

ARTICLE

4°C

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I. Introduction

Accelerating ice loss and expanding wildfire zones are potential markers of what are known as tipping points—thresholds along a nonlinear pattern of system change that accelerate the pace of change.¹ Scientists are concerned that our global climate system is dangerously close to passing these points.²

This trend has significant implications for governance and law. Climate change disruptions will extend beyond biophysical systems to social systems, including systems of governance.³ Failing to anticipate and adaptively plan for that future presents an existential threat to democratic governance.

There is now widespread agreement mitigation and adaptation must be *concurrent* governance efforts.⁴ However, adaptation inherently requires *present* governance institutions to anticipate uncertain *future* conditions in constant flux. *Anticipatory governance* reflects this challenge of formulating adaptation policy strategies built around possible future scenarios.⁵

The standard mitigation policy goal has been to contain the global average increase in temperature to 1.5° Celsius (°C) above pre-industrial levels ideally, and to 2°C at worst.⁶ Adaptation policy has likewise focused on the measures needed to adjust to this relatively limited amount of warming.⁷ Yet, research increasingly identifies warming of 2°C as a likely tipping point threshold for many ecological systems, with cascading effects on social systems, and things only get worse as the temperature keeps increasing.⁸

The vision of a 1.5-2°C future has played out in adaptation policy through three interconnected adaptation modes. First, to *resist* the impacts of climate change. Second, to build the *resilience* of social-ecological systems. Third, to *retreat* from unavoidable impacts.⁹

Moving past 2°C will require adding a fourth adaptation mode—*redesign*. By “redesign,” we mean transformational adaptation measures needed to reconfigure and relocate our nation’s population distribution, land uses, infrastructure, economic and production networks, and natural resource management.¹⁰ Engaging *now* in anticipatory adaptation is the best chance of avoiding a breakdown in democratic governance.

Editors’ Note: This Article is adapted from J.B. Ruhl & Robin Kundis Craig, 4°C, 106 MINN. L. REV. 191 (2021), and used with permission.

1. See Marten Scheffer et al., *Early-Warning Signals for Critical Transitions*, 461 NATURE 53, 53 (2009).
2. See Timothy M. Lenton et al., *Climate Tipping Points—Too Risky to Bet Against*, 575 NATURE 592, 592-95 (2019) (corrected Apr. 9, 2020). Michalea D. King et al., *Dynamic Ice Loss From the Greenland Ice Sheet Driven by Sustained Glacier Retreat*, 1 COMM’NS EARTH & ENV’T 1, 1 (2020) (corrected Sept. 4, 2020). Romain Hugonnet et al., *Accelerated Global Glacier Mass Loss in the Early Twenty-First Century*, 592 NATURE 726, 726 (2021).
3. See generally *The Ocean and Cryosphere in a Changing Climate: A Special Report of the Intergovernmental Panel on Climate Change*, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE 85 (2019), https://www.ipcc.ch/site/assets/uploads/sites/3/2019/12/SROCC_FullReport_FINAL.pdf [<https://perma.cc/C6XJ-KNAJ>].
4. See *Climate Change 2014: Synthesis Report*, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE 17 (2014), https://www.ipcc.ch/site/assets/uploads/2018/02/SYR_AR5_FINAL_full.pdf [<https://perma.cc/XFT5-EKAN>].
5. See, e.g., Karlijn Muiderman et al., *Four Approaches to Anticipatory Climate Governance: Different Conceptions of the Future and Implications for the Present*, 11 WIRES CLIMATE CHANGE, Oct. 9, 2020, at 2; Ray Quay, *Anticipatory Governance: A Tool for Climate Change Adaptation*, 76 J. AM. PLANNING ASS’N 496, 498-99 (2010); Joost Vervoort & Arti Gupta, *Anticipating Climate Futures in a 1.5°C Era: The Link Between Foresight and Governance*, 31 CURRENT OP. IN ENV’T L SUSTAINABILITY 104, 105 (2018). See, e.g., David

