Chapter 9
Effects of Climate Change on Recreation in the Northern Rockies

Michael S. Hand and Megan Lawson

Abstract Recreation has a significant economic impact throughout the Northern Rockies. A warmer climate will generally improve opportunities for warm-weather activities (hiking, camping, sightseeing) because it will create a longer time during which these activities are possible, especially in the spring and autumn "shoulder seasons." However, it will reduce opportunities for snow-based, winter activities (downhill skiing, cross-country skiing, snowmobiling) because snowpack is expected to decline significantly in the future. Recreationists will probably engage in more water-based activities in lakes and rivers in order to seek refuge from hotter summer weather. Higher temperatures may have both positive and negative effects on wildlife-based activities (hunting, fishing, birding) and gathering of forest products (e.g., berries, mushrooms), depending on how target habitats and species are affected.

Recreationists are expected to be highly adaptable to a warmer climate by shifting to different activities and different locations, behavior that is already observed from year to year. For example, downhill skiers may switch to ski areas that have more reliable snow, cross-country skiers will travel to higher elevations, and larger ski areas on federal lands may expand to multi-season operation. Water-based recreationists may adapt to climate change by choosing different sites that are less susceptible to changes in water levels. Hunters may need to adapt by altering the timing and location of hunts. Federal management of recreation is currently not very flexible with respect to altered temporal and spatial patterns of recreation. This can be at least partially resolved by assessing expected use patterns in a warmer climate, modifying opening times of facilities, and deploying seasonal employees responsible for recreational facilities earlier in the year.

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9.1 Introduction

Lands administered by federal agencies and other organizations provide opportunities for outdoor recreation as an important benefit throughout the Northern Rockies. National forests in the U.S. Forest Service (USFS) Northern Region and Greater Yellowstone Area have 13.3 million visits per year; Yellowstone, Grand Teton, and Glacier National Parks have an additional 8 million visits per year (NPS 2014). Recreation opportunities in national forests and national parks are diverse in both type and location, with recreation experiences being largely inseparable from ecosystems and natural features. Natural and ecological conditions help determine the overall recreation experience, regardless of whether it consists of skiing, hiking, hunting, camping, visiting developed sites, exploring the backcountry, or simply a driving tour.

Climatic conditions and environmental characteristics determine the availability of and demand for recreation opportunities (Shaw and Loomis 2008). Changing climate may affect the supply of and demand for recreation opportunities, causing potential changes in visitation patterns, experiences, and benefits in the future. It has been suggested that climate change will increase outdoor recreation participation in general (Bowker et al. 2013), primarily because of increased summer and warm-weather activities outweighing decreased winter activities (Loomis and Crespi 2004; Mendelsohn and Markowski 2004). Variability can be expected both spatially and at seasonal and much longer time scales.

In a warming climate, federal land managers will face a complex and evolving challenge of managing recreation opportunities as ecological conditions and recreational preferences change. Investments in recreation infrastructure and facilities maintenance, and decisions about recreation development contribute to recreational setting and the kinds of recreational opportunities that are available. Federal agencies often classify these opportunities using the Recreation Opportunity Spectrum (ROS), which has been used in planning and management for decades (Clark and Stankey 1979). Recreation visitor behavior and values can be mapped in the ROS, providing managers with information about tradeoffs associated with different types of investments and development (Rosenthal and Walsh 1986; Swanson and Loomis 1996).

Although broad trends in recreation participation under climate change are expected, little is known about how recreation in the Northern Rockies will change. This chapter describes the broad categories of recreation activities that may be sensitive to climate-related changes in the Northern Rockies, using the available scientific literature to infer projected effects of climate change on recreation participation.

9.2 Relationships Between Climate Change and Recreation

Supply and demand for recreation opportunities are sensitive to climate via two general pathways: (1) *direct effects* of altered temperature and precipitation on availability and quality of recreation sites, and (2) *indirect effects* of climate on characteristics and ecological condition of recreation sites (Loomis and Crespi 2004; Mendelsohn and Markowski 2004; Shaw and Loomis 2008) (Fig. 9.1).

