (2013) 18 *Ecology and Society* 1–10, 1, 3.

[122] Ibid 57; Newig and others, "Environmental Performance," 290–291; Krister P. Andersson and Elinor Ostrom, "Analyzing Decentralized Resource Regimes from a Polycentric Perspective" (2008) 41 *Policy Sciences* 71–93, 76.

[123] Erin Ryan, "Environmental Federalism's Tug of War Within" in Kalyani Robbins (ed), *The Law and Policy of Environmental Federalism: A Comparative Analysis* (Edward Elgar 2015) 355–418, 362–363.

[124] Florian Kern and Michael Howlett, "Implementing Transition Management as Policy Reforms: A Case Study of the Dutch Energy Sector" (2009) 42 *Policy Sciences* 391–408, 401, 403; Karoline S. Rogge and Kristin Reichardt, "Policy Mixes for Sustainability Transitions: An Extended Concept and Framework for Analysis" (2016) 45 *Research Policy* 1620–1635, 1626; Marie Byskov Lindberg, Jochen Markard and Allan Dahl Andersen, "Policies, Actors and Sustainability Transition Pathways: A Study of the EU's Energy Policy Mix" (2019) 48:103668 *Research Policy* 1–15, 10; Anders Branth Pedersen, Helle Ørsted Nielsen and Carsten Daugbjerg, "Environmental Policy Mixes and Target Group Heterogeneity: Analysing Danish Farmers' Responses to the Pesticide Taxes" (2020) 22 *Journal of Environmental Policy and Planning* 608–619, 616.

may result in there being no, or no effective, regulation in important respects. This may occur where one level of government comes to expect that another will act, and ceases its own environmental protection action, posing potential problems where the other level's regulation contains important omissions.[125]

Sometimes, however, duplication and redundancy provide insurance against agency capture and greater opportunity for policy experimentation and interest group input as a valuable check and balance in a politically controversial area, and a facilitator of innovation.[126] Indeed, environmental issues may be so complex, interconnected, and disrespectful of territorial boundaries that it would be impossible and undesirable to eliminate duplication.[127]

The passage of time itself produces the need for coordination, since policy layering and drift over time can create incoherent goals between agencies and levels of government.[128] Allocations of legislative authority over the environment, and the degree to which this authority is exercised by different levels, can also change due to constitutional amendment, shifting judicial interpretation, or negotiation.[129]

The insidious nature of cumulative environmental problems and accompanying risks for maintaining political salience of the problem suggest that there may also be "side benefits" from involving more regulatory actors in

[125] Sara Dillon, "The Mirage of EC Environmental Federalism in a Reluctant Member State Jurisdiction" (1999) 8 *NYU Environmental Law Journal* 1–73, 13–15.

[126] Robyn Hollander, "Rethinking Overlap and Duplication – Federalism and Environmental Assessment in Australia" (2010) 40 *Publius* 136–170, 137, 139, 153–156; Gupta and Pahl-Wostl, "Global Water Governance," 55; Andersson and Ostrom, "Analyzing Decentralized Resource Regimes from a Polycentric Perspective," 76; Erin Ryan, "Negotiating Environmental Federalism: Dynamic Federalism as a Strategy for Good Governance" (2017) *Wisconsin Law Review* 17–39, 37; Barbara A. Cosens and Craig A. Stow, "Resilience and Water Governance: Addressing Fragmentation and Uncertainty in Water Allocation and Water Quality Law" in A. S. Garmestani and C. R. Allen (eds), *Social-Ecological Resilience and Law* (Columbia University Press 2014) 142–175, 156–157; Florian Brossette, Claudia Bieling and Marianne Penker, "Adapting Common Resource Management to Under-use Contexts: The Case of Common Pasture Organizations in the Black Forest Biosphere Reserve" (2022) 16 *International Journal of the Commons* 29–46, 38.

[127] Hollander, "Rethinking Overlap," 151–153.

[128] Kern and Howlett, "Implementing Transition Management," 395–397; Michael Howlett, Ishani Mukherjee and Jeremy Rayner, "Understanding Policy Designs over Time: Layering, Stretching, Patching and Packaging" in Michael Howlett and Ishani Mukherjee (eds), *Routledge Handbook of Policy Design* (Taylor & Francis 2018) 136–144, 137–138.

