Chapter 12: Effects of Climate Change on Cultural Resources

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Introduction

As with all resources on public lands, cultural resources are subject to environmental forces such as climate change. Climate change can affect cultural resources directly (e.g., heat, precipitation) or indirectly (e.g., vegetation, wildfire, flooding). Cultural resources include archaeological sites, cultural landscapes, ethnohistoric and historic structures and artifacts, and ethnographic resources. As weather patterns become more extreme and more unpredictable, they will introduce new risks to the management of cultural resources. In such circumstances, risk management and adaptation options can be complicated because many resources are unique and have strong ties to a specific location. Cultural resources and cultural landscapes are approached differently from a management perspective compared to other resources because they are nonrenewable—once they are lost, they cannot be restored.

The 1906 Antiquities Act requires Federal land management agencies to preserve historic, scientific, commemorative, and cultural values of archaeological and historic sites and structures of public lands for present and future generations (NPS 2011; NPS 2015a). It also gives the President of the United States authority to designate national monuments as a means to protect landmarks, structures, and objects of historic or scientific significance. The Historic Sites Act of 1935, National Historic Preservation Act of 1966, Archaeological Resources Protection Act of 1979, and Native American Graves Protection and Repatriation Act of 1990 reaffirm the importance of cultural resources. Although these laws differ in their focus, they collectively mandate the protection and management of cultural resources on Federal lands. The National Park Service has a particularly strong emphasis on protection of cultural resources (box 12.1).

Protection of cultural resources is focused on physical sites, structures, and artifacts that are associated with the past, as well as ongoing cultural practices of the present. Many cultural resources are vulnerable to natural biophysical factors as well as anthropogenic effects. Wildfire and biological processes degrade and destroy cultural resources, particularly those made of wood or located in erosion-prone environments. Vandalism, illegal artifact digging, arson, and other depreciative human behaviors also damage cultural resources. Although management actions can help protect and mitigate many of these adverse effects, the protection of cultural resources is a resource-intensive task that often exceeds agency capacity.

Box 12.1—The National Park Service and Cultural Resources

The National Park Service (NPS) was assigned the role of preserving historic sites, buildings, and objects of national significance through the National Historic Preservation Act and the Federal Historic Sites Act. Specifically, a cultural resource is considered to be "an aspect of a cultural system that is valued by or significantly representative of a culture, or that contains significant information about a culture" (NPS 2015c). Cultural heritage and its preservation are emphasized in the agency's Cultural Resources, Partnerships and Science directorate (NPS 2011), which instructs the agency to:

- Preserve cultural resources in cooperation with Indian tribes, Alaska Native villages and corporations, Native Hawaiian organizations, States, territories, local governments, nonprofit organizations, property owners, individuals, and other partners;
- Provide leadership in research and use of advanced technologies to improve the preservation of the Nation's cultural heritage;
- Establish standards and guidance for managing cultural resources within the National Park System and communities nationwide; and
- Enhance public understanding of and appreciation for the Nation's cultural heritage.

The NPS emphasizes minimizing loss and disturbance of culturally significant material in management and protection activities, and communicates this focus through educational and interpretive information.

Overview of Cultural Resources

Defining Cultural Resources

Cultural resources located on Federal lands fall into two broad categories. First, resources are categorized as archaeological and historic sites if they represent the tangible story of past human activities on the landscape and are generally over 50 years in age. Second, ongoing relationships between American (and Native American) people and ecology managed by Federal agencies can also be considered to have cultural significance. Ecology is used here in the holistic sense of the landscape, environment, flora-fauna, and extant human interaction, including the management of Native American sacred sites and traditional cultural properties.

According to 36 CFR 60.4 and *The National Register Bulletin: How to Apply the National Register Criteria for Evaluation*, cultural resources may be considered significant and eligible for the National Register of Historic Places if they have a quality that is of significance in American history, architecture, archaeology, engineering, or culture and if that significant quality is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and

- That are associated with events that have made a significant contribution to the broad patterns of our history; or
- That are associated with the lives of significant persons in our past; or
- That 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
- That have yielded or may be likely to yield, information important in history or prehistory.

The majority of cultural resources located on Federal lands in the Intermountain Adaptation Partnership (IAP) region, especially on national forests, have yet to be identified because most field surveys of cultural resources have focused on the area of potential effect of proposed undertakings; those inventories were not performed solely to identify cultural resources where they are most likely to exist. Most lands within national forests in the U.S. Department of Agriculture Forest Service (USFS) Intermountain Region have not been subject to basic cultural resource inventories. Section 110 of the National Historic Preservation Act (NHPA) broadly spells out the responsibilities of Federal agencies to ensure that historic preservation is an integral part of overall Federal land management programs.

When considering management of cultural resources in light of climate change, we must also consider the future management of landscapes that are likely to contain cultural resources not yet identified. Tangible physical remains of the human past on the landscape are not only objects and features, but also the archaeological, historical, and cultural value we place on them that make them important and worth preserving (NPS 2015a). Changing values and scientific research may change the perceived value of cultural resources over time. Archaeological and historic sites that may not have been considered eligible for the National Register of Historic Places in the past, may now be considered eligible because of changing attitudes about the historic past and the archaeological record.

