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Transformative Environmental Governance

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Abstract

Transformative governance is an approach to environmental governance that has the capacity to respond to, manage, and trigger regime shifts in coupled social-ecological systems (SESs) at multiple scales. The goal of transformative governance is to actively shift degraded SESs to alternative, more desirable, or more functional regimes by altering the structures and processes that define the system. Transformative governance is rooted in ecological theories to explain cross-scale dynamics in complex systems, as well as social theories of change, innovation, and technological transformation. Similar to adaptive governance, transformative governance involves a broad set of governance components, but requires additional capacity to foster new social-ecological regimes including increased risk tolerance, significant systemic investment, and restructured economies and power relations. Transformative governance has the potential to actively respond to regime shifts triggered by climate change, and thus future research should focus on identifying system drivers and leading indicators associated with social-ecological thresholds.

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Keywords

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INTRODUCTION

Planet Earth has entered a new epoch, the Anthropocene, wherein human activity has caused, and will continue to spur, significant change in the fundamental biophysics of our globe (1–3). Scientists warn that Earth systems and processes critical to supporting life may be approaching or have already crossed critical thresholds or tipping points (4, 5) that may cause ecological and social systems to undergo abrupt, surprising change (6). As the limitations of social systems to deal with these changes have become apparent—particularly in relation to managing global consumption and conservation of natural resources—new configurations of environmental governance have emerged with the explicit goal of mitigating the consequences of unpredictable and sudden change and adapting to new environmental conditions (7). Mitigation and adaptation, however, may be inadequate to ensure that nested social-ecological systems (SESs) will not collectively exceed the sustainable limits of Earth's biosphere (8, 9). Put simply, the Earth is likely changing too fast for society to mitigate or adapt, and regime shifts are expected. Thus society is faced with a choice: to passively observe these expected changes, or attempt to manage them so that the outcomes are more likely to sustain human and planetary welfare.

In this review we present transformative governance as an approach to environmental governance that has the capacity to respond to, manage, and trigger regime shifts in coupled SESs at multiple scales. Transformative governance describes governance with the capacity to shape nonlinear change in complex systems of people and nature. In contrast to adaptive governance, which has the goal of building resilience and enabling adaptive management in a desirable SES regime, the goal of transformative governance is to actively shift a SES to an alternative and inherently more desirable regime by altering the structures and processes that define the system (10). The processes of transformation require disrupting internal and external system drivers, or introducing new drivers that displace entrenched forms of environmental governance and provide space for innovation, thereby fostering fundamental, positive change in the nature of a SES. We address the potential of transformative governance, by both recognizing the characteristic of transformability of systems (10) and analyzing what is required of governance actors, networks, organizations, and institutions to actively catalyze and shape regime shifts in SESs.

In the sections that follow, we review interdisciplinary literatures contributing to the development of the concept of transformative governance to illustrate conceptual origins in theories of change in complex adaptive systems, distinguishing features between transformative and other forms of environmental governance, and potential guidance for encouraging transformative governance where appropriate. Many disciplines and subfields have contributed to the fledgling concept of transformative governance, and we attempt to capture recent and foundational literature from relevant disciplines including ecology,

sustainability science, and transition management, among others. We conclude with a proposed research agenda aimed at further synergizing theoretical conceptions of transformative governance with realistic attempts to foster shifts toward greater sustainability in nested SESs locally, regionally, and globally.

GOVERNANCE

Governance refers to the ways and means employed by society to make collective decisions, choose collective goals, and take action to achieve those goals (16). Reference to governance encompasses the relationships between government and society including the means through which private actors, markets, and interest-based networks influence policy decisions (17–19). Environmental governance specifically addresses issues of access, use, protection, and management of common-pool natural resources (19). Hardin (20) called upon two mechanisms to prevent overexploitation of common-pool resources: private ownership (and thus market mechanisms to respond to change) and state regulation. Ostrom (21) identified a third mechanism for environmental governance by documenting the emergent, self-organization of communities reliant on common-pool resources with or without markets and regulation. Self-organized environmental governance can respond more nimbly and adaptively than government regulation and simultaneously address issues that arise in market failure. Emergent, often informal and nongovernmental aspects of environmental governance are common in approaches referred to as adaptive comanagement (22–24), collaborative governance (25, 26), good governance (27, 28), and adaptive governance (7, 29–34).

ECOLOGICAL THEORY AND ENVIRONMENTAL GOVERNANCE

We begin with the observation that environmental governance (see sidebar, Governance) and environmental management are strongly connected to ecological theories of change (11). Since the 1970s, ecologists and practitioners have realized that prevailing strategies for governing ecological resources were destined to fail because they were largely based on linear and equilibrium models of ecosystem dynamics (11–14). At the time, one of the common assumptions underlying environmental governance was that ecosystems behaved in ways that were stable, persistent and predictable (12). Moreover, governance and management in developed parts of the world attempted to control unwanted ecosystem variation in order to provide a consistent stream of ecosystem services including raw materials, food and other ecosystem functions such as water purification and nutrient cycling. Renewable resources were managed (if at all) under the paradigm of maximum-sustained yield—harvest as much as possible, while reserving enough for the resource to replenish itself through reproduction or regeneration—a concept closely associated with fishery and forest management (11). This paradigm, however, assumed near perfect information about the resource in question and failed to account for inherent uncertainty in ecological knowledge; unknown or unexpected SES dynamics affecting the resource across scales; and threshold behavior in ecosystems including the existence of multiple alternative system states (6, 15).

Holling (12) was among the first to discuss the inherent unpredictability in ecological dynamics in a watershed article on stability, persistence, and change in managed ecosystems. He introduced the concept of "resilience" of ecosystems as "a measure of the ability of [systems] to absorb changes of state variables, driving variables and parameters, and still persist" (12, p. 17). Today, the term resilience is currently entangled in a myriad of meanings and applications (35), but was originally employed by Holling to estimate "the size of a stability domain or the amount of disturbance a system could take before it shifted into [an] alternative configuration" (12). Since then, scientists have observed regime shifts between multiple stable states across a wide range of ecological systems (e.g., 36–38) and coupled SESs (e.g., 39, 40). Regime shifts occur when the controlling factors and subsequent feedbacks in a system change (10), which adds uncertainty and unpredictability and creates often insurmountable problems for governance that is predicated on stationarity and a consistent set of driving variables (41, 42).