Direct effects of altered climate will affect most outdoor recreation activities in some manner, especially for skiing and other snow-based activities that depend on seasonal temperatures and the amount, timing, and availability of snow (Irland et al. 2001; Englin and Moeltner 2004; Stratus Consulting 2009). Warm-weather activities are also sensitive to direct effects of climate change. For example, higher minimum temperatures have been associated with increased national park visits in Canada, particularly during non-peak "shoulder" seasons (Scott et al. 2007). Number of warm-weather days is positively associated with expected visitation for national parks in the United States, although visitation may decline during extreme heat (Richardson and Loomis 2004; Bowker et al. 2012). Temperature and precipitation

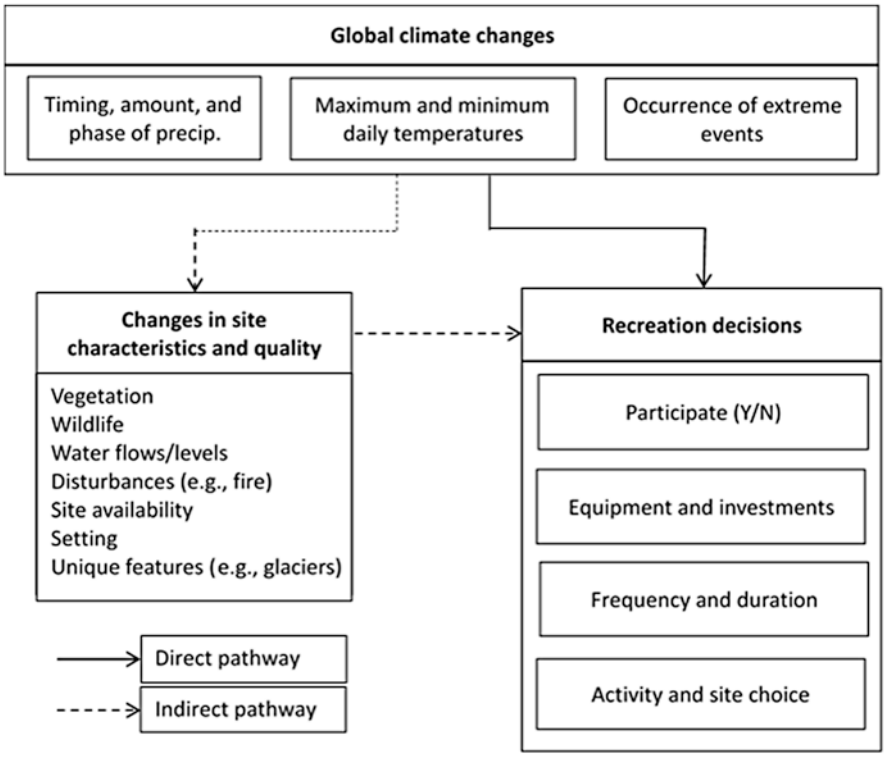

Fig. 9.1 Direct and indirect effects of climate on recreation decisions

will also affect the recreation experience (comfort, enjoyment) (Mendelsohn and Markowski 2004).

Indirect climate effects affect recreation activities that depend on additional ecosystem components, such as vegetation, surface water, and wildlife. Fishing for native cold-water species is expected to decrease as stream temperature increases, especially at lower elevation, where fish habitat will be degraded the most (Jones et al. 2013; Chap. 4). Surface water and streamflows are important for water-based recreation (e.g., boating), and forested area affects several outdoor activities (e.g., camping and hiking) (Loomis and Crespi 2004). Recreation visits to sites with valued natural characteristics (e.g., glaciers, charismatic wildlife species) (Chaps. 3, 8) or scenic qualities may decrease if the quality of those characteristics are threatened (Scott et al. 2007). Indirect effects of climate on disturbances, especially wildfire (Chap. 7), may also affect recreation behavior, although spatial and temporal patterns of recreation response will probably vary across the Northern Rockies (Englin et al. 2001).

9.3 Outdoor Recreation in the Northern Rockies

People participate in a wide variety of outdoor recreation activities in the Northern Rockies. The National Visitor Use Monitoring (NVUM) survey, administered by the USFS to monitor recreation visitation and activity in national forests, identifies 27 recreation activities in which people participate. Visitors are sampled using a stratified random sampling technique designed for assessing use on national forests. Sampling sites are stratified according to type of recreation site and times of day and week. Interviewees are selected at random, and are asked about different categories of travel-related spending within 80 km of the interview site (English et al. 2001). NVUM surveys include 25% of national forests in each region each year, so each unit is re-surveyed every 4 years. In this analysis, we used the most recent data available for each national forest, ranging from 2008 to 2012 (Fig. 9.2).

