

Review Article - recreation

Climate Change and Recreation in the Western United States: Effects and Opportunities for Adaptation

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Abstract

Climate change is affecting natural resources globally, altering ecosystems that support outdoor recreation. In the western United States, effects such as warming temperatures, increased drought, reduced snowpack, and widespread wildfires will change the outdoor recreation landscape. In this article, we synthesize the state of science regarding the effects of climate change on outdoor recreation in the western US and summarize adaptation options that can reduce the consequences of climate change, considering the adaptive capacities of recreationists and managers. We draw from a series of climate change assessments in which researchers and managers collaborated to understand recreation vulnerability to climate change and develop effective adaptations. We conclude that building climate resilience requires a shift in planning and resource allocation decisions, including (1) longer-term planning timeframes, (2) interdisciplinary teams, and (3) collaboration among agencies, recreation providers, and communities.

Study Implications: Outdoor recreation in the western US is changing due to the effects of climate change. Organized by five recreational categories, this study describes the vulnerability of outdoor recreation to climate change and synthesizes strategies to adapt recreation management to these vulnerabilities. Multiple direct and indirect factors influence individual recreationists' and land managers' capacities to adapt to climate change, as we describe through a diagram. Climate-resilient land management requires long-term planning, integration of multiple resource areas, and collaboration across agencies, recreation providers, and communities.

Keywords: outdoor recreation, protected areas, climate change, adaptation, long-term planning

As climate change continues to affect ecological systems, the services that humans derive from those systems are affected as well. Outdoor recreation is one of the primary ways in which humans benefit

from the continued production of ecosystem services (Haines-Young and Potschin 2012). Through outdoor recreation, individuals are able to obtain a variety of nonmaterial benefits, such as educational

opportunities, psychological restoration, and improved physical health (Winter et al. 2020b). These recreational services are important to individuals' lives and to the economies of communities and regions that rely on outdoor recreation and tourism (Hermes et al. 2018). In addition, they can serve as a buffer to psychological stress associated with climate change impacts (Evans 2019, Winter et al. 2020b).

Most articles focused on the effects of climate change on outdoor recreation have investigated how outdoor recreation opportunities and participation have responded or will respond to changes in a single biophysical indicator (e.g., air temperature, precipitation, etc.). There is general agreement that warmer temperatures will expand the seasons for warm-weather recreation, increase demand for water-based recreation on hot days, and shorten the seasons and geographic extent of areas supporting snow-based recreation (Hand et al. 2018, O'Toole et al. 2019, Winter et al. 2021). A subset of this literature has focused on climate-related hazards by quantifying the impacts of hazard events on the quality of outdoor recreation experiences and participation rates (Sánchez et al. 2016, Bedsworth et al. 2018, Winter et al. 2021). Recent work has provided a conceptual framework of the complex interactions between climate change and outdoor recreation (Monz et al. 2020) and developed approaches that land managers can use to adapt to climate-related impacts (O'Toole et al. 2019). The vulnerabilities of outdoor recreation to climate change include a wide range of changes in supply of and demand for outdoor recreation opportunities, altering both the quantity and quality of outdoor recreation experiences, and the resulting benefits obtained by participants and economies.

In this article, we (1) synthesize the state of science regarding the effects of climate change on outdoor recreation, with a focus on the western US, and (2) summarize adaptation options that can be implemented to reduce negative consequences of climate change. We draw from a series of climate change assessments conducted by the USDA Forest Service (USFS) in collaboration with other federal and state agencies, organizations, and universities. We add to these assessments by citing relevant literature focused on Western wildlands in general, including recreation resources that cross administrative boundaries (e.g., water bodies and wildlife). This synthesis highlights adaptation options documented in assessments and peer-reviewed literature and derived through participatory engagement with land managers and stakeholders.

Recent Climate Change Assessments on US Federal Lands

Land management agencies have addressed the projected effects of climate change on recreation across much of the western US. Climate change vulnerability and adaptation assessments were initiated by federal agencies in the early 2010s. For example, the USFS implemented a Climate Change Scorecard to report accomplishments and plans for improvements regarding climate change. The agency accomplished a goal for improved climate preparation and literacy across all national forest units in 2016 (USFS OSC 2017). The agency has also been proactive in identifying the vulnerability of a range of natural resources to climate change through the development of the Climate Change Adaptation Library for the Western US (<http://adaptationpartners.org/library.php>). The library contains over nine hundred adaptation options across ten resource disciplines, including outdoor recreation. Outdoor recreation has also been included as a focus area in several regional assessments focused on the Northern Rockies (Hand and Lawson 2018), Intermountain West (Hand et al. 2018), Sierra Nevada (Winter et al. 2021), and Pacific Northwest (Hand et al. 2019a, 2019b; Miller et al. in press, Peterson et al. in press). Social, cultural, and economic vulnerabilities have been incorporated into these assessments using a social-ecological systems approach to outdoor recreation (e.g., Winter et al. 2021). In keeping with vulnerability assessments in other federal, state, and municipal agencies, human groups and communities with greater sensitivities to climate change impacts have been highlighted in some of these assessments. These assessments connect specific ecological, social, and economic vulnerabilities with management and planning options intended to increase the resilience of outdoor recreation activities, human communities, and organizations to climate change (for more detail, see USDA FS [2021]).

The National Park Service (NPS) has also been active in assessing climate-related impacts on recreation resources, through their Climate Change Response Program (USDOI NPS 2019). Established in 2010, this program supports parks by providing technical expertise, research, guidance, training, project and planning support, and communication products. Working across NPS units, the program has developed a guidance document for park planners and managers (USDOI NPS 2021) as well as many other park- and resource-specific publications. The program applies climate science at local scales and with broader application and

plans to compile a database of adaptation actions for the NPS (USDOI NPS 2019).

The USFS and NPS do not stand alone in their assessments of climate change impacts and adaptation options related to outdoor recreation resources. For example, the US Fish and Wildlife Service has developed a climate change website (<https://climatechange.lta.org/usfws-climate-change/>) that addresses mitigation and adaption strategies for habitat and wildlife. A resilience guide offers step-by-step application of science-based approaches to climate adaptation, and a series of case studies provides additional support in addressing both positive and negative effects of climate change. The Bureau of Land Management's (BLM) series of Rapid Ecoregional Assessments (<https://landscape.blm.gov/geoportal/catalog/REAs/REAs.page>) considers interactions between climate change, wildfires, development, and invasive species. The BLM has also contributed to the Climate Change Adaptation Library. The agency's assessments and their contributions to the Climate Change Adaptation Library are notable given the massive extent of public lands under the agency's management and the vulnerabilities of those lands to climate-related impacts (Brice et al. 2020).