RESILIENCE AND ADAPTIVE CYCLES

Resilience—defined simply as a measure of the amount of disturbance a system can absorb while maintaining structure and processes—is a property of SESs. Resilience is influenced by the internal dynamics of a SES. SESs go through sequential phases of growth, senescence, collapse, and renewal (6). The initial phase of rapid growth is characterized by increases in structure, connectivity, and complexity. Over time, systems mature and enter a conservation phase, when the system becomes overconnected, less flexible, and more vulnerable to disturbances, hence less resilient (52). External disturbances or minor variations can generate a sudden release of accumulated capital or structure. Following this collapse or release, the system reorganizes, and a new system configuration emerges. The emergent trajectory can be similar to the prior system or quite different (e.g., undergone a regime shift). This pattern of rapid, then slowing growth, swift destruction, and reformation, has been observed in many systems, including pest outbreaks and fires in temperate forests (52), plankton dynamics (44), and SESs such as the Great Barrier Reef management (51, 53) and other SES resource systems (15, 43, 54).

PANARCHY

Panarchy describes the influence of cross-scale interactions on system trajectories and internal system dynamics. Disturbances or periods of destruction can arise from larger spatial or temporal phenomena or from contagious, small-scale phenomena, described as revolt processes (6). Revolt processes include phenomena such as forest fires or disease outbreak, occur quickly, can grow in size, and are attributed to a switch in ecosystem controls. During the reorganization phase, larger systems provide context and system memory, hence these cross-scale interactions are called processes of remember (6). This type of top-down interaction is important at times of change and renewal. Once a crisis or collapse is triggered at a scale, the opportunities and constraints for the renewal of the cycle are strongly organized by conserved structures at the larger scale. After a fire in an ecosystem, for example, processes and resources accumulated at a larger scale slow the leakage of nutrients that have been mobilized and released into the soil. In addition, the

options for renewal draw upon the seed bank, physical structures, and surviving species that form biotic legacies that have accumulated during the growth of the forest.

As a result of this work, the concepts of resilience and adaptive cycles (see sidebar, Resilience and Adaptive Cycles) and more recently, panarchy (see sidebar, Panarchy) have enjoyed widespread application across both the ecological and social sciences, from both theoretical and applied perspectives (e.g., 43–45). The growth, recognition, application, and subsequent critique of resilience (e.g., 46–48) have coincided to some degree with a renewed attempt by scholars in the early twenty-first century to explicitly link social and biophysical systems in research, because any attempt to separate the two blatantly ignores their coupled, dynamic nature and likely conflates attempts to address environmental crises (49). In the context of environmental governance, resilience and panarchy theory describe at least three categories of change in SESs that have been critical for rethinking governance and management of natural resources: (a) gradual or incremental change, (b) adaptive change, and (c) transformative change (6). Incremental changes occur slowly and predictably, as systems mature and develop. In contrast, adaptive change often occurs abruptly as a result of disturbances or regime shifts. Regime shifts can result in dramatic change in the types of goods and services provided by the ecosystem (50), inherently affecting society, and are often translated into powerful narratives of environmental crisis (40). These narratives can, and should, be framed as windows of opportunity (51), not just for adaptive change but also for transformative change toward more desirable SESs.

Understanding Transformation

Walker et al. (10) introduced the concept of transformability as an attribute of complex SESs that partially (along with resilience and adaptability) helps to define the dynamics and future trajectories of a system. Recognizing the need to manage novel ecosystems in the future, the authors defined transformability as the “capacity to create a fundamentally new system when ecological, economic, or social (including political) conditions make the existing system untenable” (10). Thus, the concept of transformation has always included space for human agency. At the scale of a SES, a transformation is a deliberate, societally initiated process of pushing a system across a threshold by “a phased introduction of one or more new state variables” (55). This notion of transformation contrasts with that of scholars who claim that transformations are of two varieties: (a) intentional or deliberate, and (b) unintentional or unexpected as a result of a process or event (56). In both intentional and unintentional transformations, a SES crosses a threshold and undergoes a regime shift. However, what defines a true transformation is when the regime shift experienced is a direct result of human vision, planning, and action, in other words, human agency (57).

The phenomenon of transformation is scale dependent and multilevel, and can be system-wide or nested as personal, organizational, or other levels of subsystem transformation (56, 58, 59). The concept of panarchy is central to understanding transformation. The capacity to transform is likely the product of the dynamics of a nested system influenced by cross-scale interactions, in other words, highly “dependent on the nature and extent of adaptive actions being taken at other interacting scales” (59, p. 119), both above and below the SES. For example, larger-scale transformation may occur only as personal or individual

transformations are scaled up to forge the collective capacity to drive change (59, 60). In this context, deliberate transformation (56) has also been referred to as directional or purposeful transformations (61). Despite word choice, a true transformation describes a deliberate, human-driven change in the dominant processes and structures that control a SES (i.e., maintain a particular SES regime). These processes and structures vary for any SES at a particular scale but can include biophysical cycles (e.g., hydrologic cycles), ecological hierarchies (e.g., food web interactions), human activity (e.g., resource extraction), or social institutions (e.g., laws, rules, or policies). It follows that transformative governance builds on the capacity of society to alter these processes to foster new regimes in SESs that more closely achieve societal priorities such as the provision of ecosystem services.

Adaptive Governance

In the era of increasing human population and dominance, widespread resource extraction, and unprecedented, human-enhanced climate change, it is clear that ecologically inspired concepts of adaptive and transformative change are relevant to rethinking environmental governance aimed at the sustainability of SESs (62). Adaptive governance is an emergent configuration of environmental governance mechanisms (including actors, organizations, networks, and institutions) that addresses the societal need and desire to adapt to changing conditions (7, 29, 30, 33). Adaptive governance represents a series of innovations predicated on the societal goal of maintaining larger-scale system dynamics and preserving the configuration of factors that control the structure and processes of a particular SES (i.e., maintaining a desired SES regime).

Adaptive governance describes the type of environmental governance necessary to govern complex SESs when human knowledge of a system is incomplete (29). Emphasis is placed on the need for governance systems to be flexible enough to shift and change with feedbacks from both the social and biophysical parts of the system. Theories of adaptive governance emerged from (a) scholars studying self-organization of small-scale groups of actors uniting to collectively manage common-pool natural resources (29), (b) political scientists studying community-based collaborations intended to advance natural resource governance through open decision-making structures (31), and (c) the research of resilience scholars (10, 30, 40). Adaptive governance is thus a product of local self-organization of resource users in collaboration with government officials, agencies, and nongovernmental organizations (NGOs), often in response to a resource crisis or a recognized need for adaptation in a SES to maintain a desired regime (30, 31, 63). However, without some degree of institutional change, this organic shift in governance is destined to remain a transient, self-organized collaboration without any lasting claim of legitimacy or governance authority (45, 64, 65). Olsson et al. (51) describe a necessary bridge as a window of opportunity that links the processes of emerging adaptive governance with some degree of institutional change. Scholars have recognized the presence of key factors and processes necessary to create space for both the emergence and institutionalization of adaptive governance (45), including nested leadership, informal network formation, polycentric governance, increased public participation, experimentation, and social learning (66).

