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Adapting Conservation Policy and Administration to Nonstationary Conditions

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ABSTRACT

False assumptions of stationarity, the idea that natural systems fluctuate within a set and predictable range, are common in conservation policies and public expectations developed since the late 1800s. With examples from United States national forest and water quality policy, we discuss the challenges of nonstationarity for planning and policy. We also raise questions about how resilience is becoming institutionalized. One central problem of managing for resilience is that it does not address the nuances and tradeoffs of managing nonstationary systems, such as keeping some components stable while transforming others. We recommend four paths forward: address root causes of change, increase adaptive capacity, develop science for nonstationarity, and enhance pragmatic flexibility without lowering environmental standards. Dealing effectively with nonstationarity in resource management and science, within our legal and management system of overlapping authorities and capacities, is critical for the intertwined future of people and nature.

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Introduction

Adaptation to nonstationary conditions including climate change poses deep challenges for environmental conservation and natural resources management. Stationarity, "the idea that natural systems fluctuate within an unchanging envelope of variability," has long been embedded in natural system planning and engineering (Milly et al. 2008). The concept assumes that any variable (such as annual flood peaks) can be predicted, within a range of variance, based on past measurements. However, past expectations may no longer apply, as exemplified by shifts in floods, megafires, extreme storms, drought, spread of invasive pests and diseases, species habitat, and food and fiber production. Climate-driven changes co-occur with numerous other social and ecological changes that increase ecosystem novelty by shifting away from previous and familiar conditions (Radeloff et al. 2015). The magnitude of human-caused change has led engineers and others to state that "stationarity is dead" (Milly et al. 2008). These shifts are straining the tools in the toolbox for conservation and resource management (Rissman et al. 2018), and a heated debate is ongoing about whether nonstationarity changes the

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fundamental goals of resource management, as well (Murcia et al. 2014). Meanwhile, long-established agencies and institutions for managing natural resources (see Andrews 2006) are changing through an increasingly fragmented mix of regulatory, incentive, and market-based policies (Hutchcroft 2001).

This essay examines how nonstationary change in climate and ecosystems challenges conservation goals, policy instruments, organizations, and administrative processes. We describe the major trends in the United States (U.S.) environmental and natural resources policy and the role of scientific expertise from the Progressive Era to the present. We show how assumptions of stationary, equilibrium-based ecosystems are foundational for management and regulation but can be incorrect. Occasionally, incorrect assumptions have led to disastrous results. We then discuss implications in two sectors: (1) national forests and wildfires and (2) water quality. We close with a caution about the way one solution–a resilience approach–has been institutionalized and suggest paths forward.

Persistence, Stability, and Change in Conservation and Natural Resources Policy and Management

Because the U.S. Congress and state legislatures are unlikely to provide comprehensive guidance for dealing with nonstationarity, natural resources management will need to adapt existing agencies and laws to climate and environmental change (Owen et al. 2017). Responses from Congress that do address nonstationarity are likely to be layered over prior laws and institutions. Looking to the origins of natural resources management in the U.S. can illuminate the scope of the challenge, since agencies and laws often outlast their initial conditions (Fairfax 2005). Agencies and laws from the Progressive Era, New Deal, Great Society, and Environmental Decade tend to focus on stable persistence of equilibrium conditions and recovery from degradation.

Today's management systems are multi-organizational and layer on historic philosophies and laws, rather than replacing them outright (Raymond and Fairfax 1999). Natural resources management was institutionalized in the U.S. during the Progressive Era, roughly 1890–1920 (Hays 1999). This era reformed government and society in response to the excesses of industrialization that created abysmal labor conditions and poor quality of life. Environmental degradation included mining pollution, deforestation, extinction of passenger pigeons, and overgrazed western rangeland (Andrews 2006). Lack of collective institutions, coupled with market pressure and ready access to credit, led to resource overuse (Sayre 2017). These tragedies galvanized the conservation movement (Cubbage, O'Laughlin, and Peterson 2017). Progressive reformers had faith in scientific expertise, professional leadership, rational control, and efficiency to reverse waste, corruption, and greed (Hays 1999). However, they had excessive hubris about experts imposing order on local ecosystems and communities (Langston 1995). Early conservationists focused on sustaining reliable yields from forests, rangeland, and water use. Early conservation agencies, such as the U.S. Forest Service (USFS) and National Park Service, were driven by expertise and professional models of public service (Hays 1999). Grassroots campaigns, such as women's organizing to protect birds from overharvest, contributed to emerging institutions. In the 1930s New Deal, the Soil

Conservation Service was created in response to the Dust Bowl. The Taylor Grazing Act finally closed the public domain and provided a system of range management.