To assess how recreation patterns may change in the Northern Rockies, we identified categories of outdoor recreation expected to be sensitive to climate change. We defined a recreation activity as sensitive if changes in climate or climate-related conditions would potentially affect demand or supply for the activity. The 27 recreation activities in the NVUM survey were grouped into five climate-sensitive categories of activities, plus an "other" category of activities that are less sensitive to climate changes. Activities that comprise climate-sensitive categories are summarized in Table 9.1. These categories capture the most common types of recreation in public lands that would be affected by climate changes.

These 17 activities identified account for the primary recreation activities of 83% of visits to national forests in the Northern Rockies. Activities in the "Other" category are less sensitive to climate and are less frequently listed as a primary recreation activity. Warm-weather activities are the most popular (35.9% of visitors, 4.8 million per year), including hiking/walking, viewing natural features, developed

Fig. 9.2 Increased extent and severity of wildfires in a warmer climate will create forest conditions that may affect decisions by recreationists about hiking and other recreational activities (Photo courtesy of Dave Pahlas, http://IdahoAlpineZone.com)

and primitive camping, bicycling, backpacking, horseback riding, picnicking, and other non-motorized uses (Table 9.1). Hiking/walking was the most popular for 16.9% of visitors (2.2 million). Snow-based winter recreation was also popular (25% of visitors, 3.3 million), including downhill skiing, cross-country skiing, and snowmobiling. Wildlife-related activities, including hunting, fishing, and viewing wildlife, were the primary activity for 18.5% of visitors (2.5 million); hunting was the most popular with 11% of visitors (1.5 million). Gathering forest products, such as berries and mushrooms, was the primary activity for 2.4% of visitors (300,000). Motorized and non-motorized water activities (other than fishing) comprised 0.7% of visitors (97,000) (Fig. 9.3).

Non-local visitors (who live >50 km from the forest boundary) spent $601 million (in 2014 dollars) per year within 80 km of national forest boundaries (Table 9.2). This represents money spent in local communities that would not have occurred except for the motivation to recreate. Lodging expenses comprise 31% of total expenditures, followed by restaurants (18%), gas and oil (17%), and groceries (12%). Expenditures for other transportation, activities, admissions and fees, and souvenirs comprise 21% of spending.

Table 9.1 Participation in recreational activities in national forests in the Northern Rockies

Activity	Visitors for whom this was their primary activity		Relationship to climate and environmental conditions
	Number	*Percent*	
Warm-weather activities	**4,770,616**	**35.9**	Participation occurs during warm weather, dependent on the availability of snow- and ice-free sites, dry weather with moderate daytime temperatures, and availability of sites where air quality is not impaired by smoke from wildfires.
Hiking/walking	2,248,171	16.9	
Viewing natural features	1,136,245	8.6	
Developed camping	375,174	2.8	
Bicycling	286,707	2.2	
Other non-motorized	265,476	2.0	
Horseback riding	168,175	1.3	
Picnicking	164,638	1.2	
Primitive camping	74,876	0.6	
Backpacking	51,154	0.4	
Winter activities	**3,318,426**	**25.0**	Participation depends on timing and amount of precipitation as snow, and cold temperatures to support snow coverage. These activities are inherently sensitive to climatic variability and interannual weather patterns.
Downhill skiing	1,695,621	12.8	
Snowmobiling	843,778	6.4	
Cross-country skiing	779.027	5.9	
Wildlife activities	**2,452,053**	**18.5**	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 outbreaks) may affect amount, distribution, and spatial heterogeneity of suitable habitat.
Hunting	1,503,520	11.3	
Fishing	708,589	5.3	
Viewing wildlife	240,944	1.8	
Gathering forest products	**313,475**	**2.4**	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)	**96,643**	**0.7**	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 heat refuge during periods of extreme heat.

From USFS (n.d.)