Learning, knowledge dissemination, and the coproduction of knowledge (67) are necessary elements for bridging the emergence of adaptive governance with processes that institutionalize it in various forms within existing governance structures (45). Although the creation of multilevel and multiscale networks facilitates the distribution of both tacit and scientific knowledge within a SES, adaptive management is a critical process for production and coproduction of new knowledge—allowing disparate stakeholders to jointly create a vision of system function and ask questions relevant to achieving sustainable resource management trajectories. Adaptive management refers to a systematic application of ecological hypotheses as management experiments where results are continuously monitored to further inform and adjust future management (68). Adaptive management was initially pursued as the preferred approach to implement resource management decisions in the face of extreme uncertainty when inaction was not a viable alternative (11, 69). Adaptive management has been difficult to implement (70) and requires the networks and adaptive capacity (e.g., leadership, trust) of adaptive governance to be operationalized (30).

The emergence of adaptive governance is becoming more frequently recognized (33), especially in a developed world context (7, 34), but institutionalization of adaptive governance remains elusive. This failure may stem from both the transient nature of adaptive governance processes themselves as well as the changing nature of environmental problems and SESs attempting to be governed. The rapid trajectory of global change is likely outpacing societal abilities to preserve desirable regimes in many SESs nested within a global system, further constraining societal capacity to remain within the sustainable limits of the biosphere. There is a further need for models of environmental governance that actively encourage and permit the transformation of current resource-use patterns to create sustainable SESs at nested scales across the globe. Actors engaged in such a governance model could employ the capacity not only to maintain SES regimes but, more importantly, to catalyze transformation of degraded SESs by pushing them over thresholds to more desirable regimes in pursuit of global sustainability. Seedlings of this type of governance model can be found across a wide swath of interdisciplinary research on environmental governance, societal transitions, and SESs. We aim here to build synergy around the concept of transformative governance, nurture its growth, and inspire future research and action.

TRANSFORMATIVE GOVERNANCE

As demonstrated above, the roots of transformative governance are built on a synthesis of broad theories of complex change and evolving bodies of empirical research (both ecological and social) that describe rhythms of collapse and renewal in SESs (45). Although very few scholars have specifically employed the term transformative governance (64), foundational concepts have been converging in the literature over the past decade, including the development of a robust literature on adaptive governance combined with increasing attention to the need for society to undergo so-called sustainability transitions (71). The idea of managing a societal transition toward sustainability has inspired broad new academic literatures including those of socio-technical transitions (72) and transition management (73). Below we briefly highlight key contributions of research on transitions in an attempt to demonstrate the critical importance of these ideas to building the concept of transformative governance.

Synergy: Transition Studies and Adaptive Governance

Research on transitions (including the fields of transition management and socio-technical transitions) is a relatively recent development with important implications for the development of a theory of transformative governance. Transition-based scholarship shares many characteristics with resilience-based concepts such as adaptive governance, emphasizing a dynamic systems approach that examines nonlinear change and multiscalar dynamics (73). Transitions research, however, differs in orientation in critical ways. Whereas research on adaptive governance strategies is most often associated with efforts to maintain current SES regimes, research on transitions aligns with system change as the entry point to research and analysis. The focus is on characteristics of new trajectories, developing strategies to foster system transformation, and enhancing the sustainability of new regimes (74).

The field of transitions research that emerged in the late 1990s expanded the concept of a transition (from origins in biology and population dynamics) to describe broad social, ecological, and economic changes and to explain their mutual connection (75–77). The concept of a societal transition, transformation, or sustainability transformation derives from the premise that many current societies are based on an unsustainable organizational design (78). To address this problem, transformational changes are often required to precipitate radical, systemic shifts in values and beliefs; patterns of social behavior; and multilevel governance and management regimes (79–82). The research challenge becomes how to understand the characteristics and processes of structural social change to realize a more sustainable future (78).

Related research specifically on socio-technical transitions places a specific emphasis on transformation of technical regimes, defined as the relatively stable configurations of institutions, techniques, practices, and networks that determine the course of development and use of technology (83). Research in this arena focuses on fostering the creation and diffusion of new, more sustainable technologies and transforming the structural characteristics of technological regimes and trajectories (74, 84). This type of research explicitly acknowledges the roles of human agency and power relations in the maintenance of current trajectories and the need to examine the ways in which the empowerment or disempowerment of various actors influences how regimes are conceptualized, operationalized, and ultimately transformed (79, 84).

Transition management, as a distinct research field (73), is more squarely focused on the governance approaches needed to facilitate transformations and to guide societal change in the face of uncertainty. Transition management outlines a new governance approach based on specific types of network configurations and decision-making processes (85). Loorbach (73) outlines several key characteristics of transition management, many of which have parallels in adaptive governance approaches and taken together, inform the nascent concept of transformative governance: (a) a multi-actor approach that widens the scope of participation to a broad set of values and beliefs within society, (b) a long-term perspective balanced with short-term objectives, (c) a focus on learning and experimentation, and (d) a systems-based approach that emphasizes dynamics across temporal and spatial scales. The focus of transition management research is on fostering and creating space for “niches”

within systems that cultivate incremental, novel shifts and encourage innovative interventions that can cluster to create more radical, structural change. Fischer-Kowalski & Rotmans (86) outline the cycle of transition management involving (a) problem-solving and establishment of a transition arena that integrates insights and analysis; (b) development of sustainability visions, pathways, and a transition agenda; (c) initiation and execution of transition experiments; and (d) monitoring and evaluating the transition process. This process resembles adaptive governance, which is generally recognized as a key strategy for the operationalization of adaptive management (30).

The approach and assumption of transition studies, specifically the governance-based approach of transition management, has the potential to elevate the approaches set forth in adaptive governance beyond the goal of maintaining desired regimes in SESs. Put simply, the emphasis on SES transformations toward sustainability, rather than on maintaining current SES regimes, provides a realistic option for catalyzing the societal change necessary to transform SESs in less desirable states, such as poverty traps. Transitions research can also inform adaptive governance research by increasing the analytical emphasis on (a) societal heterogeneity and the role of economic and technological forces; (b) societal behavior and capacity for societal change; and (c) the role of power relations existing within formal and informal institutions and organizations, including the recognition of great disparities in resource distribution and associated, historically situated inequities (79, 84, 87). Olsson et al. (79) observed that work on adaptive governance could benefit greatly from the insights from transition management on the role of power in innovation, specifically to analyze both the structural power of regimes to sustain their position as well as innovative power to transform regimes.