State and local agencies and nongovernmental organizations have contributed to the Climate Change Adaptation Library, and some state and local government agencies have advanced our understanding of the effects of climate change on outdoor recreation. For example, park managers in San Antonio, Texas, have used large sun screens to block western sun exposure from outdoor recreation facilities in afternoon hours (Dolesh 2017). In Colorado, Denver Parks and Recreation focuses on resiliency by integrating the city's recreation plan with stormwater control and management (Dolesh 2017).

Engaging with Visitors About Climate Change Impacts and Adaptation Options

Central to several of these assessments have been efforts to understand not only how climate change will impact the supply and demand of outdoor recreation opportunities but also how climate-related impacts to outdoor recreation opportunities can be communicated effectively to the public. Tangible impacts to valued outdoor recreation resources provide an opportunity for federal, state, and local outdoor recreation providers with an opportunity to educate visitors about not only the science of climate change but also the future conditions of outdoor recreation resources.

Research from US national parks and wildlife refuges suggests climate change messaging resonates with visitors when it is framed through the cultural values and beliefs of visitors, and when it empowers specific action (Schweizer et al. 2013). The willingness of visitors to be receptive to climate-related messaging is, of course, dependent on a variety of psychological, social, economic, and group-level factors (e.g., McCreary et al. 2019). For example, Wynveen and Sutton (2015) found stakeholder trust in management agencies to contribute to those stakeholders' awareness of climate change consequences and their sense of obligation to adopt proenvironmental behaviors. Using tangible impacts to valued outdoor recreation resources as a gateway to educating visitors about the science of climate change will likely become increasingly needed as resource conditions continue to change in meaningful ways that affect outdoor recreation participation.

Current State of Outdoor Recreation in the Western US

Use Patterns and User Demographics

Outdoor recreation participation nationwide has increased from 48% of the US population in 2008 to 53% in 2020 (Outdoor Foundation 2021). Similar trends have been documented on public lands managed by the USFS and NPS. The USFS National Visitor Use Monitoring program estimates that 150 million visits occurred on national forests annually between 2015 and 2019, a 5% increase since 2005–2009 (USDA FS 2020). The NPS (2020) reported 327 million visits in 2019, a 16% increase since 2008. In the same year, the western US had 110.5 million visits to national forests and 106.6 million visits to NPS units (USDA FS 2020, USDOI NPS 2020).

Increased participation and visits may not be equitable across all population groups. Visitors to national forests tend to be White, and ethnic and racial minorities are underrepresented (Winter et al. 2020a). This pattern applies to both adults and youth, with few youth from communities of color participating in outdoor recreation (Outdoor Foundation 2021, Larson et al. 2019). Other trends offer hope in this regard. Hispanics (especially youth) have indicated a growing interest in nature compared to Whites, African-Americans, and Asian-Americans, with African-Americans and Asian-Americans having less interest than Whites (Kellert et al. 2017). Climate change will have different effects on different demographic groups, as access to preferred outdoor recreation activities, locations, and seasons are

modified. For example, numerous studies have documented Latino recreationists prefer developed day-use sites with amenities that may be affected by extended closures owing to losses from flooding or wildfire. Opportunity loss or degraded settings are of elevated concern when they have disparate effects on an underserved community (Winter et al. 2021). Adaptive responses of different groups are discussed below.

Psychological and Human Health Benefits

The outdoor recreation management literature documents how connections with nature can improve personal, social, and societal well-being (Ballew and Omoto 2018, Kellert et al. 2017). The benefits of nature-based physical recreation include an offset to sedentary activities (Brownson et al. 2005), improved psychological well-being (Pretty et al. 2007, Bratman et al. 2012, Wolsko et al. 2019), and stress relief (Hansmann et al. 2007). In addition, increased physical activity in recreation settings is associated with lower health care expenditures (Rosenberger et al. 2005). These benefits are especially important for vulnerable communities of color and those from lower income groups who tend to have less access to high quality health care, tend to have more health risks, and are underrepresented in outdoor recreation, especially on federal lands (Winter et al. 2020b).

Outdoor recreation contributes to long-term societal sustainability by providing spillover effects such as increased attachment to and appreciation for nature and development of long-standing environmental attitudes that promote proenvironmental behaviors (Collado et al. 2015, Otto and Pensini 2017, Schild 2019, Winter et al. 2020b). If climate change alters accessibility to outdoor recreation activities, locations, and seasons, human health benefits, spillover effects, and adaptive capacity for individuals and organizations will also be affected.

Economic Value

Outdoor recreation makes important contributions to the US economy, generating \$887 billion in consumer spending and 7.6 million jobs annually (Outdoor Foundation 2018). In 2016 and 2017, outdoor recreation grew slightly faster than the overall economy; however, this growth decreased in 2019 (Bureau of Economic Analysis 2019, 2020) but almost assuredly increased in 2020 as outdoor recreation participation and spending spiked with the onset of the COVID-19 pandemic (Outdoor Foundation 2021). The economic contribution of outdoor recreation to each of the US states is significant. In the Pacific region, which includes California, Oregon, and Washington, annual outdoor recreation

consumer spending was \$149.6 billion in 2017, creating 1.2 million jobs directly, and generating \$21.8 billion in federal, state, and local tax revenue (Outdoor Foundation 2018). Similarly, for the Mountain region, which includes the other western states, annual outdoor recreation consumer spending was \$104.5 billion in 2017, creating 925,000 jobs directly and generating \$14.9 billion in federal, state, and local tax revenue.

In addition to economic contribution to states' economies, outdoor recreation also generates benefits to recreationists from engaging in a particular activity. These benefits can be quantified as an economic value. Rosenberger et al. (2017) derived economic value estimates for fourteen primary recreation activities using the benefit-transfer method based on the updated Recreation Use Visitor Database for the USFS (Rosenberger and Loomis 2001, Loomis 2005) and annual visitation estimates from the National Visitor Use Monitoring survey; these estimates are presented for the western US in Table 1. The outdoor recreation activity with the highest economic value for each state is nonmotorized boating, whereas backpacking has the lowest value.

Using the values for each recreation activity, Rosenberger et al. (2017) found that for people who recreated in national forests in the USFS Rocky Mountain Region (Colorado, Kansas, Nebraska, South Dakota, Wyoming), the annual aggregate economic benefit was \$2.2 billion. Similar values were found for other USFS regions. However, this economic value is an underestimate of the true benefits individuals receive from outdoor recreation because national parks, state parks, and other public lands are not included in the estimate.

Climate change affects the supply and demand of outdoor recreation opportunities by altering the landscape, viewshed, and visitors' experiences. Therefore, climate change will affect the economic value of outdoor recreation. However, these effects will differ by outdoor recreation activity. For example, Sánchez et al. (2021a) found that drought conditions resulted in an annual reduction in economic value ranging from \$15 to \$76 million for winter-based activities for three national forests located in the Sierra Nevada region. In the same national forests, warm-weather activities had an annual economic value gain of \$6 to \$36 million (Sánchez et al. 2021a).

