Chapter 10: Effects of Climate Change on Outdoor Recreation

Michael S. Hand, Jordan W. Smith, David L. Peterson, Nancy A. Brunswick, and Carol P. Brown

Introduction

Federal agencies and other public land management agencies in Utah, Nevada, and southern Idaho provide and manage for numerous outdoor recreation opportunities. National forests in the U.S. Department of Agriculture Forest Service (USFS) Intermountain Region have nearly 19 million visits per year (table 10.1); adjacent National Park System units account for an additional 24 million visits per year (table 10.2). The popularity of publicly managed outdoor recreation opportunities is not surprising, given the numerous psychological, physiological, and social benefits derived from outdoor recreation (Bowker et al. 2012; Thompson Coon et al. 2011).

In addition to individual benefits, publicly managed outdoor recreation opportunities contribute substantially to the economic well-being of communities throughout the region (box 10.1). Nearly $1 billion is spent annually on visits to recreation destinations managed by the USFS (USDA FS n.d.), translating into economic benefits for the private sector in local communities.

Recreation opportunities offered on public lands throughout the Intermountain Adaptation Partnership (IAP) region are as diverse as the ecosystems on which they depend (table 10.3). From the dry deserts of southern Utah to the high-altitude Rocky Mountains of northwestern Wyoming, these ecosystems are highly variable. As climate change alters the conditions of these ecological systems, it also directly affects the ability of public land management agencies to consistently provide high-quality outdoor recreation opportunities to the public (Loomis and Richardson 2006; Richardson and Loomis 2004).

Changing climatic conditions will alter the supply of and demand for outdoor recreation opportunities, affecting visitor use patterns and the ability of outdoor recreationists to obtain desired benefits derived from publicly managed lands in the future (Bark et al. 2010; Matzarakis and de Freitas 2001; Morris and Walls 2009). Benefits provided by outdoor recreation opportunities are expected to increase for some recreationists as the climate warms (Loomis and Crespi 2004; Mendelsohn and Markowski 2004), but will probably vary considerably by geographic region and activity.

Although broad trends in recreation participation under climate change may emerge at the regional scale, little is known about how specific outdoor recreation activities, opportunities, or settings in the IAP region will be affected. This chapter describes the broad categories of outdoor recreation activities believed to be sensitive to climate change, and assesses the likely effects of projected climatic changes on both visitor use patterns and the ability of outdoor recreationists to obtain desired experiences and benefits.

Relationships Between Climate Change and Outdoor Recreation

The supply of and demand for outdoor recreation opportunities are sensitive to climate through an indirect effect of climate on the characteristics and ecological condition of recreation settings, and a direct effect of changes in temperature and precipitation on recreationist decisions about whether to visit a site (Loomis and Crespi 2004; Mendelsohn and Markowski 2004; Shaw and Loomis 2008) (fig. 10.1). For example, warming temperatures in the winter will reduce snowpack levels at ski resorts, diminishing the supply of outdoor recreation opportunities dependent upon skiing. This indirect pathway connects climatic conditions to the conditions of an outdoor recreation setting to the ability of that setting to provide outdoor recreation opportunities. In the same example, warming winter temperatures affect individual recreationist decisions to visit, or not to visit, a site. Whether that effect is positive or negative will depend on a variety of factors specific to individual recreationists.

Indirect effects tend to be important for recreation activities and opportunities that depend on additional ecosystem inputs, such as wildlife, vegetation, and surface water. The quality of cold-water fishing is expected to decline in the future because climate effects on temperature and streamflow will degrade cold-water fish species habitat (Jones et al. 2013) (Chapter 5). Surface water area and streamflow are also important for water-based recreation (e.g., boating). Recreation visits to sites with highly valued natural characteristics, such as glaciers or popular wildlife species (chapters 4, 9), may be reduced under some future climate scenarios if the quality of those characteristics is threatened (Scott et al. 2007). The indirect effects of climate on disturbances, and wildfire in particular (chapters 7, 8), may also play a role in recreationist behavior, although the effects may be diverse and variable over time (Englin et al. 2001; Loomis and Crespi 2004).

Table 10.1—Participation in different recreational activities in national forests in the U.S. Forest Service Intermountain Region.

Activity	National forest visitors for whom this was their primary activity[a]		Relationship to climate and environmental conditions
	Percent	*Number*	
Warm-weather activities	46.2	8,683,390	Participation typically occurs during warm weather; dependent on the availability of snow- and ice-free sites, dry weather with moderate daytime temperatures, and the availability of sites where air quality is not impaired by smoke from wildfires.
Hiking/walking	17.1	3,211,475	
Viewing natural features	16.2	3,050,410	
Developed camping	3.5	652,192	
Bicycling	3.0	559,385	
Picnicking	2.2	422,613	
Other nonmotorized	1.3	247,131	
Horseback riding	1.2	229,879	
Primitive camping	1.2	220,311	
Backpacking	0.5	89,995	
Winter activities	20.6	3,869,580	Participation depends on the timing and amount of precipitation as snow and cold temperatures to support consistent snow coverage. Inherently sensitive to climate variability and interannual weather patterns.
Downhill skiing	16.1	3,021,644	
Snowmobiling	2.5	461,262	
Cross-country skiing	2.1	386,673	
Wildlife activities	10.2	1,910,240	Wildlife is a significant input for these activities. Temperature and precipitation are related to habitat suitability through effects on vegetation, productivity of food sources, species interactions, and water quantity and temperature (for aquatic species). Disturbances (wildland fire, invasive species, insect and disease outbreaks) may affect amount, distribution, and spatial heterogeneity of suitable habitat.
Hunting	5.3	1,002,604	
Fishing	3.8	712,832	
Viewing wildlife	1.0	194,804	
Gathering forest products	0.8	141,395	Depends on availability and abundance of target species (e.g., berries, mushrooms), which are related to patterns of temperature, precipitation, and snowpack. Disturbances may alter availability and productivity of target species in current locations and affect opportunities for species dispersal.
Water-based activities, not including fishing	1.7	320,023	Participation requires sufficient water flows (in streams and rivers) or levels (in lakes and reservoirs). Typically considered a warm-weather activity, and depends on moderate temperatures and snow- and ice-free sites. Some participants may seek water-based activities as a refuge from heat during periods of extreme heat.
Nonmotorized	1.0	192,878	
Motorized	0.7	127,145	

[a] Data are from USDA FS (n.d.), collected for national forests between 2012 and 2015.

Table 10.2—Recreation visits to National Park Service units.

National Park Service unit	Number of visitors[a]	Number of overnight visitors	Three consecutive months with the most visitors
IDAHO			
City of Rocks NRES[b]	105,289	0	May–June–July
Craters of the Moon NM	246,826	17,957	June–July–August
Hagerman Fossil Beds NM	24,695	0	June–July–August
Minidoka NHS	N/A	0	N/A
NEVADA			
Death Valley NP	1,154,843	214,430	March–April–May
Great Basin NP	116,123	40,703	July–August–September
Lake Mead NRA	7,298,465	611,055	June–July–August
Tule Springs Fossil Bed NM	N/A	0	N/A
UTAH			
Arches NP	1,399,247	50,933	May–June–July
Bryce Canyon NP	1,745,804	150,488	June–July–August
Canyonlands NP	634,607	97,734	April–May–June
Capitol Reef NP	941,029	43,522	July–August–September
Cedar Breaks NM	793,601	1,337	July–August–September
Dinosaur NM	291,799	62,581	June–July–August
Glen Canyon NRA	2,495,093	1,446,023	June–July–August
Golden Spike NHS	59,147	0	June–July–August
Natural Bridges NM	94,797	7,502	April–May–June
Rainbow Bridge NM	77,270	0	June–July–August
Timpanogos Cave NM	104,023	0	June–July–August
Zion NP	3,648,846	333,781	June–July–August
WYOMING			
Fossil Butte NM	19,293	0	June–July–August
Grand Teton NP	3,149,921	631,240	June–July–August
Total	24,400,718	3,709,286	

[a] Source: NPS (2014).
[b] NHS = National Historic Site, NM = National Monument, NP = National Park, NRA = National Recreation Area, NRES = National Reserve, N/A = not available.

The direct effects of altered temperature and precipitation patterns are likely to affect most outdoor recreation activities in some way. Direct effects are important for skiing and other snow-based winter activities that depend on seasonal temperatures and the amount, timing, and phase of precipitation (Englin and Moeltner 2004; Irland et al. 2001; Klos et al. 2014; Smith et al. 2016; Stratus Consulting 2009; Wobus et al. 2017). Increases in minimum temperatures have been associated with increased national park visits in Canada, particularly during nonpeak “shoulder” seasons (spring and fall) (Scott et al. 2007). The number of projected warm-weather days is positively associated with expected visitation for U.S. national parks (Fisichelli et al. 2015), including specific regions such as Alaska (Albano et al. 2013) and the southeastern United States (Bowker et al. 2013), although visitation is expected to be lower under extreme-heat

Box 10.1—Economic Effects of National Park Visitation for Local Communities

A recent National Park Service report (Cui et al. 2013) shows that the 3,376,000 visitors to Zion National Park, Cedar Breaks National Monument, and Pipe Spring National Monument spent $159,975,000 in communities surrounding the parks, supporting 2,614 jobs in the local area.

"Zion is a world-renowned destination that offers opportunities for a range of recreational and educational experiences including passive activities and high adventure excursions," Zion Superintendent Jock Whitworth said. "The millions of visitors that come here also spend time and money enjoying the services provided by our neighboring communities."

Cedar Breaks Superintendent Paul Roelandt noted, "Cedar Breaks alone is responsible for bringing the local economy about $18 million… Cedar Breaks sees itself as an important part of the regional economy. Our location offers opportunities for visitors to experience a high-elevation scenic drive, colorful geology, and pristine night skies."

John Hiscock, Superintendent of Pipe Spring, added, "Pipe Spring may be comparatively small in size, but the rich history told here is unmatched. Visitation to the park supported an estimated 42 jobs in the local communities, including Fredonia, Arizona, Kanab and Hurricane, Utah, and on the Kaibab Paiute Indian Reservation. The National Park Service is proud to have been entrusted with the care of America's most treasured places, and delighted visitors generate significant contributions to the local economy."

The information on the three parks is part of a nationwide analysis of national park visitors' spending across the country, which documented $13 billion of direct spending by 279 million park visitors in communities within 60 miles of a national park (Cui et al. 2013). Visitor expenditures had a $30 billion impact on the U.S. economy and supported 252,000 jobs nationwide. That spending contributes to jobs in lodging, food, and beverage services (63 percent of jobs supported), recreation and entertainment (17 percent), other retail (11 percent), transportation and fuel (7 percent), and wholesale and manufacturing (2 percent).

Table 10.3—Categories of recreation activities by season. Note that these may differ somewhat from the official categories in the National Visitor Use Monitoring data (table 10.1).