Not all cultural resources are considered “historic properties.” Designation of a cultural resource as a historic property requires a certain level of Federal management of that resource as described in 36 CFR 800. Nonetheless, other cultural resources are still important and should be managed at a level deemed appropriate in light of recommendations of heritage staff after consultation with tribes, the public, and other stakeholders. In this context, this chapter provides land managers with a climate change assessment that can help inform land management decisions that minimize adverse effects to cultural resources and promote their preservation and interpretation for the public.

Cultural Resources in the Intermountain West

Indigenous Lifeways

North America was colonized by the ancestors of Native Americans sometime in the range of 14,000 to 15,000 years BP. The oldest well-dated archaeological sites located within the area that encompasses the USFS Intermountain Region are Danger Cave, Smith Creek Cave, and Bonneville Estates Rockshelter—located on the western shores of the ancient freshwater Lake Bonneville—dating to 10,600 to 12,800 years BP (Rhode et al. 2005).

Over thousands of years, successive groups of Native Americans either created or adopted different subsistence strategies adapted to the ecology of the area the group inhabited (Smith 2011). Although adaptations included hunting, gathering, foraging, horticulture, and agriculture, the salient characteristic of these strategies was their intrinsic tie to local environmental conditions and locally procured resources (Smith 2011). Even if a group was highly mobile or nomadic, or maintained trade networks with other groups, it still relied on resources from the area in which it lived.

Most of the archaeological record left behind by early peoples consists of stone tools, debris from making stone tools, and pottery from different time periods because organic material degrades. In rare cases, buried archaeological deposits, especially those found in protected rock shelters and caves, contain organic material such as wood, antlers, bones, leather, textiles, basketry, and charcoal (Rhode et al. 2005) (fig. 12.1). Common features that remain on

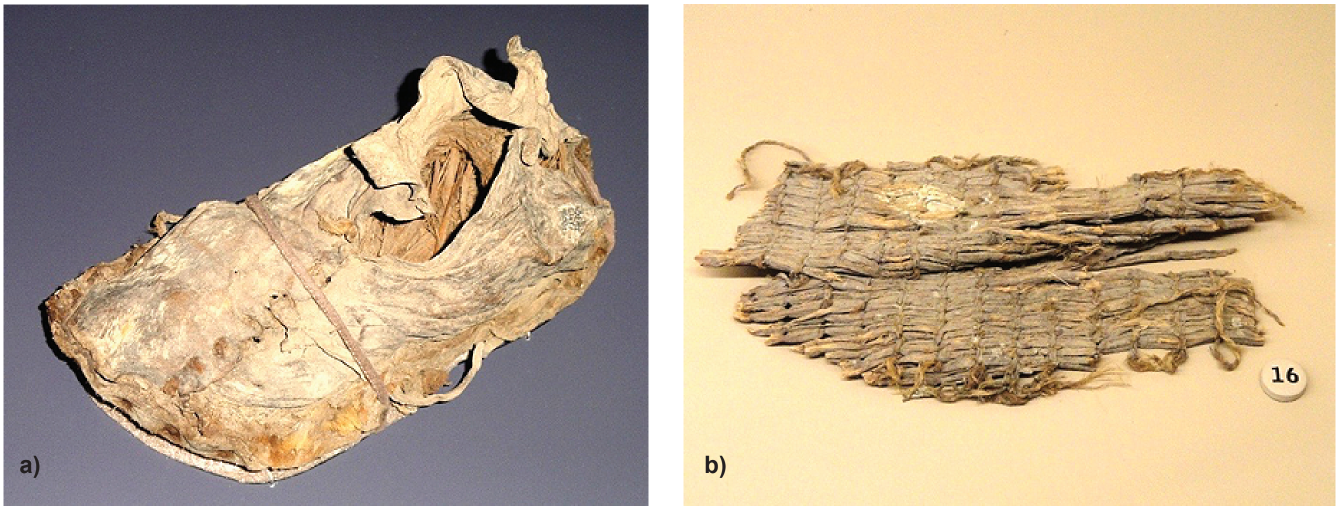

Figure 12.1—Artifacts made of organic materials: (a) Moccasin made of hide and sinew, Hogup Cave, Utah, 420 AD; (b) twined mat, 1225–1275 AD, Promontory Cave I, Utah. Artifacts made of organic materials are typically well preserved only when buried in caves or other shelters. Fluctuations in moisture and temperature cause these materials to decompose relatively quickly, especially when exposed to open air (photos: Courtesy of the Natural History Museum of Utah).

the landscape include rock art, architecture, food storage features, and stone alignments such as teepee rings and pinyon nut storage features. Less common, and dating to the protohistoric and historic period, are animal drive lines created from brush and wood (fig. 12.2), wikiup structures made from branches, brush houses, and culturally modified trees (Simms 1989).

Traces of Past Lifeways

In the IAP region, tangible remains of material culture range from isolated stone tool fragments to village sites with aboveground architecture. Each national forest and national park in the IAP region has its own unique set of archaeological sites, although there are some recurrent patterns in general types of archaeological sites. The most commonly identified type of archaeological remains, which spans all of human prehistory, are prehistoric artifact scatters found on the ground surface. These artifact scatters typically contain waste flakes from making stone tools (or lithic debitage), stone tools (Rhode et al. 2005), pottery sherds, and ground stone tools such as manos and metates, which were used as grinding implements for food processing (Adams 1993; Schlanger 1991). These types of sites are relatively common, often indicating that more cultural material is present, but buried, and not visible during a field survey.