Methods

In this article, we rely primarily on information generated by Adaptation Partners (<http://adaptationpartners.org>), a collaborative effort that supports the incorporation of

Table 1. Estimates of the average economic value of recreation benefits by primary activity (in millions of dollars).

Primary activity	Arizona & New Mexico	California	Colorado	Idaho	Montana	Nevada & Utah	Oregon & Washington	Wyoming
Backpacking	41 ^a	27	33	41	40	43	33	38
Biking	94	80	86	95	93	96	87	91
Cross-country skiing	64	50	56	65	63	66	57	61
Developed camping	43	29	35	44	42	45	36	40
Downhill skiing	90	76	82	90	89	92	82	87
Fishing	79	65	71	80	78	81	72	76
Hiking	92	78	84	93	91	94	84	89
Hunting	85	71	77	85	84	87	77	82
Motorized boating	66	52	58	66	65	68	58	63
Nature-related	68	54	60	68	67	70	60	65
Nonmotorized boating	117	102	109	117	115	119	109	114
Off-highway vehicle use/snowmobiling	58	44	50	59	57	60	50	55
Other recreation	73	58	65	73	71	75	65	70
Picnicking	57	43	49	57	56	59	49	54

Source: [Rosenberger et al. \(2017\)](#). We modified the table to report the average recreation economic values for each of the western U.S. states, instead of USFS regions. For states that belong to the same region, the economic values are the same (e.g., Arizona and New Mexico). For states that have two USFS regions within their boundaries, the average was reported (e.g., Idaho and Wyoming).

^a2016 dollars.

climate change into land management in national forests and other public lands in the western US. For the past decade, this program has engaged practitioners and scientists in developing climate change vulnerability assessments focused on a set of resource areas (vegetation, water, recreation, etc.) for a designated geographic region. Vulnerabilities within these assessments were informed by conducting literature reviews and using keyword searches in academic search engines such as Web of Science, Science Direct, and Google Scholar. This information is synthesized in this article as Projected Effects. Vulnerability assessments conducted by Adaptation Partners were presented at site-specific workshops to practitioners and other stakeholders, and facilitated discussions were used to elicit input from participants on adaptation options for each resource. Workshop participants discussed and compiled adaptation options specific to the sites they manage, supported by a standard worksheet developed to aid discussions. Workshop leaders compiled the information from the worksheets into a database, the Climate Change Adaptation Library (<http://adaptationpartners.org/library.php>). This database informed the Adaptation sections specific to five recreational activity categories in this article. Adaptive Capacity sections were informed through literature reviews and adaptation database entries.

We focus on information from climate change vulnerability assessments and seventeen workshops convened by Adaptation Partners in seven states (California, Idaho, Montana, Nevada, Oregon, Utah, Washington). Collaborations between practitioners and scientists in the majority of these projects found recreational activities could be most logically addressed in five categories, grouped by their expected similarities in climate vulnerabilities and response. These categories include warm-weather, snow-based, water-based, and wildlife-based activities as well as forest product gathering. We have maintained this structure in this article, as it is broadly applicable across the geographic scope of the western US. Furthermore, we integrate insights at the ecoregion level where it is relevant to various recreational activity categories. Although the climate change effects and adaptation options described in this article might apply outside of the western US, we focus on this region because it is where our workshops took place.

Projected Effects of Climate Change on Outdoor Recreation

A General Model of Climate Change Effects

Participation in outdoor recreation is affected by the supply of and demand for outdoor recreation

opportunities. These opportunities are sensitive to climate through (1) direct effects of temperature and precipitation on decisions by recreationists to visit or not visit a site, and (2) indirect effects of climate on the characteristics and ecological conditions of recreation settings (Loomis and Crespi 2004, Mendelsohn and Markowski 2004, Shaw and Loomis 2008). These effects also influence the adaptive capacity of organizations to supply opportunities for recreation. Furthermore, socioeconomic attributes influence individuals' capacity to adapt to the effects of climate change on recreation resources. Examples of relationships among the influences of climate change, socioeconomic attributes, and benefits derived from recreation on the adaptive capacity of individuals and organizations are shown in Figure 1.

The effects of climate change, as well as adaptive responses to them, are not always straightforward. For example, the negative effects of less snow on skiing are expected to be a prominent outcome of climate change in some areas of the western US (e.g., Wilkins et al. 2021b). The availability of conditions for skiing depends on weather patterns such as the timing, amount, and rate of precipitation and daily temperature ranges. Changes in weather patterns will directly affect skiers' decisions about where to ski, when to ski, to choose

skiing or a different recreational activity, or to choose not to recreate at all (Irland et al. 2001, Englin and Moeltner 2004, Klos et al. 2014, Wobus et al. 2017). Beyond skiing, these weather changes will also affect site characteristics and quality, such as the vegetation and wildlife present in alpine and subalpine areas (Fischlin et al. 2007, Moritz et al. 2008, Nuñez and Singleton in press, Reilly et al. in press), and the likelihood and intensity of disturbances such as fire, which can affect scenic quality in all seasons (Sánchez et al. 2016).

Changes in site characteristics indirectly affect individuals' adaptive capacity. The ability of recreationists to adapt to climate change is also affected by their socioeconomic characteristics. In the skiing example, those who have the time and money necessary to choose a different, likely more distant, site for skiing might have a higher capacity to adapt to climate change than those with more limited resources (Dawson et al. 2013). Finally, climate-altered weather patterns and site characteristics can affect the capacity of organizations to adapt to climate change. For example, organizations may need to adapt to shorter ski seasons by offering nonsnow-based recreation opportunities, planning with other agencies and organizations, or investing in snow-making equipment (Wilkins et al. 2021b). Ultimately, the benefits derived from outdoor