Fig. 9.3 As snowpack decreases, opportunities for cross-country skiing at low elevation (shown in the Beaverhead-Deerlodge National Forest) may be available for shorter periods of time (Photo courtesy of U.S. Forest Service)

9.4 Assessing the Vulnerability of Recreation to Climate Change

The overall effect of climate change on recreation activity is likely to be an increase in participation and increase in the benefits derived from recreation. This is because warmer temperatures and increased season length will facilitate warm-weather activities, outweighing decreased winter activities that depend on snow and cold temperatures (Mendelsohn and Markowski 2004). However, these general findings obscure variation in recreation between types of activities and geographic locations. Here we assess the projected effects of climate on climate-sensitive recreation activities in the Northern Rockies, based on (1) reviews of existing studies of climate change effects on recreation and studies of how recreation behavior responds to

Table 9.2 Total annual expenditures by visitors to national forests in the Northern Rockies

	Non-local spending[a]		Local spending	
	Total annual expenditures	Spending per category	Total annual expenditures	Spending per category
Spending category	*Thousands of $*	*Percent*	*Thousands of $ (2014)*	*Percent*
Lodging	*(2014)*185,355	31	14,743	6
Restaurant	109,743	18	29,618	13
Groceries	74,003	12	44,886	19
Gasoline, oil	104,319	17	78,880	34
Other transportation	3013	1	1059	0
Activities	36,376	6	14,195	6
Admissions, fees	39,482	7	19,103	8
Souvenirs	48,839	8	28,075	12
Total	601,128		230,562	

From USFS (n.d.)
[a]Non-local refers to trips that required traveling more than 80 km

Fig. 9.4 Algal blooms (shown in Hayden Lake, Idaho) may be more common in a warmer climate, creating undesirable conditions for water-based recreation (Photo courtesy of Idaho Department of Environmental Quality)

climate-sensitive ecological characteristics, and (2) projections of climate-related biophysical changes described in other chapters in this volume (Fig. 9.4).

9.4.1 Current Conditions and Management

Public lands in the Northern Rockies provide an abundance and variety of recreational options, with opportunities for people of all interests and abilities. Opportunities range from high-use developed sites near urban areas and popular tourist destinations, to remote wilderness and seldom-used sites far from paved roads. Facilities and services vary; some sites are developed with modern amenities and staffed by agency employees, and others have little evidence of human influence other than a trailhead.

Wide variation in intra-annual and interannual weather and ecological conditions are normal, including broad variation in temperature, precipitation, water flows and levels, wildlife distributions, vegetative conditions, and wildfire activity. Most recreationists are already accustomed to making decisions about participating in recreation activities that incorporate a significant degree of uncertainty about conditions at different time scales (e.g., planning for a hike next week vs. planning for a ski trip next winter). Social factors, biogeographic conditions, and stressors all affect recreation in the Northern Rockies. Increased population, particularly in proximity to public lands, can strain visitor services and facilities due to increased use, and projected population increases in the future may exacerbate these effects (Bowker et al. 2012). Increased use caused by population growth can also reduce site quality because of congestion or damage at popular sites (Yen and Adamowicz 1994). Changes in land use may alter access to public lands, contribute to fragmentation of landscapes and habitat, and potentially alter disturbance regimes that affect recreation activities.

The physical condition of recreation sites and natural resources is dynamic, with variation caused by both 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 (USFS 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 also affect recreation opportunities. For example, wildfire affects recreation demand as related to site quality and characteristics, but can also damage physical assets or exacerbate other natural hazards such as erosion (Chaps. 3, 11).

Recreation is an important component of the broader mission of public land management in the Northern Rockies. For lands managed by the USFS, sustainable recreation is a guiding principle for planning and management, seeking to "sustain and expand benefits to America that quality recreation opportunities provide" (USFS 2010, 2012b). Recreational resources are managed to connect people with natural resources and cultural heritage, and to adapt to changing social needs and environmental conditions.

9.4.2 Warm-Weather Activities

Warm-weather activities are the most common recreation activities in national forests and national parks in the Northern Rockies, comprising over one-third of all visits. Warm-weather recreation is sensitive to the length of appropriate season, depending on availability of snow- and ice-free trails and sites, and the timing and number of days having temperatures within minimum and maximum comfortable range (which may vary with activity type and site). The number of warm-weather days is a significant predictor of expected visitation behavior (Richardson and Loomis 2004), and studies of national park visitation show that minimum temperature is a strong predictor of monthly visitation patterns (Scott et al. 2007).