By shifting focus toward a critical analysis of the complexities and trajectories of social systems as well as ecological systems, transitions research strengthens a current weakness of adaptive governance scholarship, which examines the “resilience of what to what,” but often without asking the next critical question—“for whom” (88–90). Transitions research generally encourages a fourth question—how? Looking at the “how” of transformational change can also help researchers acknowledge the culturally embedded processes of knowledge production that inform various societal conceptualizations of SESs, as well as the dangers associated with determining who defines a desirable regime for transforming SESs.

From Adaptive Governance to Transformative Governance

As processes of change, adaptation and transformation share similar qualities, and some scholars even refer to both as two types of the same phenomenon: incremental versus transformative adaptation (91). Park et al. (59) argued that processes for adaptation and transformation are essentially the same. Once a transformation has occurred and a fundamentally new regime is achieved, then the process switches back to a cycle of adaptation [Park et al. (59) termed this incremental adaptation] until transformation is again required (59). It can also be a matter of timescale, with transformation occurring in relatively short time windows along a continuum of adaptive change. Adaptive governance and transformative governance also share similar qualities and, to some degree, can be considered different points on the same spectrum of governance (92). Both forms of

governance require a diversity of both individual and organizational actors operating at different levels within a SES and interacting from scales above and below the SES, intimately connected through both formal and informal networks (60). Both adaptive and transformative governance require distributed power (polycentric governance), high levels of information exchange, consistent evaluation, and innovation fostered by experimentation and learning across the governance networks in a SES (60, 64, 66).

Although adaptive governance seeks to maintain the "essence and integrity of an incumbent system" (59, p. 119) through changes in actor organization (e.g., networks) and institutional arrangements, the goal of transformative governance is to achieve a fundamentally new system through similar changes that collectively reorganize the fundamental controlling mechanisms of the SES (Figure 1). Theoretically, transformative governance is needed when (a) SES conditions have become untenable, the system is rapidly approaching a threshold with unknown or undesirable consequences, and the mechanisms of adaptive governance are insufficient to maintain desired conditions (i.e., societal influences and responses no longer match changing ecosystem conditions); (b) a SES has crossed a threshold and undergone a regime shift that has altered the SES to a point of degradation that is no longer desirable to society (e.g., at the extreme, a loss of ecosystem services and resources necessary to support life); or (c) the SES has developed in such a way that ecosystem services are produced at a low rate and social inequities are high, and a more desirable system state with greater production of services and less injustice is envisioned and possible.

These three scenarios effectively help to illustrate two ideal forms of transformative governance, one proactive and one reactive. In its proactive form, governance actors first, through collaboration with scientists and using the best available information, explicitly recognize an impending SES regime shift through rigorous experimentation, modeling, and scenario development. Latent capacity for guiding the impending regime shift is mobilized as transformative governance and the impending regime shift is navigated toward outcomes that resemble a more sustainable regime. In its reactive form, a SES regime shift has already occurred and governance actors mobilize capacity for transformative governance to deliberately alter the controlling variables of the undesirable system, guiding the SES across yet another threshold toward a regime that is more desirable, functional, and sustainable for human wellbeing. In each application of transformative governance, the processes, structures, and characteristics are much the same; however, timing and the degree of necessary societal change may differ substantially.

Similar to adaptive governance, transformative governance seeks to achieve desired societal values. Pursuing transformation instead of pursuing the maintenance of a current SES state "is a critical and complex socio-political choice, and usually happens once the system is approaching dangerous thresholds" (92, p. 188) that threaten individual, community, and global livelihoods as well as planetary life-support systems (8). In this way, transformative governance is not always desirable or inherently necessary. Instead, it is transient and latent in the capacity of governance to catalyze or direct transformation when needed. When a SES regime is desirable, the processes, structures, and functions of adaptive governance can be employed to maintain rhythms of change in a SES to locate it on a path of sustainability, based on an infusion of the best available science, local knowledge, and resembling aspects

of good governance such as fairness, equity, transparency, and legitimacy (27, 28). When, however, a SES enters an irreversible trajectory toward an impending regime shift, the latent capacity for transformative governance can be mobilized to navigate the regime shift toward a new regime, one that is socially and ecologically sustainable and resembles good governance. Post-transformation, the transformative capacity of governance is no longer necessary and becomes dormant, whereas processes of adaptive governance regain primacy.

Characteristics of Transformative Governance

Transformative governance requires governance elements that go beyond or exceed the degree of those required for adaptive governance because of the difference in desired outcomes (e.g., the transformation of SESs). On some level, transformative governance may require “radical, systemic shifts in deeply held values and beliefs, patterns of social behavior, and multi-level governance and management regimes” (60, p. 762). Imbedded, personal transformation has enhanced the emergence of adaptive governance in some cases (51), but the scale at which paradigmatic shifts in societal beliefs, vision, and ideology are necessary to legitimize transformative governance is likely to be much greater. To enhance the capacity of transformative governance, catalysts and mechanisms for these nested personal and social transformations must be understood at the collective scale, the scale of the SES to be transformed, as a function of collective skills, relationships, institutions, and network structures (93).

Thus, transformative governance is about framing and agenda setting (94). Framing involves identifying a problem (e.g., poor water quality, urban decay) and setting the stage for a transformation. Research conducted on urban transitions in Australia, focusing specifically on shifts to sustainable or green practices for water resource management, demonstrates that the narrative tone set by governance actors and organizations supports transitions from adaptive to transformative governance (64, 95). At the local level in Australia, organizational experience with public messaging and mainstreaming of other SES issues (e.g., environmental planning) appeared to play a critical role in building capacity for transformative governance (95). Governance experiments at small scales also demonstrated that a committed shadow network of actors was able to manifest a transformation in urban water management by eroding the dominant paradigm of traditional approaches to water management (96, 97), to transition from adaptive governance to transformative governance. Researchers have also found that the transformation of urban water management was influenced by networks of “frontrunners” from all areas of water management in Melbourne, Australia, which steered the transformation over decades to improved water management (98). This research corroborates similar findings that underscore the critical importance of multiple sources of nested leadership for fostering and guiding a transformation in a SES (99). Leaders can champion critical narratives, but can also take the form of “institutional entrepreneurs” who mobilize, arrange, and sustain the necessary social and political capital for change (100).