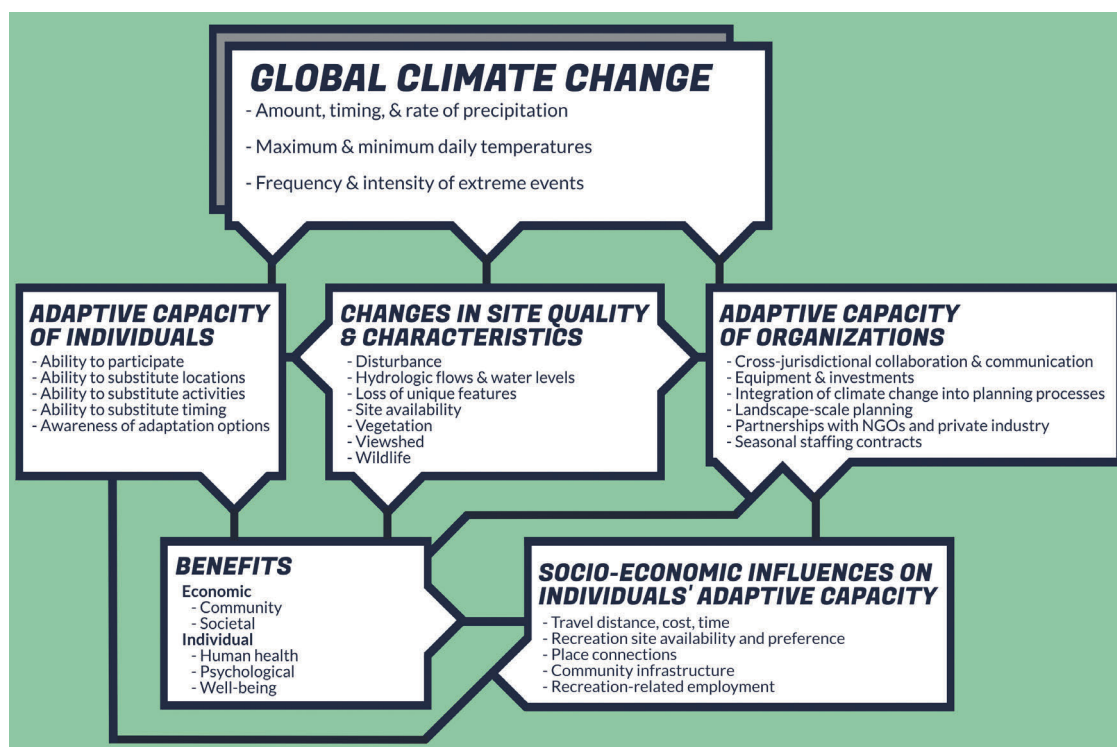


Figure 1. Direct and indirect effects of climate change on recreation organizations and individuals and factors influencing their capacity to adapt.

recreation participation will differ considerably as individuals, groups, and organizations adapt to climate change.

Trends in Use Patterns and Economic Implications

The 2010 Resources Planning Act (RPA) Assessment (USDA FS 2016) projects that climate change could alter participation for some recreation activities, but that those activities will be affected concurrently by economic conditions and population growth (Askew and Bowker 2018). Participation in most activities is projected to grow across the western US as a function of increased population but with different rates by region. Table 2 shows how recreation activities in 2060 may be affected in the RPA Pacific Coast and Rocky Mountain Regions with and without climate change.

Population increase is expected to dampen the effects of climate change on recreation, so that the net effect of climate change on participation is only slightly negative for some activities and slightly positive for others. Overall, the largest negative effects are projected for motorized water activities, motorized snow activities, primitive area use, and horseback riding on trails; the largest overall positive effects are projected for swimming. The projected effects of climate change on participation in hunting, fishing, and undeveloped skiing differ by region for the western US, with positive effects in the Pacific Coast region and negative effects in the Rocky Mountain region (Table 2). These differences highlight the importance of regional context in recreationists' response to climate change.

These inferences are premised on specific climate change scenarios and demographic projections, and on specific response functions for calculating the effects of climate change on different activities. Confidence intervals around these projected trends are likely high. It is also important to consider the nuanced interactions between these effects and experience quality. For example, increased demand may lead to an increased sense of crowding, lack of access owing to maximum capacities and visitor use limits, and diminished psychosocial benefits from recreation (Winter et al 2021). Impacts may be especially acute in areas already known for high recreation demand.

In the western US, it is possible that the frequency and extent of wildfires may increase to the point that their effects will dominate how climate change influences outdoor recreation, leading to significant economic implications for recreationists and communities adjacent to public lands. Wildfire may discourage

recreation participation due to the presence of smoke and diminished viewsheds, ultimately reducing economic benefits from recreation by limiting access or diminishing resource quality (Wigtil et al. 2016, Kim and Jakus 2019). Areas with active or recent fires are commonly closed to the public as a safety precaution. Fire and smoke damage tourism-dependent businesses, especially when nonlocal recreation declines (Hesseln et al. 2004).

Additional economic damage to local communities may occur as climate change affects how people recreate. For example, drought conditions that result in fewer days with sufficient snow may not stop all activities but may increase congestion and decrease satisfying recreation experiences, thus discouraging participation. Crowding at ski areas clearly affects the visitor experience (Pikkemaat et al. 2020). One study showed that in highly congested circumstances, Colorado skiers would be willing to pay a premium for lift tickets with shorter lift-line waiting times (Walsh et al. 1983). A comparison of pre- and post-drought snow conditions in California found an annual loss of \$56 million in economic benefits for downhill skiing in the USFS Lake Tahoe Basin Management Unit (Winter et al. 2021) and a decrease of \$37 million for downhill skiing in the Inyo National Forest (Sánchez et al. 2021b). Understanding the projected effects of climate change on the range of outdoor recreation activities is critical in planning for these shifts in demand, supply, and associated benefits (e.g., place connections and enhanced personal and social identity [Winter et al 2020b]).

Adapting to the Effects of Climate Change on Outdoor Recreation

Individuals and organizations can adapt to climate change in a variety of ways (Figure 1). Here we summarize what we have learned over the past decade about adapting outdoor recreation to climate change based on results of vulnerability assessments in the western US. First, we discuss the scope and motivations for changes in visitor behavior and management in response to climate change effects. Then, we summarize options for adapting to the effects of climate change on recreation in natural systems and human organizations. Adaptive capacity in recreation management is then addressed according to the five recreational activity categories. For each category, we provide a brief introduction to the projected effects of climate change, followed by a synthesis of adaptation options. These adaptation options are distilled from a large number of options

Table 2. Modeled projections of the effects of climate change on recreation in the Pacific Coast (PC) and Rocky Mountain (RM) Regions assessment area^a for 2060^b.

Recreation activity	Number of participants in 2008 (millions)		Projected increase in participation without climate change ^c (%)		Projected increase in participation with climate change (%)		Net effect of climate change ^d (%)	
	PC	RM	PC	RM	PC	RM	PC	RM
Developed site usage								
Visiting developed sites	31	17	68	94	67	94	-1	0
Visiting interpretative sites	26	15	72	108	71	107	-1	-1
Observing nature								
Birding	13	7	69	104	71	103	2	-1
Nature viewing	31	18	66	97	65	96	-1	-1
Backcountry activities								
Challenge activities	5	4	54	112	57	115	3	3
Horseback riding on trails	3	2	78	73	75	57	-3	-16
Day hiking	17	10	67	110	63	110	-4	0
Primitive area use	18	12	53	89	55	73	2	-16
Motorized activities								
Motorized off-roading	9	6	47	83	49	83	2	0
Motorized water activities	10	5	80	103	78	81	-2	-22
Motorized snow activities	1	1	52	30	44	21	-8	-9
Consumptive activities								
Hunting	3	3	9	32	19	15	10	-17
Fishing	10	7	52	76	54	48	2	-28
Nonmotorized winter activities								
Developed skiing	5	3	91	135	96	136	5	1
Undeveloped skiing	1	1	22	86	32	74	10	-12
Nonmotorized water activities								
Swimming	25	11	75	100	74	110	-1	10
Floating	6	3	55	71	53	71	-2	0

^aData are from the RPA Pacific Coast Region, which includes Alaska, California, Hawaii, Oregon, and Washington and the Rocky Mountain Region, which includes Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming (USFS 2016).