[129] Lee Godden and Jacqueline Peel, *Environmental Law: Scientific, Policy and Regulatory Dimensions* (OUP 2010) 127; Roderic O'Gorman, "Environmental Constitutionalism: A Comparative Study" (2017) 6 *Transnational Environmental Law* 435–462, 437; Ryan, "Negotiating Environmental Federalism," 37. Section 7.2.1 describes this issue in more detail.

coordinated efforts, as "norm sustainers."[130] If short-term political factors do not favor continued attention to a cumulative environmental problem by one regulatory actor, others may sustain attention to it. Peer pressure, including from a politically independent actor, may persuade a recalcitrant actor to act[131] and one actor may step in to compensate for another's inaction.[132] Within a single national jurisdiction, this might mean involving more levels of government or involving other bodies that can act as quasi-regulators (a type of coordination). It might also mean allowing more regulators or others to intervene. Empirically, greater coordination between policy officers and political actors can also encourage action to deal with cumulative harms.[133]

2.2.4.2 Barriers to Coordination

Despite this need for coordination, the characteristics of cumulative environmental problems suggest coordination is unlikely to emerge organically among contributors to a problem, nor among the multiple agencies and levels of government relevant to addressing it. I take these in turn.

Cumulative environmental problems lack characteristics that make collective action likely, and have characteristics that discourage collaboration. Common pool resources research has shown that stable self-governance through collective action emerges where the "user group" and boundaries of a resource are clearly defined, monitoring is undertaken in a way that is accountable to resource users, and where most individuals affected by operational rules can participate in modifying them.[134] This tends to suggest a resource that is relatively small, local scale, and managed by a relatively homogeneous user group.[135] Collaborative governance literature suggests that dense networks of linked organizations create social capital, relatively balanced power relations, and relationships of trust, which, among other factors,

[130] See generally Sharmila L. Murthy, "States and Cities as 'Norm Sustainers'" (2019) 37 *Virginia Environmental Law Journal* 1–51.

[131] See, e.g., Chapter 9 (Great Barrier Reef), Section 9.3.1.

[132] Todd S. Aagaard, "Regulatory Overlap, Overlapping Legal Fields, and Statutory Discontinuities" (2011) 29 *Virginia Environmental Law Journal* 237–303, 292–294.

[133] Elena Bondarouk, Duncan Liefferink and Ellen Mastenbroek, "Politics or Management? Analysing Differences in Local Implementation Performance of the EU Ambient Air Quality Directive" (2020) 40 *Journal of Public Policy* 449–472, 467.

[134] Frank Van Laerhoven, Michael Schoon and Sergio Villamayor-Tomas, "Celebrating the 30th Anniversary of Ostrom's Governing the Commons: Traditions and Trends in the Study of the Commons, Revisited" (2020) 14 *International Journal of the Commons* 208–224, 219 (citing Ostrom's design principles).

[135] Noting that there is increasing interest in larger-scale studies of common pool resources: ibid, 221.

promote the initiation of collaboration, whereas uncertainty and a lack of incentives (like a law requiring collaboration), discourage it.[136] By contrast, cumulative environmental problems involve larger scales and diverse contributors who do not necessarily or naturally share the same goals.[137] The problem may even escape the "physical control or even the knowledge of community-based resource management."[138] Heterogeneity among stakeholders can increase distrust, making coordination difficult.[139] The importance of formal rules increases with "larger, more complex, and more prolonged" problems[140] – all characteristics of cumulative environmental problems.

Formalizing supportive frameworks for coordination involving stakeholders secures the opportunity for ongoing, iterative engagement.[141] Indeed, the idea that cumulative environmental problems engage the shared responsibility of multiple actors and the need for a collaborative response between government, different industry sectors, and Indigenous Peoples appears in diverse principles, policies, and guides for cumulative effects assessment.[142]

Effective coordination between different agencies and levels of government to deal with a cumulative environmental problem is similarly unlikely to

[136] Kirk Emerson and Tina Nabatchi, "Initiating Collaborative Governance: The System Context, Drivers, and Regime Formation" in Kirk Emerson and Tina Nabatchi (eds), *Collaborative Governance Regimes* (Georgetown University Press 2015) 39–56, 42–49.