H. Guston, *Understanding “Anticipatory Governance”*, 44 SOC. STUD. SCI. 218, 219 (2014).

6. *Global Warming of 1.5°C*, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE 56 (2018), https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_High_Res.pdf [<https://perma.cc/5L7C-M4WK>] [hereinafter *2018 IPCC 1.5°C Report*].
7. See generally *THE LAW OF ADAPTATION TO CLIMATE CHANGE: U.S. AND INTERNATIONAL ASPECTS* (Michael B. Gerrard & Katrina Fischer Kuh eds., 2012) [hereinafter *LAW OF ADAPTATION*].
8. Will Steffen et al., *Trajectories of the Earth System in the Anthropocene*, 115 PROC. NAT. ACAD. SCI. 8252, 8253-54 (2018).
9. See *infra* Part III.A.3. We acknowledge there are other ways to name these modalities. See, e.g., Katharine J. Mach & A.J. Siders, *Reforming Strategic, Managed Retreat for Transformative Climate Adaptation*, 372 SCI. 1294, 1294 (2021).
10. See *infra* Part III.C (discussing the redesign adaptation mode).

II. Embracing 4°C: Why 2°C Is Too Conservative for Anticipatory Adaptation Governance

A. Where Are We Now? The Current Increase and Trends in Global Average Temperature

At current rates, global average temperatures will be 2°C warmer by 2067. However, “[e]stimated anthropogenic global warming is currently increasing at 0.2°C (likely between 0.1°C and 0.3°C) per decade due to past and ongoing emissions (*high confidence*).”¹¹

B. Where Are We Going? Committed Warming and Projections for Global Average Temperatures

In 2017, researchers estimated by 2100 “[t]he likely range of global temperature increase is 2.0-4.9°C, with a median of 3.2°C”¹² Barring rapid global political, social, and technological transformations, we will be fortunate to limit temperature rise to 2.6°C, and the possibility of reaching 4.0°C cannot be ignored.

III. Anticipating 4°C: What Does the World Look Like Beyond 2°C?

Climate change is, well, *change*. Envisioning governance of the United States at 4°C requires adaptation planners to imagine an accelerating *process* of discontinuous transformation.

A. Coming to Grips With Nonlinear Change

The impacts from a steadily increasing mean global average temperature are *nonlinear* in two senses. First, the amount of change occurring is often geometric. Second, at some point the changes fundamentally alter social-ecological systems.¹³ Beyond 2°C, the world is likely to look profoundly different.¹⁴ First, humans will be migrating *en masse*, as middle latitudes become increasingly uninhabitable. Second, food insecurity will become problematic.¹⁵

Third, sea-level rise, melting ice, and severe storms will transform the coasts.¹⁶ Fourth, the rest of the biosphere will suffer from climate change itself and from humanity’s attempts to adapt.¹⁷

B. Imagining the United States When the World Is 4°C Warmer

What will a 4°C warmer United States look like? Although the direct impacts may be uneven across the nation and across economic sectors, climate-induced impacts in one region or sector undoubtedly will have effects elsewhere.¹⁸

The impacts of domestic climate-induced inter-regional migration within the United States have been ignored in adaptation planning. New adaptation governance will be necessary to cope with migration impacts and the other transformations in a 4°C world.¹⁹

IV. Adapting to 4°C: Reorienting Adaptation Policy for Anticipatory Redesign

A. Resistance, Resilience, and Retreat

Current adaptation policy can be sorted into three modes: *resistance*, *resilience*, and *retreat*.²⁰

1. Resistance

Resistance policies focus on building infrastructure and other mostly technological defenses to climate change impacts in order to protect human communities.²¹ Resistance strategies often take the form of “hard” infrastruc-

¹¹ See also Éva Plagányi, *Climate Change Impacts on Fisheries*, 363 SCI. 930, 930-31 (2019).

¹² Vince, *supra* note 15.

¹³ *Id.*

¹⁴ See Rachel Warren, *The Role of Interactions in a World Implementing Adaptation and Mitigation Solutions to Climate Change*, 369 PHIL. TRANSACTIONS ROYAL SOC’Y A 217, 219-33 (2011).

¹⁵ W. Neil Adger et al., *Urbanization, Migration, and Adaptation to Climate Change*, 3 ONE EARTH 396, 396 (2020).