^bModel output is based on an average of results under the A2 (high), A1B (intermediate), and B2 (low) greenhouse gas emission scenarios.

^cPercentage changes for total number of participants are compared to 2008.

^dNet effects of climate change equal “with climate change” minus “without climate change”.

elicited from resource managers and stakeholders (see Methods section). Most of the adaptation options listed below emerged from deliberations in multiple workshops, providing confidence that there was consensus on the relevancy of these adaptation options across a diverse group of recreation planners and managers. For a detailed list of adaptation options, see the Climate Change Adaptation Library for the Western US. (<http://adaptationpartners.org/library.php>).

Adaptive Capacity in Visitor Behavior

Recreationists can change their decision to participate in outdoor recreation depending on climate-related weather patterns (Figure 1). They also have the ability to substitute the location, timing, and activity in which they participate (Brunson and Shelby 1993). However, substitution implies that the chosen alternative provides equivalent satisfaction and benefits as the original activity (Iso-Ahola 1986). Although recreationists' ability to substitute sites and activities is well established, the ways that people substitute between geographic regions and across time periods is poorly quantified (Shaw and Loomis 2008). Skiers have demonstrated substitution (location, timing, activity) in response to climate change (Dawson et al. 2011, 2013). In Sierra Nevada national forests, most forest visitors indicated they would likely go elsewhere for the same or a similar activity if the national forest visited was not available for primary activities (Winter et al. 2021).

However, substitution varies by the individual recreationist and by sociodemographic and cultural influences. Alternative sites may involve higher access costs if they are farther from home or more remote. Visitors may also be limited in their ability to change the timing of their visit, for example, due to the timing of scheduled academic breaks. Time is a commonly reported barrier to outdoor recreation participation, so shifts in timing for both travel and experiences are important considerations (Winter et al. 2020a). Furthermore, benefits derived from recreation may decrease even if substitute activities or sites are available (Loomis and Crespi 2004). Visitor motivations are complex and may involve identities linked to specific recreation activities, experiences shared with families or social networks, or specific places. Changing conditions may lead to the loss of opportunities to recreate in a planned location or to pursue similar experiences in nearby locations with similar opportunities (Winter et al. 2021).

Social equity is an important consideration affecting viable adaptation strategies as well. Traveling to alternative recreation locations may not be possible for

individuals with low incomes and limited transportation (Winter et al. 2020a). Communities of color are an integral part of the recreation-service economy, although living near high-amenity locations (e.g., resorts) is often unaffordable for these workers (Winter et al. 2014a). In addition, these communities often have minimal ability to adapt to climate-related risks. If experiences such as developed camping and picnic areas are reduced by wildfires or other climate-related causes (Davies et al. 2018), the impacts may be disproportionately severe for underrepresented populations, such as Latino visitors (Winter et al. 2021). Finally, visitors who receive and believe climate change adaptation messages are more capable of changing their behaviors to adapt to climate change (Schweizer et al. 2013, Wynveen and Sutton 2015, McCreary et al. 2019).

Adaptive Capacity in Recreation Management

Organizations have an important role in adapting recreation to climate change (Figure 1). In the face of challenges presented by climate change, organizations such as the USFS would benefit from collaborating with adjacent landowners and other natural resource management agencies in providing recreation opportunities. This can include messaging about activities in nearby areas when preferred sites are closed (Winter et al. 2021). Communities may find opportunities to aid adaptive capacity and increase recreation dollars if they are able to fill an unmet need. For example, if a campground is closed because of a climate-related impact such as a recent wildfire, an adjacent community may offer alternative housing options (Soderquist 2021). In the case of long-distance trails, a recreation resource that crosses multiple jurisdictions, administrators have found several partnership approaches to be useful (Cervený et al. 2021). Cross-jurisdictional communication strategies to provide information about alternative recreation sites are another means of adapting (Soderquist 2021). A collaborative approach to recreation service delivery that crosses institutional boundaries has been referred to as "seamless recreation" (Chavez 2005).

Agencies may need to adapt their staffing and resources to potentially be redeployed to adjacent locations if a primary area is closed (Soderquist 2021). Hiring seasons tend to be early in the year when impacts are unknown, challenging traditional models of staffing and resource forecasting. Staffing for the extended shoulder seasons (late spring, early fall) is often challenging under current hiring practices (e.g.,

typically summer only). Some agencies now use partnerships with nongovernmental organizations to fill gaps (e.g., [Hand et al. 2018](#)).

Infrastructure that supports recreation will also need to be adapted for a changing climate. Resource managers routinely face decisions regarding whether and how to replace infrastructure damaged by extreme events. [Keller et al. \(2021\)](#) outline myriad interactions between infrastructure and climate change effects. For example, trail bridges have greater vulnerability to forest fires, as they are often constructed of wood. Bridges will need to be more robust for climate-resilient design given this exposure to fire, likely proximity to hazard trees during and after fire, and exposure to increased stream flow. Development plans will need to be based on projected rather than historic peak flows to increase resilience to flooding. For example, following a fire in the Columbia River Gorge, managers needed to decide how to replace an expensive foot bridge in a location where fire or high stream flows may occur more frequently in the future ([Figure 2](#)). Trails and roads constructed in valley bottoms to take advantage of gentle grades are more susceptible to flooding and erosion, as are those in areas with high risk of landslides ([Clifton et al. 2018](#)). Adaptive approaches to improve resilience of infrastructure are described in detail in [Keller et al. \(2021\)](#).

Warm-Weather Activities

Projected Effects

Warm-weather recreation activities are sensitive to temperature and site conditions. The number of warm-weather days ([Richardson and Loomis 2004](#)), mean monthly temperatures ([Scott et al. 2007](#), [Albano et al. 2013](#), [Fisichelli et al. 2015](#)), and maximum daily temperature ([Wilkins et al. 2021a](#)) are predictors of visitation patterns. Warm-weather recreationists are also

sensitive to site quality and characteristics, such as trail conditions ([Scott et al. 2007](#)), vegetation, availability of shade, and presence of fire and smoke ([Kim and Jakus 2019](#)). Vegetation shifts may indirectly affect recreation oriented toward viewing vegetation types that will be altered or lost in certain areas (e.g., alpine and subalpine scenery), potentially affecting recreationists' decisions.