Aspects of self-organization related to the emergence of adaptive governance may also give rise to transformative governance, but much more deliberate and structured intervention is likely needed for a smooth societal transition, both during and after a regime shift. For

example, substantial political and social capacity, including financial investment, may be required to transform existing economies and livelihoods without collapsing the social or ecological aspects of a system. Rijke et al. (64) assert that in the early stages in the transformation of water management, decentralized and informal processes catalyze change, whereas centralized and formal methods are more effective in later stages of transformation. At the early stage of transformation, informal and decentralized connections and approaches have greater capacity for dealing with the dynamics of linked SESs (64). In particular, leadership, intermediaries, and the capacity for learning and experimentation are key for fostering transformation in urban systems (64)—all parallel processes in fostering adaptive governance. As the process of transformation proceeds, however, more formal and enforceable arrangements are critical to its success, as the process can fall apart over time without structured coordination between stakeholders (101). In addition, an overarching capacity to plan for multiple potential futures in the face of uncertainty must accompany an effort to force or respond to a regime shift (58)—something not likely to be attained by informal governance entities alone.

Constraints and Opportunities to Fostering Transformative Governance

Under the constraints of capitalism, all SESs—whether supporting the emergence of adaptive governance or not—will face substantial resistance to developing transformative governance when regime shifts are eminent (Table 1). Farrelly & Brown (96) identified hierarchical governance structure, market-oriented norms, organizational and institutional conservatism, and the dominance of concerns about risk, including human health risks and financial risks, as barriers to experimentation with transformations specifically in urban water systems. Although the free market positions the private sector as a key actor for innovation toward sustainability—and thus for potential leadership in transformative governance—the pursuit of endless economic growth by optimizing shareholder value and externalizing costs will continue to allow unfettered demographic growth and unsustainable resource extraction (60).

Westley et al. (60) identified three barriers to sustainability transitions related to innovations that are also relevant as barriers to transformative governance: (a) the cognitive limits of humans; (b) the failure of society to anticipate unexpected consequences of innovation; and (c) the path-dependent nature of technology, incentives, and governmental regulations of the private sector. The latter speaks to a “paradox of innovation,” that although technological innovation offers potential pathways for transformation, current trajectories of innovation contribute directly to SES degradation—and questioning technological innovation goes against the dominant worldview (60). In addition, “the path dependent (versus path breaking) character of technological innovation means there may be a lag between what we see as an emerging crisis and the available technological response” (60, p. 764). Therein lies the most significant challenges for developing transformative governance approaches: bridging the cognitive and normative barriers of society toward personal, social, technological, and eventually social-ecological and socio-technical transformation, as well as disrupting the inertia of embedded political power relations that govern most SESs toward an unsustainable maintenance of the status quo.

At the same time, however, governance actors have been purposefully transforming SESs by triggering conscious regime shifts throughout history. Historical studies of institutions, ecosystems, and society reveal that SESs periodically develop new governance structures and features to facilitate systemic change in nested SESs (103–106). For example, forests and wetlands have been intentionally converted to commercial and residential developments, and waterways have been targeted for waste disposal, commercial navigation, engineered flood control, and water-supply diversions—fundamentally altering the basic structures and processes of these linked SESs—with significant trade-offs between the supply of specific (prioritized) ecosystem services and ecological integrity. Post-transformation land-use policies, private property rights, and water governance systems, among others, evolved accordingly. Although these changes can actually increase SES resilience at a nested scale (resilience of a current, degraded regime), they are likely not sustainable when scaled up, both temporally and spatially. Even if decision-makers underestimated the breadth, depth, and timing of negative feedbacks within SESs, there was a clear choice at the time to transform landscapes and waterscapes into fundamentally different systems—providing a kernel of hope that another choice can be made to actively transform toward more sustainable SES regimes. Such a choice would undoubtedly require a conscious change in societal values toward the development of a more widely accepted set of environmental ethics (107).

TRANSFORMATIVE GOVERNANCE OPERATIONALIZED

Failure of Transformative Governance to Emerge from Adaptive Governance

It is instructive to first contextualize the concepts of transformative governance in terms of failure of governance to transform a SES even when presented with windows of opportunity. The Klamath River basin spans the border of northern California and southcentral Oregon, and has been the locus of historic failures of environmental governance (108, 109) as well as the recent emergence of adaptive governance (45, 110). The problems in the Klamath River basin stem from the historic displacement and dispossession of native peoples, land allotment patterns to Euro-American settlers, and the subsequent overallocation of rights to use water for agriculture, hydropower, and species conservation, among other uses. During the twentieth century, American reclamation policy fostered a powerful status quo of federally subsidized irrigators in the upper reaches of the Klamath basin, further entrenching irrigated agriculture in the basin as a dominant culture and rhetoric. In the late twentieth and early twenty-first century, however, the supremacy of water for irrigation was challenged by the increasing political power of Native American tribes and legal assertion of sovereignty over historically and culturally significant resources (109). This surge in tribal influence was aided by several key legal processes, including a state-level adjudication of water rights in the upper Klamath basin and the listing of several aquatic species as threatened or endangered under the US Endangered Species Act (110).

In 2001 in the Klamath basin, drought and a renewed implementation of the Endangered Species Act to provide additional water and habitat for threatened and endangered fish species triggered a shutoff of water to land served by a large federal irrigation project, affecting approximately 210,000 acres of farmland and 1,400 individual farms (108). This

event was not only a large economic disturbance to the rural agricultural communities of the upper Klamath basin, but also a cultural shock as Klamath Falls, Oregon, became ground zero for resurgent anti-Indigenous racism and renewed antigovernment protests, reminiscent of the Sagebrush Rebellion and Wise Use Movements in the Western United States. In 2002, a shifting implementation of the Endangered Species Act in the basin dictated low river flows in early fall, precipitating anoxic conditions and the rapid spread of disease that killed more than 30,000 fall-run chinook salmon migrating up the Klamath River along the banks of the Yurok and Hoopa Valley Tribal Reservations and along the banks of historic lands of the Karuk Tribe. Salmon is a historic and contemporary food source for these tribes, as well as an important ceremonial symbol and cultural icon; the widespread loss of this annual salmon run was a devastating shock to an already marginalized population. As a result of the Klamath salmon die-offs in 2002, commercial salmon fishing off the Pacific Coast of the United States was significantly curtailed or closed in the latter half of the decade, because Klamath salmon populations (caught, counted, and reported by commercial fishermen) are an indicator species for regulating commercial fishing seasons and limits. This was yet another economic and cultural shock to the greater Klamath SES. Many scientists, resource managers, and practitioners believed that the Klamath River basin SES was in a degraded state, denoted by the “rotating crisis” of ecological, economic, and cultural shocks affecting communities and ecosystems across the basin (109).

