



Expanding use of archaeology in climate change response by changing its social environment

Marcy Rockman^{a,b,1} and Carrie Hritz^c

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Climate science has outlined targets for reductions of greenhouse gas emissions necessary to provide a substantial chance of avoiding the worst impacts of climate change on both natural and human systems. How to reach those targets, however, requires balancing physical realities of the natural environment with the complexity of the human social environment, including histories, cultures, and values. Archaeology is the study of interactions of natural and social environments through time and across space. As well, the field of cultural resources management, which includes archaeology, regularly engages with values such as site significance and allocation of funding that the modern social environment ascribes to its own history. Through these two approaches, archaeology has potential to provide both data for and methods of addressing challenges the global community faces through climate change. To date, however, archaeology and related areas of cultural heritage have had relatively little role in the global climate response. Here, we assess the social environment of archaeology and climate change and resulting structural barriers that have limited use of archaeology in and for climate change with a case study of the US federal government. On this basis, we provide recommendations to the fields of archaeology and climate response about how to more fully realize the multiple potential uses of archaeology for the challenges of climate change.

heritage | sustainability | governance | cultural evolution

Climate change is a human problem. In 2018, at the conclusion of the United Nations Framework Convention on Climate Change (UNFCCC) 24th Conference of the Parties (COP24) in Katowice, Poland, world leaders referenced the findings of the Intergovernmental Panel on Climate Change (IPCC) report on limiting warming to 1.5 °C (1) and stated that what is needed most urgently is social and political ambition to act (2). Their call raises important questions of how such social and political will for climate action can be realized and how to address the complexity of historical, cultural, economic, equity, justice, and communication issues inherent in deciding what those actions should be and how to move them forward.

These questions exist at least in part because humans inhabit two types of environment, a natural environment and a social environment (3, 4). The natural environment, comprising the geophysical, atmospheric, marine, and biotic worlds, is being changed

by increases in greenhouse gas emissions deriving from human activity and related warming and alteration of the global climate. While more information and analyses of these changes are needed, methods of how to study, monitor, model, and project these changes are developing substantially (1, 5–8). The social environment is created by human interactions, values, expectations, perceptions, and beliefs. The social environment shapes what actions are considered to be possible, acceptable, and desirable (3, 4). The changes called for by world leaders at Katowice are changes in the social environment that will make possible, acceptable, and desirable action to address the factors contributing to climate change and its wide-ranging natural and social impacts.

Archaeology is a means by which the intersections of natural and social environments can be studied at multiple scales through time and across space. Archaeological sites are also part of the broader

^aInternational Council on Monuments and Sites, Climate Change and Heritage Working Group, Washington, DC 20036; ^bDepartment of Anthropology, University of Maryland, College Park, MD 20742; and ^cNational Socio-Environmental Synthesis Center, University of Maryland, Annapolis, MD 21401

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¹To whom correspondence may be addressed. Email: marcy.rockman@icomos.org.

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category of cultural heritage. As defined by the United Nations Educational, Scientific and Cultural Organization, cultural heritage is the collection of tangible sites; buildings, structures, and monuments; landscapes; museum collections and archives; and intangible expressions of culture such as oral traditions, arts, manners, rituals, practices, knowledge, and techniques that have come into the present from the past (9). Methods of doing, funding, and managing archaeology and other forms of cultural heritage directly engage modern values for the past and the historical, economic, cultural, and equity outcomes that intersections of natural and social environments have brought about.

Therefore, we propose that archaeology is valuable to the modern global climate response not only through the information it provides about the human environmental past, but also as a guide to expanding the capacity of modern global climate response to address complexity in the current human social environment. Where archaeology is currently used and not used in climate change response is an indication of how and where social environment gaps in modern climate response have developed and where strategic investment may be made to improve capacity to address human natural and social environments together.

Archaeology of Sustainability and Change

Archaeology combines analysis of artifacts, soils, and sites with models and assessments of less tangible components of human society (10) such as economic relationships (11), power and governance relationships (12), and knowledge and use of the environment (13–16). These combinations produce descriptions and interpretations of components of society that have come into the present from some point in the past.