[137] Carol M. Rose, "Ostrom and the Lawyers: The Impact of Governing the Commons on the American Legal Academy" (2011) 5 *International Journal of the Commons* 28, 36–37.

[138] Ibid 37.

[139] Arvind Lakshmisha and Andreas Thiel, "Legitimacy, Shared Understanding and Exchange of Resources: Co-Managing Lakes Along an Urban–Rural Gradient in Greater Bengaluru Metropolitan Region, India" (2023) 71 *Environmental Management* 523–537, 534.

[140] Tanya Heikkila and others, "Collaboration Dynamics: Principled Engagement, Shared Motivation, and the Capacity for Joint Action" in Kirk Emerson and Tina Nabatchi (eds), *Collaborative Governance Regimes* (Georgetown University Press 2015) 57–80.

[141] Ibid 58–64 ("principled engagement" requiring iteration through phases of discovery, definition, determinations, and deliberation).

[142] E.g., Canadian Council of Ministers of the Environment, "Canada-Wide Definitions and Principles for Cumulative Effects" (2014) 1, https://ccme.ca/en/res/cedefinitionsandprinciples1.oe.pdf; "Navigating the Implementation Impasse: Enabling Interagency Collaboration on Cumulative Effects" (July 2019) Aotearoa Cumulative Effects (ACE) Framework, 8, www.sustainableseaschallenge.co.nz/tools-and-resources/ace-framework/; Department of Planning and Environment (NSW), "Cumulative Impact Assessment Guidelines for State Significant Projects" (October 2022) 13, www.planning.nsw.gov.au/sites/default/files/2023-03/cumulative-impact-assessment-guidelines-for-ssp.pdf; Pablo Cardinale, Lorne Greig and Patricia Miller, "Good Practice Handbook: Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets" (International Finance Corporation, 2013) 48, www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/publications/publications_handbook_cumulativeimpactassessment.

emerge by itself. Cumulative environmental problems likely lack important features that promote governmental coordination. These features include leaders who perceive that their interests are served by incurring the "high … transaction costs of initiating a collaborative effort," a starting appreciation of the salience of the issue among all participants,[143] and a shared set of "policy-core beliefs," such as common "policy-related values and perceptions about whose welfare counts, the relative authority of governments and markets, the proper roles of the general public, elected officials, civil servants, experts, and the relative seriousness and causes of policy problems."[144] Regulators tend to focus on single risks due to "mission-driven agencies, sometimes with narrow legal authority; fragmented institutions, with separate specialized domains … and the omitted voices of those affected."[145]

While cooperative networks can help better understand the nature of problems and identify and facilitate implementing solutions,[146] voluntary collaboration is unlikely to arise under conditions where parties have conflicting interests, lack trust and mutual commitment,[147] or even knowledge of who all the relevant parties are. The nature of cumulative environmental problems makes it more likely that these conditions will occur, partly because of the numbers of government actors involved and the difficulty of even forming relationships in the first place. In addition, where information is power, agencies at a single level of government or between levels of government may "hoard" it.[148] Collaborative governance also presents the challenge of sustaining participation through time,[149] which is particularly important where impacts accumulate incrementally. Indeed, the "turbulence" of the public sector can make it hard to sustain collaborative approaches,[150] and the

[143] Kirk Emerson, Tina Nabatchi and Stephen Balogh, "An Integrative Framework for Collaborative Governance" (2012) 22 *Journal of Public Administration Research and Theory* 1–29, 9.

[144] John C. Calanni and others, "Explaining Coordination in Collaborative Partnerships and Clarifying the Scope of the Belief Homophily Hypothesis" (2014) 25 *Journal of Public Administration Research and Theory* 901–927, 904, citing Paul A. Sabatier and Hank C. Jenkins-Smith, "The Advocacy Coalition Framework: An Assessment" in Paul A. Sabatier (ed), *Theories of the Policy Process* (Westview, 1999) 117.