In response to the exhaustion of zero-sum strategies by many of the major stakeholder groups in the basin to regain dominance in environmental governance, several collaborative processes began to coalesce that resembled the emergence of adaptive governance (110). Specifically, a series of facilitated listening sessions around the basin served to build trust and coalitions among a network of basin leaders, from federal and state agency managers, to scientists, tribal leaders, community leaders, and environmental NGO practitioners and advocates. The focus of the emerging dialogue was on collectively defining problems at the basin scale and creating a vision for potential solutions that included all relevant stakeholders. It was at this time that a window of opportunity (51) opened to transition the informal discussion of basin-wide solutions to a more formal venue structured by the Federal Energy Regulatory Commission (FERC) hydropower relicensing process for the privately owned and operated Klamath Hydroelectric Project, a series of large, main stem Klamath River dams (and associated facilities) that bisect the Klamath River basin roughly in half, around the California–Oregon state line. This process, combined with federal involvement from the US Department of the Interior and Department of Justice seeking a Native American water rights settlement in the basin, provided the facilitated, formal structure necessary to craft a series of settlement agreements among the network of affected stakeholders in the basin, and toward a holistic restructuring of environmental governance at the SES scale (110). If the historic Klamath Agreements were to receive approval and funding from the US Congress, four main stem Klamath dams would be removed, salmon would be reintroduced to the upper basin, and basin stakeholders would undergo a massive restructuring of water use and allocation in the basin focused on aquatic habitat restoration. This effort would likely represent the realized potential for the emergent properties of adaptive governance to harness the capacity for SES transformation.

By the end of 2015, however, Congress had not passed legislation approving or funding the Klamath Agreements, and many of the Agreement provisions expired. From 2005 to 2015, the seeds of adaptive governance developed a pathway toward SES transformation and the activation of transformative capacity, but had not made the shift to transformative governance because of a lack of hierarchical investment in transformative capacity. This failure to operationalize the necessary political capital was a function of dynamics at the higher scales of environmental governance and resulted in the lack of much-needed investment and broader-scale structure. Even if the emergence of adaptive governance is institutionalized in social norms and at local-scale adjustments in rules, policies, and procedures, the failure to transform the Klamath basin at the SES scale will undoubtedly foster additional resource conflicts as the system is still in a degraded state and potentially approaching a regime shift toward an even further degraded state. In addition, the failure to adjust drivers of the Klamath River basin SES by removing dams and restoring aquatic habitat will continue to stress the bonds of trust that forged networks of adaptive governance.

In early 2016, the US Departments of Interior, Commerce, and Justice, along with the states of Oregon and California, several tribes, and a cadre of NGOs associated with previous negotiation of the Klamath Agreements, announced an effort to reaffirm the approach to holistic social-ecological restoration of the Klamath basin including the removal of the four main stem Klamath River dams by 2020. This announcement coincided with the reactivation of the FERC hydropower facility relicensing process following the expiration of the Klamath Agreements in 2015. This reinvigoration of transformative capacity underscores the idea that transformative governance is latent and needs the right contexts to emerge and take hold. It also highlights the critical importance for governance scholars to further understand lag time in developing the contexts for transformative governance. Potential lessons learned from the Klamath experience are that even when dominant power relations are challenged at a nested scale, and there is space for transformative governance to emerge, it may not occur without an overarching structure and higher-level investment in governance, and even then, it may not occur immediately. This realization also highlights why the adaptive cycle metaphor and panarchy model are critical lenses with which to dissect these governance problems toward better navigation of higher- and lower-scale barriers to transformation (6, 45, 52, 90).

Implementation of Green Infrastructure to Transform Urban Watersheds

Recent changes in how some urban SESs are governed may offer insights for further conceptualizing and perhaps operationalizing transformative governance. As complex SESs, urban environments are generally resilient to transformative change given their highly stable built infrastructure and the complex interconnections of their economies (98). However, when economic and social vitality erodes and urban SESs become economically depressed, transformation toward a more desirable regime may be essential to improve the overall wellbeing of a city and its residents. Thus, a city may want to reduce the resilience of its current regime to manifest a transformation to a new regime. Recently in many cities in the developed world, restoring natural watershed processes as controlling factors in urban SESs has emerged as the “raw material” for catalyzing urban social-ecological transformation, and

the scale of urban watersheds is an increasingly relevant spatial scale for transformative governance.

Cities are the manifestation of human adaptation to the environment, and the growth and decline of cities are dynamic processes characterized by factors that drive city growth (e.g., geography, climate, amenities, economy) and factors that result in decline (e.g., loss of manufacturing industries, natural disasters) (111). For example, Cleveland, Ohio, was one of the largest cities in the United States in the first half of the twentieth century, but has experienced a rapid decline in the late twentieth century as a result of myriad factors (e.g., loss of industrial base) (112). Thus, Cleveland has evolved from a growing city with considerable resilience to disturbances, to a shrinking city, vulnerable to disturbances both internal and external.

When the foreclosure crisis of 2008 and the associated housing bubble hit Cleveland, an already vulnerable city was thrust into a severe economic and demographic crisis. However, as Cleveland experienced (and continues to experience) political and economic turmoil, the demographic and economic decline presented a window of opportunity for the city to restore biophysical processes and functions at the watershed scale. Vacant lots, land, and industrial sites in Cleveland are being repurposed for many different functions, including as habitat for biodiversity, urban agriculture, and green infrastructure (see sidebar, Green Infrastructure) to reduce urban runoff and combined sewer overflows (combined overflow of untreated sewage and stormwater) and provide other cobenefits (e.g., increase in beneficial pollinators) (113). Combined sewer overflows from Cleveland's urban watershed significantly endanger the water quality of Lake Erie (in addition to nonpoint source pollution). As a result, the greater Lake Erie SES is approaching a threshold and potential regime shift toward decreased water quality dominated by anoxic conditions (Figure 2). Recognizing this potential regime shift, many key mechanisms of adaptive governance that had previously emerged in Cleveland began to coalesce around the goal of transforming the urban watershed from a system dominated by gray infrastructure (interception and conveyance via underground pipes and tunnels) to a system once again controlled by natural hydrologic processes such as infiltration (114).

GREEN INFRASTRUCTURE

Green infrastructure is a patchwork of natural areas (e.g., parks) at larger scales and engineered plant-soil systems (e.g., rain gardens) at smaller scales that serve an engineered or societal purpose (e.g., recreation, food production, runoff infiltration) and simultaneously enhance multiple cobenefits, including multiple ecosystem services, environmental justice, and economic benefits (114). Green infrastructure creates physical and emotional space for innovation, which in turn offers greater latitude to manage resilience in urban SESs. By adding green infrastructure to the current, dominant paradigm of gray infrastructure, governance actors in many urban SESs such as Cleveland, Ohio, have initiated the process of eroding the resilience of dominant undesirable regimes and hastening a pathway toward urban transformation and renewal by altering controlling factors of the system. However, transformation in an urban SES from a degraded regime to a more desirable regime that

mimics natural dynamics can be inhibited by existing water and sewer infrastructure, institutional and organizational arrangements, and path dependency of built approaches (97).