These early managerial systems relied heavily on assumptions of equilibrium and system stationarity to generate seemingly efficient approaches for sustained yield by reducing the effects of variability (Thrower 2006; Benson and Craig 2017). George Perkins Marsh wrote in the influential book *Man and Nature* that without human disturbance, "a condition of equilibrium has been reached which, without the action of man, would remain, with little fluctuation, for countless ages" (1864). He asserted that people were subverting the balance of nature. Equilibrium and human control assumptions underlay Progressive Era thinking and policy. However, "nature proved far more complex, and their own mastery much more illusory, than the architects of the conservation state believed" (Johnson, 2017). Many early conservationists' contempt for Native Americans and the landscape disturbances they created contributed to dogmatic policies for exerting control such as fire suppression (Johnson 2017). Later, stability was one of Aldo Leopold's criteria for good management, even though he had a more dynamic view of ecosystem change (Leopold 1949).

Assumptions of stability often resulted in ecological damage, a phenomenon that has been called the "pathology" of command-and-control natural resources management (Holling and Meffe 1996). Control becomes pathological when it increases system rigidity, ignores complex interactions, and reduces system capacity for recovery. For example, the stabilization of river flows in the U.S. West allowed invasive fish to populate rivers where previously only fish adapted to flashy hydrologic systems could survive. In systems like rangelands, ideas of equilibrium ecosystems were fundamentally flawed and created lasting ecosystem damage due to overgrazing, which led to bankruptcy and social damage (Sayre 2017). In systems like temperate forests, the stability premise held fairly well, but it has been breaking down due to nonstationarity in climate change, invasive species, property parcelization, and other drivers of change.

Great Society laws passed in the mid-1960s addressed recreation, wilderness, pollution, endangered species, and public participation in decision-making. The 1970s Environmental Decade strengthened prior pollution and endangered species laws with stronger federal mandates and more standards and oversight for federal land management. As scientific expertise became increasingly quantitative, and stakeholders and courts began demanding more precise justifications and performance measures, agencies increasingly relied on sophisticated statistical and computational models from ecology and economics (Pilkey-Jarvis and Pilkey 2008). Standards-and-enforcement technical approaches have been successful in reducing pollution, but they often embed problematic assumptions of stationarity (Milly et al. 2008).

Equilibrium ecology focuses on the balance of nature and predictable ranges of variation. It lends itself well to even resource yields. In contrast, nonequilibrium ecology is now dominant in ecological thinking. "Systems are complex, dynamic, and unpredictable across space and time" with important roles for disturbance and nonlinear change (Moore et al. 2009). Yet nonequilibrium ecology has been accused of causing a "partial unraveling of environmental law," since the equilibrium paradigm is embedded in earlier natural resources agencies, as well as more complex regulatory laws. For example, the Endangered Species Act of 1973 and parts of the Clean

Water Act, such as Section 404, which regulates dredging or filling wetlands, utilize equilibrium assumptions (Tarlock 1993). Many scientists have taken strides to emphasize that their models present estimations of real conditions and to change unrealistic expectations that science will “deliver a truth that is nonarguable” (Cullen 1990). Social scientists likewise emphasize the fallibility of science and its inability to resolve politically contentious issues (Jasanoff 1990). While legal questions often hinge on federal agency decisions being reasonable and nonarbitrary, scientific analyses that acknowledge complex systems have the potential to help agencies meet standards, even under uncertainty.

Policy Instruments and Change: National Forests and Water Quality

Conservation scholars are actively debating whether climate and other anthropogenic changes require a fundamental rethinking of conservation and resource management goals and tools (Benson and Craig 2017; Craig 2010; Kates, Travis, and Wilbanks 2012). The design of policy instruments matters because it impacts adaptation options (Rissman et al. 2018) and the politics of decision-making (Dilling and Lemos 2011; Lascoumes and Le Galès 2007). We share examples that emerged from our social science and policy research (for methods, see Daniels 2020, Wardropper, Gillon, and Rissman 2017, Selles and Rissman 2020).