Participants are also sensitive to site quality and characteristics, such as the presence and abundance of wildflowers, trail conditions, and vegetation (e.g., cover for shade, wildfire effects). The condition of unique features that are sensitive to climate changes (e.g., glaciers) affects the desirability of certain sites (Scott et al. 2007). Forested area is positively associated with warm-weather activities, such as camping, backpacking, hiking, and picnicking (Loomis and Crespi 2004), and is sensitive to a warmer climate (USFS 2012a).

Wildfire can affect participation in warm-weather activities through changes to site quality and characteristics. The presence of burned forest areas can have different effects on the value of hiking trips (positive) and mountain biking (negative), although recent wildfire activity tends to decrease the number of visits (Englin et al. 2001; Loomis et al. 2001; Hesseln et al. 2003, 2004). High-severity fires are associated with decreased visitation, whereas low-intensity 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) that are attenuated over time. Visitation in Yellowstone National Park tends to be lower following months with high wildfire activity, although there is no discernable effect of previous-year fires (Duffield et al. 2013). Potential increases in the likelihood of extreme wildfire activity may reduce demand for warm-weather activities in certain years because of degraded site conditions, impaired air quality from smoke, and limited site access during and after fire management activities.

Demand for warm-weather activities is expected to increase because of a direct effect of warmer climate on season length, resulting in earlier availability of snow- and ice-free sites and an increase in the number of warm-weather days in spring and autumn. For example, higher minimum temperatures are associated with increased number of hiking days (Bowker et al. 2012). More extreme summer temperatures can dampen participation during the hottest weeks of the year, and extreme-heat scenarios for climate change are expected to reduce visitation (Richardson and Loomis 2004; Bowker et al. 2012). The temperature that is considered “extreme” may vary between individuals and chosen activities. Extreme heat may shift demand to cooler weeks at the beginning or end of the warm-weather season, or shift demand to sites that are less exposed to extreme temperature (e.g., higher elevations).

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 may decrease even if substitute activities or sites are available (Loomis and Crespi 2004). Access to alternative sites may involve higher costs (because of remoteness or difficulty of terrain) or higher congestion if demand is concentrated among fewer desirable locations. Although the ability of recreationists to substitute sites and activities is well established, it is unclear how people substitute across time periods or between large geographic regions (e.g., choosing a site in the Northern Rockies instead of the Northwest) (Shaw and Loomis 2008).

9.4.3 Cold-Weather Activities

Winter recreation sites in the Northern Rockies contain a wide range of characteristics, attracting local, national, and international visitors. Several sites support developed downhill skiing and snowboarding operated by special-use permit on lands administered by the USFS. Sites for cross-country skiing, snowshoeing, and snowmobiling are generally maintained directly by the USFS, and national parks also provide access for these activities.

Snow-based recreation is very sensitive to variations in temperature and the amount and timing of snow. Seasonal patterns of temperature and snowfall determine the viability and length of recreation seasons (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). Indirect effects of climate, such as changes in scenery and unique features may affect winter recreation, but are expected to be relatively small.

Climate change will have negative effects on snow-based winter activities in the Northern Rockies, although effects will vary by site and especially by elevation. Warmer projected winter temperature for the region will reduce the proportion of precipitation as snow, even if total precipitation does not differ from historical amounts (Chap. 3). The rain-snow transition zone will move to higher elevations, particularly in late autumn and early spring (Klos et al. 2014), putting lower elevation sites at risk of shorter or non-existent winter recreation seasons. The highest elevation areas in the region are expected to remain snow-dominated through the end of the twenty-first century.

Studies of the ski industry in North America uniformly project negative effects of climate change (Scott and McBoyle 2007). Overall warming will reduce season length and likelihood of reliable winter recreation seasons. Climatological projections for the Northern Rockies (Chap. 2) are consistent with studies of ski area vulnerability to climate change in other regions, where projected effects of climate change on skiing, snowboarding, and other snow-based recreation activities is negative (Scott et al. 2008; Dawson et al. 2009; Stratus Consulting 2009).

