Journal of Park and Recreation Administration VOL. 36 ▪ pp. 97–120 ▪ 2018
https://doi.org/10.18666/JPRA-2018-V36-I2-8316

Special Issue

Impacts of Climate Change on Outdoor Recreation Participation: Outlook to 2060

Ashley E. Askew
J. M . Bowker

Abstract

Natural resource managers and planners must consider outdoor recreation's long-run response to shifting population density, sociodemographic factors, land uses, and climate change. Projected rises in greenhouse gases imply changing minimum/maximum temperatures, potential evapotranspiration, and precipitation. The strong link between natural resource conditions and outdoor recreation suggests that long- and short-term recreation planning requires knowledge of which activities and settings will be impacted by climate change. Climate change response is principally an adaptation strategy, as climate cannot be directly managed like park access. Effective planning requires that adaptation or mitigation strategies should be considered for activities and implemented in advance.

We used a two-step approach. The estimation step yielded models of adult participation rates and days-per-participant by activity at regional and national levels. The simulation step combined models with external projections of explanatory variables at 10-year intervals to 2060. Estimates of per capita participation and days-of-participation were combined with population projections to estimate participants and participant-days by activity. Regional and national projections through 2060 were made under three 2010 Resources Planning Act (RPA) Assessment scenarios, varying in population growth rates, socioeconomic conditions, and land uses. Adding in a climate

---

Ashley E. Askew is a postdoctoral research associate with Warnell School of Forestry and Natural Resources at the University of Georgia.

J. M. Bowker is a research social scientist with the USDA-Forest Service, Southern Research Station.

Please send correspondence to Ashley Askew, aaskew@uga.edu

variable generated a second set of projections, accounting for changing temperature, precipitation, or potential evapotranspiration. Nested models allowed comparing the results with and without the climate change, the primary focus of this paper.

Climate change impacts within each scenario were computed using the differences in participation and consumption metrics with and without climate effects, expressed as a percentage relative to 2008 baselines. This computation included the magnitude of change between the 2060 futures with and without climate change, as well as impacts relative to the baseline. A range of plausible climate-related shifts in participation and consumption was created by collapsing scenarios and climate models by activity. We focused on sensitivity to climate change, as projections of activity participation and consumption are already detailed elsewhere (Bowker et al., 2012; Bowker et al., 2013; Bowker & Askew, 2013; Bowker & Askew, 2014).

Recreation will respond differently to warmer futures, increasing potential evapotranspiration, and mixed precipitation outlooks by activity, location, and for participation versus consumption. Snowmobiling and undeveloped skiing (cross-country skiing and snowshoeing) were the most negatively affected by climate change. Participation in horseback riding on trails could increase. Horseback riding days-of-participation could see negative climate impacts nationally. Participation and days-of-participation for both fishing and motorized water activities in the North should increase. Climate change in the Rocky Mountain region will negatively impact motorized water activities, hunting, and fishing, while swimming should be affected positively. The Pacific Coast region shows the most stability, with either small climate-induced shifts or wider ranges which are ambiguous.

Keywords

Resources Planning Act, outdoor recreation, climate change, participation, consumption, National Survey on Recreation and the Environment, projections, simulation

Introduction

Most feel that long-term climate change will affect outdoor recreation. A few research and magazine articles have speculated about the relationship, which could go beyond factors such as opportunities and participation. For example, recreationist spending generates billions in economic impacts. Where recreation spending is a large share of the economy, as in rural communities, climate-induced changes in economic impacts will be significant.

Walls et al. (2009) assert that the paramount challenge to recreation supply will be mitigating the adverse effects of climate change, particularly in coastal areas and on western public lands. Thus, understanding more about climate change and recreation would help communities and land managers in formulating mitigation and adaptation strategies. Morris and Walls (2009) assert that managers should maintain future outlooks, especially with natural elements susceptible to climate change. Brice et al. (2017) emphasize that climate change dialogues include recreation, given the relationship among recreation, natural areas, and climate. Adaptation or mitigation strategies can be implemented before resources—and therefore recreation opportunities—are affected by climate change. Federal agencies planning for sustainable recreation (e.g., the Forest Service) benefit from research addressing climate change impacts for mitigation and adaptation initiatives (Brice et al., 2017).

Key questions facing planners and managers are: (1) how climate change will impact demand for outdoor recreation, (2) which activities will be most impacted, and (3) whether certain places (regional or state level) will face higher impacts than others. Addressing these questions for 17 activities, we established climate-static baseline participation and consumption projections across a range of futures. Next, we added a climate variable to each model and compared results to baselines. Results are presented for four RPA regions and the nation. Implications and suggestions for managers and planners are included.