National Forests

In the western U.S., wildfire is a tremendous factor influencing national forest management choices and agency expenditures. Climate change is increasing wildfire frequency and severity (Westerling et al. 2011). Changing disturbance regimes have profound effects for ecosystems and society (Turner 2010). However, disturbance processes such as wildfire, storms, and insect and disease outbreaks fall largely outside the control of forest managers. Wildfire management decisions are impacted by a multilayered governance system, including federal and state wildland fire laws, national forest and other management plans, public and private landownership, agency cultures and capacity, and local zoning–or lack thereof–shaping housing development (Steelman 2016). Many national forests and other public lands have persistence and restoration goals (Rissman et al. 2018). For instance, regulations guiding the management of national forests have a goal to “maintain the diversity of plant and animal communities and support the persistence of most native species in the plan area” (USFS 36 CFR § 219.9). Climate change likely means greater expense to support the persistence of native species if habitat ranges shift.

National forests are managed through plans whose updates require extensive assessment and public notice and comment under the National Forest Management Act (NFMA). The rules that guide management planning are also updated. For instance, the USFS 2012 planning rule requires national forest plans to address climate change. Yet planning–and planning to plan–can be perceived as burdensome and even endless to some stakeholders (USFS 2016; Nie 2019). USFS advisory committee members representing both grazing and environmental protection seek greater certainty from the agency. One said, "The need to sustainably manage our national forest resources in a time of increasing demands for their use and shrinking agency resources demands flexibility. The emphasis in the 2012 rule on adaptive management is a step in this direction. The catch, however, is that resource users such as the grazing industry I represent need greater certainty and stability" (Nie 2019). Planning rules and forest plans are subject to judicial review, which can create frustration and gridlock, but this public process also allows for a vetting of agency decisions.

Management for wildland fire can present different tradeoffs with management for species habitat. In the Sierra Nevada mountains of California, lack of wildfire and harvest has led to more intensive fires than those to which trees and owls have adapted. Megafires have negatively impacted owls, so thinning might be an overall benefit to owls, even if it creates some short-term disturbance (Jones et al. 2016). By contrast, in Yellowstone and the northern Rockies, lodgepole pine is already adapted to extreme fire conditions, at least within historic limits (Romme et al. 2011). A history of suppressing fire has given way to growing acceptance of using fire where allowable (USDA and USDI 2014). However, national forests and other public lands are still expected to prevent fire risk to people and the growing number of structures in the wildland-urban interface.

Water Quality

To an even greater extent than national forests, water quality is governed through an overlapping array of policies and processes. These include the federal Clean Water Act, state water quality laws, county and municipal rules, and collaborative watershed groups. The Clean Water Act embeds assumptions of stationarity in water quality policy and management through Total Maximum Daily Load (TMDL) allocations and quantitative models. Agencies are required to calculate a TMDL and pollution reductions for point sources (such as effluent from a sewage pipe) and nonpoint sources (such as agricultural runoff) in impaired waters. Agricultural pollution is addressed largely through incentives rather than restrictions, except for very large operations. A common watershed model for calculating TMDLs is the Soil and Water Assessment Tool (SWAT), which calculates pollutant loads from nonpoint sources and was developed to help implement the Clean Water Act (Gassman et al. 2007; Rissman and Carpenter 2015). SWAT uses historic average precipitation, development, and agricultural land uses, which can lead to recommendations unlikely to keep pace with future change (Gillon, Booth, and Rissman 2016; Wardropper, Gillon, and Rissman 2017).

A watershed in southern Wisconsin provides an example of how assumptions of nonstationarity create benefits and risks to different actors' interests. The Yahara Watershed, within the larger Rock River Basin, has a mosaic of urban and agricultural land uses surrounding an iconic river and chain of lakes. For the last century, the most pressing surface water quality objective has been to control algal blooms caused by phosphorus from agricultural fertilizers, manure, and urban stormwater runoff. A TMDL for phosphorus in the Rock River Basin requires phosphorus pollution reductions, estimated by SWAT. Yet confidence in SWAT model estimates is tempered by nonstationary conditions in land use, agriculture, and precipitation that are not incorporated in the model (Gillon, Booth, and Rissman 2016). Increasing rates of urbanization, wetland and pasture loss, and agricultural intensification mean that baselines from which pollution is measured are dynamic and thus difficult to use as a starting point for model estimates. Compounding these changes, annual precipitation and storm events have increased, bringing more surface phosphorus into waterways (Rissman and Carpenter 2015), which can impact the health and livelihoods of communities counting on cleaner water in local lakes and the downstream Gulf of Mexico.

