Toward Climate Resilience

A Framework and Principles for Science-Based Adaptation

HIGHLIGHTS

Communities and nations of the 21st century face a great challenge: to protect people from the harm caused by an increasingly volatile climate. The damaging impacts of climate change will grow as the climate changes and adaptation fails to keep pace, unless societies take steps to increase their resilience through aggressive action on both climate mitigation and adaptation. The Union of Concerned Scientists' (UCS) focus here is adaptation, where choosing among possible actions is often not straightforward or intuitive. In this report, UCS describes 15 principles for decision makers to use to prioritize investments in climate change adaptation, ensuring that their investments are scientifically sound, socially just, fiscally sensible, and adequately ambitious.

We live in a warming world, with growing threats from climate change, and in an innovative world, where the opportunities for creative responses continually grow. But the window of opportunity to avoid dangerous changes to our climate is closing quickly. Climate adaptation is needed on an unprecedented scale. How can we proceed swiftly, but with appropriate care? How can decision makers put their limited resources to best use, formulating policies and funding programs that are likely to be sound and effective in an uncertain future?

Following is a framework and set of principles for building climate resilience in the United States. The Union of Concerned Scientists (UCS) developed these to be useful to decision makers, citizens in conversation with decision makers, and citizens directly engaged in adaptation work. The **climate resilience framework**

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Adaptation can provide multiple benefits. After a disastrous flood in 1984, the city of Tulsa, Oklahoma, adopted a proactive approach to flooding problems and storm-water management. Soliciting public input along the way, Tulsa has converted flood-prone areas to landscaped buffers, drainage basins, and parks. As a result, there has been no record of flooding in any structure built before 1987, and residents have access to high-quality recreational facilities (LRAP n.d.).

Union of Concerned Scientists

describes how climate adaptation and mitigation are intrinsically linked and how, together, they create resilience. The **adaptation principles** are grounded in science and committed to equity. Together, the framework and principles are durable and flexible enough to be used in a wide variety of contexts. UCS will update these periodically, as practitioners of adaptation learn and share new lessons.

Framework

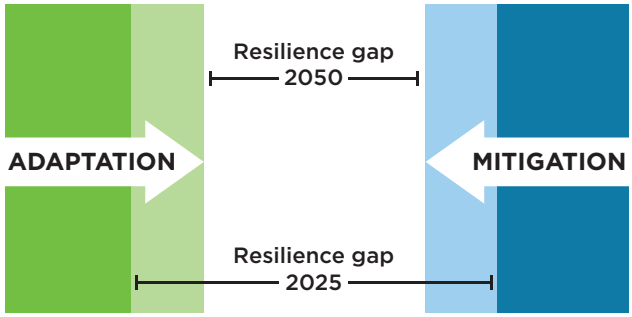
The climate resilience framework outlined here reflects the idea that climate change policy should "manage unavoidable changes and avoid unmanageable ones" (Bierbaum et al. 2007) and describes how policies can best meet these goals. It starts with the concept of a *climate resilience gap*, which UCS defines as the scope and extent of climate change–driven conditions for which people (individuals, communities, states, and even countries) remain unprepared, leaving them open to potentially harmful impacts (see the figure).[1]

Responding effectively to climate change requires us to narrow the climate resilience gap through aggressive action on both climate mitigation and adaptation. Nearly all countries have agreed on a science-based goal of climate change *mitigation*, expressed in the Paris Agreement signed on December 12, 2015, as "holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels" (UNFCCC 2015). Less clear, however, is what should guide policy makers' decisions about investment in climate change *adaptation*.

Adaptation and mitigation measures are tightly bound, and it is critical to appreciate the connection between the two. Stronger mitigation efforts will not only moderate the long-term climate impacts for future generations, but will make our preparedness efforts today more enduring and worthwhile. Aggressive mitigation can increase our confidence that the preparations we make will not be quickly overwhelmed by an increasingly disrupted climate. Investing in mitigation today can lower the costs of adaptation in the future.

However, even if heat-trapping emissions were reduced to zero today, their concentration in the atmosphere will remain elevated above historical levels for many years (Clark et al. 2016; Solomon et al. 2009; Matthews and Caldeira 2008; Meehl et al. 2005; Wigley 2005). Adaptation actions to help reduce the resilience gap will be needed for generations.