Snow-based recreationists in the Northern Rockies have moderate capacity to adapt to changing conditions, because many winter recreation sites exist in the region. For minimally developed site activities (cross-country skiing, backcountry skiing, snowmobiling, snowshoeing), recreationists may seek higher elevation sites where snow is more likely to persist. Downhill skiing sites are fixed improvements, although potential adaptations include snowmaking, higher elevation development, and new run development (Scott and McBoyle 2007). Warmer temperature and higher precipitation as rain may increase availability of water for snowmaking in the near term, but warmer temperature also reduces the number of days when snowmaking is possible.

The Northern Rockies may have a comparative advantage in a warmer climate if the duration of snow-based recreation is longer than in other regions. In that case, recreationists may view recreation sites in the Northern Rockies as a substitute for other regions (e.g., the Southwest), although inter-regional substitution patterns are unclear (Shaw and Loomis 2008). Increased inter-regional substitution combined with shorter seasons may result in concentrated demand at fewer sites on fewer days, creating potential congestion.

9.4.4 Wildlife Activities

Wildlife recreation activities involve terrestrial or aquatic animals as a primary component of the recreation experience. Wildlife recreation can involve consumptive (e.g., hunting) or non-consumptive (e.g., wildlife viewing, birding, catch-and-release fishing) activities, and depend on distribution, abundance, and population of target species. These factors influence "catch rates," that is, the likelihood of catching or seeing an individual of the target species. Sites with higher catch rates can reduce costs associated with a wildlife activity (time and effort tracking targets), enhancing enjoyment of recreation (e.g., more views of a valued species).

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

The availability of highly valued targets affects benefits derived from wildlife activities (e.g., cutthroat trout [*Oncorhynchus clarkii*] for cold-water anglers) (Pitts et al. 2012), as does species diversity for hunting (Milon and Clemmons 1991) and non-consumptive activities (Hay and McConnell 1979). Temperature and precipitation are related to general trends in participation (Mendelsohn and Markowski 2004; Bowker et al. 2012), although the precise relationship may be specific to activity and species. For example, hunting for deer and elk (*Cervus elaphus*) is

enhanced by cold temperatures and snowfall to aid in tracking, field dressing, and packing out animals.

Warmer temperature is expected to increase participation in terrestrial wildlife activities in the Northern Rockies because more days will be available for recreation. This concurs with previous documentation that hunting, birding, and viewing wildlife are associated with warmer weather (Bowker et al. 2012). However, hunting that occurs during discrete seasons may depend on weather conditions during a short period of time, and desirability of hunting may decrease if warmer weather reduces snow cover at specific times.

Habitat for target species is a function of interactions among species dynamics, vegetation, and disturbances, making it difficult to project the effects of climate change on habitat in complex landscapes. Although vegetative productivity may decrease in the future, effects on hunted species populations may be neutral, depending on size, composition, and spatial heterogeneity of vegetation used as forage (Chap. 8). The effects of disturbances on target species harvest rates will vary considerably depending spatial and temporal patterns of post-disturbance vegetation and on animal species requirements.

Higher temperatures will decrease populations of native cold-water fish species as climate refugia retreat to higher elevations (Chap. 4), with potential increases in (nonnative) fish species that can tolerate warmer temperatures. However, it is unclear if shifting populations of species (e.g., substituting rainbow trout [*O. mykiss*] for cutthroat trout) will affect catch rates because relative abundance of fish may not change. Higher interannual variability in precipitation, extreme drought, and reduced snowpack could lead to higher peakflows in winter and lower low flows in summer, creating stress for fish populations. Increased incidence and severity of wildfire may increase the likelihood of erosion that degrades aquatic habitat, degrading the quality of individual streams and potentially reducing the desirability of angling as compared to other activities.

9.4.5 Gathering Forest Products

Gathering forest products for recreational purposes accounts for a small portion of primary recreational activities in the Northern Rockies, although it is more common as a secondary activity (e.g., as part of day hike). Forest products are also important for cultural and spiritual uses. An avid population of enthusiasts for certain types of products supports a small but steady demand for gathering activities. Small-scale commercial gathering competes with recreationists for popular and high-value products such as huckleberries (*Vaccinium* spp.) in some locations.

