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Too Complex to Fail: The Stability of Global Environmental Governance Beyond Hegemony

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ABSTRACT

The recent US disengagement from global governance has revived concerns—first theorized in the 1970s and 1980s—about the vulnerability of international institutions to hegemonic decline. While these concerns appear valid in many issue areas, the global environmental regime complex presents a notable exception. Unlike more centralized global governance structures, it has a high degree of complexity and this characteristic enhances its capacity to absorb shocks, including the withdrawal of US leadership. In hindsight, it may be fortunate that proposals to centralize global environmental governance, such as the creation of a World Environmental Organization, never materialized. Complexity, once viewed as a weakness of global environmental governance, may now prove to be its greatest strength in an era of geopolitical turbulence.

1 | Will Global Governance Systems Survive the US Disengagement?

As the United States retreats from global governance, questions first raised in the 1970s and 1980s, when its hegemony appeared to wane, are resurfacing with a vengeance. Chief among them is whether international institutions can endure the erosion of hegemonic leadership. As Robert Keohane asked in his seminal *After Hegemony*: "Can cooperation take place without hegemony and, if so, how?" (Keohane 1984, 9). Although it is now primarily the US willingness, rather than its capacity, to lead that is in decline, the two are closely interconnected, and the resulting disengagement threatens institutional stability at least as much as it did in the 1980s.

Since Keohane first posed this question, scholars have made significant progress in their theoretical understanding of international institutions. Early debates on hegemonic stability theory adopted an atomistic view of international regimes, treating them as isolated and independent from one another. This atomistic perspective was even part of the initial appeal of the concept of "regime", as it broke with the all-encompassing scope of concepts like the "international system". However, this assumption of independent regimes has since been rejected. It is now well established that regimes are embedded within broader "regime complexes", which are structures composed of interrelated and overlapping institutions (Raustiala and Victor 2004). More recently, scholars have begun to explore variation within regime complexes, including their varying degrees of complexity (Alter and Meunier 2009), a variable absent from the classic debates on hegemonic stability theory.

We argue that complexity can moderate the impact of declining hegemony on institutional stability. We illustrate this claim by examining the global environmental regime complex, one of the regime complexes with the highest degree of complexity. While the US may paralyze the World Trade Organization (WTO), place the World Health Organization under financial strain, coerce the United Nations Educational, Scientific, and Cultural Organization into changing its policy toward Palestine, and pressure North Atlantic Treaty Organization members toward greater self-reliance, it cannot exert the same level of influence over an entire regime complex, particularly not one as institutionally diverse and decentralized as the environmental

regime complex. Although the US played a leadership role in establishing some environmental institutions, the structure of this regime complex suggests it is well positioned to adapt to a political context marked by US disengagement. Even as the Trump Administration openly expresses its aversion to environmental regulations, the global environmental regime complex is likely to display greater stability than more centralized complexes.

The rest of the paper is divided into six sections. The first discusses the variable of complexity. The second operationalizes this variable to characterize the global environmental regime complex. The third and fourth explain how the complexity of the global environmental regime complex increases its potential for adaptation. The fifth revisits the debate over the centralization of global environmental governance and argues that adaptability to hegemonic withdrawal has been an overlooked benefit of complexity. The last section concludes.

2 | From Complexes to Complexity

It is necessary to clarify the concepts of regime complexes and complexity. Both terms are increasingly used in international relations and are central to this paper. However, they originate from different theoretical traditions and refer to distinct phenomena.

Raustiala and Victor (2004) coined the term "regime complex" to describe an array of partially overlapping institutions governing a specific issue area. A regime complex is a structure composed of elemental institutions, which may be formal or informal, public or private, multilateral or regional (Abbott and Faude 2022). These institutions interlock through shared mandates and overlapping memberships. The concept is compelling because it moves beyond the assumption that institutions are created and operate in isolation. Instead, it emphasizes that institutions are embedded in broader governance structures. Building on this insight, scholars have examined regime complexes across a range of issue areas, including energy (Colgan et al. 2012), human trafficking (Gómez-Mera 2016), finance (Henning 2019), and Antarctica (Green 2022).