The Resilience Gap



The "resilience gap" represents the degree to which a community or nation is unprepared for damaging climate effects—and therefore the degree to which people will suffer from climate-related events. The arrows show the two ways to narrow the gap. We can adapt (left arrow) by preparing for climate impacts, and mitigate carbon emissions (right arrow) to slow the pace at which climate risks grow more severe or more common over time. The changing size of the resilience gap in 2025 versus 2050 conveys the potential for society's resilience gap to be narrowed, though not eliminated, through concerted effort on both fronts.

> ***Responding to climate change requires us to narrow the climate resilience gap through action on both climate mitigation and adaptation.***

Because climate and weather have always included extreme and damaging conditions, and because we as a society cannot afford to prepare for every contingency, we will never entirely close this gap. It is physically impossible and fiscally impractical to avoid every possible natural disaster, and climate change impacts are no different. However, climate impacts are a rapidly growing threat, and, through adaptation, the climate resilience gap can be narrowed. Communities can take concrete steps to prepare for the expected impacts of climate change. They can, for example, restore wetlands for

1 *A resilience gap is distinct from an adaptation deficit. The latter refers to the inadequacies of current adaptation efforts resulting largely from a lack of resources and capacity to support such efforts (Fankhauser and McDermott 2014; Burton and May 2004). A resilience gap takes into account a society's or community's efforts on both adaptation and mitigation.*

flood control or plant urban forests for shade cover, effectively building their climate resilience even as seas rise, temperatures increase, and the climate becomes more variable and unpredictable. The range of potential actions is wide. The adaptation principles that follow are designed to guide decision makers in focusing their investments.

Principles

The following 15 principles were designed to be used by decision makers and practitioners from the local to the federal level. They are structured around three basic themes: science, equity, and commonsense ambition. The application of these principles can help to ensure that actions taken in the United States in the name of climate adaptation are scientifically justified, ambitiously conceived, and equitably implemented.

CLIMATE ADAPTATION ACTION SHOULD USE RIGOROUS SCIENCE

Decisions aimed at building resilience at all levels must be consistent with and responsive to the best-available science about climate change and our knowledge of how it will affect human and natural systems.

Decision makers should:

1. Consider projected climate conditions. It has become clear that historical patterns can no longer be used to predict future climate conditions. When communities and countries plan for historical climate conditions that no longer exist, they can make themselves *more* vulnerable to current and future climate risks (Milly et al. 2008). The federal National Flood Insurance Program, for example, by providing flood insurance at rates substantially lower than the true risks would dictate, is widely seen as having contributed to the high degree of exposure to coastal flooding found today along much of the US coast; it is widely considered to need science-based reform (TMAC 2015; Cleetus 2013; Heinz Center 1999).

> ***When communities plan for historical climate conditions that no longer exist, they can make themselves* more *vulnerable to current and future climate risks.***

Decision makers must look at historical, present, and projected conditions in order to fully understand the range of climate threats that warrant preparation (Craig 2010; Milly et al. 2008). For instance, decision makers should consider the emerging science around climate-driven changes in heat and drought when crafting new policies and plans or when revising existing ones, such as federal wildfire management planning in western states. They should also integrate knowledge of how ecosystems and human communities coped with prior droughts and wildfires in order to better understand how new threats may play out.

2. Use systems thinking. Systems thinking acknowledges that we live in an interconnected world (Moser and Hart 2015; Odum 1983; Patten and Odum 1981). A systems approach can help decision makers understand how a change in one component of the system can trigger changes in other components. For example, a dam can reduce the downstream flow of nutrients, which can reduce the vitality of marshlands; this in turn can damage fisheries upon which local livelihoods depend (Nilsson et al. 2005; Pringle, Greathouse, and Freeman 2003).

Some climate adaptation measures provide multiple benefits within a system, while others exacerbate or even create new risks. In coastal areas, for example, improving natural

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Natural wetlands (such as these in Jamaica Bay, New York) provide coastal communities protection from storm surge, provide treatment for runoff, and enhance wildlife habitat. Restoring wetlands for flood control are one way in which communities can take concrete steps to prepare for the expected impacts of climate change.

wetlands can serve the broader surrounding system, providing coastal communities protection from storm surge, providing treatment for runoff, and enhancing wildlife habitat (Erwin 2008; Boesch et al. 1994; Farber 1987). In contrast, some coastal armoring measures can alter shoreline dynamics in such a way that can actually increase damages to neighboring unarmored areas and bring harm to residents there (Dethier et al. 2016; Pace 2011; Swann 2008). A systems approach often illuminates the cost-effectiveness of "green" infrastructure and other nature-based solutions (Hansen and Pauleit 2014; Benedict and McMahon 2006). It can also highlight choices that serve both mitigation and adaptation ends, as in renewable energy options that improve the reliability of local power supply in the face of storms and flooding (McNamara et al. 2015). Identifying benefits like these can give decision makers a greater range of viable investment options as they serve their constituents' needs.