Forest product gathering is sensitive to climatic and vegetative conditions that support the distribution and abundance of target species. Participation is comparable to warm-weather recreation, depending on moderate temperatures and accessibility of target sites. Vegetative change and increased interannual variation in precipitation may alter the geographic distribution and productivity of target species

(Chaps. 5, 6). Increased wildfires may eliminate sources of forest products in some locations (e.g., berries), but in some cases may encourage short- or medium-term productivity for other products (e.g., mushrooms). Long-term changes that reduce forest cover may decrease viability of gathering in areas that transition to less productive vegetation.

Recreationists engaged in forest product gathering may be able to select different gathering sites as the distribution and abundance of target species changes, although tradeoffs may exist, such as increased travel and expense. Those who engage in gathering as a secondary activity can select alternate activities to complement primary activities. The magnitude of climate effects on forest product gathering is expected to be low—it is generally not a primary activity, and users may be able to substitute other sites or activities without much loss in recreational value. Longer warm-weather seasons may increase opportunities for gathering, although these changes may not correspond with greater availability of target species. The likelihood of effects is expected to be moderate, although significant uncertainty exists regarding direct and indirect effects on forest product gathering.

9.4.6 Water-Based Activities (Not Including Fishing)

Apart from angling, water-based activities are a small portion of primary recreation activity participation on federal lands. Lakes and reservoirs provide opportunities for both motorized and non-motorized boating and swimming, although boating is commonly 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 following wildfires).

Availability of desirable locations for water-based recreation is sensitive to reduced water levels caused by warming temperatures, increased variability in precipitation (including severe droughts), and decreased precipitation as snow. Lower water levels may also have an indirect effect on the aesthetic qualities of some water-based recreation sites (e.g., exposure of "bathtub rings" at reservoirs with low water levels). Reduced surface-water area is associated with less participation in boating and swimming (Loomis and Crespi 2004; Mendelsohn and Markowski 2004; Bowker et al. 2012), and streamflow is positively associated with number of days spent rafting, canoeing, and kayaking (Loomis and Crespi 2004). Warmer temperature is also generally associated with higher participation in water-based activities (Loomis and Crespi 2004; Mendelsohn and Markowski 2004), although extreme heat may reduce participation (Bowker et al. 2012).

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 lake levels on federal lands (Chap. 3), which is associated with reduced site quality and suitability for some activities. Increased demand for surface water by downstream users may exacerbate low water levels in drought years. Warmer temperatures are expected to increase demand for water-based

recreation as the viable season lengthens, and although extreme heat encourages some people to seek water-based activities to cool off, it can also discourage 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 (Bowker et al. 2012).

9.4.7 Summary

Several recreation activities in the Northern Rockies are considered sensitive to direct effects of a warmer climate and indirect effects on site conditions and extreme events (including disturbances) (Table 9.3). However, recreation activities are diverse, and the effects of climate will vary widely between different activities and across geographic areas within the region. Overall, participation in recreation activities is expected to increase, primarily because longer warm-weather seasons will

Table 9.3 Summary of climate change assessment for recreation in the Northern Rockies, where positive (+) and negative (−) signs indicate expected direction of effect on overall benefits derived from recreation activity

Activity	Magnitude of climate effect	Likelihood of climate effect	Direct effects	Indirect effects
Warm-weather activities	Moderate (+)	High	Warmer temperature (+), higher likelihood of extreme temperatures (−)	Increased incidence, area, and severity of wildfire (+/−), increased smoke from wildfire (−)
Snow-based winter activities	High (−)	High	Warmer temperature (−), reduced precipitation as snow (−)	
Wildlife activities	Terrestrial wildlife: low (+); fishing: moderate (−)	Moderate	Warmer temperature (+), higher incidence of low streamflow (fishing -), reduced snowpack (hunting -)	Increased incidence, area, and severity of wildfire (terrestrial wildlife +/−), reduced cold-water habitat, incursion of warm-water tolerant species (fishing -)
Gathering forest products	Low (+/−)	Moderate	Warmer temperature (+)	More frequent wildfires (+/−), higher severity wildfires (−)
Water-based activities (not including fishing)	Moderate (+)	Moderate	Warming temperatures (+), higher likelihood of extreme temperatures (−)	Lower streamflows and reservoir levels (−)

make more recreation sites available for longer periods of time. Increased participation in warm-weather activities will probably be offset to some extent by decreased snow-based activities. Receding snow and shorter seasons in the future will reduce the number of available days and sites for winter recreation.