Archaeological sites located in caves and rock shelters often preserve a broad range of artifacts and features that do not typically survive in open-air sites. People used caves and rock shelters throughout prehistory. These places protected not only people but objects from the elements. The high degree of preservation allows leather and hide, basketry, textiles, cordage, and artifacts of wood, bone, antler, and ceramic to persist, along with other organic material such as charcoal and plant material (Beck and Jones 1997).

Figure 12.2—Wichman Corral, Great Basin, Nevada. Deer traps were used to drive animals into a confined area where they could be killed. These cultural features are relatively subtle across the landscape and are susceptible to damage from wildfire (photo: B. Hockett, Bureau of Land Management, Nevada State Office).

Archaeological features defined as nonportable material include rock art, architectural remains, stone alignments such as teepee rings or storage features, trails, and culturally modified trees. In addition, highly distinctive resources are found in the southern portion of the IAP region. Between about 600 and 1250 AD, this area was occupied by the Fremont culture, whose lifeway was tied to maize horticulture (Coltrain and Leavitt 2002). Fremont-era sites often contain the remains of pithouse structures, aboveground and belowground food storage features (granaries), pottery, portable art object (e.g., clay figurines), and rock art (Kloor 2007; Madsen and Metcalf 2000). Most of the easily identifiable Fremont sites are located in Manti-La Sal National Forest, but there are also sites in Ashley, Dixie, Fishlake, Humboldt-Toiyabe, and Uinta-Wasatch-Cache National Forests.

The IAP region also has a significant presence of Puebloan culture related to the Anasazi, also known as the Ancestral Puebloans, which dates to between 300 and 1300 AD (Allen and Baker 2000; Jennings and Norbeck 1955). The Anasazi were focused on maize agriculture; archaeological sites contain aboveground architecture, villages, multiroom structures (pueblos), granaries, kivas (large storage and ceremonial structures), and rock art sites (Lekson 2008; Lyneis 1992). Most Anasazi sites are in Manti-La Sal National Forest, with additional sites in Dixie, Fishlake, and Humbolt-Toiyabe National Forests.

Ethnographic Resources as a Legacy of Indigenous Lifeways Still in Practice

Because indigenous people continue to use traditional landscapes as part of their modern cultural practices, Native Americans have an active relationship with Federal lands in the IAP region. All cultures change with time, and aspects of the active relationship that indigenous people have with the land change as well. The concept that current relationships are as culturally valid as historical ones is an important aspect of contemporary land management.

Given the number of Federally recognized tribes with whom Federal agencies in the IAP region have relationships (table 12.1), incorporating Native American values and perspectives can seem overwhelming. The most effective way to approach this issue is to invite tribes to be partners in management of public lands rather than treating them only as consulting parties. Land managers benefit from an indigenous perspective on ecosystem management, and an ongoing relationship helps land managers to understand current concerns of tribal entities and identify traditional uses that may be affected by climate change. Identifying current cultural practices and resource use allows land managers to make decisions that may mitigate adverse effects on those resources.

Agricultural and Industrial Activities

Euro-American exploration in what is now the IAP region began in the late 1700s, followed by more intensive settlement in the mid-1800s. Thereafter, settlements of people of European, Asian, and African descent expanded quickly in population size and settlement extent. In addition, Native American peoples increasingly participated in the new agricultural and industrial economies brought by European settlers.

Visible footprints from these new economies take primarily three forms. First, there are the remains of the work and residential locations associated with agricultural and industrial activities, generally taking the form of archaeological sites that include homesteads, mines, towns, trash scatters, and campsites. Second, this wave of settlement created landscape features such as roads, dams, railroads, and canal systems. Third, there are remains of changes to landscapes caused by agricultural and industrial activities, including stream channel alteration caused by hydraulic mining, stump fields associated with tie cutting, and field clearing associated with farming (Merritt 2016; South 1977).

These different lines of evidence about past activities inform us about not only past human settlements and activities, but how these activities have affected current human and ecological communities, and how these changes set the stage for the future. They also provide visitors to Federal lands an opportunity to observe the effect of industrialization in the American West. We need to consider the potential effects of climate change on all of these lines of evidence across the current-day landscape. Beyond protecting cultural resources, resource managers may benefit from understanding how past management practices produced current outcomes. Looking into the history of landscape management may help inform future climate change adaptation. Appropriate scales of inquiry include individual archaeological sites as well as larger landscapes where particular activities took place (e.g., a mining district or homesteading area). Even larger landscapes are relevant in some cases, such as watersheds around the Comstock Lode in western Nevada, which was affected by mining, logging that supported the mining, and transportation systems associated with both of these activities.