Another complication is administrator discretion in measuring baseline and ongoing water quality. Using stationary assumptions in pollution modeling provides more certainty for regulated entities but may mean poorer water quality if models do not account for large runoff events. For instance, an administrator at the Wisconsin Department of Natural Resources, which is responsible for implementing the Clean Water Act, told us they advised their monitoring staff, "Don't go sample during storm time … " because the water quality tends to be poor during a storm event; instead, "we want to sample under regular conditions." Of course, this begs the question: what are regular conditions? Manual monitoring of water quality is still the norm across most of the U.S., although in the Yahara watershed, substantial funding in the 2010s increased the number of stream gages that take continuous measurements to capture the effect of large storm events that carry most nutrients downstream.

Institutionalizing Resilience

Rise of Resilience

Managers and policymakers are adapting to change by moving beyond assumptions of predictable ecosystems, while still facing the high expectations of citizens, stakeholders, legislators, appointed leaders, and many agency staff. Agencies remain accountable for delivering sustained yields, preventing catastrophic wildfires, protecting species, and restoring water and air quality. What solutions are available to address these expectations under nonstationary conditions?

Resilience is part of the answer, according to some scientists and conservation practitioners. Resilience is an emergent approach, fostered by the Resilience Alliance (established in 1999) and increasingly accepted by natural scientists. "Resilience is fundamentally a system property. It refers to the magnitude of change or disturbance that a system can experience without shifting into an alternate state that has different structural and functional properties and supplies different bundles of the ecosystem services that benefit people" (Utah Resilience Alliance 2010). Rather than resist change or transform to new system conditions, resilience embraces variability and disturbance within a range of conditions (Millar, Stephenson, and Stephens 2007).

Resilience has occasionally become formalized in high-level U.S. government policy. Yet the concept has sometimes proven difficult to institutionalize, given variable interpretations of the term. This tension is especially clear in the context of forest management. While the use of the term "resilience" in national forest management planning accompanied the rise of attention to climate change, it has sometimes been replaced by more easily defined terms (Selles and Rissman 2020). The word "resilient" was initially included in the draft 2012 national forest planning rule but then replaced with the word "integrity" in the final rule. The USFS explained it replaced "healthy and resilient" with "ecological integrity" because of public concern about how to define health and resilience. The USFS argued that ecological integrity was already a "scientifically supported term" with "established metrics for measurement" and in use by the National Park Service and the Bureau of Land Management (77 Fed. Reg. 68 21208 (April 9, 2012)).

In 2014, Congress amended the Healthy Forests Restoration Act of 2003 to make it easier for the USFS to conduct hazardous fuel reduction projects in national forest treatment areas to "increase the resilience to insect or disease infestation" (16 U.S.C. 6591d). The amendment was passed through the 2014 Farm Bill (Agricultural Act of 2014). In 2018, "resilience" was included in a U.S. budget law; "wildfire resilience projects" became a type of categorical exclusion from National Environmental Policy Act review for hazardous fuel reduction projects under 3,000 acres. The law also states that when applying this categorical exclusion, projects must maximize retention of old-growth or large trees "to the extent that the trees promote stands that are resilient to insects and disease, and reduce the risk or extent of, or increase the resilience to, wildfires" (16 U.S.C. 6511). If harvest plans are challenged, it will be illuminating to see how courts interpret resilience, since large trees may be more susceptible to insects and disease, but a fire-adapted old-growth stand could better withstand wildfire. A bill, Resilient Federal Forests Act of 2019, would "return resilience to overgrown, fire prone forested lands" by increasing the categorical exclusion for wildfire resilience projects from 3 to 10 thousand acres (H.R. 2607). Another bill for Wildfire Resilient Communities would provide $1 billion of mandatory funding for national forest hazardous fuels reduction (S. 1691). The use of resilient in these titles reflects its positive framing for multiple constituencies.

In water quality contexts, resilience is often invoked to reduce vulnerability and foster recovery from hazards like extreme storms. Resilience terminology was recently institutionalized in federal law related to drinking water quality through America's Water Infrastructure Act of 2018, which amended the Safe Drinking Water Act. Communities over a certain size are now required to develop or update risk and resilience assessments. The Environmental Protection Agency provides resources, such as risk assessment protocols and storm surge scenarios, for comprehensive planning for extreme weather through its Creating Resilient Water Utilities initiative (https://www.epa.gov/crwu).