3. Match the scope of planning to the magnitude of projected change. The best-available science tells us that, in some cases, large and rapid adaptation responses are needed. The projected inundation of populated areas in southeast Florida, for example, is a case in point. There, decision makers must act with urgency to bring science to the fore, understand the implications of the science, and construct policies and plans that enable communities to act quickly in the face of impending change (Brown 2014; Moser and Boykoff 2013). The implementation of such plans will likely require effective public awareness campaigns and capacity-building in communities (Moser 2016).

Where scientific findings anticipate more gradual change, as in the case of coastal erosion in parts of the northeastern United States, decision makers should support efforts to incorporate climate concerns into relevant decision making and to ensure that, over time, they work toward more resilient communities, economies, and infrastructure. Decision makers in these locations also must be increasingly prepared for climate extremes and surprises (Melillo, Richmond, and Yohe 2014; Hallegatte and Corfee-Morlot 2011; Rosenzweig et al. 2010).

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4. Aim for robust decisions and policies. One approach that decision makers can take when there is uncertainty about how and when climate impacts will occur is to strive for robustness—the ability of a policy to perform well under a wide variety of conditions (Lempert et al. 2013; Hallegate et al. 2012). Robust approaches accommodate the range of likely future conditions and point to policies that either can adapt to changing conditions over time or are simply successful across a range of projected outcomes (Rickards et al. 2014; Hallegatte 2009). Robust decision making was recently used, for example, in the Colorado Basin to plan for future and uncertain stream flow that is increasingly subject to drought. Examining a variety of scenarios, decision makers used a

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Severe drought in parts of the western Unites States has driven water levels in the Lake Mead reservoir (shown here in September 2009) to record lows. Decision makers in the Colorado Basin and elsewhere are striving to implement robust policies—that is, policies that perform well under a variety of climatic conditions (such as varying degrees of precipitation or drought)—to minimize the impacts of these events on communities, while still being affordable and feasible to implement.

computer-based tool to look at a portfolio of management options. Rather than select an option that would protect communities from every period of drought, from mild to severe, they identified the portfolio of actions that would minimize the number of years in which reduced stream flow would harm those communities (Groves et al. 2013). Robust decisions do not eliminate all risk. But they give communities and decision makers a higher degree of confidence that the chosen options will serve communities well over time and across a range of climate scenarios, while still being feasible to implement and affordable.

5. Create opportunities to revise and change course. Science is not static. As decision makers base policies and plans on the best-available science of the time, they should expect to update their policies and shift priorities as science proceeds. For example, Louisiana policy makers might modify the state's long-term coastal restoration plan as they learn more about feedback mechanisms between land loss and the implementation of the original plan. States will need to revisit hazard mitigation planning to account for new patterns that emerge over time, taking into account, for example, the influence of increasingly strong and frequent El Niños on seasonal weather extremes.

CLIMATE ADAPTATION ACTION SHOULD SUPPORT EQUITABLE OUTCOMES

Relevant policies must ensure that the climate risks faced by the most vulnerable groups of people are manageable and that these residents have access to tractable options. A growing body of evidence describes the important relationship between climate hazards exposure, socioeconomic vulnerability, and community actions needed to prepare for climate impacts; each of these interrelated drivers plays a key role in a community's climate resilience (IPCC 2014a; Melillo, Richmond, and Yohe 2014; Friend and Moench 2013; Adger 2006; Berkes and Folke 1998).