Activities in the Historic Period

Each location in the IAP region has a unique history affected by the primary economic activities that initially attracted settlers to that area. For example, an emphasis on mining created different types of archaeological sites and landscape features than agriculture or logging. These differences shifted through time, as local economies changed or diversified. The establishment of national reserves, forests, and parks affected the scale and nature of some of these activities. Most national forests contain some of the remains associated with particular economic activities. Others contain resources that are unique to one or more national forests, such as the presence of Chinese communities during and after the building of the Transcontinental Railroad in the mid-19th century (Ambrose 2001).

Table 12.1—Geographic locations in the U.S. Forest Service Intermountain Region where tribal groups have a legacy of natural resource use.

Tribe	Lead national forests for tribal consultation	State
Battle Mountain Band (Shoshone)	Humboldt-Toiyabe	Nevada
Bridgeport Indian Colony (Paiute)	Humboldt-Toiyabe	Nevada, California
Carson Colony (Washoe)	Humboldt-Toiyabe	Nevada
Confederated Tribes of Goshute	Uinta-Wasatch-Cache	Utah
Dresslerville Community (Washoe)	Humboldt-Toiyabe	Nevada
Duckwater Shoshone Tribe	Humboldt-Toiyabe	Nevada
Eastern Shoshone	Bridger-Teton	Wyoming, Utah
Elko Band (Western Shoshone)	Humboldt-Toiyabe	Nevada
Ely Shoshone	Humboldt-Toiyabe	Nevada
Fallon Colony (Paiute and Shoshone)	Humboldt-Toiyabe	Nevada
Fort McDermitt	Humboldt-Toiyabe	Nevada
Las Vegas Paiute	Humboldt-Toiyabe	Nevada
Lovelock Paiute	Humboldt-Toiyabe	Nevada
Moapa Band of Paiute	Humboldt-Toiyabe	Nevada
Navajo Nation	Manti-La Sal	Utah, Arizona, New Mexico
Nez Perce Tribe	Payette, Salmon-Challis, Sawtooth	Idaho
Northern Arapaho	Bridger-Teton	Wyoming, Utah
Northern Ute Tribe	Ashley, Fishlake, Manti-La Sal, Unita-Wasatch-Cache	Utah
Northwestern Band of Shoshoni Nation	Unita-Wasatch-Cache, Sawtooth	Utah
Paiute Indian Tribe of Utah (includes: Shivwits, Cedar City, Koosharem, Kanosh, Indian Peaks Bands	Dixie, Fishlake, Manti-La Sal	Utah
Pyramid Lake Paiute	Humboldt-Toiyabe	Nevada
Reno-Sparks Colony (Washoe, Paiute, Shoshone)	Humboldt-Toiyabe	Nevada
San Juan Southern Paiute	Manti-La Sal	Utah, Colorado
Shoshone-Bannock Tribes	Bridger-Teton, Caribou-Targhee, Payette, Salmon-Challis, Sawtooth	Idaho
Shoshone-Paiute Tribes	Boise, Caribou-Targhee, Humboldt-Toiyabe, Payette, Salmon-Challis, Sawtooth,	Nevada, Idaho
Skull Valley Band of Goshute	Uinta-Wasatch-Cache	Utah
South Fork Band Colony	Humboldt-Toiyabe	Nevada
Stewart Colony (Washoe)	Humboldt-Toiyabe	Nevada
Summit Lake Paiute Tribe	Humboldt-Toiyabe	Nevada
Te-Moak Tribe of Western Shoshone	Humboldt-Toiyabe	Nevada
Ute Mountain Ute Tribe (Weeminuche Band)	Manti-La Sal	Utah, Colorado
Walker River Paiute	Humboldt-Toiyabe	Nevada
Washoe Tribe (includes: Carson, Dresslerville, Stewart, Washoe, Reno-Sparks, Woodsfords Colonies)	Humboldt-Toiyabe	Nevada, California
Wells Band Colony	Humboldt-Toiyabe	Nevada
Winnemucca Indian Colony (Paiute and Shoshone)	Humboldt-Toiyabe	Nevada
Woodsfords Community (Washoe)	Humboldt-Toiyabe	Nevada, California
Yerington Paiute	Humboldt-Toiyabe	Nevada
Yomba Shoshone	Humboldt-Toiyabe	Nevada

Figure 12.3—Cabin used by a railroad tie cutter in the Uinta-Wasatch-Cache National Forest, Utah. Such historic structures are highly susceptible to damage from wildfire (photo: C. Merritt, Uinta-Wasatch-Cache National Forest).

The historic period is generally considered to start when written records began to be available. In the IAP region, it began in the late 1700s with the arrival of Spanish and English explorers (Fernández-Shaw 1999). A historic archaeological site can include sites as recent as 50 years old, because all sites of that age can be considered for inclusion in the National Register of Historic Places.

People involved in all historic period activities needed places to live, acquire supplies, and educate their children. As a result, communities of various sizes and structure are associated with all historic period activities. Some of these communities were located in what are now national forests (e.g., mining towns, dispersed homesteads), and others were located adjacent to national forests, but with infrastructure (e.g., dams, canals, roads) established on National Forest System lands. The archaeological remains of these communities include standing or collapsed houses, commercial buildings, roads, trash scatters, power houses, power lines, rail lines, dams and canals, spring developments, and buried water lines (fig. 12.3).