While no past society is a direct model of present societies, past societies provided similar arrays of services to their members, such as economic and trade relationships, food and shelter, belief systems, governance structures, social norms, and cultural traditions. At the same time, there is evidence that the forms of past societies also have influenced, to varying degrees, institutions and settlement patterns that exist today (17–20).

Two examples illustrate the power of combinations of archaeological approaches to track such connections from past to present. The first is from Lake Mývatn in northeastern Iceland. This area is a major breeding ground for both North American and Eurasian waterfowl and is currently understood to host some of the greatest diversity of waterfowl on the planet. Archeological work at Lake Mývatn, undertaken as part of research on human settlement and adaptation to variable environments and climates across the North Atlantic, has identified significant numbers of waterfowl eggshell remains in sites in the area, but not bones from the waterfowl themselves. Bones of terrestrial birds such as grouse are evident, which indicates that lack of waterfowl bones is not due to lack of preservation (21). Current waterfowl harvesting in the Mývatn area prohibits taking of ducks themselves and limits egg collection to not more than half the eggs in any one nest. Historic documents describe such management practices as dating back into the 18th century. Archaeological evidence suggests that these practices go back substantially further, to the first settlement of the region in the early 10th century CE. This combined evidence suggests that human exploitation of the Mývatn bird populations is an example of a sustainable harvesting system that has operated on a millennial scale (21, 22).

This example directly addresses links between climate change and the concept of sustainability. The United Nations (UN) Sustainable Development Goals include action on climate as one of 17 targets for a more livable global future (23). In this frame, a

more livable global future cannot develop without action on climate change, but also action on climate change will not be successful without work in areas that together comprise what we understand as culture (24). These include economic relations (goals 1 and 10), sustainable production and consumption (goal 12), and peace, justice, and strong institutions (goal 16). Furthermore, while sustainability goals can be set in the present, sustainability itself can only be realized over long periods of time. These findings from archaeology in Iceland describe, in a way no other scientific approach can, an outcome that the global response to climate change is looking to create. What the community around Lake Mývatn achieved was a balance between natural and social environments, production, and consumption shaped and held over generations by cultural understanding. This archaeological work shows that such sustainability is possible and what it can look like.

The second example is from historic Lowell, Massachusetts, where textile factories were built as some of the earliest installations of industrialization in the United States. Construction of the water-powered mills began in the 1820s and included company housing for the first mill workers, unmarried women, and the agents assigned to oversee their work and daily lives. Archaeological work at these housing sites, including analysis of ceramics, glassware, and variable placement of changes in plumbing, tracks transitions from early paternalistic but generally equitable relations between unskilled laborers and the skilled and managerial workers to more rigid and less equitable class structures by the end of the 19th century. Evidence of decline of maintenance of the housing over the course of the 19th century follows changes in labor from a primarily US-born to a more immigrant workforce and rise in competition from other new industrial centers, particularly those able to maximize use of fossil fuels such as coal (25, 26).

Archaeology in Lowell, Massachusetts, describes the history of the system that has created the modern phenomenon of climate change. Climatic change was not an objective of the builders of the mills, but the processes of investing capital, drawing labor from workers, and responding to forces of profit and competition set in motion dynamics that led to emphasis of fossil fuels and changes in land use that in turn have increased emissions of greenhouse gasses up to the present (25, 26). Economic concerns front many present-day discussions of how to respond to climate change, ranging from how much action on climate change will cost to what not acting on climate change will cost (27, 28). Seen from a vantage point of 100 to 200 years, archaeology in Lowell shows that there is no singular form of capitalism. Rather, it has continuously shifted over time and manifested its shifting values in real tangible ways for the people who lived, and are living, through them. When capitalism can be viewed as a dynamic construct that has previously realigned to reflect emergent priorities, future changes to incorporate values such as those outlined by the UN Sustainable Development Goals may become easier to visualize and actualize.