In contrast, complexity characterizes systems in which collective behavior emerges from interactions among multiple elements, even in the absence of hierarchical control (Mitchell 2009). The defining feature of complex systems is that the whole is not reducible to the sum of its parts (Jervis 1998). Classic examples include market economies, bee colonies, and jazz bands. In each case, no central authority directs the behavior of individual actors, be they market agents, bees, or musicians, yet their actions adjust to one another, producing emergent outcomes such as economic growth, swarm intelligence, and musical harmony.

Complexity scholars distinguish complex systems from those that are merely complicated. A car is complicated but not complex. It consists of many components, and its mechanics may be difficult to understand, but it can be analyzed by decomposing it into its parts. Unlike a stockholder responding to market trends, a bee adjusting to a swarm, or a saxophonist reacting to a trumpet player, a car's parts do not dynamically adapt to one another. Complicated systems are reducible, linear, and predictable, whereas complex systems are emergent, non-linear, and self-organizing. They seem to have a life of their own.

Few studies occupy the overlapping space between the literatures on regime complexes and complex systems (Alter and Meunier 2009; Green 2013; Kim 2013). Despite occasional conflation, these concepts have generated distinct bodies of scholarship. Most regime complex research is grounded in institutionalist theory and focuses on processes such as forum shopping (Morse and Keohane 2014), institutional competition (Kijima and Lipscy 2023), or orchestration (Abbott and Snidal 2010; Hofmann et al. 2025). Conversely, studies applying complexity thinking to international relations tend to pay little attention to institutions. Instead, they examine how order emerges in an anarchic system through repeated interactions among international actors (Bousquet and Curtis 2011; Gunitsky 2013; Jervis 1998; Kavalski 2007; Rosenau 1970).

Yet some regime complexes exhibit the defining features of complex systems. Complex (but not necessarily complicated) regime complexes consist of multiple heterogeneous institutions that operate without central coordination and whose interactions generate system-level properties. These institutions respond to one another's behavior and collectively give rise to emergent patterns of coordination. Before advancing the argument that regime complexes with these features are more likely to adapt to the US disengagement than centralized institutional arrangements, the following section demonstrates that the global environmental regime complex is one such system.

3 | The Global Environmental Regime Complex as a Complex System

Regime complexes vary in their degree of complexity. Although there is no universally accepted measure of complexity, complex systems typically consist of dense networks of diverse elements organized into multiple clusters (Kim 2020). Their degree of complexity tends to increase with the multiplicity, heterogeneity, and interconnectivity of the nodes that comprise them.

For the purposes of this paper, the representation of the global environmental regime complex is limited to intergovernmental agreements. In practice, many other institutional forms are integral to this regime complex, including city networks, public-private partnerships, private regulatory schemes, scientific forums, transnational initiatives, and civil society coalitions (Abbott and Faude 2022; Green 2013). Nonetheless, since this paper examines the potential impact of the US retreat from global leadership, it is appropriate to focus on the institutional form that relies most heavily on state action. It is also reasonable to assume that other institutional forms are less likely to be harmed by the US disengagement. Some may even be revitalized, as several American cities, states, NGOs, businesses, universities, and foundations plan to increase their investment in global environmental governance, partly to compensate for diminished federal leadership (Bomberg 2017).

The global environmental regime complex includes at least 2333 bilateral and 606 multilateral treaties (Mitchell et al. 2020). While the number of new agreements peaked in the

1990s, new ones continue to be concluded each year, covering a wide range of interconnected issues from fisheries to oil spills and from migratory birds to e-waste trade. Recent examples include the 2023 Agreement on the Conservation and Sustainable Use of Marine Biological Diversity Beyond National Jurisdiction and the 2024 Treaty on Intellectual Property, Genetic Resources and Associated Traditional Knowledge. This ongoing proliferation has led some analysts to describe the situation as "treaty congestion" (Anton 2012; Hicks 1998).