[145] Wiener, "Learning to Manage the Multirisk World," 2139.

[146] Head and Alford, "Wicked Problems," 725–728 (citations omitted).

[147] Ibid 727–728.

[148] B. Guy Peters, "Information and Governing: Cybernetic Models of Governance" in David Levi-Faur (ed), *The Oxford Handbook of Governance* (OUP 2012) 113–128, 123.

[149] Neil Gunningham and Cameron Holley, "Next-Generation Environmental Regulation: Law, Regulation, and Governance" (2016) 12 *Annual Review of Law and Social Science* 273–293, 284.

[150] Head and Alford, "Wicked Problems," 728.

sheer difficulty and resource intensity of collaboration in this setting leads some scholars to urge public managers: "don't do it unless you have to."[151]

2.3 SYNTHESIS: THE NEED FOR RULES AND DESIGN FEATURES

Collectively, the many disciplinary insights outlined earlier both demonstrate the desirability of a rule-based (regulatory) approach to cumulative environmental problems and inform the design of rules to deal with these problems. This aligns with calls for stronger legal approaches in the cumulative effects assessment literature,[152] and points to key functions that those rules should support. In relation to coordination in multilevel natural resources contexts, resilience theorists similarly argue that governance should involve explicit written legal requirements, frequent information sharing, adequate local resources, harmonized methods and regulations, and formal structures that build on existing informal networks.[153]

Table 2.1 summarizes the key challenges indicated by the earlier discussion, and how they suggest that rules would be beneficial, as well as the key design features to which they point. These form a starting point for the discussions that each of the CIRCle Framework function chapters (Chapters 4 to 7) continues, developing and illustrating desirable design features.

2.4 THE CIRCLE FRAMEWORK OF REGULATORY FUNCTIONS

The earlier discussion has produced four deductively derived functions for laws to undertake to help address the inherent difficulties posed by cumulative environmental problems. Focusing on legal functions is an established way to analyze and compare laws across diverse jurisdictions and legal subject matters.[154] It also aligns with existing scholarship that seeks to understand

[151] Chris Huxham and Siv Vangen, *Managing to Collaborate: The Theory and Practice of Collaborative Advantage* (Routledge 2013) 13.

[152] E.g., Hodgson, Halpern and Essington, "Moving Beyond Silos," 3; Noble, Liu and Hackett, "The Contribution of Project Environmental Assessment," 544; Therivel and Ross, "Cumulative Effects Assessment: Does Scale Matter?," 372.

[153] Cosens and Stow, "Resilience and Water Governance," 161–162.

[154] Catherine Valcke and Matthew Grelette, "Three Functions of Function in Comparative Legal Studies" in Maurice Adams and Dirk Heirbaut (eds), *The Method and Culture of Comparative Law: Essays in Honour of Mark Van Hoecke* (Hart 2014) 99; Elizabeth Fisher and others, "Maturity and Methodology: Starting a Debate about Environmental Law Scholarship" (2009) 21 *Journal of Environmental Law* 213–250, 242–243 (calling for the development of such comparative approaches). See also Section 1.2.1, note 25 and accompanying text.

TABLE 2.1 *Challenges to addressing cumulative environmental problems and implications for regulatory responses*

Why is it hard to address cumulative environmental harms?	Formal rules can help because they can...	Rules should be designed to...
Function 1: Conceptualization		
Adequately articulating what we care about protecting from cumulative harm is complex: It has multiple dimensions (e.g., the place of people in the matter of concern, spatial boundaries, the influence of time on acceptable conditions, and the limits of acceptable change) and involves subjective, value-rich decisions – there is no objectively correct answer	Ensure the required dimensions of conceptualization are articulated, and that this occurs in a transparent way	Facilitate clearly and transparently conceptualizing the matter of concern
Incoherently conceptualizing a matter of concern between regulatory actors can obstruct effective responses to cumulative environmental problems, but intentional adaptive change in a conceptualization may be needed over time	Encourage coherence in how a matter of concern is conceptualized through time and between actors	Provide for coordination between actors relevant to conceptualization, including coordination to adapt a conceptualization
Function 2: Information		
Perceiving gradual change to a matter of concern without data is difficult, and risks shifting baselines	Require information collection to avoid shifting baselines	Provide for long-term, ongoing collection of comparable data about the matter of concern
Collecting data about matters of concern and numerous threats can be costly and collecting and sharing it can encounter commercial, community and political resistance	Apply data collection and sharing incentives or mandates, with appropriate safeguards, to counter disincentives	Provide for comprehensive data about threats that may be cumulatively significant; address cost and other concerns about collecting, sharing and analyzing data in a structured way