Agricultural settlements have two patterns: (1) farmers living directly on their land, in which case they are parts of dispersed communities of similar families; or (2) farmers or livestock operators living in clustered communities, then traveling to their farms (Leone 1973). The latter is often associated with Latter-Day Saint (or Mormon)-settled towns in Nevada, Utah, and Idaho (Arrington 1993). Some lands now administered by national forests were originally homesteaded under various homesteading acts. When these homesteads failed in the 1930s, they were purchased by the Federal government and conveyed to National Forest System management. These larger homesteading landscapes include roads, canals, reservoirs, cleared fields, fences, and other features.

Some agricultural features are marked by the presence of cultivated plant species (e.g., fruit trees, flowers) that may have been planted decades ago but still exist. Some failed farmlands were seeded by the USFS with smooth brome (*Bromus inermis*) or crested wheatgrass (*Agropyron cristatum*) to reduce wind erosion. These nonnative crops are a visible reminder of past farming activities even after houses and barns are no longer visible on the landscape.

The archaeological evidence of livestock grazing includes campsites (often artifact scatters), fences, watering troughs, dams, and arborglyphs (signatures and drawings on aspen trees). People from diverse backgrounds participated in this activity, including Basques, other Southern Europeans, Native Americans, Central Americans, and South Americans (Mallea-Olaetxe 2008). Unmanaged livestock grazing altered the composition of some plant communities and led to extreme soil erosion, producing effects that are still visible in some landscapes.

Mineral extraction, which included hard-rock mining and to a lesser degree coal mining, was the primary motivation for settlement in many areas, and its imprint on the landscape is highly visible in many areas. Archaeological remains from mining include entire towns, isolated cabins, tailings piles, headframes, tramways, roads, railroads, water flumes, and ventilation shafts. Hydraulic mining and placer mining moved millions of tons of earth within or next to stream channels, leaving mounds of gravel within highly altered landscapes in Idaho and Nevada and thus severely altering the soil and water processes in these areas.

A significant social component of mining was the many ethnic groups who were drawn to the industry, including Italians, Slavs, Finns, Georgians, Germans, Asians, Spanish-speaking Americans, and Native Americans, who have contributed to the demographic composition of communities in those areas today (Brown 1979; Paul 1963). Chinese and Japanese residents worked in support industries such as restaurants, transportation, logging, and laundry services. These ethnicities are recognized in the archaeological record, providing information critical to understanding the histories of people who were often marginalized in the written record of these mining ventures (Voss and Allen 2008).

Archaeological evidence of rock quarrying can be seen in settlements, but more commonly in road and railroad systems and by the remains of the quarries themselves. The production of lime from limestone was marked by stone kilns, broken limestone, and piles of discarded lime. These kilns were widespread near many historic communities and were in operation until commercially produced lime and cement became available.

Oil and gas development began in national forests in the late 1800s in many parts of the region. Much of this work was largely exploratory, whereas other fields were successfully developed for longer periods of time. These locations are often marked archaeologically by capped wells, cleared pads with associated ponds, artifact scatters, collapsed cabins or derricks, roads, and abandoned pipelines.

Logging was the most widespread form of extractive industry in the IAP region, and continues today. Past logging activity was conducted on a variety of scales, and the associated archaeological remains and environmental effects vary. Logging in support of mining or railroad development left a large footprint, including large camps or commissaries where workers lived, road networks, railroads, water diversions, and sawmills. Smaller scale logging is often marked by smaller camps, sawmills, roads, and water diversions.

The cutting of railroad ties associated with the Transcontinental Railroad and later rail lines was carried out at multiple scales. In addition to the usual archaeological footprint associated with logging, "tie hacking" affected stream channels. In this practice, ties were cut in winter, piled next to streams, and transported down those streams during spring runoff. The resulting rush of water and logs scoured stream channels, altering their character and function.

Charcoal-making produced fuel for railroads, smelters, and household use. It was done on a small scale in many areas, especially in Nevada. Charcoal sites are marked archaeologically by stone or brick kilns, often accompanied by campsites, small settlements, artifact scatters, roads, and rail lines. This work was often conducted by ethnic minorities, including Italians (Straka 2006).

The first travel routes associated with exploration and settlement of the western United States in the 1800s were foot and pack animal trails or wagon routes, some of which are still partially intact and remain historically important. Historic trails in national forests today include the Lewis and Clark Trail, Old Spanish Trail, Oregon Trail, and Mormon Trail. The physical remains of these trails are often ephemeral, and the trail routes are generally considered to include the landscape settings of those trails, often defined as their viewshed.

Road systems developed soon thereafter connected communities with each other and with resources and centers of activity near communities (e.g., sawmills, mines). Although the narrow original footprint of these roads was often covered by modern gravel, asphalt, or concrete roads, native surface historic roads continue to exist in national forests, often associated with historic camping and trash disposal. Completion of the Transcontinental Railroad in 1869 set the stage for development of a network of railroads that connected communities in the IAP region with the rest of the United States, which facilitated the development of mining, logging, and other industries. Narrow-gauge rail lines connected mines, logging districts, quarries, and other industrial operations with major railroad and road systems. Many of these smaller rail lines remain on national forests, marked by railroad grades and cuts, culverts, bridges, tunnels, and work camps.