Importantly, no central authority coordinates these treaties. The United Nations Environment Programme (UNEP) is widely considered weak, decentered, and underfunded (Ivanova 2021). It administers only a small fraction of multilateral agreements and does not oversee some of the most important ones, such as the Framework Convention on Climate Change (UNFCCC), the Ramsar Convention on Wetlands, and the Convention on the Law of the Sea. Other UN agencies, including the Food and Agriculture Organization (FAO), the International Maritime Organization, the International Atomic Energy Agency, and the United Nations Economic Commission for Europe, also host environmental treaties. In fact, most of the 606 multilateral environmental agreements are administered outside the UN system. As a result, there is no single assembly, executive secretariat, or dispute settlement mechanism with overarching authority. Many treaties maintain their own legislative, administrative, and judicial functions (Biermann et al. 2009). This decentralization sharply contrasts with other regime complexes, such as those on human rights, labor standards, or intellectual property, where key agreements are housed within a central intergovernmental organization and peripheral agreements typically defer to it.

Moreover, no state serves as a substitute for a central organization to orchestrate the global environmental regime complex. Individual states may lead in some areas while remaining passive or even obstructive in others (Sprinz and Vaahtoranta 1994). The US, in particular, has played a leading role in the development of the 1973 Convention on International Trade in Endangered Species (CITES), the 1982 whaling moratorium, the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer, and, beginning in the 1990s, the inclusion of strong environmental provisions in trade agreements. Yet the US has never ratified some major environmental treaties, including the Convention on Biological Diversity, the Convention on the Law of the Sea, and the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal. In total, the US has signed 130 multilateral and 349 bilateral environmental agreements, which is fewer than France, Germany, or Sweden, but more than Canada, Brazil, or China (Mitchell et al. 2020). The US is also an important but not a dominant financial supporter of environmental cooperation, ranking between fourth and sixth in contributions to UNEP's Environment Fund from 2014 to 2024. While the US has exerted influence, it does not function as the central actor in global environmental governance. In fact, since most multilateral treaties have fewer than 15 parties and no state is party to more than one-third of them, the network does not have a clear center of gravity.

The absence of a central coordinator does not imply an absence of coordination. Rather, coordination within the global environmental regime complex is primarily bottom-up and often self-organized. Treaty bodies, such as conferences of the parties or secretariats, pursue coordination with other institutions they consider relevant. As a result, clusters emerge along geographical, thematic, and functional dimensions. For example, a partnership on forests includes 14 international organizations, such as the FAO, UNEP, and the UNFCCC secretariat. On biodiversity, a liaison group facilitates coordination among the secretariats of the Convention on Biological Diversity, CITES, the Convention on Migratory Species, the Ramsar Convention, and the World Heritage Convention.

Although these forms of coordination are often ad hoc and limited, they have emerged to manage certain types of regime interaction and spillover effects (Johnson and Urpelainen 2014). For example, the phaseout of certain ozone-depleting substances has increased reliance on alternative greenhouse gases, while many ozone-depleting substances are themselves potent greenhouse gases whose phaseout has delivered important climate cobenefits (Velders et al. 2007). Reflecting this interdependence, the UNFCCC preamble explicitly acknowledges the contributions of the Montreal Protocol. Such instances are part of a broader pattern: Kim (2013) identified over 1001 treaty citations across 747 multilateral environmental agreements, underscoring a high level of interconnectivity within the dense regime complex.

These interconnections are not necessarily established when treaties are first concluded. They unfold over time. Multilateral environmental treaties are often designed under conditions of uncertainty, and many have demonstrated the capacity to adjust to evolving circumstances, including changes in the broader regime complex in which they operate. One key adaptive mechanism is treaty amendment (Brunnée 2012; Laurens et al. 2023; Young 2010). For example, the Montreal Protocol was amended in 2016 to amplify synergies with the UNFCCC. Similarly, the 2003 Convention on the Protection and Sustainable Development of the Carpathians was amended in 2017 to incorporate commitments related to climate mitigation and adaptation. Across the regime complex, more than 800 amendments have been documented (Mitchell et al. 2020).