Climate change effects on warm-weather recreation participation will likely vary across climate zones ([Hewer et al. 2016](#), [Wilkins et al. 2021a](#)). In cooler zones, the lengthening warm seasons will lead to increased supply of warm-weather recreation opportunities, particularly in spring and autumn ([Bowker et al. 2012](#), [Albano et al. 2013](#), [Fisichelli et al. 2015](#)).

Areas projected to experience more extreme heat may see demand shift to cooler weeks at the beginning or end of the warm-weather season, or to alternative sites that are less exposed to high temperatures (e.g., at higher elevations or near water bodies) ([Richardson and Loomis 2004](#), [Scott et al. 2007](#), [Bowker et al. 2012](#), [Smith et al. 2018](#)). Areas subject to extreme storm surges or flooding may also see reduced visitation, especially when access to recreation sites is cut off ([Coe 2016](#)).

In some areas of the western US, the increased frequency and extent of wildfire are expected to reduce the supply of warm-weather activities in years when fire alters site quality and leads to safety-related closures and when smoke degrades air quality ([Miller et al. in press](#), [Peterson et al. in press](#)) ([Figure 2](#)). However, recreationists react differently to fire, such as by activity type, fire type, and geographic region ([Hesseln et al. 2003](#)). Areas with relatively low incidence of wildfire and smoke might have increased visitation during extreme fire seasons in adjacent areas ([Miller et al. in press](#)). Recent wildfire activity generally corresponds with



Figure 2. The Eagle Creek fire (2017) closed many trails in the Columbia River Gorge National Scenic Area. The fire resulted in damaged recreational infrastructure (bridge on left), and the severity of the fire affected the scenic value of the area (right). Trails remain closed at the time of writing, 3.5 years after the fire. Source: USDA Forest Service.

decreased visitation rates, varying by activity. For example, participation in mountain biking, camping, and backcountry recreation decreased following recent wildfires (Englin et al. 1996, Loomis et al. 2001, Hesslen et al. 2003, 2004, Rausch et al. 2010). However, recent wildfires can also attract recreationists, particularly hikers, to areas recovering from low-severity wildfires (Sánchez et al. 2016) and prescribed burns (Loomis et al. 2001, Hesslen et al. 2004). Wildfire can affect the connectivity of long-distance hiking trails (Miller et al. *in press*), affecting recreation year round and altering ecosystems, aesthetics, and access. Reduced air quality from wildfire smoke can affect the quality, timing, and location of recreational visits by nonlocal visitors (Sage and Nickerson 2017), with reduced recreation by local residents (Richardson et al. 2012).

Adaptation

The primary adaptation strategies for warm-weather recreation involve a sharper focus on sustainable recreation under new conditions while increasing flexibility of existing programs and practices. Adaptation tactics include (1) increase the capacity of existing recreation sites; (2) adjust the timing of road, trail, and facility openings; (3) develop budget and management approaches that support a longer season; (4) use partnerships with other local organizations and landowners to assist with recreation management and provide economic opportunities; and (5) manage public expectations for recreation availability through effective communication. Shoulder seasons will be a nexus of increased recreation in many locations, requiring adaptation tactics that include identifying emerging recreation opportunities, increasing staff available for recreation management, and ensuring roads and other infrastructure can be readily accessed.

Some recreationists will be able to adapt the timing and location of their warm-weather activities; however, this adaptability will differ by socioeconomic characteristics and ecoregion, depending on diversity of local microclimates and availability of facilities for various activities (Wilkins et al. 2021a). Considering visitation patterns specific to ecoregions and the ability of agencies to manage recreation at large spatial scales will be critical in adapting to climate change. Interorganizational partnerships across jurisdictional boundaries have the potential to create larger networks that can manage recreation with greater flexibility across large landscapes (Winter et al. 2021).

Snow-Based Activities

Projected Effects

Snow-based recreation is highly sensitive to variation in temperature and the amount and timing of snowfall (Wobus et al. 2017). Seasonal snowfall and temperature patterns determine the likelihood of a site having a viable season (Scott et al. 2008). Throughout the western US, mountain snowpack has declined in recent decades, and snowfall is projected to decrease below around 2,000 m (Mote et al. 2018), particularly in late autumn and early spring (Klos et al. 2014). Lower-elevation winter recreation sites, such as those in southwestern Oregon (Figure 3), will risk shorter or absent snow-based recreation seasons. Similar projections are published in reports for other regions of the western US (e.g., Hand et al. 2019a, Miller et al. *in press*). Based on a high greenhouse gas emission scenario, snowmobiling, cross-country skiing, and downhill skiing in Western states may lose up to 50% of current visits by 2050, with season lengths shortening considerably in many areas (Figure 4) (Wobus et al. 2017). In areas where participation does not decrease with supply, shorter seasons and smaller snow-covered areas may result in snow-based recreation being concentrated in smaller areas. Climate change will have negative consequences for communities where snow-based recreation is a large component of the local economy.

Adaptation

Adaptation tactics specific to snow-based recreation include (1) diversify beyond snow-based recreation, (2) invest in temporary or mobile structures amenable to seasonal changes in snow availability and divest in inflexible infrastructure, (3) expand options for summer and year-round recreation at large recreation sites (e.g., ski resorts), and (4) increase awareness of safety issues.

Snow-based recreationists have moderate capacity to adapt to changing conditions, and adaptation must be considered at large scales, because recreationists may choose an alternative location rather than an alternative activity or time if their first choice is unavailable. For undeveloped or minimally developed site activities (e.g., cross-country skiing, snowmobiling), recreationists may move to higher elevation sites (Hand and Lawson 2018), which may require considerable travel (Orr and Schneider 2018) and will not be possible for individuals with limited time or money. Some ski resorts are already adapting through increased snowmaking (Scott and McBoyle 2007), although the cost of such improvements may decrease profitability.