Flooding and drought, for example, can have disproportionate impacts on low- and fixed-income communities (Melillo, Richmond, and Yohe 2014). The most vulnerable residents may live in places that are more exposed to flood waters or in older, less safe housing. Elderly, sick, and disabled residents can be particularly isolated and vulnerable to climate effects (Lane et al. 2013). Additionally, low- and fixed-income households may not be able to afford insurance that would cover their losses. At a larger scale, poorer communities simply have fewer resources to prepare for and cope with impacts (Martinich et al. 2013). As a nation, we have a moral obligation to protect the health, safety, and well-being of those most vulnerable and

Key Terminology

Throughout this document, UCS relies on the following terms and definitions, quoted verbatim or adapted from two sources: the glossaries of terms used by the Intergovernmental Panel on Climate Change and the United States Global Change Research Program.

Adaptation. The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm, or exploit beneficial opportunities (IPCC 2014b).

Mitigation. Measures to reduce the amount and speed of future climate change by reducing emissions of heat-trapping gases or removing carbon dioxide from the atmosphere (USGCRP 2016).

Resilience. The capacity of social, economic, and environmental systems to cope with a hazardous event, trend, or disturbance, responding or reorganizing in ways that maintain systems' essential function, identity, and structure while also maintaining the capacity for adaptation, learning, and transformation (IPCC 2014b).

Preparedness. Actions taken to build, apply, and sustain the capabilities necessary to prevent, protect against, and ameliorate negative effects (USGCRP 2016).

Risk. The potential for consequences to life, health and safety, the environment, economic well-being, and other things of value when the outcome is uncertain. Risks are often evaluated in terms of how likely an event is to occur (probability) and the damages that would result if it did occur (consequences) (USGCRP 2016).

Vulnerability. The propensity or predisposition to be adversely affected. Vulnerability includes susceptibility to harm and lack of capacity to cope and adapt (IPCC 2014b).

Climate impacts. Effects on natural and human systems of extreme weather and climate events and of climate change. Impacts refer to effects on people's lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure; effects that are due to the interaction of climate changes or hazardous climate events occurring within a specific time period; and the vulnerability of an exposed society or system (IPCC 2014b).

least empowered. Climate resilience policy and action is a new frontier where this obligation must be met.

Decision makers should:

6. Ensure that the costs of responding to climate change and the benefits of resilience-building are equitably shared. As communities, states, and the federal government invest in climate adaptation, it is important that the costs are fairly distributed and the benefits are widely felt. Poor and working class people face a dual challenge: they tend to be more vulnerable to the impacts of climate change than their more affluent neighbors, and they are less able to bear the costs of recovering from impacts (Eakin, Lemos, and Nelson 2014; Engle 2011; Mearns and Norton 2010). They are at risk, in other words, not just from the direct impacts of an extreme event, but from a downward spiral that can take hold in the aftermath (Martinich et al. 2013). Further, while poor communities tend to contribute less than affluent ones to the problem of carbon emissions over time, the resilience-building opportunities that can benefit households, such as flood-proofing incentives, are often financially out of their reach or not available at all (Bullard and Wright 2012; Zahran et al. 2008).

When considering the damage inflicted by events such as powerful storms, public officials tend to focus on the monetary value of such damage (UNISDR 2015; Kousky 2012). This tendency can lead to damage-mitigating public investments being preferentially allocated to higher-value locations and thus wealthier households, farms, or communities (Sarmiento and Miller 2006). A clear example is the repeated taxpayer bailouts of high-value properties that repeatedly suffer damage

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FEMA

Decision makers at every level need to ensure that climate policies and programs are fair, so that those residents least able to cope with damage to their home or community—such as these residents of Jefferson Parish in Louisiana, awaiting evacuation in the wake of Hurricane Katrina—receive support and have access to the resources necessary to preserve and enhance their resilience. Although these principles are meant to inform US decision making, climate change vulnerability and the need for adaptation resources and capacity are acute in many parts of the world.

from events such as wildfires, droughts, or floods (Kousky and Michel-Kerjan 2016; Ellis 2015; Daley 2014; NWF 1998). Public officials need to be aware of this bias and make a sustained effort to respond to the preparedness and recovery needs of less-wealthy residents.

As climate impacts unfold in the decades ahead, decision makers at every level need to ensure that those residents least able to cope with damage to their home or community receive the necessary support. Fair climate policies and programs should—by design—work to protect and benefit vulnerable populations, by delivering access to the resources necessary to preserve and enhance their resilience (Cleetus, Bueno, and Dahl 2015).