Outdoor Recreation and Climate Change

Recreation participation models fall into three classes: site-specific user models, site-specific aggregate models, and population-level models. Cicchetti (1973) pioneered cross-sectional population-level models using the 1965 National Survey of Recreation to estimate annual participation and use for outdoor recreation activities. Models were combined with U.S. Census Bureau projections to project participation and consumption to 2000. This approach has since been used to model and project participation and use for activities at regional and national levels (Bowker, 2001; Bowker et al., 1999; Hof & Kaiser, 1983a, 1983b; Leeworthy et al., 2005; Walsh et al., 1992). Alternatively, population data have been combined with individual site-level data to project participation or consumption (Bowker et al., 2006; Cordell & Bergstrom, 1991; Cordell et al., 1990; Englin & Shonkweiler, 1995; English et al., 1993). Bowker et al. (2012) used the National Survey on Recreation and the Environment (NSRE) dataset (USDA Forest Service, 2009) to model national outdoor recreation participation rates and annual days-of-participation for 17 activities. Additionally, Bowker et al. (2012) factored in a climate proxy to assess climate change scenarios. Generally, climate change had minor negative effects on recreation participation but induced dramatic downturns for snowmobiling and undeveloped skiing (USDA Forest Service, 2012).

Mendelsohn and Markowski (1999) indicated direct and indirect climate effects on recreation, including severe weather affecting physical comfort, varying season lengths, and alterations to natural resource settings. Many expect the impacts of climate change on outdoor recreation to be negative, but Gregory (2011) argued the opposite for adventure recreation and that rising temperatures could open new opportunities worldwide.

Research linking climate change and outdoor recreation can be broadly classified as either individual survey-based or aggregate modeling studies. The individual survey approach has focused on a specific activity, a limited area, or both. Ahn et al. (2000) conducted a survey in North Carolina to determine trout fishing behavior response to declining habitat under global warming, finding significant welfare loss. Richardson and Loomis (2004) surveyed summer tourists at Rocky Mountain National Park to relate potential climate scenarios and anticipated recreation trips, finding significant increases in visitation under all climate change scenarios. Lise and Tol (2002) found that with global warming, tourists would alter their holiday patterns in Europe, with effects varying by age and income.

Individual survey-based approaches elicit perceptions of climate change and stated behavior under contingent climate scenarios. Using survey data for modeling has limitations: (1) respondents may remember the annual number of trips or days spent in an activity/location, but may not remember weather conditions for all those days; (2) even when the survey explains future climate scenarios, responses are hypothetical; and (3) linking individual surveys with regional climate data generally mismatches measurements (e.g., individual trip data versus state- or county-level climate data). Thus, an indirect approach to demand modeling, which measures observed participation and climate data on a seasonal basis for specific areas, can contribute useful information.

A few studies used aggregate visitation modeling to evaluate the impacts of climate change on outdoor recreation. Wake et al. (2006) combined annual time-series skiing and snowmobiling days data with weather data (snow cover days, snowfall, winter temperature) to estimate a negative relationship with temperature, implying that warming negatively impacts winter recreation. Mendelsohn and Markowski (1999) used state-level data for the conterminous 48 states to find mixed effects from temperature and precipitation on outdoor recreation, while predicting an overall welfare gain. Loomis and Crespi (1999) examined state-level data on total park visits and rounds of golf played in relation to climate variables, finding that many activities would be negatively affected by climate change, though golf and freshwater recreation would be positively affected.

Climate-induced changes in the environment affect the quality of recreation settings (Brice et al., 2017). Leones et al. (1997) considered river recreation impacts on a regional economy in the Southwest, translating the impacts of sufficient streamflow on the local economy through modeling and simulation. Frisvold, Ma, and Ponnaluru (2011) simulated the impacts of changing resource conditions (i.e., increasing long-term average temperature and reduced lake surface area) on visitation and local economic impacts. The same authors assessed the efficacy of a carbon tax on gasoline prices as a mitigation policy. For ski operations facing potentially warmer futures and higher precipitation variability, Bark and Colby (2011) assessed the economics of snowmaking as an adaptation. Another opportunity for collaboration toward mitigation and planning is on federally managed public lands, which currently provide ample opportunities for recreation at varying scales (Brice et al., 2017). For example, the Forest Service and National Park Service can strategize for recreation sustainability under climate change through continuing research and improving collaborations among agencies at multiple scales (Brice et al., 2017).