Unpacking Resilience

While a resilience approach offers opportunities to incorporate nonstationary assumptions into natural resources management, several potential problems are associated with resilience goals as they have become defined in policy and management. Climate adaptation planners with the National Park Service have questioned whether resilience is actually "maladaptive" for climate change planning because it is too vague. These planners argue that the concept includes so many approaches to address changing conditions–including resistance to change, accommodation of change, and intentional directed change toward new desired conditions, also known as intentional transition or transformation–that it is not clear how to take a resilience approach to planning

(Fisichelli, Schuurman, and Hoffman 2016). Positive and vague language has benefits for high-level policy because it can broaden coalitions and serve as a "boundary object" for collaboration (Steger et al. 2018), but it can also cause confusion in planning and implementation.

Another challenge of resilience is that it often focuses on persistence of stable states within a range of variable conditions, rather than transformative approaches for climate adaptation (Kareiva and Fuller 2016; although see exceptions below). Craig has declared, "stationarity is dead: long live transformation," and suggested an approach of principled flexibility when dealing with climate change to enhance resilience and adaptive capacity, while embracing unyielding precautionary regulation when dealing with all non-climate impacts (2010). Managers may need to combine managing for resilience with managing for change, since transformations in some ecosystem conditions will sometimes be inevitable, or even desirable to achieve other goals. For instance, high-severity wildfire may not be controllable through forest thinning, so transformations in human development practices would be needed to prevent loss of life and structures (Schoennagel et al. 2017). In another controversial example, managers may choose to retain nonnative plants because they provide habitat for rare animals (Radeloff et al. 2015).

There are some positive examples of experimentation with more transformative approaches to resilience-based management (RBM). Some U.S. agencies are experimenting with resilience and transition approaches in their guidance, such as the Adaptation Workbook developed by the Northern Institute for Applied Climate Science (Swanston and Janowiak 2016). Compared to the U.S., international bodies have moved further toward RBM for water quality by requiring clear goals and frequent revision of protocols to achieve them. In the European Union, the 2000 Water Framework Directive has 'programmes of measures' to achieve certain objectives that must be revised every six years, and each member state sets its own ecological, chemical, and other standards that allow it to meet certain requirements (Clarvis, Allan, and Hannah 2014).

Unfortunately, there are some unforeseen problems associated with the use of the term resilience in policy and management. In land use policy, scholars suggest that resilience has been coopted by some governments and other organizations to mean "resistance, control, and attempts to return to normalcy" (McGreavy 2016), as opposed to an embrace of complexity or justice. In international development, resilience has become a pervasive term tied to "crisis management, financial (de)regulation and development economics" for "future events that (we are told) we cannot predict or prevent, but merely adapt to by 'building resilience'" (Walker and Cooper 2011). Holling's theory of resilience was a critique of rigid sustained yield and equilibrium economic and ecological models, but Walker and Cooper (2011) argue that resilience and the systems perspective frames ecological and financial disasters as unmanageable and inevitable. The framing of resilience in ways that naturalize disasters, ignore root causes of problems, and avoid accountability may not be as prevalent in natural resources management as in international development, but this is a concern to guard against.

Paths Forward

Innovations often include the seeds of new problems. This was true in the Progressive Era, New Deal, Great Society, and Environmental Decade, and it appears to be true now, as Congress and agencies experiment with institutionalizing resilience. Stable social-ecological conditions are longstanding goals in conservation and natural resources management. These goals are predicated to some degree on assumptions of stationary and equilibrium ecosystems that have been largely rejected by ecologists in recognition of ecosystems as changing, variable, and unpredictable. Adaptation to anthropogenic environmental change challenges some foundations of resource management regimes, suggesting the need for a shift in natural resources policy management paradigms not just in means, but sometimes also ends. We suggest several paths forward below.

Address Root Causes

We need more attention to root causes of environmental change. Polarization and insufficient political will means we have not yet seen federal legislative changes to address many root causes of accelerating nonstationarity. These include greenhouse gas emissions, habitat loss, and pollution from agriculture and development. The need for federal action to reduce greenhouse gas emissions is tremendous but continues to be stymied at the national level. We find optimism, however, in climate mitigation efforts at state and municipal levels in the U.S and globally (van der Ven, Bernstein, and Hoffmann 2017).