The emergence of adaptive governance in Cleveland (113) and other urban SESs (e.g., 64) has helped create space for a break in path dependency and can help transition SES governance to manage for social-ecological resilience. In Cleveland, leadership, intermediaries, and the coordination between formal and informal organizations have been critical in the process of manifesting an urban transformation that is still in process. This coordination across levels of governance, a key aspect of adaptive governance, is important for allowing information flow up to higher levels of government (e.g., state, federal) and down to the local level (113, 115). Science, the law, and local knowledge play important, complementary roles in fostering transformation in urban systems (116, 117).

In Cleveland and other US cities, the rigid structure of law and government regulations may actually be the tipping point that shifts the emergence of adaptive governance toward transformative governance. The US Clean Water Act requires sewer and stormwater discharges to meet permitted end-of-pipe limits (118). These permits prohibit combined sewer overflows and have resulted in increased enforcement of the Clean Water Act in recent years (118). Gray infrastructure is the default solution for dealing with stormwater management in the United States, as engineering expertise and solutions have traditionally dominated this arena. Although gray infrastructure provides a degree of comfort for the public and the entities responsible for stormwater management, these engineered solutions are often prohibitively expensive and have failed to meet water quality objectives for many cities such as Cleveland (114). The enforcement of the Clean Water Act combined with the high costs of engineered solutions has provided the legitimacy and opportunities for financial investment, and in some cases, the authority for networks of adaptive governance to explicitly seek transformation of the urban watershed through widespread implementation of green infrastructure (113, 114). In this case, law has provided the necessary structure for governance actors to collectively attempt to alter the controlling factors of a SES to manifest transformation. In addition, the diffuse, polycentric nature of this approach to governance makes it better able to navigate issues among multiple jurisdictions and across multiple spatial and temporal scales of a SES, and has been effective at fostering the continued implementation of green infrastructure (113) for transformation by further eroding the dominance of gray infrastructure.

CONCLUSIONS AND RESEARCH AGENDA

Much like adaptive governance, transformative governance is likely to be an emergent phenomenon, responding to the need for transformation in SESs when both social and biophysical conditions present unique contextual circumstances for emergence and growth of new approaches to governance. Our understanding of transformative capacity in governance systems is in its infancy, and investigations of real examples are needed at multiple scales to define the mechanisms by which governance can influence social-ecological transformation. Specifically, what mechanisms for transformation exist under current law and policy, and are they realistic given entrenched power relations, social structures, politics, and economies? How do the governance mechanisms that facilitate

transformation vary spatially and temporally (79)? What role do key cross-scale interactions (both social and biophysical) play in catalyzing capacity for transformative governance? A better theoretical and applied understanding of transformative governance is essential given the impending effects of global climate change. How will governance actors judge that adaptation is no longer relevant and transformation is the preferred option? Furthermore, what manifestations of individual and collective human agency are most effective at breaking pathologies that reinforce degraded SES regimes? Perhaps more importantly, who gets to decide it is time to transform, and under what conditions is the social and ecological risk worth the action? How are potential social, cultural, and economic scenarios weighted in the decision to transform SESs?

Continued study of transformative governance is critical because many contemporary studies do not document whether desired ecological changes have occurred. Much attention is given to plans and strategies that have the aim and potential to transform SESs, but data about whether systemic change has occurred are lacking. Some studies (e.g., 103, 119) describe significant improvements in environmental conditions and ecosystem functions, but it is unclear whether these new conditions correlate or coincide with desirable and lasting social-ecological regimes. There is potential for seemingly transformative policies and institutions to be merely aspirational, incomplete, or short-lived. For example, Wamsler (95) observed that integration of ecosystem-based climate change adaptation into SES planning (including substantial changes to urban ecological conditions) has promise but has encountered many obstacles in eight German cities. Further research is needed on how and why some SESs overcome these barriers and others do not, and on whether partial governance reforms are enough to achieve desired SES transformations.

The fundamental problem facing future research on transformative governance is that the direction and goals of transformative governance are inherently contested. Decisions about desired SES regimes are deeply political, ethical, and value-driven, not solely scientific, and will be made fundamentally in political systems (90). Moreover, questions of social justice and disparities in power and resources pervade the choices that transformative governance systems must make (120, 121). For example, low-income populations may depend on existing systems for essential livelihoods (120) and may perceive initiatives for change (e.g., the investment of green infrastructure or dam removal) as serving only high-income, nonminority populations (122), and therefore may perceive planned SES transformation as illegitimate.

Importantly, there are no blueprint solutions for transformation in SESs. Rather, guidance must be developed from a preponderance of evidence from case studies, as local governance is best adapted to the context-dependent issues of an individual SES due to social-ecological memory and the vested interests of local people as they map out their livelihood futures (117). A network of stakeholders can bolster financial, political, and public support, which helps to create the momentum to break institutional and organizational inertia (e.g., adaptive governance). With substantial investment and structure from higher scales, as well as scaled-up collective change (paradigm shifts, innovations) from lower scales, adaptive governance has the potential to shift into transformative governance, wielding the capacity to trigger and direct regime shifts in SESs.

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SUMMARY POINTS

1. Transformative governance describes processes for abrupt, emergent, and systemic change in SESs.
2. Transformative governance is rooted in ecological theories to explain cross-scale dynamics in complex systems, as well as social theories of change, innovation, and technological transformation.
3. Transformative governance arises from established (or transient) adaptive governance when a social-ecological regime shift is eminent or the need for a regime shift (e.g., a severely degraded SES) is apparent to provide for human and ecosystem wellbeing.
4. Transformative governance is similar to adaptive governance, involving a broad set of governance components (e.g., institutions, actors, networks, and organizations) and structures (e.g., legitimacy, power, and human behaviors), but requires additional capacity (e.g., leadership, innovation) to foster new ecological and social-ecological regimes.
5. The primary differences between transformative governance and adaptive governance are (a) the framing of governance in terms of adaptation versus transformation; (b) the substantially higher level of risk tolerance necessary for transformation; (c) the need for structured government investment to legitimize and facilitate transformation; (d) the lasting change in dominant power relations; and (e) the restructuring of economies and social structure favoring equity, fairness, and justice that is required for transformation.
6. Various pathways have been identified for the development of transformative governance, including the role of moments of opportunity created by ecological, social, or political instability; the innovative and creative processes of individuals and groups; and dramatic shifts in social norms, values, or ethics.
7. Obstacles to transformative governance can arise from vested interests that control and benefit from existing system configurations or from legacies and stabilizing feedbacks that generate pathological trajectories.
8. Transformative governance is a subset of governance configurations and processes and may be applicable to only a small set of SESs.