In this paper, we quantify how outdoor recreation responds to climate change in the long run. Previous phases of this research (e.g., Bowker et al., 2012; Bowker et al., 2014; Bowker & Askew, 2013) examined two participation and two consumption measures, without and with climate change, for activities nationally and regionally. In our focus on climate, we quantify the differences in projected measures with and without climate effects in the models, expressing the impacts relative to 2008 (baseline) levels. We discuss management implications for four RPA Assessment regions and the nation. Agencies charged with sustaining or improving outdoor recreation may apply the results directly or, if the resources are available, conduct their own analyses (e.g., at the state level) using the same methodology.

Resources Planning Act (RPA) Assessment and Regions

The 2010 RPA Assessment was the fifth assessment mandated by the 1974 Forest and Rangeland Renewable Resources Planning Act (P.L. 93-378, 88 Stat 475, as amended). The Assessment provides analytics, every 10 years, on the status, trends, and projected future of the nation's renewable resources. The Assessment has a long-term perspective, using 50-year projections for forests, rangelands, wildlife and fish, biodiversity, water, and outdoor recreation, as well as climate change effects. Analyses explore trends and drivers of change relevant for management and planning, at regional and national levels.

There are nine Forest Service administrative regions for national forests and grasslands (Figure 1). The RPA Assessment uses four regions, each comprised of one or more Forest Service regions: North, South, Rocky Mountain, and Pacific Coast regions (Figure 2). Assessment studies by regions are consistent across research areas, from forest inventory to outdoor recreation. Regional groupings are important for climate considerations. For instance, Assessment projections for the South exclude winter activities, due to historical conditions and increasingly warmer futures (Bowker et al., 2014).

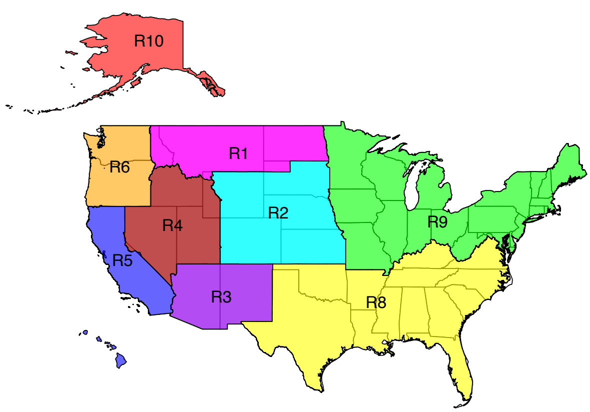

Figure 1. Forest Service administrative regions.

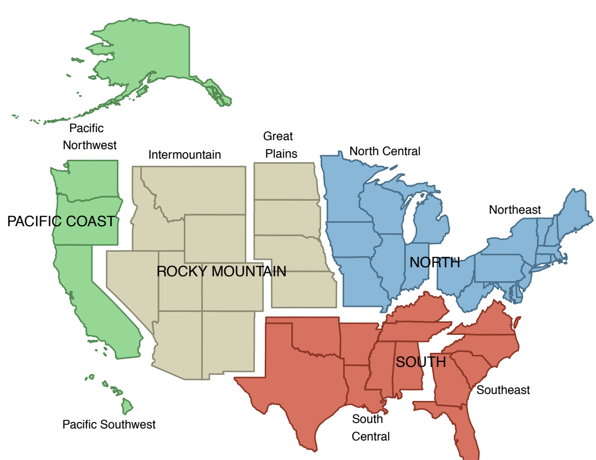

Figure 2. RPA regions and sub-regions

RPA Future Scenarios: Supply and Climate

Drivers affecting future renewable resource conditions include personal preferences, population, economic conditions, land use change, and climate. Recreation participation and use projections to 2060 incorporate a set of futures with varying economic and ecological conditions, including climate. These projections provide a framework wherein managers and legislators can evaluate equilibrium quantities (participants and participant-days) responding to supply and demand conditions. The Assessments cover plausible ranges of future resource conditions and climate changes regionally and nationally. The outlooks under static and changing climate conditions can indicate activities potentially most sensitive to climate change.

Comprehensive global scenarios from the Intergovernmental Panel on Climate Change (IPCC) Third Assessment (TAR) and Fourth Assessment (AR4) provide context and linkages between national and global trends. The IPCC scenarios provided a spectrum of futures from which to derive those for the United States (USDA Forest Service, 2012). RPA scenarios describe national, regional, and county-level futures linked to globally consistent IPCC assumptions and projections of population growth, economic growth, bioenergy use, and climate (Alcamo et al., 2003; IPCC, 2007; Nakićenović et al., 2000). IPCC global data were scaled to national, regional, and county levels to facilitate analyses (USDA Forest Service, 2010; Zarnoch et al., 2010).