Moreover, at least 230 environmental treaties have established collective bodies that regularly adopt decisions (Morin et al. 2021). Some of these bodies, such as those created by the Convention for the Establishment of the European and Mediterranean Plant Protection Organization and by CITES, have each adopted over a thousand decisions. This intense normative activity has created opportunities for institutional interconnectivity. For example, at least 417 decisions from 70 non-climate-focused treaties refer to the UNFCCC, the Kyoto Protocol, or the Paris Agreement (Olivier and Morin 2025).

The adoption of amendments and decisions has facilitated the emergence of key norms across the regime complex, such as the precautionary approach, the polluter pays principle, and the principle of common but differentiated responsibilities and respective capabilities (Morin et al. 2024). These autopoietic and self-organizing processes suggest that the global environmental

regime complex functions as a complex system, displaying emergent behavior even in the absence of a central coordinating authority.

Figure 1 presents the network of a subset of multilateral environmental agreements, connected by citations in the original treaty text or subsequent decisions. It reveals a large, dense, clustered, and interconnected network, all indicators of a system with a high degree of complexity. The next section argues that this complexity mitigates the risk that the US retreat from global leadership will significantly destabilize the global environmental regime complex.

4 | Complexity Facilitates Adaptation

A system with high complexity is more likely to be adaptive than one with low complexity. The more a system has several clustered and interconnected units, the more feedback loops connect system-level changes to unit-level behavior and generate collective adaptation. Units respond to systemic changes by reshaping their interactions, collectively transforming the system's structure and dynamics.

By adaptation, we refer to reactive and evolutionary changes at the system level that allow a regime complex to maintain its core governance functions. Adaptation involves change and is distinct from resilience, defined here as the ability to return to a previous state after disruption. At the same time, adaptation presupposes a degree of stability, as radical shifts in a regime complex's fundamental principles go beyond adaptation. Importantly, adaptation does not necessarily lead to improved effectiveness or performance. A well-adapted regime complex may persist in a suboptimal equilibrium as long as it continues to fulfill its established governance functions. Our focus is on system-level adaptation, rather than stability at the level of individual institutions. Within an adaptive regime complex, some institutions may change more than others, but its core governance functions remain stable.

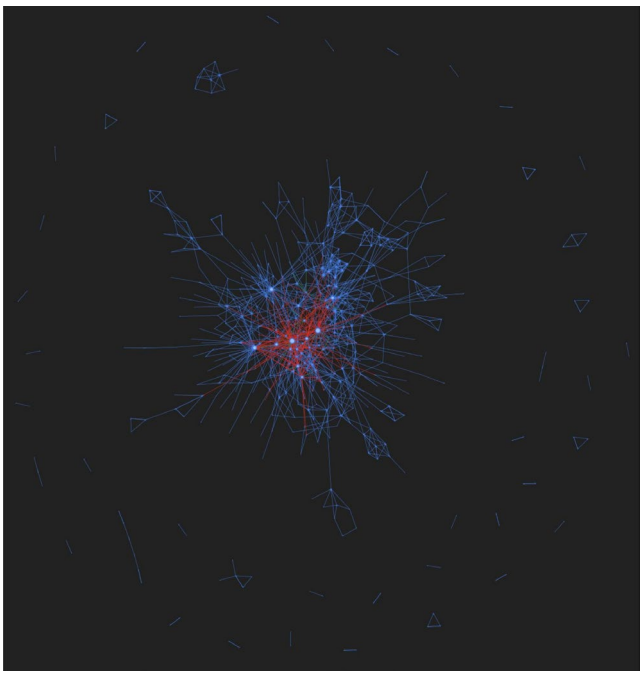

FIGURE 1 | Network of multilateral environmental agreements and COP citations. Node size reflects centrality. Blue links show citations in original treaty texts. Red links mark COP citations to treaties not cited in the original text.