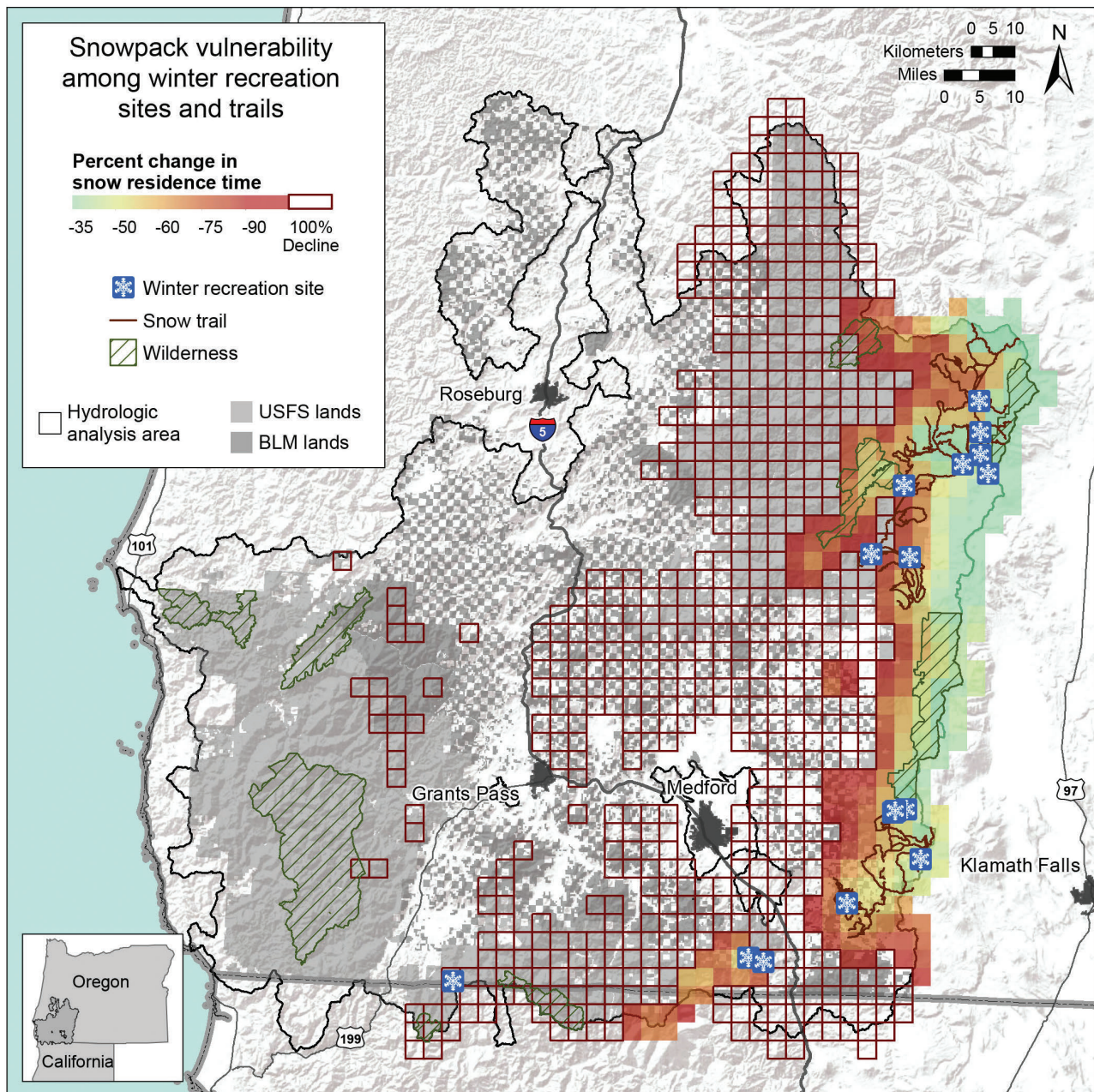


Figure 3. Locations where snow residence time is expected to decrease significantly (more than 35%), thus altering snow-related activities on federal lands in southwest Oregon. Change in snow residence time is based on a 3°C increase in December through March average temperature at SNOTEL sites. Source: USDA Forest Service.

In locations where snow disappears for all or most of the winter, few adaptation options will be available.

Water-Based Activities

Projected Effects

Climate change is expected to alter the timing and quantity of water available in lakes and streams and reduce water quality in some locations. Decreased water quality can make water-based recreation unsafe, such as the occurrence of harmful algal blooms (Moore

et al. 2008, Hand and Lawson 2018) (Figure 5) or elevated pollutant loads in rivers (Clow et al. 2011). Poor water quality and low water levels are associated with decreased participation in boating, rafting, and swimming (Loomis and Crespi 2004, Mendelsohn and Markowski 2004, Bowker et al. 2012, Smith and Moore 2013). Although a warmer climate will shorten the period of time when desirable conditions for river recreation are available in some areas, higher air temperatures are expected to lengthen the overall

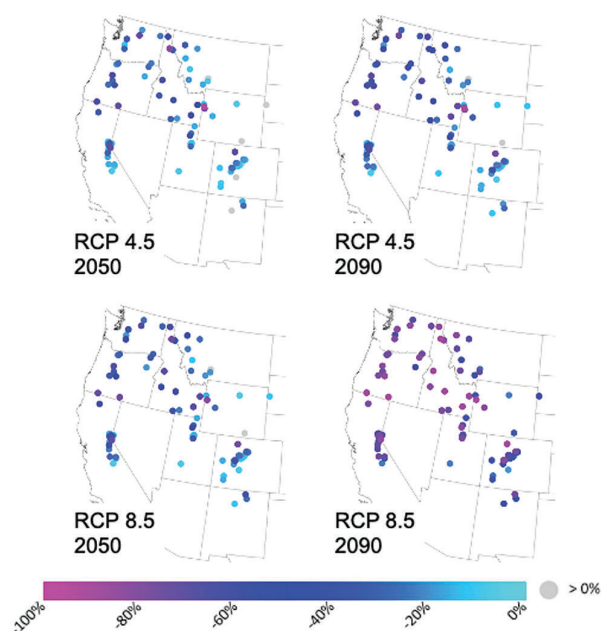


Figure 4. Average percent reduction in annual cross-country skiing and snowmobiling season lengths for skiing locations in the western United States. Maps are based on projections from an average of five global climate models, two greenhouse gas emission scenarios (representative concentration pathway [RCP] 4.5 and RCP 8.5), and two time periods (2050, 2090). Figure is modified from [Wobus et al. \(2017\)](#); used with permission from Cameron Wobus.

water-based recreation season and increase recreation demand as people increasingly seek water-based opportunities during episodes of extreme heat ([Loomis and Crespi 2004](#), [Mendelsohn and Markowski 2004](#)).

Adaptation

The primary adaptation strategies for water-based recreation will account for changes in demand for water-based recreation and increase flexibility in site management and facility design. Adaptation tactics include (1) identify locations where water-based recreation may decline or be more concentrated, (2) reconsider facility (e.g., campground) locations to optimize comfort (especially shade) during hot weather, (3) develop flexible opening and closing dates depending on weather, (4) manage lake and river access capacity, (5) increase the length of boat ramps, and (6) manage public expectations for recreation access and facilities.

Recreationists flock to water bodies on hot days ([Loomis and Crespi 2004](#), [Mendelsohn and Markowski 2004](#)), and some recreationists are able to adapt to climate change by choosing recreation sites appropriate for changing weather patterns ([Bristow and Jenkins 2018](#)). Visitors adjust their behavior with respect to proximity to water bodies depending on near-term



Figure 5. Algal blooms (shown in Haystack Reservoir, Crooked River National Grassland, Oregon), are encouraged by extended periods of warm weather, resulting in undesirable and unhealthy conditions for water-based recreation. Source: USDA Forest Service.

weather conditions, although this behavior differs by ecoregion ([Wilkins et al. 2021a](#)). Individuals who seek respite from high ambient temperatures may experience conflicts with other users, crowding, or physical discomfort that diminishes the overall benefits of outdoor recreation ([Evans 2019](#), [Winter et al. 2021](#)).