¹⁶ See J.B. Ruhl, *Climate Change Adaptation and the Structural Transformation of Environmental Law*, 40 ENV’T L. 363, 387-89 (2010) (using the terms resist, transform, move); see also Robert R.M. Verchick & Joel D. Scheraga, *Protecting the Coast*, in LAW OF ADAPTATION, *supra* note 7, at 239 (using the terms resistance, adjustment, and retreat); Trip Pollard, *Damage Control: Adapting Transportation to a Changing Climate*, 39 WM. & MARY ENV’T L. & POL’Y REV. 365, 378 (2015) (listing the various terms); Mark Scott & Mick Lennon, *Climate Disruption and Planning: Resistance or Retreat?*, 21 PLAN. THEORY & PRAC. 125, 130 (2020) (using a variety of these terms); A.R. Siders & Jesse M. Keenan, *Variables Shaping Coastal Adaptation Decisions to Armor, Nourish, and Retreat in North Carolina*, 183 OCEAN & COASTAL MGMT., Jan. 1, 2020, at 2.

¹⁷ See Ruhl, *supra* note 20, at 385-86; see also Robert R.M. Verchick & Joel D. Scheraga, *Protecting the Coast*, in LAW OF ADAPTATION, *supra* note 7, at 235-37; Mach & Siders, *supra* note 9.

¹¹ See, e.g., *Global Warming of 1.5°C*, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE 56 (2018), https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_High_Res.pdf. [hereinafter *2018 IPCC 1.5° Report*], at 4.

¹² Adrian E. Raftery et al., *Less Than 2°C Warming by 2100 Unlikely*, 7 NATURE CLIMATE CHANGE 637, 639 (2017).

¹³ See Mark Stafford Smith et al., *Rethinking Adaptation for a 4°C World*, 369 PHIL. TRANSACTIONS ROYAL SOC’Y A 196, 196 (2011).

¹⁴ See Mark New et al., *Four Degrees and Beyond: The Potential for Global Temperature to Increase Four Degrees and Its Implications*, 369 PHIL. TRANSACTIONS ROYAL SOC’Y A 6, 6 (2011).

¹⁵ Gaia Vince, *The Heat Is On Over the Climate Crisis. Only Radical Measures Will Work*, GUARDIAN (U.K.) (May 18, 2019), <https://www.theguardian.com/environment/2019/may/18/climate-crisis-heat-is-on-global-heating-four-degrees-2100-change-way-we-live> [<https://perma.cc/R9AK-ZZQY>];

ture, which comes with significant environmental impacts and economic costs.²²

2. Resilience

Climate resilience policies are designed to facilitate a community's capacity to cope with climate change where impacts cannot be avoided or effectively resisted.²³ Enhancing resilience capacity technology and response management strategies has long been a focus of public policy independent of climate change.²⁴

3. Retreat

Retreat policies focus on intentionally abandoning areas subject to harms and relocating the people and structures to less vulnerable locations.²⁵ Retreat is increasingly recognized as a necessary mode of adaptation, while accommodating a variety of social values, including increased equity.²⁶

B. The Three Rs Versus 4°C

Current adaptation policy proposes deploying the Three Rs to manage the key drivers of adaptation need.²⁷ This focus on incremental adaptation carried out largely at state and local scales has led to a heavy emphasis on “climate proofing” at a small scale through resistance and resilience strategies,²⁸ with an assumption that adaptation will continue to occur in situ.

However, the 2°C mark is likely the threshold at which climate change takes on new and unmanageable properties and mass migrations occur with increasing frequency.²⁹ Consequently, transformational adaptation policies will

need to operate at larger scales, introduce novel strategies, and contemplate major changes.³⁰

C. Reframing Adaptation for Redesign

The Three Rs are not aimed at managing the fundamental redesign of biophysical systems that 4°C will impose, and an anticipatory adaptation policy must also prepare to redesign *social* systems.³¹ Redesign is about designing and facilitating relocations and reconfigurations necessary for successful adaptations for a “beyond 2°C” world.