Recreation activity	Winter	Spring	Summer	Fall
Boating		X	X	X
Camping, picnicking		X	X	X
Cycling (mountain biking, road biking)		X	X	X
Hunting	X	X	X	X
Fishing		X	X	X
Hiking, backpacking (incl. long-distance hiking)		X	X	X
Horseback riding		X	X	X
Motorized recreation (snowmobiles)	X			
Motorized recreation (off-road vehicles)		X	X	X
Nonmotorized winter recreation (downhill skiing, cross-country skiing, fat-tire bikes, dog sledding, sledding and tubing, general snow play, mountaineering)	X			
Recreation residences	X	X	X	X
River rafting		X	X	
Scenic driving (nature viewing)	X	X	X	X
Special forest products (e.g., mushrooms, cones)		X	X	X
Swimming			X	
Other forest uses (Christmas tree harvest, firewood cutting)	X	X	X	X

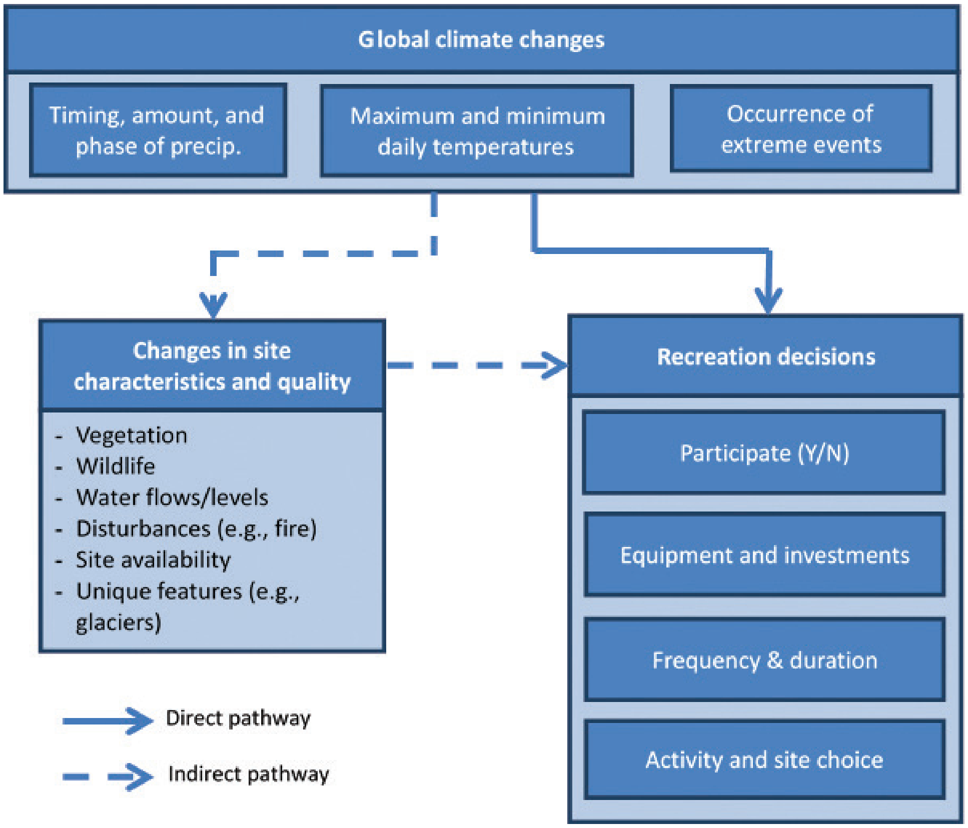

Figure 10.1—Conceptual model of the effects of climate change on recreation, showing direct and indirect pathways of effects.

scenarios (Richardson and Loomis 2004). Temperature and precipitation directly affect the comfort and enjoyment that participants derive from engaging in an activity on a given day (Mendelsohn and Markowski 2004).

The recent update to the USFS 2010 Resources Planning Act (RPA) assessment modeled the effects of climate change on different recreation activities (USDA FS 2016). Model results indicate that projected changes in recreation are expected to vary considerably (both positively and negatively) by geographic location and activity (table 10.4). For the IAP region, the number of participants in warm-weather activities in 2060 is projected to increase significantly (mostly as a result of population increase), but with minimal effects of climate change, except for primitive area use. Significant climate change effects (negative) are projected for hunting, fishing, and undeveloped skiing.

Recreation Participation and Economic Value

Recreation is an important component of public land management in the IAP region, and recreation managers aim to provide diverse recreation opportunities that span the Recreation Opportunity Spectrum, from modern and developed to primitive and undeveloped (Clark and Stankey 1979) (box 10.2). For lands managed by the USFS, sustainable recreation serves as a guiding principle for planning and management purposes (USDA FS 2010, 2012b). In the USFS, sustainable recreation seeks to "sustain and expand benefits to America that quality recreation opportunities provide" (USDA FS 2010). The National Park Service (NPS) emphasizes visitor enjoyment of the parks while recognizing that it is necessary to preserve natural and cultural resources and values for the enjoyment, education, and inspiration of present and future generations (NPS 2006). Recreational resources are managed to connect people with natural resources and cultural heritage, and to adapt to changing social needs and environmental conditions.

The USFS Intermountain Region classifies recreation sites in 31 categories. Of the 2,335 sites across 12 national forests, trailheads (691), campgrounds (628), interpretive sites (126), boating sites (102), and picnic sites (104) account for 70 percent of the total. The Uinta-Wasatch-Cache National Forest has the most sites (451), followed by Bridger-Teton National Forest (234) and Boise National Forest (233); Dixie National Forest has the fewest sites (106).

People participate in a wide variety of outdoor recreation activities in the IAP region. The USFS National Visitor Use Monitoring (NVUM) program surveys recreation visitation and activity on national forests, and monitors 27 recreation activities in which visitors participate. These include a variety of activities and ways that people enjoy and use national forests and other public lands. Current recreation visitation (tables 10.1, 10.2, 10.5, 10.6), activities (table 10.3), and expenditures (table 10.7) illustrate the importance and diversity of recreation in this region.

Table 10.4—Modeled projections of the effects of climate change on recreation in the Intermountain Adaptation Partnership region[a] for 2060. Model output is based on an average of results under the A2, A1B, and B2 emissions scenarios.

Recreation activity	Number of participants in 2060	Projected change without climate change[b]	Projected change with climate change	Net effects of climate change[c]
	----*Millions*---	---------*Percent*---------		
Visiting developed sites	17	94	94	0
Visiting interpretive sites	15	108	107	-1
Birding	7	104	103	-1
Nature viewing	18	97	96	-1
Day hiking	10	110	110	0
Primitive area use	12	89	73	-16
Motorized off-roading	6	83	83	0
Motorized snow activities	1	30	21	-9
Hunting	3	32	15	-17
Fishing	7	76	48	-28
Developed skiing	3	135	136	+1
Undeveloped skiing	1	86	74	-12
Floating	3	71	71	0

[a] Data are from the "RPA Rocky Mountain Region" (USDA FS 2016), which includes the U.S. Forest Service Intermountain Region.
[b] Percentage changes for total number of participants are compared to 2008.
[c] Net effects of climate change equal "with climate change" minus "without climate change."

The activities listed in table 10.3 account for the primary recreation activities for 79 percent of visits to national forests in the IAP region. Warm-weather activities are the most popular, and include hiking/walking, viewing natural features, developed and primitive camping, bicycling, backpacking, horseback riding, picnicking, and other nonmotorized uses. These were the main activity for 46.2 percent of national forest visitors (8.7 million visits per year) (table 10.1). Of these, hiking/walking was the most popular, and is the primary reason for a visit for 17.1 percent of visitors (3.2 million visits). Snow-based winter activities (primarily downhill skiing, snowmobiling, and cross-country skiing) were the primary activities for 20.6 percent of visitors (3.9 million visits). Wildlife-related activities (primarily hunting, fishing, and viewing wildlife) were the primary activity for 10.2 percent of visits (1.9 million visits). Gathering forest products (e.g., berries and mushrooms) was the primary activity for 0.8 percent of visitors (141,000 visits). Motorized and nonmotorized water activities (other than fishing) drew 1.7 percent of visits (320,000 visits).

Nonlocal visitors (those who report a home ZIP code that is more than 30 miles from the national forest boundary) spend $686 million (in 2014 dollars) per year within 50 miles of the forest boundaries (table 10.7). We focus on spending by nonlocal visitors because these individuals spend money in local communities that would not have occurred otherwise, and in this case account for 70 percent of spending. Lodging expenses make up nearly 30 percent of total expenditures, followed by gas and oil (18 percent), restaurant (17 percent), and groceries (13 percent). The remaining expenditure categories of other transportation, activities, admissions and fees, and souvenirs account for 23 percent of all spending.

Outdoor recreation opportunities supported by Federal lands are complemented by additional recreation opportunities offered on State lands (table 10.6). For example, the Idaho State park system, which includes 32 units such as State parks and State recreation areas (Statewide, not just in the IAP region), had over 5 million day-use visitors in 2014 (ISPAR 2013; Leung et al. 2015). Off-highway visitors accounted for 1 million visits and $434 million in expenditures (Anderson and Taylor 2014). In 2011, 246,000 hunters accounted for 3.2 million hunting days and $478 million in expenditures; 447,000 anglers accounted for 5.5 million angling days and $422 million in expenditures; and 558,000 wildlife watchers accounted for 3.8 participant days and $432 million in expenditures (USFWS 2013).

Recreation on public lands is very important to State economies. For example, in Utah, $7.4 billion was spent on travel, tourism, and recreation in 2012 (75 percent in the Wasatch Front), with $5.3 billion spent by out-of-State visitors (Leaver 2014). This economic activity supports 129,000

Box 10.2—The Recreation Opportunity Spectrum

The Recreation Opportunity Spectrum (ROS) is a classification tool used by Federal resource managers since the 1970s to provide visitors with varying challenges and outdoor experiences (Clark and Stankey 1979; USDA FS 1990). The ROS classifies lands into six management class categories defined by setting and the probable recreation experiences and activities it affords: modern developed, rural, roaded natural, semi-primitive motorized, semi-primitive nonmotorized, and primitive.

Following are the setting characteristics that define the ROS.

- Physical: type of access, remoteness, size of the area
- Social: number of people encountered
- Managerial: visitor management, level of development, naturalness (evidence of visitor impacts and management activities)

The ROS is helpful for determining the types of recreation opportunities that can be provided. After a decision has been made about the opportunity desirable in an area, the ROS provides guidance about appropriate planning approaches and standards by which each factor should be managed. Decisionmaking criteria include: (1) relative availability of different opportunities, (2) their reproducibility, and (3) their spatial distribution. The ROS Primer and Field Guide (USDA FS 1990) specifically addresses access, remoteness, naturalness, facilities and site management, social encounters, and visitor impacts. The ROS can be used to:

- Inventory existing opportunities,
- Analyze the effects of other resource activities,
- Estimate the consequences of management decisions on planned opportunities,
- Link user desires with recreation opportunities,
- Identify complementary roles of all recreation suppliers,
- Develop standards and guidelines for planned settings and monitoring activities, and
- Help design integrated project scenarios for implementing resource management plans.