Some activities described as historic remain important economic activities for people today. For example, hard-rock mining continues in some areas, but global economics and the cost of domestic mining have made most mining ventures unprofitable. Oil and gas development is prevalent in some national forests and adjacent lands (especially Bureau of Land Management and private lands), with on-the-ground activities subject to fluctuation in global energy markets. Logging remains an important economic industry in national forests, but at a much lower level and smaller scale than 30 years ago, often serving as a tool for hazardous fuels reduction and restoration. Livestock grazing is the most widespread historic activity that remains on Federal lands, and is important economically to individual families and some small communities. Tourism is an important economic activity associated with archaeological remains of all historic activities, including visitation at mining districts, historic trail systems, and railroads. Preservation of historic resources that attract visitors contributes to the economies of communities who depend on tourism.

Climate Change Effects on Cultural Resources

Context

Climate change will affect several environmental factors that will in turn potentially alter cultural resources and cultural landscapes. Some areas may experience increased aridity and drought, whereas others may be subject to seasonal flooding. The physical implications of climate change will not be uniform either spatially or temporally.

Areas that are most at risk can be identified by considering the following questions (Rockman et al. 2016): (1) How will climate and environments change over time? (2) How will animal and plant communities change as a result of human use? and (3) How will human use change over time in response to climate change? The following topics can serve as a starting point for land managers to consider when making management decisions relative to climate change and cultural resources: (1) physical traces of past human use, (2) paleoenvironmental data, (3) culturally significant native vegetation, (4) culturally significant native fauna, (5) forest visitor use and pressure areas (change associated with climatic and ecological shifts), and (6) livestock grazing regimes.

The projected effects of climate change through the 21st century include increased temperature and drought, decreased snowpack, and increased ecological disturbance (wildfires, insect outbreaks, floods in some areas) (chapters 3, 4, 8). These effects will have ramifications for the physical cultural resources on the landscape, and, in turn, affect the intangible cultural values that are linked to the physical manifestations of archaeological and historic sites, landscapes, and ongoing traditional use. The National Park Service provides a detailed list of how direct and indirect climate change effects influence cultural resource management (NPS 2017).

Land managers can understand how cultural resources will be affected by changes in climate through systematic monitoring programs. As noted previously, however, the majority of cultural resources have yet to be identified. In the absence of large-scale cultural resource inventory data, managers can use predictive models to identify areas that are likely to contain unidentified cultural resources, and infer the likely character of those resources. These models can be used to direct future inventories and to proactively manage those areas based on their likelihood of containing significant cultural or historic resources. Such geospatial studies have been done at the Bering Land Bridge National Preserve and Cape Krusenstern National Monument, Alaska (NPS 2015b).

This assessment is general because little has been written about the effects of climate change on cultural resources compared to other resources (Morgan et al. 2016; Rockman 2015). The diversity of cultural resources and the locations where they are found make it difficult to infer the spatial extent and timing of specific effects. Therefore, we base inferences on the relevant literature and professional knowledge to project how an altered climate will modify the condition of, and access to, cultural resource sites.

Biophysical Effects on Cultural Resources

Climate change has the potential to exacerbate existing effects from the natural environment on cultural resources (table 12.2). One of the most prominent outcomes of a warmer climate will almost certainly be increased frequency and extent of wildfires across western North America (McKenzie and Littell 2017; McKenzie et al. 2004) (Chapter 8). Wildfires burn cultural resources made of wood and other combustible materials, such as aboriginal shelters and game drives, or historic homesteads, mining ruins, and buildings. Wildfire suppression tactics, including fireline construction using hand tools or heavy equipment, can damage standing structures and archaeological sites in forest soils. Fire retardant can also damage and stain cultural resources (Ryan et al. 2012) (fig. 12.4). In addition, flooding and debris flows after fire can threaten cultural resources that have been exposed by the fire. On a positive note, fire can expose cultural sites that may have been obscured by vegetation or surface soil, allowing these sites to be documented and preserved.

Federal agencies can reduce the effects of wildfire on cultural resources through various actions, such as encasing historic structures in fire-proof material, constructing fireline away from cultural sites, and protecting cultural resources that could be damaged by flooding events. But large wildfires are typically too large for these approaches to have a measurable effect in reducing cultural resource loss. Therefore, higher wildfire frequency in a warmer climate could significantly increase damage to cultural resources in the IAP region. Some climate-induced vegetation shifts in designated cultural landscapes could be partly mitigated through silvicultural treatments and prescribed burning, although the effectiveness of proposed treatments relative to the scope and scale of the cultural landscape is difficult to evaluate. More details on vegetative treatment can be found in Chapter 14.

Seasonal aridity and prolonged drought can exacerbate soil deflation and erosion, thus exposing archaeological sites that may have been previously buried. Wind and water reveal artifacts and features such as cooking hearths and tool-making areas, leaving artifacts vulnerable to illegal collecting and damage. Although dry climate and drought have occurred for millennia in the IAP region, with corresponding episodes of soil erosion (Meltzer 1990; Ruddiman 2007), increasing temperatures outside the historical range of variability (IPCC 2014; Mayewski and White 2002) (Chapter 3) may accelerate cultural resource loss through drought and erosion, particularly in drier areas of the IAP region.