The scale of redesign adaptation requires shifting the primary policy locus from local and state to regional and national.³² Local adaptation planning will still look inward to manage local needs, but it will also need to look *outward* to plan coherently with larger-scale redesign needs.

V. Governing at 4°C: Conceptualizing, Planning, and Implementing Redesign Adaptation

The most important consequence of transformational 4°C warming for conceptualizing the governance of redesign adaptation is massive human migration within the United States.³³ Preservation of a functional democracy imposes two additional requirements. First, governance of these changes must be legitimate, so citizens accept and comply with the changes. Second, governance of these changes must be equitable.³⁴

That leaves two last questions: First, How should the United States plan, finance, and coordinate this national-scale adaptation effort?; and, second: Who's in charge?³⁵ Given the scale of redesign adaptation, we posit the answer to both questions will lie primarily in the federal government. Human migration within the United States will require a national perspective, coordination, and budget.³⁶ The governance challenges and solutions from the Great

22. See Robert R.M. Verchick & Joel D. Scheraga, *Protecting the Coast*, in *LAW OF ADAPTATION*, *supra* note 7, at 240-41.

23. See Ruhl, *supra* note 20, at 385-86; Robert R.M. Verchick & Joel D. Scheraga, *Protecting the Coast*, in *LAW OF ADAPTATION*, *supra* note 7, at 239; see also Mach & Siders, *supra* note 9.

24. See Sierra C. Woodruff et al., *Adaptation to Resilience Planning: Alternative Pathways to Prepare for Climate Change*, J. PLAN. EDUC. & RSCH. 1, 1-3.

25. See Ruhl, *supra* note 20, at 388-89; Robert R.M. Verchick & Joel D. Scheraga, *Protecting the Coast*, in *LAW OF ADAPTATION*, *supra* note 7, at 239; Mach & Siders, *supra* note 21.

26. Mach & Siders, *supra* note 9, at 1296-99.

27. See *Climate Change Impacts in the United States: The Third Climate Assessment*, U.S. GLOB. CHANGE RSCH. PROGRAM U.S. 9 (2014), https://nca2014.global-change.gov/downloads/high/NCA3_Climate_Change_Impacts_in_the_United%20States_HighRes.pdf [<https://perma.cc/DV6W-6CF3>] [hereinafter 2014 U.S. CLIMATE IMPACT REPORT], at 201-02, 671-706 (discussing “[a]daptation in the context of biodiversity and natural resource management”); *Adapt Now: A Global call for Leadership on Climate Resilience*, GLOB. COMM'N ON ADAPTATION 3, 9-11, 19-21, 31-34 (2019), https://gca.org/wp-content/uploads/2019/09/GlobalCommission_Report_FINAL.pdf [<https://perma.cc/9GYN-969W>] [hereinafter *Adapt Now*].

28. See generally Robert W. Kates et al., *Transformational Adaptation When Incremental Adaptations to Climate Change Are Insufficient*, 109 PROC. NAT. ACAD. SCI. 7156 (2012); Mark Scott & Mick Lennon, *Climate Disruption and Planning: Resistance or Retreat?*, 21 PLAN. THEORY & PRAC. 125, 142 (2020). See Justine Bell & Mark Baker-Jones, *Retreat From Retreat—The Backward Evolution of Sea-Level Rise Policy in Australia, and the Implications for Local Government*, 19 LOC. GOV'T L.J. 23, 24-30 (2014).

29. See Steffen et al., *supra* note 8, at 8254-56.

30. Kates et al., *supra* note 28, at 7158; see also Kirstin Dow et al., *Limits to Adaptation to Climate Change: A Risk Approach*, 5 CURRENT OP. ENV'T SUSTAINABILITY 384, 385-86 (2013); Alark Saxena et al., *Knowledge, Attitudes and Practices of Climate Adaptation Actors Towards Resilience and Transformation in a 1.5°C World*, 80 ENV'T SCI. & POL'Y 152, 157-58 (2018); Giacomo Fedele et al., *Transformative Adaptation to Climate Change for Sustainable Social-Ecological Systems*, 101 ENV'T SCI. & POL'Y 116, 116-20 (2019); Tyler Felgenhauer, *Addressing the Limits to Adaptation Across Four Damage-Response Systems*, 50 ENV'T SCI. & POL'Y 214, 214-15 (2015).