Why is it hard to address cumulative environmental harms?	Formal rules can help because they can…	Rules should be designed to…
With many actors involved, data are unlikely to be collected in a way that makes them comparable and interoperable, nor shared and aggregated to reveal aggregate harm, without formalized arrangements	Facilitate interoperability and aggregation through "FAIR" data collection standards and allocation of responsibility for aggregation/analysis	
Predicting future cumulative conditions may make models desirable and uncertainty unavoidable; uncertainty discourages take-up of information and can allow for inappropriate manipulation of models	Require relevant contributors to harm and decision-makers to engage with complexity and uncertainty in a transparent way	Provide for coordination between relevant actors regarding information and models
Function 3: Intervention		
Risk perception, a sense of futility and short-termism can obstruct individual and decision-maker responses to individually minor and slowly accumulating harms	Supply incentives or mandates to address threats	Address threats comprehensively, including individually minor but collectively significant threats
It can be unclear and ethically ambiguous how to allocate responsibility to act among many actors, including those that cause individually minor impacts and lack relevant information or resources	Supply elements that are ethically required for intervention, such as information about causation and consequences of actions, or resources, e.g., through incentives	
Complex, uncertain problems require adaptive management of interventions, but adaptation strikes challenges related to fairness, path dependence and "single action bias"	Structure decision points for adaptation	Expressly address fairness concerns

(*continued*)

TABLE 2.1 (*continued*)

Why is it hard to address cumulative environmental harms?	Formal rules can help because they can...	Rules should be designed to...
Function 4: Coordination of conceptualization, information, and intervention		
Coordination between government and stakeholders is needed to respond to cumulative environmental problems in relation to each foregoing function, but heterogeneity of stakeholders can create distrust and sustaining interaction can be challenging	Supply institutionalized structures for coordination involving diverse stakeholders and governments	In undertaking conceptualization, information and intervention, establish and maintain links among governments and stakeholders; and provide for resolving disputes
Coordination between governments is needed to avoid mutually undermining approaches, duplication, and policy gaps, but is unlikely to arise organically or be easy to sustain	Support the initiation and maintenance of coordination between governments	

multilevel governance by reference to regulatory functions.[155] Focusing on functions also facilitates connecting with disciplines and areas of practice that tend to focus on particular functions, say, information in the case of ecology and coordination in the case of multilevel governance scholarship.

Summarizing, then, the "CIRCle" Framework (Figure 2.1) comprises four key legal functions that encompass, respectively, formal mechanisms to support:

(1) Clearly and coherently **conceptualizing** the matter of concern that is the focus of protection or restoration, including the threshold conditions beyond which effects are unacceptable;

[155] Alejandro E. Camacho and Robert L. Glicksman, "Designing Regulation across Organizations: Assessing the Functions and Dimensions of Governance" (2021) 15(S1) *Regulation and Governance* S102–S122, S106.