The theoretical literature linking complexity to adaptation focuses on two main causal mechanisms: selection and learning (Holland 1995; Young 2010; Kim and Mackey 2013). Selection operates through differential performance in changing environments. Some elements struggle to survive, while others thrive due to certain advantageous traits. Over time, the system adapts as its least fit elements disappear and its fittest proliferate, gradually reshaping its internal composition. The second mechanism, learning, occurs through numerous small-scale trials and errors across multiple elements. Since these elements are interconnected and embedded within a complex networked structure, information spreads and successful strategies are replicated.

Both mechanisms can support the adaptation of the regime complex to the US disengagement from environmental cooperation. Some institutions, such as those with high political visibility, may recede, while others, like those favoring more proximate value chains, may prove more compatible and flourish. Institutions may also learn that certain behaviors, such as forming partnerships with private foundations or subnational entities, enhance their reach in politically hostile environments.

An additional factor contributing to the stability of the global environmental regime complex is that complex systems are difficult to capture. This does not imply that they are inherently egalitarian (Green 2022). Powerful actors are often better equipped to navigate institutional complexity and exploit opportunities for forum shopping (Drezner 2009; Morrison et al. 2019). However, it is more difficult for any actor, no matter how powerful, to control a dynamic and decentralized system than one organized around a focal institution. Complex governance systems also provide counter-hegemonic forces with pre-established channels through which to organize, coordinate, and resist, thereby bypassing the hegemon and its preferred institutions (Helfer 2004). Just as decentralized criminal networks are harder for law enforcement to dismantle than hierarchical organizations, a hegemon faces greater constraints in disrupting a complex governance system. In short, the global environmental regime complex, by virtue of its complexity, is slippery in the hands of any international actor, including a hegemon.

5 | Complexity and the Withdrawal from the Paris Agreement

The most visible action of the US government threatening the global environmental regime complex is its withdrawal from the Paris Agreement. However, the redundancies inherent in complex governance systems help mitigate the negative impacts of this withdrawal. Several environmental agreements connect nearly every pair of states, often addressing overlapping issues. As a result, even though the US has withdrawn from the Paris Agreement, it remains a party to several other

multilateral agreements, such as the Minamata Convention on Mercury and the London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter. These treaties do not attract the same level of public and presidential attention, but they play a significant role in sustaining environmental cooperation.

Moreover, the US withdrawal from the Paris Agreement has not triggered a broader cascade of political disengagement. This is partly because the Paris Agreement does not operate on a logic of direct reciprocity, unlike the trade regime complex. While diffuse reciprocity makes such systems harder to negotiate, it also renders them more adaptive when individual actors exit. In some respects, the 2017 US withdrawal even catalyzed a countervailing wave of recommitment that reinforced the Paris Agreement (von Allwörden 2025).

Importantly, the Paris Agreement and the UNFCCC are not the only multilateral institutions addressing climate change (Keohane and Victor 2016; Rowan 2021). Some institutions do not include the US, such as the Central American Convention on Climate Change or the Agreement on Climate Change, Trade and Sustainability. Others, including the World Bank and the International Renewable Energy Agency, continue to engage in climate mitigation efforts with US participation. Notably, the US remains a party to the Montreal Protocol, which is arguably the treaty with the most substantive impact on the Earth's climate (Young et al. 2021). Its 2016 amendment alone is projected to reduce global warming by up to 0.4°C by 2100 (Perry et al. 2024). The Montreal Protocol also retains significant climate mitigation potential through mechanisms such as the acceleration of reduction schedules and the inclusion of additional substances (Park et al. 2021), measures that have been taken more than twenty times in the past 35 years.

In sum, the complex interactions, redundancies, and overlaps that characterize the global environmental regime complex make it unlikely that US withdrawal from any single agreement would derail broader international cooperation on environmental issues. At least, the risk appears much reduced in the global environmental regime complex than in more centralized governance systems.