Archaeology in Modern Climate Change Response

For all that archaeology and other components of cultural heritage have to offer to the global response to climate change, currently they are not widely recognized as central components of that response. To date, heritage has been most fully recognized in climate response with respect to indigenous communities. Recent reports such as the US Fourth National Climate Assessment (NCA4) (7, 8) and the IPCC Special Report on Climate Change and Land (6) correctly describe indigenous communities as having

history and heritage that will be affected by climate change and knowledge and practices that may help address climate change. In the NCA4, indigenous peoples are described in a separately titled chapter that sets indigenous peoples as a sector.

However, indigenous communities and archaeology and heritage are not mutually defined. Indigenous peoples are contemporary communities with all of the vitality and concerns present-day communities entail—health, economy, and infrastructure, and so forth. Similarly, all human communities and societies, including those that are not indigenous, have history and heritage. That heritage also is being and will be affected by climate change (29–32). As the heritage of nonindigenous communities includes the development of the modern socioeconomic systems that have led to modern anthropogenic climate change, such as described by the archaeology of Lowell, Massachusetts, above (25, 26), it also has information relevant to addressing climate change.

Primary linkage of heritage with living indigenous communities in climate change response also masks gaps in engaging information from the full depth of the human past. There has been growing attention in recent years to the value and complexity of local and indigenous environmental knowledge and how it may be respectfully and appropriately used as part of climate change response (33–35). We fully support continuation of this work. Our concern here is for knowledge that comes from times and experiences in human history that are known only partially in living memory, if at all. Connection to such knowledge may have been lost for a range of reasons, including but not limited to processes such as colonization and migration, events such as epidemics, and complex processes of information transmission over time (4, 36). Archaeology brings these histories and experiences into the present day. Currently, however, methodological tools for using these histories and experiences are underdeveloped.

For example, in the IPCC Fifth Assessment Working Group II Report (37), a one-page box outlines multiple major examples of past societies, such as the Classic Mayan civilization, early Mesopotamia, and the medieval Viking settlements in Greenland. That this IPCC case study ends with the statement “It would be useful to consider how lessons learned from historical experience may relate to the perceived multiple environmental changes characterized by the ‘Anthropocene’” (37) is strong evidence that use of archaeological information for climate change action is not yet clearly defined or practiced. As evidenced by the sustainability identified in Iceland at Lake Mývatn (21, 22), findings of archaeology and other heritage studies from a millennium or more in the past can speak to concerns of all present human communities and societies, both indigenous and nonindigenous. The work to bring the full range and depth of human experience, including experiences that can be seen as adaptive and those now understood to have been maladaptive, into the modern global response to climate change has not yet been done.

Case Example: Social Environment of Archaeology in the US Federal Government

Archaeology does not yet hold a clear role in global climate response. We propose that this is not because it does not have information and unique approaches to offer, but because, due to other forces, its contributions have not yet been realized. To explore what these forces are and how they might be addressed, we return to the concept of natural and social environments, using the case example of the US federal government.

Archaeology and heritage preservation at the US federal level shapes policy, guidance, and funding for states, tribes, and local

governments. It also influences how the United States speaks for and influences (or does not do so) archaeology and heritage issues at the international level. In saying this, it is important to recognize other voices that are speaking for heritage at the international level. For example, action by Small Island Developing States (SIDS) was essential in including heritage in the UNFCCC Warsaw Mechanism for Non-Economic Loss and Damage (38). Heritage also infuses the Talanoa Dialogues approach to climate adaptation that Fiji brought to the UNFCCC beginning at COP23. What we show here is how the social environment of the United States has shaped how archaeology and heritage are presented in national- and global-level climate reports and the organization and funding of a range of climate response organizations. If this social environment can be adapted to better incorporate archaeology and other approaches to heritage, more support may be possible for the leadership SIDS are taking.