In summary, the ROS approach provides a framework for Federal land managers to classify recreational sites and opportunities, and to allocate improvements and maintenance within the broader task of sustainable management of large landscapes.

Table 10.5—National Forest visits by activity category for five of the six Intermountain Adaptation Partnership subregions.

Activity category	Middle Rockies[a]	Southern Greater Yellowstone	Uintas and Wasatch Front	Plateaus	Great Basin and Semi Desert
	------------------*Percentage of annual visitors reporting main activity*[b]----------------				
Warm-weather activities[c]	19.6	29.9	38.4	34.2	16.1
Snow-based winter activities	40.3	32.5	20.0	9.9	1.2
Wildlife activities	10.6	13.5	10.8	21.2	1.9
Forest product gathering	2.1	1.6	0.2	1.6	0.1
Water-based activities, not including fishing	3.4	1.8	2.1	0.2	0.0

[a] To estimate activity participation, subregions are defined by groups of national forests as shown in table 2.1.
[b] Data are from USDA FS (n.d.), collected for national forests between 2012 and 2015.
[c] Percentages do not sum to 100 because not all visitors report activities, and not all activities are included in climate-sensitive categories (e.g., nature center activities, visiting historic sites).

Table 10.6—Outdoor recreation settings managed by State park systems in States that are totally or partially within the Intermountain Adaptation Partnership region.

State	State park units[a]	Area	Trails		Improved campsites	Primitive campsites	Visitation
		Acres	*Number*	*Miles*			
Idaho[b]	32	58,922	3	108	1,762	172	5,008,136
Wyoming	41	119,559	286	129	109	1,418	3,917,507
Utah	50	150,758	105	302	1,416	574	3,536,704
Nevada	25	146,225	114	290	401	960	3,217,125

[a] Includes parks, recreation areas, natural areas, historic areas, environmental education areas, scientific areas, forests, and fish and wildlife areas.
[b] Source: Leung et al. (2015).

Table 10.7—Total annual expenditures by visitors to national forests in the U.S. Forest Service Intermountain Region, by spending category.

Spending category	Non-local spending[a,b]		Local spending[b]	
	Total annual expenditures[c]	Spending for each category	Total annual expenditures[c]	Spending for each category
	Thousands of $ (2014)	*Percent*	*Thousands of $ (2014)*	*Percent*
Lodging	205,286	30	18,575	6
Restaurant	116,559	17	40,713	14
Groceries	91,260	13	47,998	17
Gasoline, oil	120,165	18	87,975	31
Other transportation	3,639	1	723	0
Activities	43,799	6	28,300	10
Admissions, fees	53,735	8	33,923	12
Souvenirs	51,655	8	29,206	10
Total	686,093		287,409	

[a] Non-local refers to trips by visitors who reported a ZIP code greater than 30 miles from a national forest boundary.
[b] Data are from USDA FS (n.d.), collected for national forests between 2012 and 2015.
[c] Expenditures within 50 miles of a national forest (USDA FS n.d.).

jobs (directly and indirectly). Public lands play a big role in the Utah economy; during the past 30 years, national park visits have increased from 2 million to 7.2 million, and skier days have increased from 2 million to 4 million (Gardner Policy Institute 2016).

Climate Change Vulnerability Assessment

Managing recreation on public lands is a complex enterprise that varies from year to year and season to season. It includes (1) maintaining standard opportunities and facilities (e.g., hiking trails, primitive campgrounds), (2) providing access for harvesting animals and plants, (3) regulating access for motorized vehicle use (e.g., off-highway vehicles, snowmobiles), and (4) coordinating with concessionaires who operate large ski resorts with thousands of visitors putting millions of dollars in circulation in the local economy.

Providing high-quality opportunities, adequate facilities, and satisfying experiences for a diverse population of recreationists is a significant challenge, and responding to the effects of a warmer climate will require monitoring of changing opportunities and demands for recreation. Because the majority of recreation occurs during warm weather, Federal agencies add large numbers of staff for the summer season to assist with all aspects of recreation. In recent years, declining budgets have made it difficult to employ a

Box 10.3—Summary of Climate Change Effects on Recreation

All categories of recreation considered to be potentially sensitive to the effects of climate change in the IAP region were aggregated into five activity categories. Positive (+) and negative (-) signs indicate expected direction of effect on overall benefits derived from recreation activity; (+/-) indicates that both positive and negative effects may occur.

Warm-weather activities (e.g., hiking, camping, sightseeing)

- Magnitude of climate effect: Moderate (+)
- Likelihood of climate effect: High
- Direct effects: Warmer temperature (+), higher likelihood of extreme temperatures (-)
- Indirect effects: Increased incidence, area, and severity of wildfire (+/-); increased smoke from wildfire (-)

Snow-based winter activities (e.g., downhill skiing, cross-country skiing, snowmobiling)

- Magnitude of climate effect: High (-)
- Likelihood of climate effect: High
- Direct effects: Warmer temperature (-), reduced precipitation as snow (-)
- Indirect effects: Increased incidence, area, and severity of wildfire (+/-); increased smoke from wildfire (-)

Wildlife activities

- Magnitude of climate effect: Terrestrial wildlife: low (+); fishing: moderate (-)
- Likelihood of climate effect: Moderate
- Direct effects: Warmer temperature (+); higher incidence of low streamflow (fishing: -); reduced snowpack (hunting: -)
- Indirect effects: Increased incidence, area, and severity of wildfire (terrestrial wildlife: +/-); increased smoke from wildfire (-); reduced cold-water habitat, incursion of warm-water tolerant species (fishing: -)

Gathering forest products

- Magnitude of climate effect: Low (+/-)
- Likelihood of climate effect: Moderate
- Direct effects: Warmer temperature (+)
- Indirect effects: More frequent wildfires (+/-), higher severity wildfires (-)

Water-based activities (not including fishing)

- Magnitude of climate effect: Moderate (+)
- Likelihood of climate effect: Moderate
- Direct effects: Warmer temperature (+), higher likelihood of extreme temperatures (-)
- Indirect effects: Lower streamflows and reservoir levels (-), increase in algal blooms (-)

sufficient seasonal workforce to accommodate recreation demands, especially during the shoulder seasons (late spring, early fall). The scope and complexity of management vary considerably across the IAP region, as do the projected effects of climate change (box 10.3) and how climate change is perceived by resource managers (box 10.4).

Current climatic and environmental conditions within the region are characterized by large intra-annual and interannual (within and between years) variability. These highly variable climatic and environmental conditions include: temperature and precipitation (Chapter 3), water flows and levels (Chapter 4), wildlife distributions (Chapter 9), vegetative conditions (chapters 6, 7), and wildfire activity (Chapter 8). Recreationists are probably already accustomed to making decisions with a significant degree of uncertainty about conditions at the time of participation.

Recreation in the IAP region is affected by several existing challenges and stressors. Increased population, particularly near public lands, can strain visitor services and facilities because of increased use; projected population increases in the future may exacerbate these effects. Increased use can reduce site quality because of crowding (Yen and Adamowicz 1994).

The physical condition of recreation sites and natural resources is constantly changing due to human and natural forces. Recreation sites and physical assets need maintenance, and deferred or neglected maintenance may increase congestion at other sites that are less affected or increase hazards for visitors who continue to use degraded sites.

Box 10.4—How Do Recreation Managers View Climate Change?

We asked recreation managers throughout the USFS Intermountain Region to provide their perspectives on current conditions for recreation opportunities and facilities and on the potential effects of climate change. The following narratives indicate that recreation managers are aware of current stressors on the recreation enterprise, anticipate significant changes in a warmer climate, and have ideas for how to adapt.

Trish Callaghan (Salmon-Challis National Forest)

"Staffing is inadequate for a longer shoulder season—an earlier summer would be the biggest issue. We do staff into the fall, mostly to accommodate hunters and fall steelhead anglers. Our largest spring use is also anglers, but for the spring steelhead run in March.

"I think some of our water systems are actually getting less reliable due to the extended summer heat season and shorter winters. When we have to turn off systems because they don't flow correctly, or because they fail the required monthly tests, then we will lose visitation. Our warm-weather users will have reduced water flow for river-related activities, and some of our natural lakes will lose water earlier in the season, becoming less attractive for visitors.

"Our 'make your own winter trail' type of skiing, snow shoeing, and snowmobiling has tapered off pretty slowly over the past several years. Recreationists are very reactive to actual day-to-day snowfall information and weather conditions."

Jane Cropp (Payette National Forest)

"We don't have the staffing to open our campgrounds earlier, but would find some way to manage if our seasons were longer due to earlier snowmelt. We don't have concessionaires here, so we would need to rely on our temporary workforce. Hopefully we could collect more funds in the campgrounds to help us pay for a longer working season. Mountain biking would probably increase if summers were longer, because trails would open up earlier in the year.

"Our winter season is as busy as our summer season. Shorter winters would affect cross-country skiing opportunities; in fact, they have already been affected over the last several years, with shorter seasons. Our two downhill ski areas would be affected by shorter winters. The biggest impact would be to snowmobile users, because the Payette National Forest is a very popular snowmobiling destination. A shorter winter season, with fewer snowmobilers coming into the area, would have negative economic effects to the towns of McCall and Donnelly."

Nell Highfill (Boise National Forest)

"With longer shoulder seasons, funding would not be available to keep campgrounds open, especially in the spring. Most of the ranger districts lock the restrooms in the winter until the site is open. Because there are no staff to patrol, and visitors are accessing the developed recreation sites while they are closed, they have had a human waste issue in the campgrounds in the spring. Some sites are not gated, and those were especially heavily used in early shoulder seasons, but did not have the staff for operating the site, cleaning, etc. Concessionaires have not wanted to open early or stay later because although there is use, it is not profitable.

"Most roads in the Boise National Forest are not gated and are available year round. Some are groomed for snowmobile use. Longer wet periods that are free from snow will result in increased maintenance needs to repair damage. Also, more year-round use on roads will result in longer periods of wildlife disturbance, especially during spring nesting, calving, etc.

"Bogus Basin Ski Area is a lower elevation ski resort. They are already adding more summer recreation activities to supplement shorter ski seasons. They have an active snowmobile grooming program in some areas, and grooming is being reduced to 2–3 months a year. Many of the small mountain towns depend on snowmobile use economically, and have been doing studies to determine economic loss. Fewer people are buying snowmobiles and are using ATVs that can have tracks attached for winter use. Boise has a popular yurt system operated by the State for cross-country skiing. Most use is in winter, but it is also available in summer. Milder winters and more warm weather could change use patterns or make their operation less viable.

"When it is warmer in populated valleys, people will seek to go higher and travel farther to get out of the heat. We also anticipate an increase in water-based recreation. It may be necessary to build or expand facilities near water amenities if use increases. Whitewater rafting is important in Idaho. If the rafting season gets shorter as expected, it will have a negative effect on outfitter guides."