The scenarios, like the climate projections in Joyce et al. (2014), are possible future outcomes rather than "predictions" (p. 68). No scenario is considered more likely than another. We retained the designations used in the IPCC Third and Fourth Assessments. These scenarios are tied to IPCC assumptions, with some adjustments made, and designated as RPA A1B, RPA A2, and RPA B2. Table 1 summarizes the global and national characteristics of these scenarios.

Table 1

Characteristics of the RPA Scenarios

Characteristics (2010-2060)		Scenario	
	RPA A1B	RPA A2	RPA B2
IPCC[a] general global description	Globalization, economic convergence	Regionalism, less trade	Slow change, localized solutions
IPCC global real GDP[b] growth	6.2X[c]	3.2X	3.5X
IPCC global population growth	1.3X	1.7X	1.4X
IPCC global expansion of primary biomass energy production	High	Medium	Medium
U.S. GDP growth[d]	3.3X	2.6X	2.2X
U.S. population growth	1.5X	1.7X	1.3X

[a]IPCC = Intergovernmental Panel on Climate Change
[b]U.S. Gross Domestic Product
[c]Factors of change from 2010 to 2060
[d]Not based on IPCC assumptions

Each IPCC scenario had associated climate projections based on greenhouse gas emissions. Each of the three scenarios was linked with three climate models chosen from six general circulation models (GCMs) (Table 2), rather than relying on a single climate model (USDA Forest Service, 2012). Documentation for the scenario-based projections and downscaling process can be found in USDA Forest Service (2012) and Joyce et al. (2014). For the conterminous United States, A1B projects the warmest and the driest climate for 2060, A2 the wettest, and B2 the coolest, albeit with small precipitation changes at the national scale to 2060. All regions of the United States show increases in temperature, but variations occur geographically (USDA Forest Service, 2012).

Table 2

General Circulation Models (GCM) for the RPA Scenario-Climate Combinations in Recreation Participation Models

RPA scenario	Climate 1[a]	Climate 2[a]	Climate 3[b]	Model Vintage
	General Circulation Model			
A1B	CGCM3.1 (T47)	CSIRO-Mk3.5	MIROC3.2 (medres)	AR4
A2	CGCM3.1 (T47)	CSIRO-Mk3.5	MIROC3.2 (medres)	AR4
B2	CGCM2	CSIRO-Mk2	HadCM3	TAR

[a]AR4 CGMs from the World Climate Research Program Climate Model Intercomparison Project 3 web site.
[b]TAR 47 CGMs from the IPCC Data Distribution Center (Joyce et al., 2014)

Participation and Use

Participation in an activity implies engaging at least once in the preceding 12 months. Participation can indicate market size and public interest. If over 80% of the population engages in day hiking and only 4% in snowmobiling, resource managers and planners would benefit from knowing that demand for hiking trails could outpace that for snowmobiling opportunities.

Another measure of recreation use is consumption, measured as the number of days, visits, or trips within a year or other interval. Consumption is important for understanding how often and how long people engage in an activity. Participation and consumption are complementary measures of outdoor recreation markets. Consumption for these analyses is defined as the number of days annually that an American adult (16 years of age or older) participated in an activity. A day thus follows the NSRE definition of an activity day (Cordell, 2012). These metrics are origin-based and not linked to specific sites. Research shows, however, that most outdoor recreation happens within a few hours' drive of the visitor's residence (Hall & Page, 1999).

Methods and Data

We used a two-step approach to develop projections of participation and consumption for 17 outdoor recreation activities to 2060 (Table 3). Details on modeling and projection results are available in Bowker and Askew (2012) and in Bowker et al. (2012). For both participation and consumption, Figure 3 displays the general hierarchy of modeling. This paper represents a shift in focus to quantifying the impact of adding a climate change proxy for each activity.

Table 3

Activities by Category for RPA 2060 Projections

Category and activity
Visiting developed sites
Developed sites – family gatherings, picnicking, developed camping
Interpretative sites – nature centers, zoos, historic sites, prehistoric sites
Viewing and photographing nature
Birding
Viewing – viewing, photography, study, or nature gathering related to fauna, flora, or natural settings
Backcountry activities
Challenge – caving, mountain climbing, rock climbing
Equestrian – horseback riding on trails
Hiking – day hiking
Visiting primitive areas – backpacking, primitive camping, wilderness
Motorized activities
Motorized off-road – off-road driving
Motorized snow – snowmobiling
Motorized water – motorboating, waterskiing, or using personal watercraft
Hunting and fishing
Hunting – small game, big game, migratory bird, other
Fishing – anadromous, coldwater, saltwater, warmwater
Non-motorized winter activities
Developed skiing – downhill skiing, snowboarding
Undeveloped skiing – cross-country skiing, snowshoeing
Non-motorized water activities
Swimming – swimming, snorkeling, surfing, diving, visiting beaches or watersides
Floating – canoeing, kayaking, rafting