Recreation demand is governed by several economic decisions with interacting dependencies on climate. For example, decisions on whether to engage in winter recreation, activity type (e.g., downhill vs. cross-country skiing), location, frequency of participation, and duration of stay per trip depend on climatic and ecological characteristics of recreation sites. Climatic effects on recreation depend on spatial and temporal relationships between sites, as well as on biophysical conditions, and human decisions.

The exact effects of climate on recreation sites and target species will be difficult to predict across the Northern Rockies, although these effects will play a role in recreation decisions for some activities. The adaptation response of recreationists is also uncertain, because inter-regional and inter-temporal substitution behavior is poorly understood (Shaw and Loomis 2008), although substitution will almost certainly be an important consideration. Many popular activities have several alternate sites, or timing of visits can be altered in response to a warmer climate. However, substitution may lead to reduced benefits if the alternate sites are more difficult or costly to access, or provide a lower quality recreational experience.

9.5 Adapting Recreation and Recreation Management to Climate Change

9.5.1 Adaptation by Recreation Participants

For the most part, warm-weather recreationists will benefit from a warmer climate through a longer recreation season, and will not need to adapt significantly. If extreme heat becomes more common, they have the option of selecting alternate sites at higher elevation or perhaps near water. Increasing temperatures will have significant negative effects on snow-based recreation, reducing season length and possibly snow quality. Many skiers will have the option of going to other ski areas (downhill skiing) or sno-parks (cross-country skiing) that have suitable snow, requiring them to be aware of local conditions and often be willing to travel farther.

Water-based recreationists may adapt to climate change by choosing different sites that are less susceptible to changes in water levels (e.g., by seeking higher-elevation natural lakes) and changing the type of water-based recreation activity (e.g., from motorized boating on reservoirs to non-motorized boating on natural lakes).

Hunters may need to adapt by altering the timing and location of hunts. However, state rules on hunting season dates impose a constraint on this behavior unless states change hunting seasons based on expected climate changes. Hunters may also target different species if the abundance or distribution of preferred species changes.

Wildlife viewers may change the timing and location of viewing experiences and target different species. They have more flexibility than hunters to shift timing to coincide with appropriate weather conditions or species movements. Anglers may adapt by choosing different species to target (e.g., shifting from cold-water to warm-water species) and choosing sites that are less affected by higher temperatures (e.g., higher-elevation streams). The former is less costly, although some anglers may place a high value on certain target species and have a lower willingness to target warm-water species.

9.5.2 Adaptation by Federal Land Management

Resource managers may need to reconsider how infrastructure investments and availability of facilities align with changing ecological conditions and demands for recreation settings. The ROS can be used to match changing conditions and preferences with available opportunities. Adaptation may include responding to changing recreation patterns, but also helping to shape the settings and experiences available to recreationists on public lands.

Recreation managers have options for responding to changing patterns in warm-season recreation demand in order to provide sustainable recreation opportunities. A critical first step will be to assess changing patterns of use, then adjust as necessary to increase capacity of recreation sites with higher use (e.g., campgrounds can be enlarged, more signs and gates can be installed). Some adjustments may be driven by increased congestion and resource damage, although expansion may be limited in locations that have environmental constraints (e.g., USFWS 2013). Timing of trail closures, food storage orders, and special-use permits may need to be adjusted to ensure sustainable recreation programs. For example, the season for whitewater rafting permits may need to be modified in response to altered streamflows.

A general adaptation strategy for winter recreation is to transition recreation management to address shorter winter recreation seasons and changing recreation use. There may be opportunities to expand facilities into areas of concentrated use. In addition, snow-based recreation can be diversified to include more snowmaking, additional ski lifts, and higher-elevation runs. Adaptation tactics related to supply and quality of winter recreation could result in tradeoffs with other activities, including warm-weather access to high-elevation sites or effects of snowmaking on streamflow.

Increased frequency of disturbances (fire, flooding) have the potential to cause increased damage to infrastructure associated with recreation activities. Recreation sites can be managed to decrease risks to public safety and infrastructure. Assessments can be used to determine which sites and infrastructure are most at risk from disturbance, and strategic investments can be made to ensure that facilities are sustainable in the future and accommodate changing use.

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