31. See Kates et al., *supra* note 28, at 7159.

32. See generally Kates, *supra* note 28 (“In some places . . . vulnerabilities and risks may be so sizeable that they can be reduced only by novel or dramatically enlarged adaptation.”).

33. See generally Warren, *supra* note 18, at 228 (discussing cross-regional migration resulting from 4°C warming consequences).

34. Iselin Theien, *Food Rationing During World War Two: A Special Case of Sustainable Consumption?*, ANTHROPOLOGY FOOD 55, Sept. 2009, at ¶ 31; Wendy Moore, *Oh! What a Lovely Diet*, GUARDIAN (U.K.) (Jan. 13, 2001), <https://www.theguardian.com/theobserver/2001/jan/14/life1.lifemagazine5> [<https://perma.cc/974K-7E2B>].

35. See Robert L. Glicksman, *Climate Change Adaptation: A Collective Action Perspective on Federalism Considerations*, 40 ENV'T L. 1159 (2010); see also ALEJANDRO E. CAMACHO & ROBERT L. GLICKSMAN, REORGANIZING GOVERNMENT: A FUNCTIONAL AND DIMENSIONAL FRAMEWORK 197-205 (2019).

36. Exec. Order No. 14008, 86 Fed. Reg. 7619 (Jan. 27, 2021) [hereinafter BIDEN CLIMATE CHANGE E.O.] at §§102(f), 202, 203.

Depression, Dust Bowl, and World War II provide historical precedents for redesign adaptation.

However, that is not to say transitioning to governance for a 4°C nation will be easy. There are four critical starting points. Our public and private governance institutions must recognize: (1) transformative change will occur in diverse modalities simultaneously, complicating the governance of redesign adaptation; (2) the various governance tools available require careful deployment toward coordinated goals; (3) such deployment will require a coherent, anticipatory model for designing policy strategies around the intersections of change modes with governance modes; and (4) there is a need *now* to actively plan for redesign adaptation and its governance.

A. Different Modes of Change: A Planning Typology for Redesign

The decision to migrate or stay in the face of a climate-induced threat is influenced by a complex interaction of forces.³⁷ Geographer Robert McLeman outlines a progression of thresholds:

Six types of thresholds in response to climate hazards are identified: (1) Adaptation becomes necessary; (2) Adaptation becomes ineffective; (3) Substantive changes in land use/livelihoods become necessary; (4) In situ adaptation fails, migration ensues; (5) Migration rates become non-linear; and (6) Migration rates cease to be non-linear.³⁸

Collectively, McLeman's six stages embody the three modes of change resulting from climate change-induced human migration. Baseline linear change remains the dominant mode of migration in stages 1-3, which might look little different from current baseline population movement patterns in the United States. Nonlinear change begins in stage 4 and continues into stage 5, the stage representing the concern for 4°C adaptation.³⁹ By stage 6, cascade change becomes the dominant mode, during which human migration triggers numerous other system changes.⁴⁰

1. Baseline Linear Change

Many of the direct effects of climate change will transpire in incremental, linear trends over relatively long time frames.⁴¹ Long-term effects of baseline linear migration, such as move-

ment from rural to urban areas, thus eventually can present policy challenges from accumulating effects, such as increased competition for employment and housing.⁴²

2. Nonlinear Change

Climate change already is having effects departing from baseline linear change,⁴³ such as population migration. Sea-level rise is expected to produce this kind of nonlinear migration wave.⁴⁴ Policy issues are sure to arise as out-migration threatens economic and social prosperity in some areas and influxes of population in other regions stress housing supply, employment opportunity, and infrastructure capacity.⁴⁵

3. Cascade Change

Rising temperatures will cause ecological and social systems to cross tipping points. Such tipping point "sudden onset" events have triggered migration cascades in the past, such as the Dust Bowl and post-Katrina relocations.⁴⁶

B. The Toolbox: An Implementation Typology for Redesign

1. Laissez-Faire

Faith in the invisible hand of the market may work surprisingly well to push and pull adaptation in the right directions. One important player in climate-affected markets is likely to be the private insurance industry. An important adaptation role for private insurance companies is as market signalers of when in situ adaptation is becoming too expensive to be profitable.^{47 48}

2. Planning and Prodding

A soft mode of government intervention involves planning to guide public policy and prodding to guide private actors into stepping in line with those policies.