6 | Rethinking Centralization and Redundancy

In UN policy circles, two messages dominate discussions on governance architecture: the need to address institutional fragmentation through greater central coordination and the imperative to reduce wasteful redundancy. However, the complexity perspective developed in this article suggests that institutional complexity is not a weakness to be corrected, but a strength to be nurtured.

The low degree of centralization in the global environmental regime complex has long been viewed as a structural weakness. Proponents of a stronger regime complex have often envied central institutions in other domains: those with strong coordination by the US, such as the International Monetary Fund; robust enforcement capabilities, like the WTO; executive authority in times of crisis, such as the UN Security Council; or high multi-stakeholder legitimacy, as in the case of the International Labour Organization.

In the early 2000s, this framing led to calls to upgrade UNEP into a World Environment Organization. Biermann, for example, argued that "the establishment of a World Environment Organization would improve the coordination of global environmental governance" (Biermann 2007, 119). The underlying logic was to transform what is admittedly a messy system into a streamlined architecture with a clear division of labor, minimal redundancy, and limited institutional overlap (Esty 1996; Runge 2001; Whalley and Zissimos 2001; Charnovitz 2002; Biermann 2007). Essentially, the goal was to reorganize global environmental governance to resemble the bureaucratic structure of a national government. More than fifty states expressed support for the creation of a World Environment Organization.

A few systems thinkers, such as Oran Young, Adil Najam, and Peter Haas, raised objections. One of their main arguments was that a complex governance architecture is more suitable for addressing the complexity of environmental degradation. Young argued that "governing complex systems is likely to require the development of a portfolio of governance strategies" (Young 2017, 215); Najam noted that "centralization makes little conceptual sense for issues related to the environment" (Najam 2003, 378), and Haas concluded that "strong centralized institutions are fundamentally unecological" (Haas 2017, 506).

What they overlooked, however, is the strength of institutional complexity in enhancing the stability of the governance system itself. When the debate over centralization in global environmental governance took place in the early 2000s, US dominance seemed unshakable. The perceived economic decline of the 1970s and 1980s was dismissed as illusory. The idea that the US could retreat from global leadership was not factored into the debate.

Ultimately, political factors, more than theoretical arguments, sidelined proposals for a World Environment Organization. Too few actors, especially those benefiting from the existing power structure, saw sufficient interest in the project to overcome the diplomatic and administrative challenges it would entail (Vijge 2013). In retrospect, it may be fortunate that calls for greater centralization through the creation of a World Environment Organization did not materialize. Complexity, long perceived as a weakness of global environmental governance, may now prove to be one of its greatest strengths in an era of geopolitical turmoil.

7 | Conclusion

Keohane and Nye distinguished between a hegemon's capacity and willingness to maintain interstate rules (Keohane and Nye 1977). In the 19th century, the US lacked capacity; in the interwar period, it lacked willingness. Today, these conditions are intertwined: a perceived material decline is driving the US withdrawal from global governance, further eroding its ability to lead.

We are not naïve optimists: US disengagement will harm environmental cooperation, especially where cooperation depends

heavily on US participation and redundancy is thin. However, global environmental governance, by virtue of its complexity, is less likely to unravel than other regime complexes. As a complex adaptive system, it is structurally equipped to absorb shocks and reconfigure itself. Its decentralization and redundancy help preserve its core functions and normative foundations better than centralized regime complexes. Features long regarded as weaknesses, such as fragmented authority and overlapping mandates, are emerging as pillars of adaptability and stability. Just as policymakers in trade, security, and other domains have recently come to recognize the value of redundancy and diversified partnerships, the global environmental regime complex may serve not just as a counterpoint, but also as a blueprint for designing governance systems that can endure in periods of global turbulence.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available in IEADB at https://www.iea.ulaval.ca/en. These data were derived from the following resources available in the public domain: —IEADB, https://www.iea.ulaval.ca/en.

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