Box 10.4 (*continued*)—How Do Recreation Managers View Climate Change?

Carol Majeske (Uinta-Wasatch-Cache National Forest)

"Our concessionaire mobilized to open some sites early last season when it was warm, and likewise kept some sites open longer as a test on the Spanish Fork Ranger District. In some cases, it's difficult to keep people out of sites when it's warm, although technically they're closed. I'm not sure the longer shoulder seasons were economically viable for the concessionaire, because there were additional expenses (e.g., trash removal), although having recreation sites available did please some of the public.

"It's not always possible to open water systems early or keep them open in fall when spring sources and infrastructure may be under snow or there's a freeze threat. We can advertise that no water is available, but some sites have flush toilets. It might be possible to rent porta-potties, although they're not allowed in some locations and would incur additional costs.

"For recreation sites operated by national forests, limitations on seasonal staff appointments (1039 hours) may limit staffing for longer seasons unless it's done by permanent employees. For both the Forest Service and concessionaires, it's difficult to hire and train employees concurrent with opening sites (water system requirements, hazard inspections, hazard tree removal, etc.). Likewise in the fall, it can be difficult to retain personnel who return to school or are ready to move on to other jobs. In a warmer climate, our dispersed sites would be accessible for a longer period and used more heavily (trails, rock climbing, etc.). Repair and maintenance of trails and infrastructure could become more challenging and costly."

Dan Morris (Humboldt-Toiyabe National Forest)

"Currently there is no staff to operate longer shoulder seasons. Memorial to Labor Day is the common recreation season, and that would probably change. I don't really think climate change would increase summer use, but perhaps demand in spring and fall.

"For the Sierra Nevada, winter recreation is pretty big. Many of our winter staging areas are at an elevation where slightly warmer seasons could make them useless for winter. It could be necessary to construct new snow parks at higher elevations. Snowmobilers would be most affected because they are restricted to open areas, although backcountry skiing could also be affected."

Jamie Fields (Humboldt-Toiyabe National Forest)

"I echo what Dan [Morris] says that the expanded season of activities associated with summer (biking, hiking, off-highway vehicles, etc.) is probably the biggest management challenge. We don't have staff or funding to open trailhead or camping facilities earlier or to close them later. I would expect human waste issues and people being grumpy that they cannot use the facilities. Also, trail crews will not have been out in early season to open trails that have a lot of down trees, so I would expect complaints about that and resource impacts from people trying to go around blockages on uncleared trails. This would cause more trail and rehab work to be accomplished by trail crews when they arrive during the 'normal' season. I think the main impacts we would see from extreme heat events is more people going uphill into national forest land to recreate and escape the heat in the valleys.

"The impact on winter recreation is obviously substantial. We may occasionally have some issues with people just wanting to get out snowmobiling when there's not enough snow to protect the vegetation underneath, but the greatest challenge is just that people cannot get out to recreate when there's no snow. Or they will go higher and become more concentrated in places that might not have the capacity to handle more people cramming into shrinking snow areas. It might cause conflicts between uses and safety issues in some locations. There could be a potential increase in snowmobile incursions into wilderness if people are losing motorized snow opportunities at low elevation. We don't have capacity to prevent or enforce snowmobile wilderness incursion.

"Increased fuel loads from fire suppression plus the drought and invasives that come with climate change mean more intense fire seasons that could close recreation opportunities temporarily or permanently. Hazard trees may become a greater concern from forests stressed by beetles and drought, as well as a possible increase in extreme weather events.

"I would expect that more animal species will be threatened/endangered when they are unable to adapt to changes in habitat. Besides hunting, recreational uses could stress those animals—I know there are lots of studies about trail use impacts on birds and ungulates, including impacts of climbing on nesting raptors. If some animals are already stressed from climate change, and if they're listed, there may be closures or new restrictions on recreational opportunities. That's a far-out, if-then situation that is hard to quantify, but I do think it's coming."

Unmanaged recreation can create hazards and contribute to natural resource degradation (USDA FS 2010). This stressor may interact with others, such as population growth and maintenance needs, if degraded site quality or congestion encourages users to engage in recreation that is not supported or appropriate at certain sites or at certain times of the year. Natural hazards and disturbances may create challenges for the provision of recreation opportunities. For example, wildfire affects recreation demand (as a function of site quality and characteristics), but may also damage physical assets or exacerbate other natural hazards such as erosion (chapters 4, 8, 12).

The biggest effect of climate change on recreation activity is likely to differ between warm-weather activities (increase in participation) and snow-based activities (decrease in participation). In general, warmer temperatures and increased season length appropriate for warm-weather activities will increase the duration and quality of weather for activities such as hiking, camping, and mountain biking, whereas reduced snowpack will decrease the duration and quality of conditions for downhill skiing, cross-country skiing, and snowmobiling. However, these general findings mask potential variation in the effects of climate on recreation between types of activities and geographic locations.

To assess how recreation patterns may change in the IAP region, categories of outdoor recreation activities are identified that may be sensitive to climatic changes (fig. 10.2). For the purposes of the recreation assessment, an outdoor recreation activity is sensitive to climate change if changes in environmental conditions that depend on climate would result in a significant change in the demand for or supply of that outdoor recreation activity. The recreation activities identified in the NVUM survey are grouped into five climate-sensitive categories of activities, plus an "other" category of activities that are judged to be less sensitive to climatic changes. (Note that although participation in many of the activities in the "other" category is probably linked to climate in some way, other factors are likely to be more important determinants of participation, such as maintenance of infrastructure for visiting interpretive sites.) Each category includes activities that are likely to be affected by changes to climate and environmental conditions in similar ways (fig. 10.2).

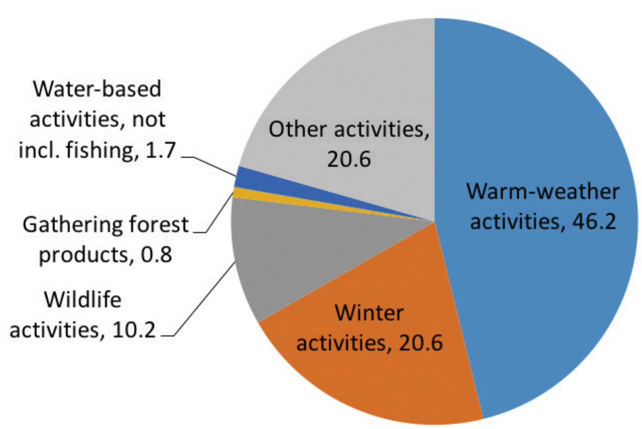

Figure 10.2—Percentage of total visits to national forests in the U.S. Forest Service Intermountain Region, by climate-sensitive primary activity (USDA FS n.d.).

This section provides an assessment of the likely effects of climate on major climate-sensitive recreation activities in the IAP region. Two sources of information are used to develop assessments for each category of recreation activity. First, reviews of existing studies of climate change effects on outdoor recreation and studies of how recreationist behavior responds to climate-sensitive ecological characteristics are used to draw inferences about likely changes for each activity category. Second, projections of ecological changes specific to the IAP region, as detailed in the other chapters in this volume, are paired with the recreation literature to link expected responses of recreation behavior to specific expected climate effects.

Warm-Weather Activities

Warm-weather activities are the most common recreation activities in national forests and national parks in the IAP region. Warm-weather recreation is sensitive to the availability of snow- and ice-free trails and sites, and the timing and number of days with temperatures within minimum and maximum comfortable range (which may vary with activity type and site). The number of warm-weather days (Richardson and Loomis 2004) and minimum temperature are positively correlated with visitation (Albano et al. 2013; Fisichelli et al. 2015; Scott et al. 2007).

Participants are also sensitive to site quality and characteristics, such as the presence and abundance of wildflowers, condition of trails, vegetation, and shade. The condition of unique features that are sensitive to climate change, such as glaciers and snowfields, may affect the desirability of certain sites (Scott et al. 2007). Forested areas are positively associated with warm-weather activities, such as camping, backpacking, hiking, and picnicking (Loomis and Crespi 2004), and are sensitive to future climatic changes (USDA FS 2012a).

Wildfire can also affect participation in warm-weather activities through changes to site quality and characteristics (fig. 10.3). Wildfires may have a diverse and temporally nonlinear effect on recreation (Englin et al. 2001). The presence of recent wildfires has differential effects on the value of hiking trips (positive) and mountain biking (negative), although recent wildfire activity tends to decrease the number of visits (Hesseln et al. 2003, 2004; Loomis et al. 2001). The severity of fire may also matter; high-severity fires are associated with decreased recreation visitation, whereas low-severity fires are associated with slight increases in visitation (Starbuck et al. 2006). Recent fires are associated with initial losses of benefits for camping (Rausch et al. 2010) and backcountry recreation activities (Englin et al. 1996), but these losses are attenuated over time. Research in Yellowstone National Park showed that visitation tends to be lower during and immediately after high wildfire activity,

Figure 10.3—Increased occurrence of wildfires in the future may cause safety concerns, reduce access, and impair air quality and vistas for hikers (photo courtesy of K. Schwartz).

although there is no discernible effect of previous-year fires (Duffield et al. 2013).

Overall demand for warm-weather activities is expected to increase because of the direct effect of climate change on season length. Temperatures are expected to increase 5 to 12 °F across the region by the year 2100 (Chapter 3), which is expected to result in earlier availability of snow- and ice-free sites and an increase in the number of warm-weather days in spring and autumn (Albano et al. 2013; Fisichelli et al. 2015). For example, higher minimum temperatures are associated with an increased number of hiking days (Bowker et al. 2012). Higher maximum summer temperatures are associated with reduced participation in warm-weather activities (Bowker et al. 2012), so extreme heat scenarios for climate change are expected to reduce visitation in some cases (Richardson and Loomis 2004). Extreme heat may shift demand to cooler weeks at the beginning or end of the warm-weather season, or shift demand to alternative sites that are less exposed to extreme temperatures (e.g., at higher elevations, near lakes and rivers).

Adaptive capacity among recreationists is high because of the large number of potential alternative sites, ability to alter the timing of visits, and ability to alter capital investments (e.g., appropriate gear). However, benefits derived from recreation can vary whether or not substitute activities or sites are available. For example, some alternative sites may involve higher costs of access (because of remoteness or difficulty of terrain). In addition, limits on ability to alter seasonality of visits may exist (e.g., the timing of scheduled academic breaks). Although recreationists commonly shift to substitute sites and activities, how people substitute across time periods or between large geographic regions (e.g., choosing a site in the IAP region instead of in the Southwest) is poorly quantified (Shaw and Loomis 2008).