37. See Mathew E. Hauer et al., *Sea-Level Rise and Human Migration*, 1 NATURE REVS. EARTH & ENV'T 28, 29 (2020).

38. Robert McLeman, *Thresholds in Climate Migration*, 39 POPULATION & ENV'T 319, 319 (2018).

39. *Id.* at 324.

40. *Id.* at 325-26.

41. See Andrew C. Kemp & Benjamin P. Horton, *Contribution of Relative Sea-Level Rise to Historical Hurricane Flooding in New York City*, 28 J.Q. SCI. 537, 539 (2013) (charting linear sea-level rise since 1775); see also Syun-Ichi Akasofu, *On the Present Halting of Global Warming*, 1 CLIMATE 4, 5 (2013); see also John P. McCarty, *Ecological Consequences of Recent Climate Change*, 15 CONSERVATION BIOLOGY 320, 323 (2001) (cataloguing effects of climate change on various species).

42. Michelle Leighton, *Population Displacement, Relocation, and Migration*, in LAW OF ADAPTATION, *supra* note 7, at 693-94.

43. Robin Kundis Craig, "Stationarity Is Dead"—*Long Live Transformation: Five Principles for Climate Change Adaptation Law*, 34 HARV. ENV'T L. REV. 9, 23-27 (2010); P.C.D. Milly et al., *Stationarity Is Dead: Whither Water Management?*, 319 SCI. 573, 573-74 (2008).

44. See Matthew E. Hauer, *Migration Induced by Sea-Level Rise Could Reshape the US Population Landscape*, 7 NATURE CLIMATE CHANGE 321, 321-25 (2017).

45. Qin Fan et al., *Climate Change, Migration and Regional Economic Impacts in the United States*, 5 J. ASS'N ENV'T & RES. ECONOMIST 643, 644-45 (2017).

46. McLeman, *supra* note 38, at 324-27; Robert A. McLeman et al., *What We Learned From the Dust Bowl: Lessons in Science, Policy, and Adaptation*, 35 POPULATION & ENV'T 417, 429, 433-34 (2014).

47. Christopher Flavelle, *California Bars Insurers From Dropping Policies in Wildfire Areas*, N.Y. TIMES (Nov. 5, 2020), <https://www.nytimes.com/2020/11/05/climate/california-wildfire-insurance.html> [<https://perma.cc/VD64-VX7Y>].

48. Rebecca Moybray, *Five Years After Hurricane Katrina, Home Insurance Prices Remain Astronomical*, NOLA.COM (June 25, 2019), https://www.nola.com/news/business/article_a6b466ee-28c4-5096-a6bf-0baa7565bd98.html [<https://perma.cc/83TV-N6VS>].

a. Planning

Redesign adaptation will require massive planning. First, redesign adaptation requires a spatial rearrangement of both people and land uses on a national scale.

Second, there is considerable agreement the United States' basic infrastructure already warrants increased investment. The bipartisan appeal of investment makes infrastructure a leading candidate to kickstart adaptation.^{49 50}

Third, redesign adaptation will require increased and directed research across the sciences and engineering to better project climate change impacts; to identify important tipping points and thresholds; and to both identify and develop tools for the multiple transitions.

Finally, redesign adaptation requires significant amounts of money. Thus, financial planning must also be part of the adaptation toolbox.

b. Prodding

Disaster relief is another area governments could adjust to better serve adaptation, taking the form of relocating destroyed communities and retraining and education for victims.

Tax incentives can help incentivize voluntary contributions to redesign adaptation. State and federal governments could conceivably add their own tax inducements encouraging businesses to begin the migration to redesign-desirable new locations.

A final incentive includes land swaps. Government-owned land can once again become a tool to effectuate policy, this time incentivizing settlement into safer areas while simultaneously shifting other kinds of public uses to depopulated regions.