Currently, the United States does not have a clearly named agency for archaeology and cultural heritage. Many countries have a government entity such as an antiquities department that leads on cultural heritage and archaeology and indicates that role in its name (examples include Historic England and Historic Environment Scotland in the United Kingdom, Ministry of Culture and Sport in Greece, and Ministerio de Cultura in Peru). In the United States, the lead federal agency for cultural heritage is the National Park Service (NPS). The NPS is responsible for management of cultural heritage (inclusive of archaeology, historic buildings, cultural landscapes, ethnographic resources, and museum and archive collections) in all 419 units of the national park system. As assigned by legislation (including but not limited to the National Historic Preservation Act of 1966 [NHPA, Public Law 89-665; 54 USC 300101 *et seq.*]), the NPS also provides policy and guidance for management of archaeology and historic resources on federal land and processes funding to states, tribes, and local governments. All federal agencies that manage land or property are responsible for the cultural heritage on their property; this work is led by the agency federal preservation officer. Other archaeological curation and research are undertaken by the Smithsonian Institution; academic research in archaeology is funded by the National Science Foundation (NSF) and at a smaller scale by the National Endowment for the Humanities (NEH); and international education and diplomacy aspects of heritage are led by the Department of State.

This fragmented approach to managing archaeology and cultural heritage at the national level and the cultural resources management system established by the NHPA together limit capacity to address the intersections of climate change with archaeology and other types of cultural heritage. However, the system established by the NHPA also has elements that hold potential benefits for the global climate response.

The NHPA requires that any federal undertaking, defined as a project taking place on federal land, using federal money, or which for other reasons must comply with federal regulations, must assess the potential impacts of the project on significant archaeology and other cultural heritage; it is a “polluter pays” system. If significant archaeology or other cultural heritage will be affected, appropriate mitigation of those impacts must be developed (39).

Significance means a site or other heritage meets criteria of the National Register of Historic Places (NRHP) and has sufficient integrity to convey one or more of those criteria. The criteria are (summarized) as follows: Criterion A: associated with events that have made a significant contribution to the broad patterns of our

history; Criterion B: associated with the lives of significant persons in our past; Criterion C: embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or Criterion D: have yielded or may be likely to yield, information important in history or prehistory (36CFR60.4).

All criteria can be used to evaluate archaeology, although Criterion D is used most often. Research in the history of the NRHP indicates that what information is “important in history or prehistory” is not predetermined, but rather is expected to be defined and redefined as needed and desired to meet the needs of contemporary society (40). In this approach, sites holding waterfowl eggshell in Iceland (were US criteria to be applied there) and traces of workers’ daily lives in Lowell, Massachusetts, could be considered significant under Criterion D for the contributions they stand to make to global climate response.

Decisions about treatment for significant heritage are made through the NHPA Section 106 consultation process. This process identifies stakeholders, shares information about anticipated impacts, and develops consensus regarding appropriate mitigation of the impacts (39). Mitigation is most often directed at the sites or other heritage that will be directly affected, and for archaeology often takes the form of either avoidance or excavation, but it does not have to be. As described by Sebastian (41), the Section 106 process allows for a great deal of creativity and can be used to preserve, recover, and interpret and share archaeology and heritage in a wide variety of ways, limited only by the agreement of stakeholders, managing agencies, and State Historic Preservation Offices or Tribal Historic Preservation Offices.

This means there are already in place policies to assess what is known about the past and what present-day society needs and wants to know about the past. There is a process for engaging associated communities and stakeholders with risks to places that are important to them and developing consensus around appropriate actions to address those risks. Together, these combine attention to a great range of economic, historical, cultural, and equity issues such as those the global climate response needs to address to further climate action. In addition, the archaeologists and cultural resource managers who work with these policies and processes are skilled in using them. However, because of how archaeology and heritage management are structured in the US federal government system, these policies and skills are not being activated for use in climate change response.