Summary

Projected climatic changes are expected to result in a moderate increase in warm-weather recreation activity and benefits derived from these activities. Longer warm-weather seasons will increase the number of days when warm-weather activities are viable and increase the number of sites available during shoulder seasons. The effects of a longer season may be offset somewhat by negative effects on warm-weather activities during extreme heat and increased wildfire activity. The likelihood of effects on warm-weather recreation is high because the primary driver of climate-related changes to warm-weather recreation is through direct effects of temperature changes on the demand for warm-weather recreation. The climate scenarios outlined in Chapter 3 differ in their projection of the magnitude of warming, but overall they project rising temperatures. Indirect effects on recreation, primarily through wildfire effects, may be harder to project with certainty and precision (particularly at small spatial scales).

Cold-Weather Activities

The IAP region contains many winter recreation sites that in total exhibit a wide range of site characteristics and attract local, national, and international visitors. Twenty-one developed sites support downhill skiing and snowboarding operated by special permit on lands administered by the USFS (table 10.8). Sites for cross-country skiing, snowshoeing, and snowmobiling tend to be maintained directly by the USFS, although national parks also provide access for these activities.

Snow-based recreation is highly sensitive to variations in temperature and the amount and timing of precipitation as snow. Seasonal patterns of temperature and snowfall determine the likelihood of a given site having a viable season (Scott et al. 2008). Lower temperatures and the presence of new snow are associated with increased demand for skiing and snowboarding (Englin and Moeltner 2004).

Climate change is expected to have a generally negative effect on snow-based winter activities (Wobus et al. 2017), although a wide range of effects at local scales is possible

Table 10.8—Location of developed downhill ski areas on national forest lands in the U.S. Forest Service Intermountain Region.

National forest	Ski area
Boise	Bogus Basin
Bridger-Teton	Jackson Hole
	Snowking
	White Pine
Caribou-Targhee	Kelly Canyon
	Pebble Creek
	Grand Targhee
Dixie	Brian Head
Humboldt-Toiyabe	Las Vegas Ski and Snowboarding Resort
	Mount Rose
Payette	Brundage
	Payette Lakes
Sawtooth	Magic Mountain
	Pomerell
	Soldier Mountain
	Sun Valley
Uinta-Wasatch-Cache	Alta
	Brighton
	Snowbasin
	Snowbird
	Solitude

because of variations across the region in site location and elevation. Warmer projected winter temperatures for the region are expected to reduce the proportion of precipitation as snow, even if the total amount of precipitation does not deviate significantly from historical norms (Chapter 4). The rain-snow transition zone (i.e., where precipitation is more likely to be snow rather than rain for a given time of year) is expected to move to higher elevations, particularly in late fall and early spring (Klos et al. 2014). This effect places lower elevation sites at risk of shorter or nonexistent winter recreation seasons (fig. 10.4), although the highest elevation areas in the region remain snow-dominated for a longer portion of the season in future climate scenarios. In some cases, climate-related disturbance (e.g., insect outbreaks) can reduce the quality of downhill skiing (box 10.5, fig. 10.5).

Studies of the ski industry in North America uniformly project negative effects of climate change (Scott and McBoyle 2007). Overall warming is expected to reduce expected season length and the likelihood of reliable winter recreation seasons. Climatological projections for the IAP region (Chapter 3) are consistent with studies of ski area vulnerability to climate change in other regions, in which projected effects of climate change on skiing, snowboarding, and other snow-based recreation activities is negative (Dawson et al. 2009; Hamlet 2000; Mote et al. 2008; Scott et al. 2008; Stratus Consulting 2009; Wobus et al. 2017).

Snow-based recreationists have moderate capacity to adapt to changing conditions given the relatively large number of winter recreation sites in the region. For undeveloped or minimally developed site activities (e.g., cross-country skiing, backcountry skiing, snowmobiling, snowshoeing), recreationists may seek higher elevation sites with higher likelihoods of viable seasons (Hand and Lawson 2018). Although developed downhill skiing sites are fixed improvements, potential adaptations include snowmaking, and new run development at higher elevation (Scott and McBoyle 2007). Warmer temperatures and increased precipitation as rain may increase availability of water for snowmaking in the near term during winter, but warmer temperatures may also reduce the number of days per season when snowmaking is viable. Large ski resorts owned and operated by corporations will probably be more resilient and have more options for maintaining viable skiing opportunities than smaller, locally owned businesses.

Although far fewer people participate in snowmobiling than in skiing (table 10.1), snowmobiling is locally important as a recreation activity and an economic driver in small communities. In the IAP region, snowmobiling is prominent in the Boise, Caribou-Targhee, Dixie (Cedar City Ranger District), and Uinta-Wasatch-Cache (Logan and Ogden Ranger Districts) National Forests. At least one study suggests that snowmobiling may be more vulnerable than downhill skiing to reduced snowpack in a warmer

Figure 10.4—Low snowpacks, which are expected to be more common in a warmer climate, can reduce the amount, quality, and safety of skiing in some locations (photo: J. Cronan, U.S. Forest Service).

climate (Scott et al. 2008), which is consistent with projections in the RPA assessment (USDA FS 2016).

Changes in snow conditions in the IAP region relative to other regions may also be important. If other regions experience relatively large effects of climate on snow-based recreation, recreationists may view sites in the IAP region as a substitute for sites in other regions (e.g., the Southwest) (Hand and Lawson 2018). However, interregional substitution patterns for recreation activities are poorly understood (Shaw and Loomis 2008), and limits exist on distances people are willing to travel to recreate at alternative sites. In the mountainous IAP region, it may not be possible to simply go to higher elevations to find adequate snow, especially if wilderness restricts certain uses (e.g., snowmobiling).

Summary

The magnitude of negative climate-related effects on snow-based winter activities is expected to be high. Warmer temperatures are likely to shorten winter recreation seasons and reduce the likelihood of viable seasons at lower elevation sites. Developed sites may have limited ability to adapt to these changes unless additional areas are available and feasible for expanded development. In comparison to other regions, winter recreation sites at high elevation in the IAP region may see fewer effects from climate change; interregional substitution could mitigate losses in some years if participants from other regions visit IAP region sites. The likelihood of negative effects is expected to be high for snow-based recreation, although variation across sites is possible because of differences in location and elevation. Climate models generally project warming temperatures and a higher-elevation rain-snow transition zone, which would leave additional sites exposed to the risk of shorter seasons.

Box 10.5—How Do Insects Affect Skiing?

Interactions among biophysical and social factors make it challenging to project the effects of climate change on natural resources. Brian Head Ski Resort on the Dixie National Forest in southern Utah provides a case in point.

A spruce beetle population grew to epidemic levels on the Cedar City Ranger District in the early 1990s. By 2003, the beetle outbreak had spread across the Markagunt Plateau, killing all mature and intermediate-age Engelmann spruce trees over thousands of acres. The spruce-dominated landscape is regenerating in quaking aspen that will dominate forest structure for many decades to come.

Photos of Brian Head Ski Resort before and after the beetle outbreak (fig. 10.5) show a stark difference in forest cover over a period of 6 years. Previously sheltered ski runs are now open to high wind and sun exposure, negatively affecting the experience of downhill skiers. Ski lifts are subject to frequent stoppage (wind holds) during windy conditions. Snow is scoured from ridge tops and on the most exposed slope locations, creating variable snow depth and quality at relatively fine spatial scales—challenging conditions for most skiers. In addition, because most of the ski runs are on south or southwest aspects, the sun reaches more of the snow cover for longer periods of time in the absence of forest cover. This increases snowmelt and induces a continual freeze-thaw cycle that can create icy snow.

The future of ski resorts like Brian Head is uncertain. Downhill skiing may continue for decades, although a shortened ski season caused by reduced snowpack, combined with undesirable snow conditions, may reduce the quality of the recreation experience and the economic viability of ski operations.

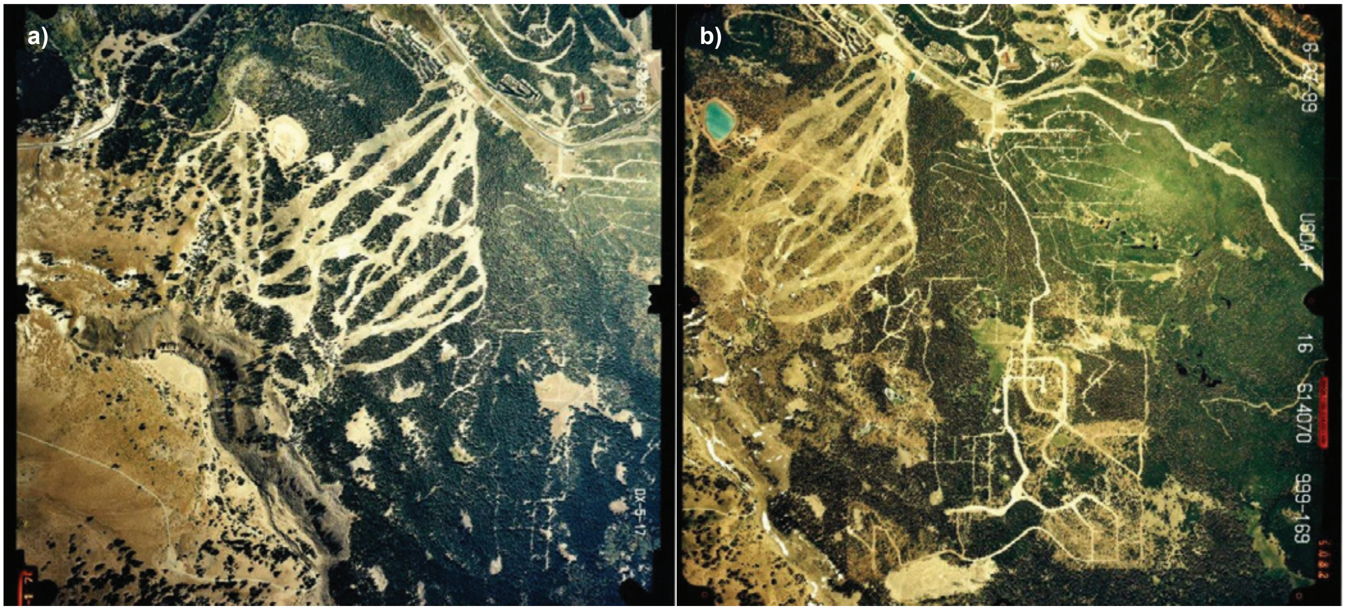

Figure 10.5—Aerial photos of Brian Head Ski Resort (Dixie National Forest) in 1993 (a) and 1999 (b), showing extensive mortality of Engelmann spruce caused by spruce beetle (photos: Dixie National Forest).

Wildlife-Dependent Activities

Wildlife-dependent recreation activities involve terrestrial or aquatic animals as a primary component of the recreation experience. Wildlife recreation can involve consumptive (e.g., hunting) or nonconsumptive (e.g., wildlife viewing, bird watching, catch-and-release fishing) activities. Distinct from other types of recreation, wildlife activities depend on the distribution, abundance, and population health of desired target species. These factors influence activity "catch rates," that is, the likelihood of harvesting or seeing an individual of the target species. Sites with higher catch rates can reduce the costs associated with a wildlife-dependent activity (e.g., time and effort tracking targets) and enhance overall enjoyment of a recreation day for that activity (e.g., greater number of views of highly valued species).