7. Decide *with*, not for. Communities or groups affected by climate preparedness decisions should be directly engaged in shaping those decisions (NAACP 2015; Few, Brown, and Tompkins 2007; Tompkins and Adger 2004). For example, post-disaster rebuilding should aim to "build back better" not just from a disaster-risk perspective but from a quality-of-life perspective (Lyons 2009). The determination of those actions that would improve quality of life must be done by local residents themselves.

The wisdom of this approach is being borne out, for example, in the federally funded Rebuild by Design initiative. This program was launched in the aftermath of Hurricane Sandy with a commitment to "build back smarter" in large part by placing "local communities and civic leaders at the heart of a robust, interdisciplinary, creative process to generate implementable solutions for a more resilient region" (Rebuild by Design 2016). The work of Rebuild by Design in places like Bridgeport, Connecticut, has been widely hailed, in large measure because of the centrality of community involvement to its success. It is now seen as a key long-term approach to hazard mitigation (Ovink 2014).

Post-disaster rebuilding should aim to "build back better" not just from a disaster-risk perspective but from a quality-of-life perspective, as determined by local residents themselves.

FEMA

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8. Minimize harm and maximize options. Tight budgets will always be a challenge for society's ability to implement effective adaptation actions, and decision makers will inevitably face tradeoffs. For example, the strain and cost of relocating homeowners to a safer location will need to be weighed against the strain and cost of supporting them to remain in a high-risk place (Bronen and Chapin 2013). When tradeoffs involve government resources, as in taxpayer-funded projects, decision makers often favor their constituents who have political power over those who do not (Been and Ellen 2016; Sarmiento and Miller 2006). But for equitable adaptation outcomes, decision makers will need to not only ensure that tradeoffs do not harm constituents who are most vulnerable to climate impacts but also invest in adaptation actions that increase these communities' resilience to future impacts.

Poor, working class, and minority households tend to depend more heavily than affluent ones on the local economy, social networks, civil society institutions, and natural resources (Malik 2014). Preparedness policies—resettlement is a prime example—should be designed in such a way that they minimize disruption to these relationships and interconnections. If disruptions must occur, policies should provide communities with safeguards and options. For example, if a neighborhood is to be abandoned because of untenable flood risk, measures should be taken to help residents manage the strain of buyouts, relocation, or other actions. If home values are low relative to those in alternative locations, home sales may not provide enough income for homeowners to obtain housing in safer areas, and renters may lose out completely. Moreover, if residents must move a considerable distance, they may be disconnected from jobs, family support, social

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In southern Louisiana, the Biloxi-Chitimacha-Choctaw tribe and the United Houma Nation have watched their home on Isle de Jean Charles disappear. Rapidly sinking land and extreme erosion caused by fossil fuel development and other activities in the area, exacerbated by sea level rise, leave the tribes with no other option but to resettle. In 2016 the federal government allocated funds explicitly for relocating the tribes while creating options for them to sustain their cultures into the future.

networks, and important cultural heritage. In such cases, policy makers should aim to leave people and communities as financially, socially, and culturally intact as possible. Such policies need to be formulated using early and proactive consultation with community members.

In southern Louisiana, two Native American tribes, the Biloxi-Chitimacha-Choctaw and the United Houma Nation, have watched their home on Isle de Jean Charles disappear so quickly that resettlement is now the only option. Oil and gas companies have dredged canals to build pipelines, and engineers have attempted to control the Mississippi delta, resulting in rapidly sinking land and extreme erosion exacerbated by sea level rise. In this case, the harm is done, and in an early case of climate change displacement, many residents have come to accept this fate. But for the first time, in 2016 the federal government allocated funds explicitly for a community's relocation, aimed at creating options for the tribes to sustain their culture into the future (HUD 2016; Maldonado et al. 2013).

9. Equip and empower local experts. As the United States becomes more fully engaged in adaptation, it will need to build out the resources, systems, and capacity for local communities to make the adaptation planning and implementation processes their own. The relevant information, data, and tools, though increasingly *available* through government and other online sources, tend to be *usable* by only a narrow set of expert users. For the long-term success of adaptation policies, communities and technical experts must work together (Bierbaum et al. 2014). Local experts must be trained to use the available information, data, and tools so that they may translate climate risks and adaptation options for their community, taking into account its history and specific needs.