Evidence from across the US national park system and other landmarks of national importance (30, 31) and across the Arctic (42) shows that climate change is already damaging archaeological sites and the range of sites at risk and types of damage are likely to increase (7, 8). This damage has not and will not respect national park boundaries or other jurisdictional limits. Currently, there is no polluter who can be tapped to pay for adaptation measures for archaeology and other heritage. With responsibility for managing archaeology and heritage distributed to each land-managing federal agency, and practice that requires impacts to be identified on a site-by-site basis before development of management actions, there are few mechanisms for proactive or cross-jurisdiction response to climate impacts on archaeology and other heritage.

The consequences of the changing natural environment for archaeology within this system should be considered dire in its own terms (43). We contend that the US federal structure for

archaeology and heritage also has created a social environment that suppresses attention to archaeology and heritage and solutions that both their data and management practices offer to broader climate response. By outlining this social environment and its consequences briefly as follows, we propose that it becomes easier to envision climate response—like the forms of capitalism captured in Lowell—as relationships in motion and in which strategic investment and attention can make new relationships possible, feasible, and desirable.

While the NPS is the lead federal agency that addresses archaeology and cultural heritage, it was not always clear this would be the case. Historic resources are mentioned in the founding legislation of the NPS in 1916 (National Park Service Organic Act), but care of battlefields remained the responsibility of the War Department until they were transferred to the NPS by the Historic Sites Act of 1935 (44). Archeological and historic preservation responsibilities increased in 1966 with passage of the NHPA and continued to grow from that time forward, including but not limited to the Historic Preservation Tax Credit, oversight of the Native American Grave Protection and Repatriation Act, and the American Battlefield Protection Program in 1976, 1992, and 1991 (authorized by Congress in 1996), respectively, and growth of historic documentation programs for buildings, engineering, and landscapes, established respectively in 1933, 1969, and 2000.

Despite this proliferation of outreach roles for archaeology and heritage, the NPS prioritizes its responsibilities with respect to national parks and natural resources. An estimated two-thirds of all national park units were founded to protect cultural and historic resources (45), and the NPS is responsible for management of the cultural resources that exist in every park even if those resources are not the primary reason a park unit was founded. For example, NPS funding and staffing for natural and cultural resources were relatively equivalent in 1995. However, between 1995 and 2008 (the most recent available data), funding and staffing for natural resources programs and positions increased by 71% and 31%, respectively, while cultural resources funding and staffing decreased by 19% and 27% (45).

This imbalance of natural vs. cultural at the NPS is replicated in the structure of federal programs to address climate change, such as the US Global Change Research Program (USGCRP). The USGCRP was founded in 1990 with the charge to develop and coordinate “a comprehensive and integrated United States research program which will assist the Nation and the world to understand, assess, predict, and respond to human-induced and natural processes of global change” (PL 101-606). It is composed of 13 federal departments and agencies. At a basic visual level of representation, as shown in *List 1. Departments and Agencies of the USGCRP* below, several USGCRP agencies with legislative mandates to address the natural world reference these responsibilities in their names, such as the Fish and Wildlife Service, National Oceanic and Atmospheric Administration, and the US Geological Survey. As the NPS is the lead federal agency for cultural heritage but does not have the responsibility clearly identified in its agency name, archaeology and cultural heritage are effectively invisible in the makeup of the USGCRP.

List 1. Departments and Agencies of the USGCRP (46)

- Department of Agriculture
- Department of Commerce

Department of Defense
 Department of Energy
 Department of Health and Human Services
 Department of the Interior
 Bureau of Indian Affairs
 Bureau of Land Management
 Bureau of Ocean Energy Management
 Bureau of Reclamation
 Bureau of Safety and Environmental Enforcement
 Fish and Wildlife Service
 National Park Service
 Office of Surface Mining
 US Geological Survey
 Department of State
 Department of Transportation
 Environmental Protection Agency
 National Aeronautics and Space Administration
 National Science Foundation
 Smithsonian Institution
 US Agency for International Development