Participation in wildlife-dependent activities is sensitive primarily to climate-related changes that affect expected catch rates. Catch rates are important determinants of site selection and trip frequency for hunting (Loomis 1995; Miller and Hay 1981), substitution among hunting sites (Yen and Adamowicz 1994), participation and site selection for fishing (Morey et al. 2002), and participation in nonconsumptive wildlife recreation (Hay and McConnell 1979). Altered habitat, food sources, or streamflows and water temperature (for aquatic species) may alter wildlife abundance and distribution, which, in turn, influence expected catch rates and wildlife recreation behavior.

Wildlife-dependent activities may also be sensitive to other direct and indirect climate change effects. The availability of highly valued target species (e.g., cutthroat trout [*Oncorhynchus clarkii*] for cold-water anglers) affects anglers' ability to obtain desired benefits from fishing (Pitts et al. 2012) (box 10.6). Similarly, the diversity of game species present can affect hunt satisfaction (Milon and Clemmons 1991) and enjoyment of nonconsumptive wildlife-dependent activities such as birdwatching (Hay and McConnell 1979). Temperature and precipitation are related to general trends in participation for multiple wildlife activities (Bowker et al.

Box 10.6—Drought, Rivers, Fish, and Recreation

Climate change is expected to cause longer periods of drought in the IAP region, leading to lower streamflows in summer, warmer stream temperatures, and reduced populations of cold-water fish species (chapters 3, 4, 5). Extremely low snowpacks in the Sierra Nevada and adjacent areas in the winter of 2014–2015, following three previous drought years, resulted in natural resource effects that may become more common in the future. The following article explores the connection among drought, streams, fish, and recreation for the Truckee River, a portion of which flows through Humboldt-Toiyabe National Forest in Nevada.

Trout Drought: Anglers Ready for Long, Dry Summer (By Benjamin Spillman)

(Reprinted from the Reno-Gazette Journal, June 11, 2015)

Tucked away in a bucolic, residential neighborhood on Reno's west side, Ambrose Park looks like little more than a parking lot and a patch of grass and trees.

Box 10.6 (*continued*)—Drought, Rivers, Fish, and Recreation

But it's also an ideal access point to, "classic trout territory," on the Truckee River according to Jason Edwards and other anglers.

That's because the boulders form breaks and seams in the water and the tree-lined banks make shade and help bugs and other critters thrive, a combination that makes for great habitat for rainbow and brown trout.

> "People travel all over the world to try and get a 30-inch brown trout and they are pretty much all through this river," said Edwards, 26, during a recent fly fishing session. "We are pretty lucky to have this right in our backyard."

But the snowpack that feeds the Truckee River via Lake Tahoe, not to mention streams throughout the Sierra Nevada, was nearly non-existent last winter. And several consecutive years of drought have sapped reservoirs that serve as storage for lean years.

It means trout and people who fish for them are likely to be left high and dry this summer. Edwards and other anglers can only hope there's enough water to keep the fish alive until more rain and snow replenishes the system.

> "This is just a killer little section of river but soon enough it is going to be dried out," he said. "Those fish are going to have to move down and condense in one pool and that is when things start to get really scary."

For anglers the reality of the drought is nothing new. They've been watching Sierra Nevada streams and reservoirs shrink for several years.

What's new this season is that the problem is worse than ever.

On June 6, the flow rate in Reno was about 100 cubic feet per second (cfs). On this date in 2014 and 2013, the river was flowing around 500 cfs or more. Last year, it did not dip to around 100 cfs until about mid-July. The year before it hovered around 300 cfs from July through November.

> "We're four years into it and we have been able to get along the last few years based on the reservoir storage," said Kim Tisdale, Nevada Department of Wildlife supervising biologist for western Nevada. "It has kind of cushioned the blow from the drought. Last fall we ran out of that cushion. The reservoirs are depleted so now we are really seeing the impacts of the drought we are in."

The multi-year drought in the Sierra Nevada is taking a toll on the Truckee River. The problem extends throughout Nevada.

Wildlife officials haven't stocked trout Wild Horse Reservoir, a popular northeastern Nevada fishing spot, in two years, said Joe Doucette, regional outdoor education coordinator for NDOW. He said the reservoir came out of winter at 20 percent capacity and is likely to get lower before relief arrives in the form of significant snow or rain. "It will probably continue to be fairly severe," Doucette said. "I suspect Wild Horse will get down below 10 percent of capacity before summer is over, if not even lower."

There's nothing anglers can do to bring more snow to the Sierra Nevada. But they can still improve the odds that Truckee River trout will survive to see another season.

One of the main ways they can help is to avoid fishing during extremely low flows, especially in the afternoon when the water is warm. That's because low water levels force fish to congregate in pools instead of spreading throughout the river.

The concentration of too many fish in small pools combined with low oxygen levels in the warm water make it difficult for the trout to survive. Fishing them out of the water only adds to their misery and increases the likelihood they won't survive the summer.

> "As humans we can be sensitive to the conditions for the fish," said Reno Fly Shop owner Jim Litchfield. "We can voluntarily give them a break from angling pressure when the water temperature gets above 70 degrees."

Anglers can also fish places where there's still sufficient water to maintain the fishery at a healthy level. Litchfield mentioned reservoirs such as Frenchman, Davis and Eagle Lake. He also said streams in Feather, Yuba and American systems could be good spots. "We're going to focus on some of those this summer and lay off the Truckee River," he said.

Guide Mike Sexton, who works at Reno Fly Shop, said it's difficult for anglers to watch the river they love dwindle to a trickle. Sexton, a former member of Fly Fishing Team USA, said the Truckee is among the best rivers he's fished. The rushing waters, boulders and alpine surroundings give it the feel of a classic western trout stream. It's location in the center of a mid-size city adds to the allure. Those factors also make it more difficult for anglers forced to stand by when it's imperiled.

> "It is a special place to fish," Sexton said. "I try not to think about it much because it is kind of depressing."

2012; Mendelsohn and Markowski 2004), although the precise relationship may be specific to the activity or species. Some activities (e.g., big game hunting) may be enhanced by cold temperatures and snowfall at particular times to aid in field dressing, packing out harvested animals, and tracking. Other activities may be sensitive to climate change effects similar to warm-weather activities, in which moderate temperatures and snow- and ice-free sites are desirable.

Warming temperatures projected for the IAP region are expected to increase participation in terrestrial wildlife activities because of an increased number of days that are desirable for wildlife-dependent outdoor recreation. In general, warmer temperatures are associated with higher participation in and number of days spent hunting, bird watching, and viewing wildlife (Bowker et al. 2012). However, hunting that occurs during discrete seasons (e.g., elk and deer hunts managed by State agencies) may depend on weather conditions during a short period of time. The desirability of hunting during established seasons may vary if warmer weather later into fall and early winter alters harvest rates (positively or negatively). This issue is also relevant for outfitters who operate under legal hunting and fishing seasons and may also operate under special-use permits with specific dates and areas. These regulatory constraints could become less aligned with "catch rate" based on climatic conditions.

The effects of changes in habitat for target species are likely to be ambiguous because of complex relationships among species dynamics, vegetation, climate, and disturbances (primarily wildfire and invasive species) (Chapter 8). Overall vegetative productivity may decrease in the future, although this is likely to have a neutral effect on game species populations, depending on the size, composition, and spatial heterogeneity of forage opportunities in the future (chapters 6, 7, 9). Similarly, the effects of disturbances on harvest rates of target species are ambiguous because it is unknown exactly how habitat composition will change in the future.

An interesting context for the future of hunting is an ongoing decrease in hunting participation. For example, in Utah, the number of mule deer permits issued annually has declined from around 100,000 to 80,000 between 1995 and 2015, while elk permits remained relatively constant (Bernales et al. n.d.). Deer and elk populations both increased by about 50 percent over this time. Effects of climate change on both animal populations (Chapter 8) and demand for harvesting animals will shape the overall effects on wildlife-dependent recreation.

Higher temperatures are expected to decrease populations of native cold-water fish species as climate refugia retreat to higher elevations (Chapter 5). This change favors increased populations of fish species that can tolerate warmer temperatures. However, it is unclear whether shifting populations of species (e.g., substituting other fish species for cutthroat trout) will affect catch rates, because relative abundance of fish may not necessarily change.

Increased interannual variability in precipitation and reduced snowpack could cause higher peakflows in winter and lower low flows in summer (Chapter 4), creating stress for fish populations during different portions of their life history (Chapter 5). The largest patches of habitat for cold-water species will be at higher risk of shrinking and fragmentation. Mountain lakes currently used for ice fishing will have a decreased period of time available for this activity. Increased incidence and severity of wildfire may increase the likelihood of secondary erosion events that degrade streams and riparian habitat (Chapter 8). These effects could degrade the quality of individual sites in a given year or decrease the desirability of angling as a recreation activity relative to other activities.

Summary

The magnitude of climate-related effects on activities involving wildlife is expected to be low overall for terrestrial wildlife activities and moderate to severe for fishing, depending on location and fish species. Ambiguous effects of vegetative change on terrestrial wildlife populations and distribution suggest that conditions may improve in some areas and deteriorate in others. Overall warming tends to increase participation, but may create timing conflicts for activities with defined regulated seasons (e.g., big game hunting). Anglers may experience moderate negative effects of climate change on benefits derived from fishing. Opportunities for cold-water species fishing are likely to be reduced as cold-water refugia contract and move to higher elevations and are eliminated in some areas. Cold-water species tend to be high-value targets, suggesting that this habitat change will decrease benefits enjoyed by anglers. Warm-water tolerant species may increasingly provide targets for anglers, mitigating reduced benefits from fewer cold-water species. Warmer temperatures and longer seasons encourage additional participation, but indirect effects of climate on streamflows and reservoir levels could reduce opportunities in certain years. The likelihood of climate-related effects on wildlife activities is expected to be moderate for both terrestrial and aquatic wildlife activities. Uncertainties exist about the magnitude and direction of indirect effects of climate on terrestrial habitat and the degree to which changes in available target species affect participation.

Forest Product Gathering

Forest product gathering accounts for a small portion of primary visit activities in the IAP region, although it is relatively more common as a secondary activity. A small but avid population of enthusiasts for certain types of products supports a small but steady demand for gathering as a recreation activity. Small-scale commercial gathering probably competes with recreationists for popular and high-value products such as huckleberries (*Vaccinium* spp.), although resource constraints may not be binding at current participation levels. In addition, traditional foods (often called first foods) have high cultural value for Native Americans and rural residents. For example, pinyon nuts (seeds within cones) from single-leaf pinyon (*Pinus monophylla*) and twoneedle pinyon (*P. edulis*) are collected in many areas of the IAP region. In recent years, seeds collected from native plants are increasingly used for restoration of native vegetation where nonnative species have become prevalent.