3. Preemption and Mandates

The United States is no stranger to more forceful modes of public governance intervention, including mandates and preemption. Although controversial, it is difficult to imagine how adaptation policy could succeed without such measures.

a. Cooperative Federalism

Cooperative federalism embedded in multiple environmental and natural resources statutes provides one tested mechanism for coordinating federal and state governments toward a common goal. The U.S. Congress generally uses its constitutional authority to force all states into baseline protections, but leaves each state free to enact more stringent protections.⁵¹

b. Public Works Programs

If the federal government is going to fund redesign adaptation infrastructure, it might consider doing so through a public works program creating paying jobs and providing training in skills that remain employable throughout the nation's adaptation curve. The most obvious model for this program is President Franklin Delano Roosevelt's "alphabet soup" of programs during the Great Depression.

This alphabet soup could start with an infrastructure focus. First steps include upgrading infrastructure capacity in the areas of future concentrated human settlement and building the infrastructure necessary to decarbonize the energy system. Additionally, the federal government could build on its existing authority under federal pollution statutes to anticipatorily clean up toxic hotspots.⁵² New programs could encourage farmers and universities to diversify agricultural production with climate-resilient crops and promote deepwater marine aquaculture.⁵³

c. Social Support Networks

The envisioned migration scenario will be disruptive. Governments will need to expand social support networks. Fully portable health coverage would be beneficial. Personal migration financing may become a financial planning specialty and require governmental underwriting.

d. National Economic Policy

The federal government played a key leadership role in preparing the nation economically for World War II.⁵⁴ The economic conversion was matched, moreover, by a new wartime administrative bureaucracy.⁵⁵

Redesign adaptation will require a similar scale of economic and societal conversion. This scale of redesign is best coordinated from the national government.

C. Anticipatory Governance: Building Future Scenarios for Policy Strategy Design

Anticipatory adaptation policy design must anticipate both multi-modal change and governance. For that purpose, our vastly simplified models of three modes of change and three modes of governance produce a three-by-three matrix of intersection possibilities, as shown in Table 1 (next page).

Two important points can be derived from this exercise. First, state and local governments are unlikely to be able to manage these nine change-governance modal intersections, meaning that anticipatory redesign governance needs to occur

49. Jeff Stein, *Trump's 2016 Campaign Pledges on Infrastructure Have Fallen Short, Creating Opening for Biden*, WASH. POST (Oct. 18, 2020), <https://www.washingtonpost.com/us-policy/2020/10/18/trump-biden-infrastructure-2020/> [https://perma.cc/63HX-GL8F].

50. BIDEN CLIMATE CHANGE E.O., *supra* note 36, at §§212, 213.

51. *E.g.*, Clean Water Act, 33 U.S.C. §1370.

52. 42 U.S.C. §§9601-9675.

53. *Q&A With Aquaculture Policy Expert Kat Montgomery*, STRONGER AM. THROUGH SEAFOOD (Jan. 29, 2021), <https://www.strongerthroughseafood.org/tipping-the-scales/2021/2/1/qampa-with-aquaculture-policy-expert-kat-montgomery> [https://perma.cc/9A2W-J38G].

54. Christopher J. Tassava, *The American Economy During World War II*, EH.NET ENCYCLOPEDIA (Feb. 10, 2008), <https://eh.net/encyclopedia/the-american-economy-during-world-war-ii/> [https://perma.cc/CM52-G8W5].