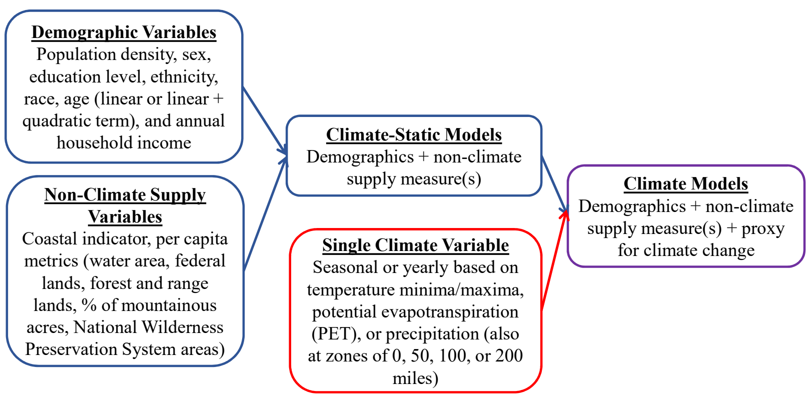

Figure 3. The process of modeling wherein the non-climate models are based on demographic and non-climate supply variable(s). After adding a single climate measure (proxy for climate change), the climate model projections can be compared against those from the non-climate models.

Research linking climate to recreation participation and consumption is limited. Climate variables were based on temperature, potential evapotranspiration, and precipitation on seasonal and yearly bases, as well as at zones of 0, 50, 100, and 200 miles of respondents' counties. An ad hoc approach was used wherein climate variables were based on 6-year moving averages and arbitrary distances from county centroids. A single climate variable was fitted to each model, allowing comparison to a baseline with no climate proxy. Climate variables were developed for the respondents' origin rather than destinations which were unknown.

Parameter estimates were combined with projections of covariates to create indexed per capita participation and consumption estimates at 10-year intervals to 2060. Estimates were then combined with population projections to develop participant and participant-days indices. The indices were applied to baseline estimates by activity derived from weighted 2005 to 2009 NSRE data, yielding projections of participants and participant-days.

Regional and National Results

Projections were derived for participation rates, total participants, days-per-participant, and participant-days, each over three RPA scenarios, without and with climate change. The complete set of regional and national participation and consumption measures included 3,936 projections in total. Here, we report the impacts of climate change as ranges over all RPA scenarios, reducing the set of projections to 656. The ranges provide intervals of projections across future conditions assumed equally likely.

The results discussed below are differences between the projections in 2060 without and with climate change, as percentages relative to the 2008 values. Suppose annual participant-days of hiking were 10,000 in 2008, and the 2060 projection indicated 20,000 without, and 18,000 thousand with, climate change. The increases in days were 100% and 80% respectively, but the difference due to climate change would be a decrease by 20%.

North RPA Region

The North had the most activities with climate change differences, especially for total participants and participant-days (Table 4). Table 4 shows three columns per statistic: per capita participation, total participants (1,000s), annual days-per-participant, and participant-days (millions). The first column is the initial value for 2008. The second column displays the percentage change from 2008 values for the 2060 projections without climate change. The third column compares the projections with and without climate change, taking the difference between outlooks and expressing as a percentage relative to the 2008 value. The third column's range is based on the minimum and maximum deviations across all RPA scenarios and climate model combinations. For example, total participants visiting developed sites for the North was 80.8 million in 2008. Without climate change, the numbers could grow by 21% to 51% to 2060. Climate change impacts the outlooks by -10% to -2% relative to 2008 values. We report four metrics per activity, but the discussion focuses on total participants and participant-days, the most relevant measures for managers.

Climate change dampened participation, especially for snowmobiling and undeveloped skiing, followed by primitive area use, whitewater activities, and hunting. Undeveloped skiing participation correlated negatively with warmer maximum temperatures (winter, 200-mile zone), projected to increase through 2060. Rising potential evapotranspiration seasonally translated to reduced participation for snowmobiling (winter, 200-mile zone), primitive area use (fall, 200-mile zone), whitewater activities (summer, 200-mile zone), and hunting (fall, 100-mile zone). Rising potential evapotranspiration positively impacted participation in horseback riding on trails (summer, 200-mile zone), motorized water activities (summer, 50-mile zone), and fishing (summer, 100-mile zone). Visiting interpretative sites was the only activity with participation unaffected by climate change.