FUTURE ISSUES

1. Transformation poses a significant risk to the stability (and livability) of SESs and thus requires a rigorous development of scenarios and range(s) of possibilities prior to pursuing a transformation to a new regime.
2. Increasing research on leading indicators (both social and ecological) and other identifying features of social-ecological thresholds is necessary to support and further develop transformative governance with the best available science, as well as other forms of information such as traditional knowledge.
3. Critical to the evaluation of transformative governance are quantitative and qualitative approaches to measure state variables at different scales in SESs, and to ultimately assess how transformation is affected by and affects the resilience of SESs.
4. To achieve sustainable trajectories at a global scale, it will be necessary to assess transformative governance under a wide array of social-ecological constraints including different governance regimes, economic systems, social strata, and worldviews (e.g., ethics, religions, or belief systems).
5. Researchers and practitioners need to develop a set of global case studies investigating transformative governance to test the limits of constraints and opportunities and to highlight the role of governance as a destabilizing force in pathologically stable or resilient, but socially or ecologically degraded, systems.
6. Future research should build a better understanding of cross-scale dynamics (e.g., mechanisms and emergent properties) of SESs by testing theories of panarchy, resilience, and adaptive cycles via qualitative and quantitative assessment pathways for transformative governance, specifically with relation to climate change and interactions between climatic drivers and social variation.

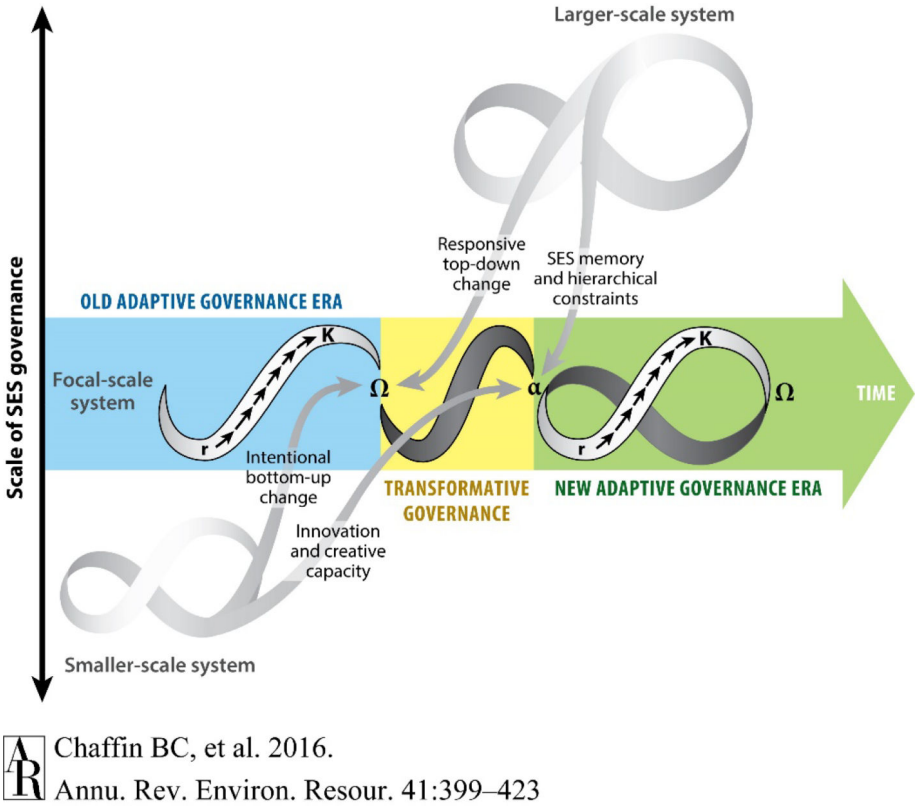

Figure 1.

Although adaptive governance seeks to maintain the “essence and integrity of an incumbent system” (59, p. 119) through changes in actor organization (e.g., networks) and institutional arrangements, the goal of transformative governance is to achieve a fundamentally new system through similar changes that collectively reorganize the fundamental controlling mechanisms of the SES.

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Figure 2.

Combined sewer overflows from Cleveland's urban watershed significantly endanger the water quality of Lake Erie (in addition to nonpoint source pollution). As a result, the greater Lake Erie SES is approaching a threshold and potential regime shift toward decreased water quality dominated by anoxic conditions.

Table 1.

Constraints and opportunities for transformative governance

Constraints	Description
Entrenched power relations	Dominant power relations can hold SESs in traps; the system as a result may be resilient to change from an unsustainable trajectory. Exposing the limitations of deeply entrenched power relations (including narratives) and creating opportunities for a SES to undergo natural rhythms of collapse and renewal can illuminate pathways for SES transformation (90).
Capitalism and dominant economic and political subsystems	As the dominant world economic system, capitalism structures and reinforces many economic and political systems at a global scale. In some cases, SES transformation may work against capitalist ideals and dominant political systems. The nested nature of SESs will make this type of change difficult and likely require at least a restructuring of local economies and devolution of decision-making authority related to natural resource use and conservation.
Cognitive limits of humans	Humans often lack the innate ability to question dominant social-structuring paradigms (60). Although the human capacity for imagination is great, we have difficulty conceptualizing ideas beyond the physical senses. It is difficult enough to ask what we do not know that we do not know, but it is even more difficult to ask why.
Law, formal institutions, and governmental structure	Institutions can provide legitimacy for shifting the status quo of governance in the form of new legislation and court decisions (102). They also provide the structure necessary for major investment that can transition adaptive governance mechanisms toward the explicit pursuit of transformation (64). Sanctions and regulatory incentives, both positive and negative, are more likely to change behaviors of corporations and citizens than an appeal to attitudes and beliefs (60).
Previous success of adaptive governance	Successful emergence and institutionalization of adaptive governance (45) can build lasting capacity for adaptive and transformative change in SESs. In addition, adaptive governance actors and networks produce powerful narratives of change that can be leveraged to publicly frame the need for SES transformation.
Human agency and imagination	Human agency and imagination allow humans to envision alternative futures and scenarios of change (46). Humans can willingly act as tactical change agents in explicit pursuit of SES transformation by viewing crises as opportunities to innovate and undermine status quo governance (57).