Wildlife-Based Activities

Projected Effects

Participation in wildlife-dependent recreation depends on (1) the “catch rate,” or likelihood of encountering an individual of the target species, and (2) the desirability of conditions for the recreationists. The catch rate is influenced by a target species’ distribution, abundance, and population health, which can be altered by conditions associated with climate change.

As warmer temperatures are generally associated with higher rates of recreation participation ([Fisichelli et al. 2015](#)), warmer temperatures may increase participation in hunting and wildlife viewing, although extreme heat may have a negative effect on recreation participation and experiences ([Bowker et al. 2012](#),

Evans 2019). Extreme heat may cause wildlife populations to become concentrated around local water sources (Abdu et al. 2018), thereby improving catch rates in the short term. However, longer-term effects of extreme temperatures, and especially prolonged periods of drought, may result in lower catch rates for some species (Fuller et al. 2021).

Climate change may contribute to a reduction in recreation-derived benefits for anglers, especially those targeting cold-water species. As refugia for cold-water species shrink to higher elevations and disappear in some areas, opportunities for catching cold-water species will be reduced (Isaak et al. 2012). The effects of climate change on fishing will depend on water quantity, water quality, and availability of target species (Hunt et al. 2016).

Adaptation

The primary adaptation strategy for wildlife-based recreation will be to increase flexibility in wildlife and fish management to accommodate seasonal changes in animal abundance. Adaptation tactics include (1) determine which species and populations may be at risk, (2) understand how warmer weather and altered habitat may affect the behavior of hunters and anglers, (3) modify regulations and access as needed, and (4) manage public expectations for availability of recreation opportunities.

Climate-related changes in availability of valued target species will affect recreationists' ability to attain benefits (Pitts et al. 2012). The diversity of species present can also affect hunt satisfaction (Milon and Clemmons 1991) and enjoyment of nonconsumptive activities such as birding (Hay and McConnell 1979). It appears that adaptation may already be occurring in some places. For example, on the Yellowstone River (Montana), fishing outfitters and guides reported that anglers (1) alter catch-and-release practices, (2) shift trips to avoid fishing during the hottest period of the day, (3) shift trips to fish in cooler waters, (4) avoid fishing during the hottest part of the year and during droughts, and (5) target warm-water fish species rather than native cold-water species (Lamborn and Smith 2019). By targeting warm-water-tolerant fish, anglers mitigate the reduced benefits caused by less access to cold-water fish (Hand and Lawson 2018).

Forest Product Gathering

Projected Effects

Similar to wildlife-based recreation, participation in forest product gathering depends on (1) the availability of target forest products and (2) the desirability

of weather and other conditions. This activity is sensitive to conditions that support the distribution and abundance of target species. An increased frequency and extent of wildfires would reduce availability of many forest products immediately after fire while improving the medium-term productivity for other products (Hand et al. 2019a). The availability of some forest products may increase in areas where growing days are projected to increase. However, increased drought stress may also influence the availability of these species. Drought-tolerant species (e.g., bear grass [*Xerophyllum tenax*]) may be resistant to some climate change effects, whereas taxa that are less drought tolerant (e.g., Christmas trees, mushrooms) might be negatively affected by drought (Chamberlain et al. 2018). In the long term, the availability of forest product gathering will likely be reduced in areas that transition to less productive vegetation types.

Adaptation

The primary adaptation strategy for forest product gathering will be to manage product harvest timing, location, and user types (e.g., subsistence, heritage, commercial). Adaptation tactics include (1) monitor and adaptively manage special forest products and related vegetation types, (2) track changes in use over time to inform permitting for sustainable harvests, (3) assess use patterns for cross-resource effects (e.g., wildlife habitat) and direct use away from vulnerable areas, and (4) quantify effects from increased access due to longer shoulder seasons and target management efforts on high-demand areas.

Participants may be able to select different sites as the distribution and abundance of target species change. However, this may increase the costs of gathering. Those who engage in gathering as a secondary activity may choose alternate activities to complement primary activities (Hand et al. 2019b).

A Look to the Future

Building climate resilience requires a shift in planning and resource allocation decisions, refocusing from short-term immediate threats or losses to building long-term sustainability for recreation settings and opportunities (Wilson et al. 2011, Winter et al. 2014b). A longer planning timeframe will require working in interdisciplinary teams across ecosystems and jurisdictions to ensure multiple resources and resource users are included. This will ensure that climate-informed management for vegetation and

other resources is compatible with climate-informed recreation management. Empowering recreation resource managers and planners to move beyond historical perspectives will be an important step in climate-adaptive recreation management. Ultimately, building flexibility into long-term planning to account for the long-term unpredictability of climate change will support the ongoing provision of outdoor recreation opportunities.

Diversifying and building resilience in recreation-dependent communities through collaboration among agencies, recreation providers, and community organizations will contribute to the long-term sustainability of outdoor recreation. Recent emphasis on shared stewardship in federal agencies demonstrates the value of leveraging collaborative energies across institutions and physical boundaries at large spatial scales (Winter et al. 2014b). For example, the Sierra Climate Adaptation and Mitigation Partnership focuses on climate action and capacity building through seven climate collaboratives in California communities (<https://www.sierrabusiness.org/archives/sierra-camp>). Multiple organizations in the Sun Valley region of Idaho are collaboratively focusing on climate change to ensure sustainability for downhill skiing, summer recreation, water for downstream irrigation, and local economies (Bossick 2016). The assessment workshops discussed above were convened by science-management partnerships that typically included more than thirty partners. These partnerships developed much of the information on climate change effects and adaptation for this paper. Ensuring the long-term durability of these partnerships can provide a foundation for future collaboration, decision making, and actions associated with climate change adaptation.

In the western US, recreational activities and corridors (e.g., trail systems) commonly traverse multiple federal and state agencies. Adaptation will be more effective if it is implemented concurrently and consistently across these different ownerships, requiring ongoing communication and planning among agencies that share a common landscape. One pivotal challenge in building effective collaborations is understanding how the missions of agencies and other organizations may differ from one another. This is especially true in collaborations that include federal, state, and local agencies (Fleming et al. 2015). Collaboration can be mainstreamed by integrating scientific information about climate change into management and planning, not as a special case, but with climate change as one of many factors being considered (e.g., Brice et al. 2020). Coordination by

recreation managers with different resource disciplines (e.g., water resources, engineering) will help ensure that adaptation approaches are complementary within and across agency boundaries (Soderquist 2021). In addition, adaptation strategies by organizations and communities will need to consider changing demographics and activity preferences by recreationists, ensuring that equity and social justice are included in outdoor recreation management and planning.

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