Days-per-participant in the North were stable albeit generally negative under climate change; small positive changes for visiting interpretive sites and fishing were exceptions. The differences between futures were much more distinct for participant-days. The most negative climate change impacts occurred with snowmobiling, undeveloped skiing, whitewater activities, primitive area use, swimming, and hunting. Total precipitation (100-mile zone) could introduce minor, ambiguous impacts on snowmobiling days-per-participant. The climate effect is negatively linked to snowmobiling consumption, but the outlooks in precipitation totals are mixed to 2060. For total snowmobiling participant-days, declines were accelerated by slow regional population growth. Undeveloped skiing and swimming could see climate-related downturns in participants and participant-days from warming winters (200-mile zone) and percentage of monthly maximum temperatures exceeding 25°C (200-mile zone), respectively. Climate change effects on developed skiing participants and participant-days were ambiguous. Hunting participant-days decreased with a rising percentage of months with maximum temperatures exceeding 25°C (100-mile zone). Activities with days-per-participant responding positively to climate change were fishing and visiting interpretative sites, due to increasing potential summer and fall evapotranspiration (200-mile zone), respectively. Population growth led to greater climate impacts on participant-days.

Climate-induced increases in participant-days for fishing, motorized water activities, and horseback riding on trails, with smaller increases for visiting interpretative sites. Motorized water participant-days had a negative relationship with increasing total precipitation (200-mile zone), but the GCMs conflicted across precipitation projections to 2060. Higher minimum temperatures in the fall were negatively related to equestrian days-per-participant, but the increase in total participants led to an overall increase in participant-days.

South RPA Region

Per capita participation for the South appeared stable under climate change. The largest changes downward, due to warmer futures, were for day hiking, challenge activities, and whitewater activities (Table 5). Challenge activity participation responded negatively to increasing projected monthly maximum temperatures in the spring. Increasing summer maximum temperatures dampened participation in whitewater activities and swimming. Day hiker participation declined with more monthly maximum temperatures exceeding 35°C (200-mile zone). Fishing participation declined with an increasing percentage of months with maximum temperatures exceeding 35°C.

Table 4

Participation and Consumption with 2008 Values, Intervals of Change from 2008 Levels Under Climate-Static Outlooks, and Ranges of Climate-Induced Shifts for the North.

RPA North	Per capita participation			Total participants (1,000s)			Days-per-participant			Participant-days (Millions)		
Activity	2008	Without CC (%)	CC versus No CC, % Change	2008	Without CC (%)	CC versus No CC, % Change	2008	Without CC (%)	CC versus No CC, % Change	2008	Without CC (%)	CC versus No CC, % Change
Visiting developed sites	0.825	[0, 1]	[-7, -2]	80,844	[21, 51]	[-10, -2]	11.69	[-3]	[-9, 0]	948	[18, 46]	[-21, -5]
Visiting interpretative sites	0.686	[5, 9]	[-1, 1]	67,349	[27, 58]	[-1, 1]	7.69	[2, 7]	[1, 10]	519	[30, 62]	[2, 15]
Birding	0.382	[6, 8]	[-17, -1]	37,389	[28, 59]	[-22, -1]	99.83	[-3, -2]	[-2, 1]	3,714	[25, 53]	[-23, 0]
Nature viewing	0.815	[2, 4]	[-6, -1]	79,905	[23, 53]	[-8, -1]	175.66	[-8, -7]	[-2, 1]	13,993	[15, 41]	[-10, -2]
Challenge activities	0.095	[-9, -4]	[-10, 5]	9,404	[10, 36]	[-13, 8]	3.89	[-1, 0]	[-3, 3]	38	[10, 34]	[-17, 12]
Horseback riding on trails	0.059	[3, 16]	[7, 38]	5,796	[25, 56]	[10, 51]	12.63	[3]	[-9, -2]	73	[29, 61]	[4, 39]
Day hiking	0.327	[5, 7]	[-13, -3]	32,574	[27, 58]	[-19, -4]	22.44	[-5, -1]	[-3, 3]	727	[26, 56]	[-22, -4]
Primitive area use	0.367	[-5, -2]	[-32, -6]	36,269	[15, 42]	[-43, -7]	11.42	[-11, -10]	[-15, -4]	417	[3, 27]	[-50, -13]
Motorized off-roading	0.176	[-9, -1]	[-12, -3]	17,344	[12, 37]	[-16, -3]	16.43	[-11]	[-3, 3]	284	[0, 22]	[-17, -2]
Snowmobiling	0.071	[-21, -12]	[-66, -28]	7,032	[-1, 19]	[-92, -33]	7.87	[-14, -8]	[-4, 3]	55	[-14, 9]	[-84, -30]
Motorized water activities	0.268	[-2, 14]	[6, 31]	26,182	[23, 54]	[8, 42]	14.65	[-1, 7]	[-4, 5]	381	[24, 64]	[8, 54]
Hunting	0.117	[-28, -18]	[-28, -6]	11,347	[-2, 9]	[-37, -7]	18.84	[-10, -9]	[-11, -3]	211	[-11, -2]	[-41, -9]
Fishing	0.296	[-10, -3]	[6, 30]	28,805	[11, 35]	[8, 40]	18.14	[-5]	[5, 24]	518	[6, 27]	[15, 79]
Developed skiing	0.116	[6, 32]	[-7, 5]	11,615	[30, 78]	[-10, 7]	6.99	[-16, -15]	[-22, 0]	82	[10, 51]	[-44, 2]
Undeveloped skiing	0.048	[-8, 2]	[-49, -11]	4,814	[15, 38]	[-73, -13]	6.66	[2, 4]	[-15, -4]	32	[19, 42]	[-85, -18]
Swimming	0.633	[6, 12]	[-16, -3]	61,958	[28, 59]	[-22, -4]	22.24	[1, 7]	[-16, -5]	1,383	[30, 62]	[-45, -11]
Whitewater activities	0.187	[-5, 6]	[-29, -8]	18,331	[16, 42]	[-39, -11]	6.82	[0]	[-26, -1]	125	[16, 42]	[-65, -21]