Increase Adaptive Capacity

Agencies, nonprofits, firms, landowners, workers, and communities need increased capacities to adapt to change. Unfortunately, there are trends in the opposite direction, with budgets that are increasingly stressed by climate impacts and emergency responses, including wildland firefighting and storm clean-up. A wholehearted reinvestment in people and resources is needed. Valuable knowledge resources for institutional capacity building for adaptation are available to be leveraged across sectors; for instance, water infrastructure adaptation options are available from the Global Water Partnership (https://www.gwp.org/en/). Major global shocks, like the COVID-19 pandemic, stress capacity on multiple levels and exacerbate inequalities (van Dorn, Cooney, and Sabin 2020). In response to these shocks, public and private sectors have an opportunity to rebuild capacity, as well as reimagine the norms and ideals that are possible through deeper social restructuring with a focus on equity (Davidai et al. 2020) and a low-carbon economy that will prevent future climate change disasters (Skarbek 2020).

Incorporate Nonstationarity into Policy-Relevant Science

Much of the science that underpins resource policy is designed for persistence, but we increasingly face shocks and transitions. We recommend improvements in regulatory science for nonstationarity and then suggest ways to mitigate the challenges this change may create for public understanding and participation. First, regulatory science should better account for nonstationarity. Models underpin environmental analysis of plans, alternatives, standards, and regulations. Yet decision-makers often rely on equilibrium models based on historical data. At the same time, there are promising innovations in computational and mechanistic models that deal with nonstationarity by predicting ecosystem responses under dynamic conditions (Motew et al. 2018). While many of these models are too time- and data-intensive for use by decision-makers, innovations toward addressing nonstationarity are occurring (Westra et al. 2014). For instance, some TMDL processes have included climate change projections in models (Blankenship 2018).

As modeling to address nonstationarity becomes more complicated, however, there must be simultaneous attention paid to communicating this science to relevant stakeholders, including the general public. There are multiple reasons that inclusion and communication are important for natural resources policy: the importance of upholding the values of participatory democracy, and, fundamentally, an acknowledgment that science-policy decisions are rightly driven by peoples' values and interests. Good decisions require getting the values and the facts right, recognizing that these are mutually constituted (Dietz 2018). We encourage a focus on democratizing participation processes so that decision-making can address nonstationarity using the best available science in ways the public can understand. We see opportunities for public inclusion and communication in boundary organizations that cross science-policy interfaces, in-depth learning forums, and iterative decision processes that explain technical information that could otherwise be overwhelming (see Jensen-Ryan and German 2019; Lemos, Kirchhoff, and Ramprasad 2012; Wagner and Ylä-Anttila 2020). Unfortunately, recent trends of sidelining of scientific advisors and information (Lin 2019) and relocating government scientists' jobs (Hardy 2019) reduce scientific capacity.

Pragmatic Flexibility

Flexibility in resource management and governance is a common adaptation strategy. Administrative processes need to allow for learning and adaptation in dynamic contexts that connect diverse networks of actors, foster behavior change, and result in measurable environmental benefits (Pahl-Wostl 2009). The growing literature on adaptive policy-making and multi-objective modeling urges a focus on tipping points after which actions no longer meet their objectives (Haasnoot et al. 2013).

The USFS 2012 planning rule provides options for adaptation while upholding resource management standards. We argue that this rule should be maintained, as it provides the pragmatic administrative flexibility needed under nonstationary conditions. For instance, tree planting requirements in NFMA may no longer be reasonable under climate change if managers experience multiple failed plantings after a wildfire. Newer forest management plans written under the 2012 planning rule can provide more administrative flexibility for these situations. However, it will be important to maintain environmental standards that could still be met under changed conditions.

In a political moment where the stated goal of some actors is to contribute to the deconstruction of the administrative state (Lewis 2019), it is important to ensure that adaptation does not become a pathway for lowering environmental standards. We should not throw out our fundamental resource and environmental laws in the name of adaptation, even when anthropogenic environmental change alters the calculus of impacts, costs, and benefits associated with our actions.

Conclusion

Bipartisan legislation has begun to institutionalize resilience, focused on reducing hazards from wildfires and threats to water infrastructure. We highlight several potential limitations of resilience, including its vagueness, continued focus on stable states, and its use in naturalizing disasters to shift responsibility away from root causes. Experiments in institutionalizing resilience will likely hinge on whether resilience goes beyond hazard prevention and engineered recovery to increasing system capacities and addressing root causes. Managers will need to address potential tradeoffs between resilience and transformation. Dealing effectively with nonstationarity, within our legal and management system of overlapping authorities, is critical for the intertwined future of people and nature.

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