As leaders bring climate change concerns into mainstream planning and management, they need to make adaptation part of the essential expertise of relevant planners and managers. In places where climate risks and current impacts are more acute, capacity-building needs to be accelerated in the hazard-mitigation as well as the rebuilding

process. Lacking this expertise, communities are unable to fully understand and respond to the climate change unfolding around them and are unprepared when important choices, such as whether to accept prescribed fire or unsightly forest management in wildfire-prone areas, confront them.

10. Maximize transparency, accountability, and follow-through. Decision making should be transparent in order to build residents' trust in the chosen policies and approaches and to encourage their participation in the actions in which their community has invested. Some community-wide responses to climate-related risks may be difficult for community members to embrace and put into practice. This only increases the need for actions to be chosen that are considered legitimate by the people they will affect.

Once an adaptation decision is made, the people charged with carrying it out need to maintain open, trusting relations with the community, following through on their commitments and being accountable over time. One widely cited example of the failure of local leaders to maintain trust is the "green dot" map for rebuilding New Orleans after Hurricane Katrina—a preliminary plan by a mayor-appointed committee of community and business leaders that was leaked to the public. The plan determined that many parts of the city were so vulnerable to future flooding that rebuilding did not make sense, and it proposed converting some of these places to parkland, indicated by green dots. Even though this was only a conceptual map, residents of the "green dot" areas considered it a threat and responded with loud protests, prompting leaders to retreat from the plan and damaging residents' trust in them (Nelson, Ehrenfeucht, and Laska 2007).

CLIMATE ADAPTATION ACTION SHOULD APPLY AMBITIOUS COMMON SENSE

Spending scarce public money on projects that do not account for climate change is a waste of precious resources. Indeed, the nation's historical willingness to fund post-disaster recovery spending while shortchanging pre-disaster resilience-building has left many citizens poorer and more vulnerable. Instead, policies should mobilize forward-looking resources, both those sufficient to address the adaptation challenge and those furthering aggressive climate mitigation. We must use our resources sensibly, but in support of highly ambitious goals.

Decision makers should:

11. Weed out maladaptation, both existing and proposed. Maladaptive policies are those that create, perpetuate, or exacerbate climate risk. Currently, many decisions and investments are making communities *less* prepared for climate change, putting residents at increased risk. These maladaptive decisions can be as simple as permitting housing or commercial development based on outdated zoning. Even policies designed explicitly for climate adaptation can be maladaptive if they increase emissions of heat-trapping gases, disproportionately burden the most vulnerable residents, reduce communities' or policy makers' incentive to adapt, or lock in decisions that limit future generations from adapting (Barnett and O'Neill 2010).

For example, a coastal restoration plan that draws funding from wetland development permits would be maladaptive, as these permits rely on activities that may weaken natural coastal barriers against storm surge or on offshore drilling proceeds that damage ocean environments. Similarly counterproductive are building regulations in historic

Many decisions and investments are making communities less prepared for climate change, such as permitting housing or commercial development in flood-prone areas (left). Restoring wetlands (right), by contrast, can provide multiple benefits—for example, controlling floods and improving water quality.

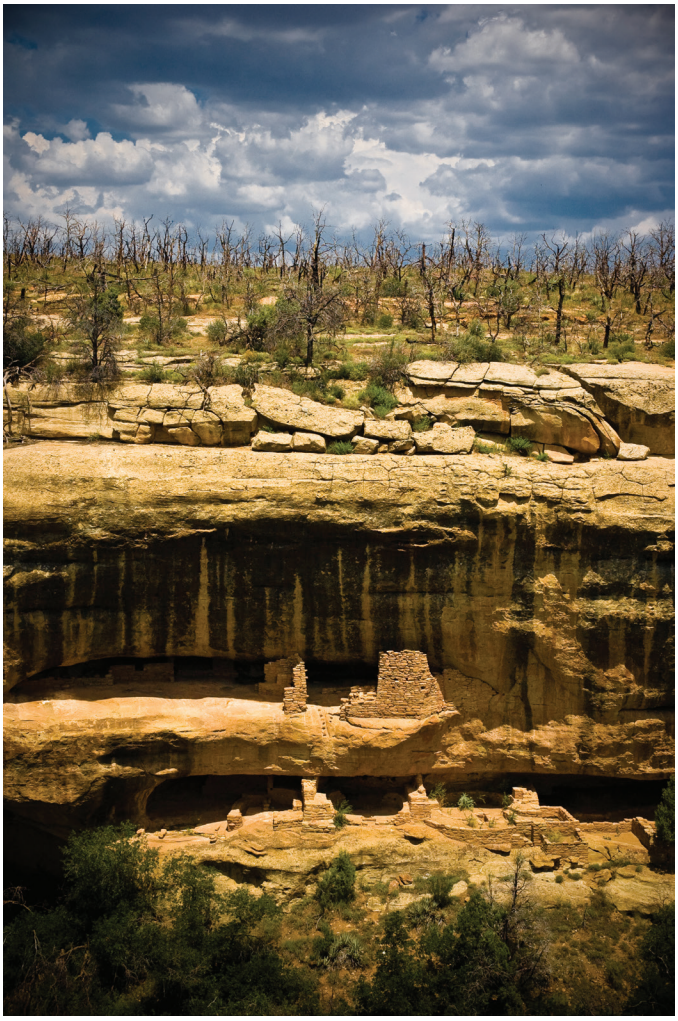
districts that maintain the historic aesthetic of a property while preventing the homeowner from taking flood control measures that protect the home in the long term.