Motorized water participation increased with the percentage of months with maximum temperatures exceeding 25°C. Birding participation increased with climate change, specifically for areas with rising potential evapotranspiration (winter, 50-mile zone). The remaining activities remained stable, with total participants changing no more than 7%.

Consumption in the South showed more variable impacts of climate change. The most positive change occurred for challenge activities, with the possibility of over 40% more days-per-participant and participant-days. Hunting participant-days increased by up to 10%, as the measure was negatively linked to the percentage of months with minimum temperatures less than or equal to -5°C (100-mile zone). This impact became less negative with projected warmer futures.

Horseback riding on trails displayed the biggest climate effect, with decreases in participant-days of 51% to 168%. Challenge activity participation dropped with warmer temperatures, but days-per-participant and participant-days rose with warmer fall seasons (100-mile zone). Whitewater days-per-participant increased with climate change; but as participation declined, the outlook for participant-days was ambiguous. Days-per-person increased with the projected rise in potential evapotranspiration (spring, 50-mile zone). Equestrian consumption, especially participant-days, declined with warmer futures. Other activities with climate-related consumption decreases were motorized off-roading, fishing, and birding. The negative effects correlated with the percentage of months with maximum temperatures above 35°C locally (fishing and birding) and 200-mile zone (motorized off-roading).

For some activities with days-per-participant negatively impacted by climate change, population growth for participant-days magnified the declines. Day hiking, primitive area use, and swimming showed declines in days-per-participant from climate change; however, for participant-days, the negative response to warmer futures was larger. Swimmers participated less (fewer participant-days) with warmer summers (200-mile zone). Primitive area use responded negatively to increasing percentages of months with maximum temperatures above 25°C (100-mile zone).

Rocky Mountain RPA Region

Stable participation under climate change occurred for visiting developed sites and interpretative sites, birding, and nature viewing (Table 6). Positive shifts occurred for swimming, driven by increasing summer potential evapotranspiration. Participation negatively impacted by rising potential evapotranspiration included fishing, motorized water activities, hunting, primitive area use, and horseback riding on trails. Potential evapotranspiration was computed annually for hunting (100-mile zone) and for summer in the other four activities. Climate change had ambiguous consequences for undeveloped skiing as shifts ranged between -28% and 17% for per capita participation and -54% to 33% for total participants. Challenge activity impacts varied from -9% to 13% for per capita participation and -18% to 25% for total participants. The range for developed skiing was -8% to 8% for per capita participation and -16% to 16% for total participation. These intervals are indicative of CGM projection variability.

Table 5

Participation and Consumption with 2008 Values, Intervals of Change from 2008 Levels Under Climate-Static Outlooks, and Ranges of Climate-Induced Shifts for the South.