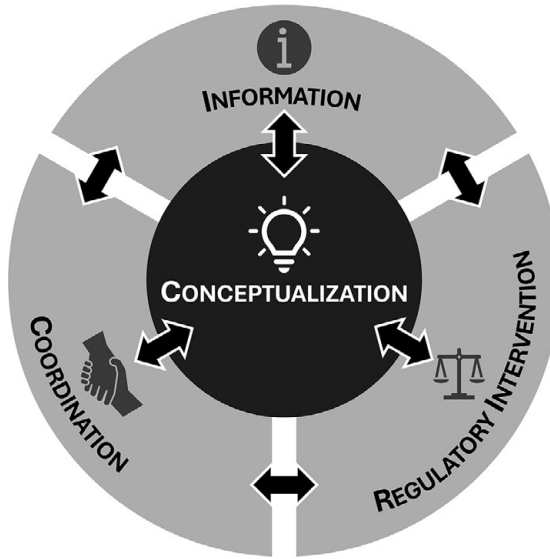

FIGURE 2.1 The CIRCle Framework: Integrated legal functions for responding to cumulative environmental problems

(2) Collecting, sharing, aggregating, and analyzing **information** about past and present environmental conditions, threats and expected future environmental conditions, taking into account the effects of multiple diverse activities and interpreting the acceptability of their cumulative effects, and the adequacy of interventions to deal with threats;
(3) **Intervening** to influence the behavior of contributors to cumulative harm to prevent or remedy unacceptable effects, or harness direct state action to do so; and
(4) **Coordinating each of the foregoing functions** between and across levels of government, and with nongovernment actors, including to resolve disputes.

Legal mechanisms that support these functions might be distributed among different individual laws, so it is necessary to think of the set of relevant laws – here termed the legal "landscape" for responding to cumulative environmental problems – as a whole. Chapter 3 sketches a wide range of areas of law that may be relevant to a cumulative environmental problem.

The CIRCle Framework recognizes that these functions interact with each other (Table 2.1; arrows, Figure 2.1) – they are *integrated*. The way that a matter of concern is conceptualized should translate into arrangements for collecting and sharing information about it, intervening in response to

information that unacceptable cumulative harm to it has occurred or may occur, and coordinating government and nongovernment actors in relation to these things. Chapters 4 to 7 elaborate on links between CIRCle Framework functions.

Risks arise if the landscape of laws omits a function. For example, laws might involve effective *coordination* between jurisdictions to gather *information* about cumulative harms to a clearly and coherently *conceptualized* matter of concern against clearly defined threats. However, these laws may not produce an effective regulatory response if they do not integrate with mechanisms for *intervention*. Having aggregated information about a matter of concern might fail to protect it from cumulative harm if agencies lack authority to *intervene* to stop undesirable harm.

Regulatory mechanisms intended to perform the CIRCle Framework functions will have the greatest chance of doing so effectively if they include design features that address important challenges to addressing cumulative environmental problems indicated by diverse disciplines (Table 2.1). Chapters 4–7 elaborate on these design features and illustrate them with legal examples from around the globe.

Challenges related to introducing, implementing, and enforcing laws are highly jurisdiction-specific, reflecting varying conditions related to political structure and function,[156] funding, and surrounding legal structures to mention a few. Since this makes generalizing legal solutions to these challenges difficult, if not impossible, discussion of functions proceeds by way of diverse examples to illustrate individual functions, and discussion of combinations of mechanisms through case studies (Chapters 8–10).[157]

Finally, a caution and a disclaimer. While formal rules have a unique and important role to play, they are unlikely to be the whole solution to cumulative environmental problems, not least because introducing, implementing, and enforcing them is rarely straightforward, trouble-free, and comprehensive. Cumulative environmental problems are so difficult that many strategies are likely to be necessary to address them.[158] Focusing on formal rules is also not to discount the importance of nonregulatory actors and the actions of regulatory actors that are not expressly foreseen by legal rules. But formal rules are inescapably part of the picture of addressing cumulative environmental problems – not only as part of the solution but because, without good design, rules

[156] Graben and Biber, "Presidents, Parliaments, and Legal Change," 368, 401–404, 406–407.

[157] For an explanation of the approach to selecting illustrative examples and major case studies, see Section 1.2.3.

[158] Robert N. Stavins, "The Problem of the Commons: Still Unsettled after 100 Years" (2011) 101 *The American Economic Review* 81–108, 102.

may also be part of the problem. Regulations have the potential to reinforce some of the challenges described here, for example, where rules in different places conceptualize shared environmental problems in an incoherent way or provide for interventions that counteract one another. Unless regulatory systems are established with cumulative effects in mind, they may inadvertently facilitate cumulative harm.