It is conceivable that decision makers might weigh the tradeoffs and still opt for a policy that perpetuates risk—for example, if those wetland development permits are the only viable source of funding for urgently needed preparedness projects in local communities. But commonsense decision making requires that the climate risks attached to different options be seen clearly (by using sound science), be clearly communicated (by using market signals to establish how best to communicate the risk), and be addressed wherever possible.

12. Consider the costs of inaction. Adaptation to climate change is not cheap, and mobilizing funding commensurate with the challenge will be a struggle at many levels. However, climate adaptation to reduce the resilience gap will only grow more costly over time (Melillo, Richmond, and Yohe 2014; Bierbaum et al. 2013; Kerr 2011). Moreover, the costs of investing in preparedness versus recovering from a disaster are striking even today—in the US coastal context, one dollar spent proactively can save as much as four dollars on recovery (Godschalk et al. 2009; MMC 2005).

Many federal and state policy makers do not yet recognize the stark choice they face between paying predictable costs today for both climate mitigation and adaptation, thus helping the costs of responding to climate impacts to remain manageable, and delaying such efforts—only to pay staggering and unpredictable costs later, when the impacts have grown unmanageable. For example, without action in Louisiana and New Jersey to elevate or move homes, flood-proof businesses, and prevent development in frequently flooded areas, the costs of a major storm in the coming years could far surpass those of Hurricanes Katrina and Sandy.[2] Systematic and prudent investments now can help protect the places we value and avoid the need to abandon homes, businesses, or entire communities later.

13. Work to protect what people cherish. Historic sites, iconic plants and animals, natural resources that support livelihoods and ways of life, and even the character of entire landscapes are some of the features of cultural heritage upon which many people depend and about which they care deeply.[3] These values transcend economic costs and benefits. They should be acknowledged and built into all adaptation responses even when they cannot be fully quantified.



In southwest Colorado, the ancient ruins of Mesa Verde face a growing threat from wildfires (damage from which is shown at the top of the cliff) and flooding. The cultural heritage and value associated with historic sites, iconic plants and animals, natural resources, and landscapes should be acknowledged and built into climate adaptation responses even when they cannot be fully quantified.

> ***Adaptation to climate change is not cheap, but the costs of investing in preparedness versus recovering from a disaster are striking even today.***

2 *In the case of resilience to coastal storms, states and municipalities are taking on some of these costs today with support from the federal government. But we need to go much further in mobilizing funds for this century's long challenge.*

3 *Cultural heritage has been defined variously in international conventions and charters, and many countries have precise definitions codified in national laws. These definitions are similar in that they recognize the importance of tangible and intangible resources of value to people at local, national, and international scales, but differ in specifics that fit the particular community of interest.*

Designed by Architerra; Image courtesy of Boston Living with Water

Boston, Massachusetts, launched its "Living with Water" design competition in 2014 and garnered dozens of ideas for gradually adapting the city's waterfront and low-lying areas to cope with rising seas. Finalists successfully transformed the city's landscapes to accommodate the water while supporting a diversity of uses and enhancing quality of life for local residents. This is one example of how, with a long-term vision in place, communities that must change can change for the better.