In addition, if winter precipitation increases (Chapter 3) and reduced snowpack leads to higher winter streamflows (Chapter 4), sites that contain cultural artifacts will be vulnerable to flooding, debris flows, and mass wasting. This already occurs to some extent following large wildfires and may become more common in the future (National Research Council 2002).

High-elevation snowfields contain artifacts from hunting and gathering excursions to mountain environments from past centuries (Lee 2012). If snowmelt increases in a warmer climate, previously ice-encased and well-preserved cultural resources such as bone, wood, and fiber artifacts will be exposed. Melting snow and ice patches provide opportunities for discovery and new scientific knowledge, but if the rate of melt exceeds the time available for inspection

Table 12.2—Summary of climate change stressors and potential effects on cultural resources in the Intermountain Adaptation Partnership region (modified from Morgan et al. 2016; see also Rockman 2014, 2015; UNESCO 2007). Human activities can exacerbate some of the expected effects of climate change (see text).

Climate change stressor	Archaeological resources	Cultural landscapes	Ethnographic resources	Museum collections	Buildings and structures
Increased temperature and drought	Microcracking of site contexts from thermal stress Faster deterioration of newly exposed artifacts and sites Deterioration of newly exposed materials from melting snow patches	Decline of some vegetation species Heat stress on culturally significant vegetation Increased stress (e.g. desiccation, warping) in constructed landscape features	Loss of habitat for significant species Loss of significant species due to disease Decreased abundance of culturally relevant species Altered cultural value due to reduced snowpack	Facilities Increased stresses on heating and cooling systems in storage facilities Increased space constraints due to more items requiring storage Increased need for environmental controls in facilities and collections Collections (without climate controls) Increased rate of chemical decay Increased stress due to fluctuations in temperature and humidity	Crystallization of salts due to increased evaporation rates, leading to increased rates of structural cracking, deterioration Increased demand for air conditioning, which can add stress to the building envelope, requiring modified structure (e.g., insulation, ducts)
Increased wildfire frequency and extent	During fire Damage or destruction of associated structures Heat alteration of artifacts Heat fracturing of stone artifacts Paint oxidation, color change Physical damage from firefighting efforts (e.g., firelines) Decreased accuracy of carbon-14 dating due to carbon contamination After fire Damage from treefall due to fire-induced mortality Increased susceptibility to erosion and flooding Increased looting	Loss or damage of associated structures Change in vegetation density and composition Bedrock and border cracking Increased susceptibility to erosion and flooding Loss of soil fertility due to high heat Damage to structure or associated landscape from fire retardant	During fire Discoloration, exfoliation, cracking, and smudging of culturally significant rock images, geoglyphs Change in subsistence resources Loss of traditional knowledge due to alteration of culturally significant resources Loss of significant species due to decreased soil fertility After fire Altered migratory patterns of animals Altered landscape features used for navigating during foraging, hunting, or other movements	Facilities Damage to storage facilities and contents Increased strain on museum facility and staff due to increased preparation and salvage operations Smoke damage, strain on heating and cooling systems Collections Damage to items, disassociation of materials and records during evacuation	During fire Damage or loss of structures, combustible components Cracking, physical damage of masonry components Discoloration caused by smoke and heat Damage from treefall due to fire-induced mortality Damage to structure and landscape from fire retardant After fire Buildings may shift or settle due to associated erosion Pressure to convert character-defining features such as wood shake roofing to fire-resistant alternatives

Table 12.2—*Continued.*

Climate change stressor	Archaeological resources	Cultural landscapes	Ethnographic resources	Museum collections	Buildings and structures
Increased flooding	During flood Physical damage to site materials carried by flood Destruction or loss of artifacts Site erosion from overflow and new channels After flood Increased risk of subsidence Impacts from postflood activities (clean up, construction)	Damage to roads, trails, and landscape features Decline of important vegetation species Loss of landscape features	Loss of cultural places due to inundation Loss or disruption of the use of foraging grounds Loss of species for subsistence, medicine, ceremonies, etc.	Facilities Stress on museum facilities and staff due to salvage operations Damage to items, disassociation of materials and records during evacuation Structural collapse from force of floodwaters Sewage backup and overflow, causing contamination and damage Damage to walls from standing water Damage to utilities, generators, and electrical systems Collections Rusting and corrosion of metals Increased decay, fungi, and insects Swelling of absorbent objects (e.g., wood) due to wetting Direct damage and destruction	During flood Structural collapse from force of floodwater Sewage backup and overflow, causing contamination and damage Damage to walls from standing water Damage to utilities, generators, electrical systems After flood Increased decay, fungi, and insects Swelling of wooden building materials and architectural features Cracking, weathering of wood, brick, and stone due to salt infiltration during drying Pressure to relocate or elevate structures

Figure 12.4—(a) A pictograph damaged by heat and spalling of the rock following the Hammond Fire (2003) in Manti-La Sal National Forest, Utah (photo: C. Johnson, Ashley National Forest); (b) White patch on the rock shows the effect of salts within sandstone following the Long Mesa Fire (2002) in Mesa Verde National Park, Colorado. Efflorescence following contact with fire retardant can pulverize sandstone through crystallization and eventually destroy the stone (photo: D. Corbeil, National Park Service).

by archaeologists, newly exposed artifacts may decay or be removed illegally without adequate documentation.