Forest product gathering is sensitive primarily to climatic and vegetative conditions that support the distribution and abundance of target species. Participation in forest product gathering is also akin to warm-weather recreation activities, depending on moderate temperatures and the accessibility of sites where products are typically found. Vegetative change due to warming temperatures and increased interannual variation in precipitation may alter the geographic distribution and productivity of target species (chapters 6, 7). Increased incidence and severity of wildland fires may eliminate sources of forest products immediately after fire, but encourage medium-term productivity for other products (e.g., mushrooms, huckleberries). Long-term changes in vegetation that reduce forest cover may reduce viability of forest product gathering in areas that have a high probability of vegetative transition to less productive vegetation types.

Outdoor recreationists engaged in forest product gathering may be able to select different gathering sites as the distribution and abundance of target species change, although these sites may increase the costs of gathering. Those who engage in gathering as an ancillary activity may choose alternate activities to complement primary activities. Commercial products serve as a market alternative for some forest products such as Christmas trees.

Summary

The magnitude of climate effects on forest product gathering is expected to be low. This activity is among the less common primary recreation activities in the region, although it may be more often engaged in as a secondary activity. Longer warm-weather seasons may expand opportunities for gathering in some locations, although these seasonal changes may not correspond with greater availability of target species. The likelihood of effects on forest product gathering is expected to be moderate, although significant uncertainty exists regarding direct and indirect effects. Vegetative changes caused by climatic changes and disturbances may alter abundance and distribution of target species, but the magnitude and direction of these effects is unclear.

Water-Based Activities (Not Including Fishing)

Apart from angling, water-based activities account for a small portion of primary recreation activity participation on Federal lands. Upper reaches of streams and rivers are generally not desirable for boating and floating. Lakes and reservoirs provide opportunities for both motorized and nonmotorized boating and swimming, although boating may commonly be paired with fishing. Existing stressors include the occurrence of drought conditions that reduce water levels and site desirability in some years, and disturbances that can alter water quality (e.g., erosion events following wildfires).

The availability of suitable sites for non-angling, water-based recreation is sensitive to reductions in water levels caused by warming temperatures, increased variability in precipitation, and decreased precipitation as snow. Reductions in surface-water area are associated with decreases in participation in boating and swimming activities (Bowker et al. 2012; Loomis and Crespi 2004; Mendelsohn and Markowski 2004), and streamflow is positively associated with number of days spent rafting, canoeing, and kayaking (Loomis and Crespi 2004; Smith and Moore 2013). Demand for water-based recreation is also sensitive to temperature. Warmer temperatures are generally associated with higher participation in water-based activities (Loomis and Crespi 2004; Mendelsohn and Markowski 2004), although extreme heat may dampen participation for some activities (Bowker et al. 2012).

River recreation, in particular commercial and private rafting, is vulnerable to the effects of climate change on drought (e.g., low streamflow) (chapters 3, 4) and wildfire (e.g., degraded scenery, reduced access). River rafters prefer mid-season, intermediate water levels and warm weather over turbulent, cold spring runoff or late-season low water (Yoder et al. 2014). A warmer climate will shorten the period of time when desirable conditions are available. High-quality whitewater rafting requires different conditions than floating the river. For example, on the Boise River, the longer period of high flows through town during spring to prevent flooding delays floating season. On rivers such as the Middle Fork of the Salmon, low flows late in the season limit the number of days for whitewater rafting (fig. 10.6). This can be a dilemma in locations where whitewater and family float trips are both popular activities, and outfitters depend on appropriate streamflows for a positive experience (Associated Press 2012). These issues are compounded when threatened and endangered fish species are present, potentially reducing rafting seasons for commercial river outfitters because low streamflow puts salmon redds at risk, in addition to reducing the quality of rafting conditions.

Increasing temperatures, reduced storage of water as snowpack, and increased variability of precipitation are expected to increase the likelihood of reduced water levels and greater variation in water levels in lakes and reservoirs on Federal lands (Chapter 4), both of which are associated with reduced site quality and suitability for certain activities. Increased demand for surface water by downstream users may exacerbate reduced water levels in drought years. Warmer temperatures are expected to increase the demand for water-based recreation as the viable season lengthens, but can also increase undesirable algal blooms (e.g., Hand and Lawson 2018), which are already a problem in Utah streams, lakes, and reservoirs (Penrod 2015). Extreme heat encourages some people to seek water-based activities as a refuge from climatic conditions, although extreme heat also

Figure 10.6—Low water level in the Middle Fork of the Salmon River in Idaho. Low water levels in streams can reduce the quality of whitewater rafting, but can be suitable for floating (photo courtesy of Northwest Rafting Company).

discourages participation in outdoor recreation in general (Bowker et al. 2012). Overall, projections of water-based activities in response to climate change tend to be small compared to the effects of broad population and economic shifts on these activities (Bowker et al. 2012).

Summary

Climate change is expected to have a moderate effect on water-based activities. Increasing temperatures and longer warm-weather seasons are likely to increase demand, although the incidence of extreme temperatures may dampen this effect in certain years. A higher likelihood of lower streamflows and reservoir levels may also offset increased demand to some extent. Climate change effects are expected to occur with moderate likelihood. Climate model projections tend to agree on a range of warming temperatures and longer seasons, although changes in precipitation are uncertain. Changes in the timing of snowmelt may increase the likelihood of negative effects to water-based activities (through lower summer flows and reservoir levels) that offset increased participation levels due to warmer temperatures.

Conclusions

Several recreation activities are considered highly sensitive to changes in climatic and environmental conditions (box 10.3). However, recreation in the IAP region is diverse, and the effects of climate are likely to vary widely between different categories of activities and across geographic areas within the region. Overall, participation in climate-sensitive recreation activities is expected to increase in the region because longer warm-weather seasons will make more recreation sites available for longer periods of time; participation is also expected to increase due to a gradual growth in population. Increased participation in warm-weather activities is likely to be offset somewhat by decreased snow-based winter activities. Receding snow-dominated areas and shorter seasons in the future are likely to reduce the opportunities (in terms of available days and sites) for winter recreation.

Beyond these general conclusions, the details of changes to recreation patterns in response to climatic changes are complex. Recreation demand is governed by several economic decisions with multiple interacting dependencies on climate. For example, decisions about whether to engage in winter recreation, which activity to participate in (e.g., downhill or cross-country skiing), where to ski, how often to participate, and how long to stay for each trip depend to some degree on climatic and environmental characteristics. On the supply side, site availability and quality depend on climate, but the effect may differ greatly from one location to another. Thus, climate effects on recreation depend on spatial and temporal relationships among sites, environmental conditions, and human decisions.

Uncertainty derives from unknown effects of climate on site quality and characteristics that are important for some recreation decisions (e.g., indirect effects of climate on vegetation, wildlife habitat, and species abundance and distribution). The exact effects of climate on target species or other quality characteristics are difficult to predict and are likely to be diverse across the region, yet these characteristics play a large role in recreation decisions for some activities. Another source of uncertainty is how people will adapt to changes when making recreation decisions. Substitution behavior between regions and over time is not yet well understood (Shaw and Loomis 2008; Smith et al. 2016). This may be important for the IAP region if in the future some sites experience relatively little effect from climate change compared with sites in other regions. For example, winter recreation sites in the region may experience shorter or lower quality seasons in the future, but experience increased demand if the quality of sites in other regions becomes relatively worse during the same time period.

Substitution will be an important adaptation mechanism for recreationists. Some popular activities may have several alternate sites, and the timing of visits may be altered to respond to climatic changes. However, spatial and temporal substitution may represent a loss in benefits derived from recreation even if it appears that participation changes little (Loomis and Crespi 2004); the new substitute site may be more costly to reach or lower quality than the preferred visit prior to climate change, although the converse could also be true. This demonstrates the complexity of accounting for benefits to the person engaging in recreation.

References

Albano, C.M.; Angelo, C.L.; Strauch, R.L.; [et al.]. 2013. Potential effects of warming climate on visitor use in three Alaskan national parks. Park Science. 30: 37–44.

Anderson, C.; Taylor, G. 2014. Economic importance of off-highway vehicle recreation: An analysis of Idaho counties. CIS 1195. Moscow, ID: University of Idaho Extension.

Associated Press. 2012. Climate change poses challenges for water managers. News report, May 9, 2012. http://magicvalley.com [Accessed October 2, 2016].

Bark, R.H.; Colby, B.G.; Dominguez, F. 2010. Snow days? Snowmaking adaptation and the future of low latitude, high elevation skiing in Arizona, USA. Climatic Change. 102: 467–491.

Bernales, H.H.; Harvey, K.R.; Shannon, J. [n.d.]. Utah big game annual report 2013. Pub. 14-22. Salt Lake City, UT: State of Utah, Department of Natural Resources, Division of Wildlife Resources.

Bowker, J.M.; Askew, A.E.; Cordell, H.K.; [et al.]. 2012. Outdoor recreation participation in the United States—Projections to 2060: A technical document supporting the Forest Service 2010 RPA assessment. Gen. Tech. Rep. GTR-SRS-160. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 42 p.

Bowker, J.M.; Askew, A.E.; Poudyal, N.C.; [et al.]. 2013. Climate change and outdoor recreation participation in the Southern United States. In: Vose, J.M.; Klepzig, K.D., eds. Climate change adaptation and mitigation management options: A guide for natural resource managers in the southern forest ecosystems. Boca Raton, FL: CRC Press: 421–450.

Bowler, D.E.; Buyung-Ali, L.M.; Knight, T.M.; [et al.]. 2010. A systematic review of evidence for the added benefits to health of exposure to natural environments. BMC Public Health 10: 456.

Clark, R.N.; Stankey, G.H. 1979. The Recreation Opportunity Spectrum: A framework for planning, management, and research. Gen. Tech. Rep. PNW-GTR-098. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 32 p.

Cui, Y.; Mahoney, E.; Herbowicz, T. 2013. Economic benefits to local communities from national park visitation, 2011. Nat. Res. Rep. NPS/NRSS/ARD/NRR-2013/632. Fort Collins, CO: U.S. Department of the Interior, National Park Service.

Dawson, J.; Scott, D.; McBoyle, G. 2009. Climate change analogue analysis of ski tourism in the northeastern USA. Climate Research. 39: 1–9.

Duffield, J.W.; Neher, C.J.; Patterson, D.A.; [et al.]. 2013. Effects of wildfire on national park visitation and the regional economy: A natural experiment in the Northern Rockies. International Journal of Wildland Fire. 22: 1155–1166.

Englin, J.; Moeltner, K. 2004. The value of snowfall to skiers and boarders. Environmental and Resource Economics. 29: 123–136.

Englin, J; Boxall, P.C.; Chakraborty, K; [et al.]. 1996. Valuing the impacts of forest fires on backcountry forest recreation. Forest Science. 42: 450–455.

Englin, J.; Loomis, J.; González-Cabán, A. 2001. The dynamic path of recreational values following a forest fire: A comparative analysis of states in the Intermountain West. Canadian Journal of Forest Research. 31: 1837–1844.