This lack of representation has influenced how federal reports have presented climate change and appropriate responses. Since the founding of the USGCRP, the National Academy of Sciences has called out the USGCRP several times for gaps in its attention to social science, of which archaeology and cultural heritage are a part (47). From 2016 to 2018, the USGCRP Social Science Coordinating Committee (SSCC) (of which both co-authors were members) led the most recent effort to address these concerns. This included a workshop (47) that brought together social science professional societies with federal social scientists and produced a series of three white papers (10, 20, 48–50). As one of these papers outlined tools of social science, including definitions of what archaeology is and how it does its work (10), this project indicated that awareness and understanding of archaeology and other cultural heritage in relation to global change across the federal agencies most responsible for addressing that global change is remedial. Both co-authors also served as peer reviewers for the NCA4, which is produced and published by the USGCRP. One of the comments submitted and discussed with the USGCRP was that the 20 authors of the NCA4 chapter on adaptation, which is an area of global change that must address the complexities of human society, did not include a single scholar with primary training in the social sciences (and by extension, no scholars with identifiable training in archaeology or cultural heritage).

These gaps in representation mean it is difficult for examples of sustainability such as that shown by the archaeology at Lake Mývatn, insights about the modern capitalist system from research in places such as Lowell, Massachusetts, or experience in bringing diverse stakeholders together in decisions about places that matter such as through the section 106 process, to be used effectively and productively in the federal space. Furthermore,

these gaps are not balanced out by academic research and climate change work in nongovernmental organizations (NGOs).

For example, NSF is the primary US government funding organization for science and social science research. Archaeology is in the Behavioral and Cognitive Sciences (BCS) Division of the Social, Behavioral and Economic Directorate. In 2019, BCS was funded with approximately \$83 million (51). In recent years, the Archaeology program has received approximately 5% of that total (52). In contrast, the National Ecological Observatory Network, which is one of NSF's programs for study of the natural world, received \$80 million in 2017 and approximately \$633 million since its founding in 2007 (53, 54). While these comparisons use only publicly available data and are not direct, they illustrate disparity in relative levels of investment.

This disparity is not balanced out by major climate- and conservation-focused NGOs. As shown in *List 2. Evidence of Archaeology and Heritage Gaps in the Distribution of Climate Attention by Major Climate and Conservation NGOs* below, major categories of NGO attention include climate models and economic and infrastructure sectors. This distribution of attention is similar across these NGOs. Where human society is addressed, it is primarily in terms of human health, jobs, and international development. Insofar as history and heritage are recognized, they are, as in the NCA4, part of attention to indigenous peoples. Archaeology and cultural heritage as a distinct area of attention is also effectively invisible here.

List 2. Evidence of Archaeology and Heritage Gaps in the Distribution of Climate Attention by Major Climate and Conservation NGOs

The Brookings Institution*	No named climate program
Conservation International†	Major topics: Climate, Food, Forests, Fresh Water, Global Stability, Livelihoods, Oceans Programs under Climate (summarized): "Blue Carbon" and Coastal Ecosystems, Sound Government Policies, Mapping Nature-Based Solutions, Ecosystem-Based Solutions, REDD+ Forest Projects, Climate Finance, Supply Chains and Deforestation
Global Environment Facility‡	Major topics listed: Biodiversity, Chemicals and Waste, Climate Change, Forests, International Waters, Land Degradation
The Nature Conservancy§	Major topics: Tackle Climate Change, Protect Land and Water, Provide Food and Water Sustainably, Build Healthy Cities Programs under Tackle Climate Change: Nature-Based Solutions, Building Resilience (by restoring habitats), Working

*<https://www.brookings.edu>. Accessed 27 June 2019.

†<https://www.conservation.org/home>. Accessed 18 June 2019.

‡<https://www.thegef.org>. Accessed 27 June 2019.