Climate change also affects cultural landscapes that are valued for both the cultural resources they contain and the environmental context in which they occur (NPS 1994). The cultural and historic value of landscapes is embedded in ecological context; thus, shifts in dominant vegetation could potentially affect the integrity of these landscapes (Melnick 2009). For example, whitebark pine (*Pinus albicaulis*) is an important component of some high-elevation landscapes used as travel routes by both Native Americans and settlers. Whitebark pine is in decline because warmer winter temperatures have accelerated the rate of mountain pine beetle outbreaks (*Dendroctonus ponderosae*) in addition to the effects of white pine blister rust (*Cronartium ribicola*), a nonnative fungal pathogen (Tomback et al. 2001) (Chapter 8). The condition of these landscapes will continue to deteriorate in a warmer climate.

Cultural sites and landscapes recognized for their traditional importance to Native Americans in the IAP region provide foods, medicinal and sacred plants, paints, and other resources, as well as places with spiritual meaning. If a warmer climate alters the distribution and abundance of vegetation, the potential exists to degrade the continuous cultural connectivity and traditional use of these areas by indigenous peoples. Monitoring of specific species of cultural significance can be useful in determining climate change effects, and help inform management actions to maintain species on the landscape. Furthermore, land management can benefit from collaboration with tribes to understand needs and wants for use of the landscape.

Historic buildings and structures may be vulnerable to the indirect effects of climate change, including extreme weather events, wildfire, flooding, and debris flows. In addition, furniture, interpretive media, and artifact collections inside historic (and nonhistoric) buildings may be affected. Subtler influences include increased heat, freeze-thaw events, insect infestation, and microbial activity, all of which can accelerate deterioration of artifacts and structures made of stone or wood and organic materials (UNESCO 2007).

Climate change may reduce the appeal of some cultural sites and landscapes for visitors. For example, large outbreaks of mountain pine beetles, which have been exacerbated by higher temperature, have turned some historic landscapes to “ghost forests” of thousands of dead trees (e.g., Logan and Powell 2001). Dead and dying forests also present hazards to hikers and other forest visitors (Chapter 10). Altered ecological conditions in cultural landscapes in the IAP region may, over time, affect tourism, recreation, and Native American practices, with secondary impacts on local communities and economies (chapters 10, 13).

Risk Assessment Summary

Climate change effects on cultural resources will vary across the IAP region by the end of the 21st century, depending on the stressor and geographic location. Wildfire will create the highest risk for cultural resources, affecting all national forests and national parks, including locations that have burned since the 1990s.

The effects of prolonged drought caused by projected temperature increase may be partly offset if winter precipitation increases in the future (Chapter 3). Although it is difficult to quantify the long-term effects of extreme events (drought, flooding, debris flows) on cultural resources, these natural processes, accelerated by climate change, may create a significant risk for cultural resources and increase the challenge of protecting them. Resource loss will be greatest in those areas prone to major hydrological events (e.g., canyon mouths, river bottoms) where cultural sites are often concentrated. In addition, these areas may be targeted by unauthorized collectors attracted to newly exposed artifacts following a flood or debris flow.

Some climate-related effects on cultural resources will be subtle and occur gradually. For example, climate change may alter tourism and visitation patterns (Fisichelli et al. 2015) (Chapter 10). In addition, altered distribution and abundance of vegetation may affect the visual integrity of some cultural landscapes. Degradation of historic structures will be gradual and cumulative (e.g., decay), and sudden and direct (e.g., structural collapse). Some plant or animal species associated with traditional cultural landscapes that continue to be used by contemporary Native Americans, may be diminished or disappear. However, increased wildfire may increase the abundance of some valued species, such as huckleberries (*Vaccinium* spp.).

Agency efforts to reduce the negative effects of climate change on some natural resources may, in some cases, affect cultural resources. For example, in anticipation of significant flooding in the future, historic-era culverts and bridge abutments made of stone may be replaced with larger metal ones. Although appropriate project design can reduce adverse effects, large-scale landscape restoration may still reduce cultural resource integrity in some locations, creating challenging tradeoffs for resource managers. A robust cultural resource management strategy in response to climate change would include (1) connecting climate effects on resources to scientific information, (2) understanding the scope of effects, (3) integrating practices across management activities (from planning to implementation to monitoring), and (4) collaborating with partners to grow and use the body of knowledge and practices (Rockman et al. 2016).

The effects of climate change on cultural resource tourism are difficult to project because of associated social and economic factors. Visiting historic sites is popular throughout the IAP region, and tourism is an important economic contributor to local communities (Chapter 10). On one hand, extremely hot summer weather could reduce public interest in visiting cultural resources, cultural landscapes, and interpretive sites, particularly in areas recently affected by severe wildfires. On the other hand, warmer winter weather could encourage greater visitation in higher elevation areas and during spring and fall. In either case, the tourism economies of local communities could be affected. Additional research is needed to understand specific effects of climate change that are unique to particular resources and their locations.

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