Fisichelli, N.A.; Schuurman, G.W.; Monahan, W.B.; [et al.]. 2015. Protected area tourism in a changing climate: Will visitation at US national parks warm up or overheat? PLoS ONE 10: e0128226.

Gardner Policy Institute. 2016. The state of Utah's travel and tourism industry. Salt Lake City, UT: University of Utah, Kem C. Gardner Policy Institute.

Hamlet, A.F. 2000. Effects of climate change scenarios on ski conditions at Snoqualmie Pass, Stevens Pass, Mission Ridge, and Schweitzer Mountain ski areas. Internal report. Seattle, WA: University of Washington, Joint Institute for the Study of Atmosphere and Oceans, Climate Impacts Group.

Hand, M.S.; Lawson, M. 2018. Effects of climate change on recreation in the northern Rockies region. In: Halofsky, J.E.; Peterson, D.L.; Hoang, L., eds. Climate change vulnerability and adaptation in the Northern Rocky Mountains region. Gen. Tech. Rep. RMRS-GTR-374. Fort Collins, CO: U.S. Department of Agriculture, Rocky Mountain Research Station.

Hay, M.J.; McConnell, K.E. 1979. An analysis of participation in nonconsumptive wildlife recreation. Land Economics. 55: 460–471.

Hesseln, H.; Loomis, J.B.; González-Cabán, A. 2004. The effects of fire on recreation demand in Montana. Western Journal of Applied Forestry. 19: 47–53.

Hesseln, H.; Loomis, J.B.; González-Cabán, A.; [et al.]. 2003. Wildfire effects on hiking and biking demand in New Mexico: A travel cost study. Journal of Environmental Management. 69: 359–368.

Idaho State Parks and Recreation [ISPAR]. 2013. Day use visitation. Boise, ID: Idaho State Parks and Recreation. http://parksandrecreation.idaho.gov/sites/default/files/uploads/documents/Visitation%20Statistics/2013%20Day%20Use%20-%202014-01-15.pdf [Accessed March 4, 2016].

Irland, L.C.; Adams, D.; Alig, R.; [et al.]. 2001. Assessing socioeconomic impacts of climate change on U.S. forests, wood-product markets, and forest recreation. BioScience. 51: 753–764.

Jones, R.; Travers, C.; Rodgers, C.; [et al.]. 2013. Climate change impacts on freshwater recreational fishing in the United States. Mitigation and Adaptation Strategies for Global Change. 18: 731–758.

Klos, P.Z.; Link, T.E.; Abatzoglou, J.T. 2014. Extent of the rain-snow transition zone in the western U.S. under historic and projected climate. Geophysical Research Letters. 41: 4560–4568.

Leaver, J. 2014. The state of Utah's tourism, travel and recreation industry. Utah Economic and Business Review. 3: 1–15

Leung, Y–F.; Smith, J.W.; Miller, A. 2015. Statistical report of state park operations: 2013–2014—Annual information exchange for the period July 1, 2013 through June 30, 2014. Raleigh, NC: North Carolina State University, Department of Parks, Recreation and Tourism Management.

Loomis, J. 1995. Four models for determining environmental quality effects on recreational demand and regional economics. Ecological Economics. 12: 55–65.

Loomis, J.; Crespi, J. 2004. Estimated effects of climate change on selected outdoor recreation activities in the United States. In: Mendelsohn, R.; Neumann, J., eds. The impact of climate change on the United States economy, Cambridge, UK: Cambridge University Press: 289–314.

Loomis, J.; González-Cabán, A.; Englin, J. 2001. Testing for differential effects of forest fires on hiking and mountain biking demand and benefits. Journal of Agricultural and Resource Economics. 26: 508–522.

Loomis, J.B.; Richardson, R.B. 2006. An external validity test of intended behavior: Comparing revealed preference and intended visitation in response to climate change. Journal of Environmental Planning and Management. 49: 621–630.

Matzarakis, A.; de Freitas, C.R. 2001. Proceedings of the first international workshop on climate, tourism, and recreation. Milwaukee, WI: International Society of Biometeorology, University of Wisconsin-Milwaukee.

Mendelsohn, R.; Markowski, M. 2004. The impact of climate change on outdoor recreation. In: Mendelsohn, R.; Neumann, J., eds. The impact of climate change on the United States economy, Cambridge, United Kingdom: Cambridge University Press: 267–288.

Miller, J.R.; Hay, M.J. 1981. Determinants of hunter participation: Duck hunting in the Mississippi flyway. American Journal of Agricultural Economics. 63: 401–412.

Milon, J.W.; Clemmons, R. 1991. Hunters' demand for species variety. Land Economics. 67: 401–412.

Morey, E.R.; Breffle, W.S.; Rowe, R.D.; [et al.]. 2002. Estimating recreational trout fishing damages in Montana's Clark Fork River basin: Summary of a natural resource damage assessment. Journal of Environmental Management. 66: 159–170.

Morris, S.; Walls, M. 2009. Climate change and outdoor recreation resources. Backgrounder Rep. Washington, DC: Resources for the Future.

Mote, P.W.; Casson, J.; Hamlet, A.; [et al.]. 2008. Sensitivity of Northwest ski areas to warming. In McGurk, B., ed. Proceedings of the 75th Western Snow Conference, April 16–19, 2007, Kailua-Kona, Hawaii. Soda Springs, CA: Western Snow Conference: 63–67.

National Park Service [NPS]. 2006. Management policies. Chapter 8. Washington, DC: National Park Service. http://www.nps.gov/applications/npspolicy/index.cfm [Accessed March 4, 2016].

National Park Service [NPS]. 2014. National Park Service visitor use statistics, park reports, 5-year visitation summary, 2010-2014. https://irma.nps.gov/Stats/Reports/Park. [Accessed June 26, 2015].

Penrod, E. 2015. It's not just Utah Lake: Toxic algae plagues 20 waterways, including drinking water sources. The Salt Lake Tribune, August 7, 2015.

Pitts, H.M.; Thacher, J.A.; Champ, P.A.; [et al.]. 2012. A hedonic price analysis of the outfitter market for trout fishing in the Rocky Mountain West. Human Dimensions of Wildlife. 17: 446–462.

Rausch, M.; Boxall, P.C.; Verbyla, A.P. 2010. The development of fire-induced damage functions for forest recreation activity in Alberta, Canada. International Journal of Wildland Fire. 19: 63–74.

Richardson, R.B.; Loomis, J.B. 2004. Adaptive recreation planning and climate change: A contingent visitation approach. Ecological Economics. 50: 83–99.

Scott, D.; McBoyle, G. 2007. Climate change adaptation in the ski industry. Mitigation and Adaptation Strategies for Global Change. 12: 1411–1431.

Scott, D.; Dawson, J.; Jones, B. 2008. Climate change vulnerability of the U.S. Northeast winter recreation-tourism sector. Mitigation and Adaptation Strategies for Global Change. 13: 577–596.

Scott, D.; Jones, B.; Konopek, J. 2007. Implications of climate and environmental change for nature-based tourism in the Canadian Rocky Mountains: A case study of Waterton Lakes National Park. Tourism Management. 28: 570–579.

Shaw, D.; Loomis, J. 2008. Frameworks for analyzing the economic effects of climate change on outdoor recreation and selected estimates. Climate Research. 36: 259–269.

Smith, J.W.; Moore, R.L. 2013. Social-psychological factors influencing recreation demand: Evidence from two recreational rivers. Environment and Behavior. 45: 821–850.

Smith, J.W.; Seekamp, E.; McCreary, A.; [et al.]. 2016. Shifting demand for winter outdoor recreation along the North Shore of Lake Superior under variable rates of climate change: A finite-mixture modeling approach. Ecological Economics. 123: 1–13.

Starbuck, C.M.; Berrens, R.P.; McKee, M. 2006. Simulating changes in forest recreation demand and associated economic impacts due to fire and fuels management activities. Forest Policy Economics. 8: 52–66.

Stratus Consulting. 2009. Climate change in Park City: An assessment of climate, snowpack, and economic impacts. Report prepared for The Park City Foundation. Boulder, CO: Stratus Consulting, Inc. http://www.parkcitymountain.com/site/mountain-info/learn/environment [Accessed March 23, 2015].

Thompson Coon, J.; Boddy, K.; Stein, K.; [et al.]. 2011. Does participating in physical activity in outdoor natural environments have a greater effect on physical and mental wellbeing than physical activity indoors? A systematic review. Environmental Science and Technology. 45: 1761–1772.

USDA Forest Service [USDA FS]. 1990. ROS primer and field guide. Washington, DC: U.S. Department of Agriculture, Forest Service, Recreation staff.

USDA Forest Service [USDA FS]. 2010. Connecting people with America's great outdoors: A framework for sustainable recreation. Washington, DC: U.S. Department of Agriculture, Forest Service. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5346549.pdf [Accessed March 24, 2015].

USDA Forest Service [USDA FS]. 2012a. Future of America's forest and rangelands: Forest Service 2010 Resources Planning Act assessment. Gen. Tech. Rep. WO-87. Washington, DC: U.S. Department of Agriculture, Forest Service, Research and Development.

USDA Forest Service [USDA FS]. 2012b. National Forest System land management planning, 36 CFR Part 219, RIN 0596-AD02. Federal Register. 77: 21162–21276.

USDA Forest Service [USDA FS]. 2016. Future of America's forests and rangelands: Update to the Forest Service 2010 Resources Planning Act assessment. Gen. Tech. Rep. WO-94. Washington, DC: U.S. Department of Agriculture, Forest Service, Research and Development.

USDA Forest Service [USDA FS]. [n.d.]. Calculations of national visitor use monitoring survey data, round 2 (Custer, Bridger-Teton, Gallatin, Shoshone National Forests) and round 3 (Beaverhead-Deerlodge, Caribou-Targhee National Forests). Washington, DC: U.S. Department of Agriculture, Forest Service. http://www.fs.fed.us/recreation/programs/nvum/ [Accessed March 24, 2015].

USDOI Fish and Wildlife Service [USFWS]. 2013. 2011 National survey of fishing, hunting, and wildlife-associated recreation–Idaho. Rep. FHW/11-ID. Washington, DC: U.S. Department of the Interior, U.S. Fish and Wildlife Service.

Wobus, C., Small, E.E., Hosterman, H.; [et al.]. 2017. Projected climate change impacts on skiing and snowmobiling: A case study of the United States. Global Environmental Change. 45: 1–14.

Yen, S.T.; Adamowicz, W.L. 1994. Participation, trip frequency and site choice: A multinomial-Poisson hurdle model of recreation demand. Canadian Journal of Agricultural Economics. 42: 65–76.

Yoder, J.K.; Ohler, A.M.; Chouinard, H.H. 2014. What floats your boat? Preference revelation from lotteries over complex goods. Journal of Environmental Economics and Management. 67: 412–430.