55. *Id.*

Table 1: Change Mode and Governance Mode Intersections

	Laissez Faire	Planning and Prodding	Preemption and Mandates
Baseline Linear	Potentially effective in most circumstances but would still benefit from coordination and/or agreed adaptation goals.	Serves an educational function and allows for the building of legitimacy and public consensus; allows equity measures to be put in place early to incentivize the most vulnerable to improve their positions; allows early adopters to prove the advantages.	Probably overkill until the trickle of changes build up over the longer term.
Nonlinear	Inadequate, because ad hoc and market policies are likely to produce uncoordinated and even contradictory responses.	Necessary to coordinate adaptation responses, promote equity, and minimize conflicts; preserves some voluntariness in individual response; provides mass incentives to induce individuals and sectors to follow preferred adaptation pathways.	Increasingly necessary in regions where nonlinear change occurs on a large scale; precautionary measures provide warning of future adaptation requirements and increase motivation to engage early with the “prods.”
Cascades	Potentially disastrous, because changes are occurring too rapidly, too transformatively, and on too large a scale for adaptation to occur equitably without significant government involvement.	Incentives aligned with the overall adaptation redesign can still help to motivate and incentivize certain groups of individuals and entities to engage in redesign adaptation semi-voluntarily.	Necessary, because at this point transformative change is happening so fast and on such a large scale that far more centralized control is necessary to achieve redesign adaptation equitably and relatively peacefully.

within a national policy framework.⁵⁶ Second, adaptation planning must explicitly build nonlinear and cascade change into adaptation plans. The next section presents our proposal for how to begin.

D. An Initial Step: Creating a National Foresight System for 4°C Adaptation Planning

Anticipatory governance is “a mode of decision-making that perpetually scans the horizon” in order to develop a data-driven “foresight system,” integrates foresight into policymaking, and uses feedback to assess and adjust policy implementation.⁵⁷ We propose the federal government construct a robust national foresight system as the first step for redesign adaptation.

To be effective, such a system must be broadly multidisciplinary, uniting climate scientists predicting climate impacts with anthropologists predicting human responses with technologists developing the predictive analytics they and the other represented disciplines will use. We propose the research be anchored and directed through a new or expanded science-based research bureau or service within the federal government, akin to the U.S. Geological Survey, rather than as a multiagency task force between existing agencies. Ideally, people with policy experience would also be key members of the research community.

This foresight system initiative thus would address a broad array of questions relevant to the next step in anticipa-

tory governance—namely, integrating the foresight into policymaking. To anticipate how to manage redesign adaptation in the “beyond 2°C” world, it will be essential for the new research bureau to build scenarios of national-scale social and economic responses that are not constrained by existing policy limits, and it must not be punished for doing so.

VI. Conclusion

Even well-functioning democratic governance systems will need to adapt in order to manage a 4°C world effectively. Our democracy focuses on preserving individual choice and protection of private property, often at the expense of public values.⁵⁸ It will take a long time to reach 4°C, but the tipping points along the way will lead to cascades of change in social-ecological systems rivaling the pandemic in their flash point disruption effects. If we had developed a robust national foresight system for pandemics and followed through with planning and implementation, the experience might have been much different. Knowing that, we can do better to prepare the nation for the path to 4°C.

58. See generally Beckett G. Cantley, *Environmental Preservation and the Fifth Amendment: The Use and Limits of Conservation Easements by Regulatory Taking and Eminent Domain*, 20 HASTINGS W. NW. J. ENV'T L. & POL'Y 215 (2014); ROBERT MELTZ ET AL., THE TAKINGS ISSUE: CONSTITUTIONAL LIMITS ON LAND USE CONTROL AND ENVIRONMENTAL REGULATION (1999). For discussions of standing limitations, see generally, for example, Jeffrey T. Hammons, *Public Interest Standing and Judicial Review of Environmental Matters: A Comparative Approach*, 41 COLUM. J. ENV'T L. 515 (2016); Robin Kundis Craig, *Removing “the Cloak of a Standing Inquiry”: Pollution Regulation, Public Health, and Private Risk in the Injury-in-Fact Analysis*, 29 CARDOZO L. REV. 149 (2007); Jeffrey W. Ring & Andrew F. Behrend, *Using Plaintiff Motivation to Limit Standing: An Inappropriate Attempt to Short-Circuit Environmental Citizen Suits*, 8 J. ENV'T L. & LITIG. 345 (1994).

56. See Quay, *supra* note 5, at 499-505 (presenting case studies of Denver, New York, and Phoenix).

57. Stefano Maffei et al., *Data-Driven Anticipatory Governance. Emerging Scenarios in Data for Policy Studies*, 3 POL'Y DESIGN & PRAC. 123, 125 (2020).