In southwest Colorado, for example, the ancient ruins of Mesa Verde face a growing threat from wildfires and flooding (Holtz et al. 2014). Designated both a national park and a World Heritage site, this place is recognized tribally, nationally, and globally for its historical and cultural value (NPS 2016). Similar sites are scattered throughout the nation and around the world. Not everything can be protected. But adaptation planning must take into account the cultural value of creatures, places, and human history to help ensure that many endure the accelerating changes brought by climate change.

14. Reflect a long-term vision. Societies' failure both to reduce emissions swiftly and to acknowledge their anticipated effects stems from humans' difficulty in prioritizing long-term needs, as well as from the somewhat abstract nature of our climate problem. However, societies are now armed with better information and a more complete understanding of the true cost of heat-trapping pollution. We must use that knowledge to rigorously adopt long-term thinking.

Too often, the lack of a long-term vision leaves communities with no clear path forward—struggling from one decision to the next, growing less vibrant, and ultimately failing to build resilience (Moser and Boykoff 2013; Hallegatte 2009). Communities that must change can, given the right conditions, change for the better. A multi-decade vision creates the necessary backdrop against which communities—and the nation overall—can weigh adaptation options that are likely to remain effective for decades to come. It can also guide smart

> ***Not everything can be protected. But adaptation planning can help ensure that creatures, places, and human history endure the accelerating impacts of climate change.***

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Working together, residents and decision makers can develop and implement plans to make their communities more resilient to climate changes happening today and in the future. The best plans will be shaped by a long-term vision of the community's future.

rebuilding after disasters strike and dictate strategic investments when infrastructure upgrades are needed. A multi-decade vision can allow for gradual transformation at a pace that people are prepared to accept.

Recent publicly sponsored design competitions reflect a growing appreciation of this need. Boston's "Living with Water" competition, for example, garnered dozens of ideas with the potential to gradually but steadily transform the city's waterfront and low-lying areas into a landscape that accommodates the water while supporting a diversity of uses, enhancing quality of life, and growing more vibrant as the city grows more resilient (Annear 2015).

15. Appreciate limits to adaptation and push mitigation. Even as cities, states, and nations work to adapt to climate change, the best way to limit the magnitude and pace of climate change is still through deep reductions in heat-trapping emissions. Adaptation measures should be low-emissions themselves, as well as work in synergy with climate change mitigation whenever possible.

As the city of Baltimore, for example, seeks to update its policy for responding to extreme heat, over time it may be hard pressed to protect vulnerable people from entire summers of 90°F heat and dozens of days over 100°F. One response—a maladaptive one—would be to increasingly rely on

Even as cities, states, and nations work to adapt to climate change, the best way to limit the pace and magnitude of climate change is still through deep reductions in heat-trapping emissions.

© Karen Gonzales/New Mexico Acequia Association

For generations, communities in New Mexico have built and maintained acequias, or canals, to transport rainwater for irrigation—a prime example of resilience-building powered and supported by communities. Adaptation principles can be interpreted and applied to a wide range of scales, situations, and actors, and help promote robust, forward-thinking solutions to protect the things we cherish.

air-conditioned spaces to provide residents with relief. But this would put added strain on an electricity system already strained. It would increase the localized heat island effect and create more heat-trapping emissions. If Baltimore, and cities globally, were to prepare itself by requiring more efficient buildings, adding carbon-absorbing shade trees to its streets (Hoverter 2012), and creating incentives to increase the use of wind and solar energy, the city could actually see emissions reductions even as it becomes more resilient to the impacts of extreme heat events (City of Baltimore 2013).

Adapt and Learn...

The adaptation principles outlined here are non-exhaustive, and they will evolve. They are deliberately broad and open, and can be interpreted and applied to a wide range of scales, situations, and actors. The principles of considering projected climate conditions and working to protect the things we cherish, for example, could lead a federal agency to establish a new marine sanctuary or lead a midwestern municipality to relocate a historic landmark out of the floodplain. At the same time, important barriers, policy and otherwise, will affect the application of these principles and will need to be better understood and addressed. Overlapping state and federal agency jurisdictions, for instance, may limit the use of a systems approach to adaptation planning, while political power may interfere with equitable adaptation investments.

Going forward, many additional considerations will need to be brought in as we build scientifically sound, equitable, and fiscally responsible resilience across the nation. UCS hopes that these broad principles, refined as our resilience-building nation adapts and learns, provide a vehicle for progress.

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