§<https://www.nature.org/en-us/>. Accessed 18 June 2019.

with Governments, Inspiring Conservation, Promote Clean Energy

Resources for the Future^f

Major topics listed: Energy and Climate; Land, Water, and Nature; Environmental Economics; Regions

Under Energy and Climate: Air Quality, Carbon Pricing, Future of Power, Oil and Gas, Social Cost of Carbon, Transportation

Under Climate Change (summarized): Technology Transfer for Sustainable Energy, Mitigation Options, Connecting Mitigation and Sustainable Development

The Rockefeller Foundation[#]

Major topics: Health, Food, Power, Jobs, Resilient Cities, Innovation, Co-Impact

World Resources Institute: Climate^{||}

International Climate Action (summarized): Transparency, NDCs, Carbon Removal Strategies, Power, China, Economy and Finance, Equity

Emissions Tracking (summarized): Science-Based Targets, Greenhouse Gas Protocol, Climate Action Transparency, Tracking Climate Action, Reporting Tools

US Climate Action (summarized): Carbon Pricing, Powering the US, Clean Power and Utilities, US Climate Impacts

Climate Resilience (summarized): Global Commission on Adaptation, Data Visualization, Adaptation Finance, Transformative Adaptation, Urban Resilience

Several types of explanation can be invoked that describe connections between the structure of the US federal government attention to climate change and the NGO approach, from the availability heuristic in behavioral economic models (55, 56) to frequency-based transmission biases that operate in cultural evolution (3, 4). Both of these types of processes describe how that which is most common in a social environment is taken to be that which should be replicated or carried forward. Microevolutionary and macroevolutionary models built in relation to archaeological research provide additional insight on these interactions (57). The outcome of these processes for the global climate response to date has been that climate change is understood, funded, and staffed to be the province of the physical sciences and the natural world, and the cultural and historical world as distinct from indigenous peoples (who also hold culture, history, and heritage) is not a widely recognized part of it.

Changing the Social Environment

As the global climate response works to build social and political will to meet the climate challenges the physical sciences are describing, archaeology and cultural heritage have much to offer to both its natural and social environments. These include illustrations of how concepts such as sustainability have been realized over the long term, such as at Lake Mývatn, the dynamics of the

web of economic relationships that contributed to the development of climate change, such as at Lowell, Massachusetts, and processes that assess and decide how to manage places that hold histories, cultures, and a great range of meanings for the communities that know them. Following are our recommendations to change the social environment of climate response, with the goal of expanding use of both the content and process benefits of archaeology and heritage as quickly as possible:

- 1) Found a federal climate heritage coordination office. We recommend founding a named climate heritage coordination office with responsibilities for connecting agencies addressing climate and/or heritage, fostering relevant research, and representing heritage in interagency and other government forums. Given the time frame of less than a decade for substantial climate action recommended by the IPCC (1), attempting to change the distribution of archaeology and heritage management within the US federal government is not a viable primary remedy for climate action. While additional analysis is needed as to whether such an office would best be set alongside or within the USGCRP or as part of another agency, such a coordination office would provide greater visibility for archaeology and heritage both within and outside of the government and leverage existing resources and knowledge (such as through rotating agency staff appointments) to address the needs of archaeology and heritage under climate change and engage their benefits.
- 2) Link archaeology and heritage in climate research and investment. Currently, NSF lists archaeology as fundamental science (58), but not other areas of heritage. While definition of areas of science is an overarching issue, as is basic vs. applied science, what we recognize here is that this approach has the effect of separating funding for research of the kind that generated archaeological sustainability findings at Lake Mývatn from support for contemporary work with climate adaptation that would benefit from such findings. This separation lands not only between funding programs, but often between funding organizations. As described above, funding for archaeology and heritage is currently limited; therefore, such separation also contributes to a social environment that limits visibility and engagement with what archaeology and heritage can do. We encourage attention to this gap by NSF, such as through its Dynamics of Coupled Natural and Human Systems program, other research bodies such as the NEH, and other programs for climate research. We recommend funding for the science-policy side of the gap, with focus on how to use archaeology and heritage-derived information in climate adaptation planning and decision-making at local, state, and national levels. Programs and agencies of the USGCRP may be effective starting points for demonstration projects of this approach.
- 3) Foster climate heritage demonstration projects. Several member agencies of the USGCRP manage or fund diverse adaptation projects. We recommend an initiative to bring aspects of heritage into such projects where they have not been used before. Examples may range from archaeological contributions to land management to consultations with communities about contemporary important places. Such demonstrations will allow assessment of heritage contributions to project outcomes and support development of relevant practices. Support for such projects could come from the recommended coordination office, be modeled on the USGCRP SSCC project described above that brought external social scientist support

^f<https://www.rff.org>. Accessed 27 June 2019.

[#]<https://www.rockefellerfoundation.org>. Accessed 27 June 2019.

^{||}<https://www.wri.org/our-work/topics/climate>. Accessed 27 June 2019.

to the government, and/or be developed in collaboration with climate or conservation NGOs.

- 4) Expand NGO attention to heritage. Rapid attention to connections of archaeology, heritage, and climate both in the United States and around the world may be most effective in the realm of NGOs. Several cultural heritage NGOs, such as the International Council on Monuments and Sites (ICOMOS), the citizen science-focused programs Scottish Coastal Archaeology and the Problem of Erosion in Scotland (59) and Archéologie Littorale et Réchauffement Terrestre (Alért) in France (60), and collaborating state or governmentally funded programs such as the Florida Public Archaeology Network (61) and the European Union-funded Climate, Heritage and Environments of Reefs, Islands and Headlands in Wales and Ireland, are mobilizing for climate change. ICOMOS, for example, has released a major road map document through which the global heritage community can work to help meet the goals of the Paris Agreement (62). Due to chronic underinvestment in heritage, these organizations cannot make the change that is needed alone. ICOMOS, for example, while it encompasses national chapters in 107 countries and 28 international scientific committees, does the vast majority of its work on a volunteer basis. However, knowledge and expertise exist in these organizations, and together they form a structure that could grow capacity with engagement and investment from more traditional climate groups.

On these bases, we recommend that climate- and conservation-focused NGOs include funding, support, and use of archaeology and cultural heritage as part of their global climate response. Currently, climate-directed NGO dollars are limited. As shown in *List 2. Evidence of Archaeology and Heritage Gaps in the Distribution of Climate Attention by Major Climate and Conservation NGOs*, there is also currently overlap in major areas of NGO attention to climate change. We are not recommending that all climate or conservation NGOs address archaeology and heritage, but one or some should. Furthermore, we suggest that incorporating archaeology and heritage would not deplete other necessary climate initiatives, but rather, given the arguments in this article, archaeology and heritage are missing components that stand to make existing climate and conservation work more effective.

Finally, to foster changes in the social environment that will broaden recognition of archaeology and heritage as

components of the global climate response, we recommend that at least a portion of NGO engagement go toward collaborative partnerships between governmental or intergovernmental climate science organizations and cultural heritage. Demonstration projects as described above or collaboration with the USGCRP for the next US NCA could be catalyzing projects. A project proposed by ICOMOS to the IPCC to expand assessment of all forms of heritage in IPCC reports is another (62).

Conclusion

In her book *This Changes Everything*, Naomi Klein (63) observed, “We know that we are trapped within an economic system that has it backward; it behaves as if there is no end to what is actually finite (clear water, fossil fuels, and the atmospheric space to absorb their emissions) while insisting that there are strict and immovable limits to what is actually quite flexible: the financial resources that human institutions manufacture, and that, if imagined differently, could build the kind of caring society we need.”

Here, we have outlined other sources of flexibility for the global climate response, those that come from working with archaeology and other fields of cultural heritage. We do recommend investing additional financial resources, but also social environment resources of attention, of understanding and building ways of bringing forward the rich complexity of how humans have balanced natural and social environments through time, and the skills and creativity that have developed through managing the records of the human past. Given the time pressures of addressing climate change, it is important to emphasize that these data and methods do not need to be developed anew. Rather, with strategic investments, knowledge and methods we already have can be used to much greater effect to meet the climate challenges currently facing the world.

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