RPA South	Per capita participation			Total participants (1,000s)			Days-per-participant			Participant-days (Millions)		
Activity	2008	Without CC (%)	CC versus No CC, % Change	2008	Without CC (%)	CC versus No CC, % Change	2008	Without CC (%)	CC versus No CC, % Change	2008	Without CC (%)	CC versus No CC, % Change
Visiting developed sites	0.799	[1, 2]	[-4, -1]	63,468	[53, 90]	[-7, -2]	10.61	[0]	[1, 4]	676	[53, 91]	[-2, 2]
Visiting interpretative sites	0.639	[6, 9]	[-3, -1]	50,884	[61, 102]	[-6, -1]	7.22	[7, 12]	[-1, 0]	368	[72, 119]	[-8, -3]
Birding	0.342	[8, 10]	[0, 3]	27,107	[64, 105]	[0, 5]	106.65	[-19, -13]	[-18, -5]	2,876	[42, 70]	[-32, -9]
Nature viewing	0.791	[0, 3]	[-3, -1]	62,907	[53, 89]	[-5, -2]	173.08	[-12, -8]	[-4, 1]	10,855	[40, 67]	[-12, 0]
Challenge activities	0.086	[9, 18]	[-20, -1]	6,948	[65, 110]	[-33, -2]	3.67	[7, 15]	[7, 47]	26	[76, 131]	[1, 41]
Horseback riding on trails	0.071	[-9, 8]	[-3, 2]	5,677	[44, 85]	[-6, 2]	17.67	[-1, 26]	[-91, -36]	99	[56, 133]	[-168, -51]
Day hiking	0.252	[12, 16]	[-16, -3]	20,383	[70, 114]	[-26, -5]	22.93	[-5, -3]	[-1, 0]	465	[65, 103]	[-26, -6]
Primitive area use	0.353	[-7, -3]	[-1, 0]	28,296	[43, 75]	[-2, 0]	14.55	[0, 1]	[-12, -3]	414	[43, 77]	[-22, -5]
Motorized off-roading	0.213	[-25, -12]	[-4, -1]	16,990	[26, 51]	[-6, -1]	33.30	[-3, -2]	[-37, -11]	564	[24, 47]	[-59, -18]
Motorized water activities	0.270	[-5, 10]	[0, 5]	21,373	[48, 88]	[0, 8]	18.21	[-9, -1]	[-2, 0]	386	[38, 86]	[-2, 6]
Hunting	0.137	[-41, -26]	[-3, 1]	10,839	[8, 25]	[-4, 2]	21.68	[-1, 0]	[1, 12]	231	[8, 25]	[0, 10]
Fishing	0.357	[-20, -12]	[-9, -3]	28,176	[30, 51]	[-16, -4]	20.58	[-3, -1]	[-24, -7]	575	[29, 48]	[-48, -14]
Swimming	0.59	[5, 11]	[-6, -2]	46,870	[60, 101]	[-12, -4]	23.76	[-4, 2]	[-8, -4]	1,118	[56, 94]	[-25, -10]
Whitewater activities	0.154	[-5, 5]	[-18, -6]	12,262	[45, 81]	[-31, -10]	6.58	[-3, -2]	[2, 12]	80	[43, 76]	[-13, 4]

Table 6

Participation and Consumption with 2008 Values, Intervals of Change from 2008 Levels Under Climate-Static Outlooks, and Ranges of Climate-Induced Shifts for the Rocky Mountain Region

RPA Rocky Mountain	Per capita participation			Total participants (1,000s)			Days-per-participant			Participant-days (Millions)		
Activity	2008	Without CC (%)	CC versus No CC, % Change	2008	Without CC (%)	CC versus No CC, % Change	2008	Without CC (%)	CC versus No CC, % Change	2008	Without CC (%)	CC versus No CC, % Change
Visiting developed sites	0.815	[1, 2]	[-1, 0]	17,303	[73, 115]	[-1, 0]	13.48	[-2, -1]	[-5, -2]	234	[72, 110]	[-10, -3]
Visiting interpretative sites	0.713	[7, 10]	[-2, 0]	15,170	[83, 130]	[-3, -1]	8.84	[3, 5]	[-2, 1]	134	[88, 136]	[-6, 0]
Birding	0.331	[6]	[-1, 1]	7,007	[81, 126]	[-3, 3]	79.61	[4, 8]	[-8, -2]	555	[96, 135]	[-20, 0]
Nature viewing	0.829	[1, 4]	[-1, 0]	17,604	[74, 116]	[-1, 1]	157.38	[-11, -6]	[-3, 1]	2,762	[63, 92]	[-7, 3]
Challenge activities	0.177	[8, 14]	[-9, 13]	3,803	[85, 130]	[-18, 25]	8.54	[-8, -6]	[-2, 3]	34	[74, 112]	[-21, 29]
Horseback riding on trails	0.093	[-16, -3]	[-14, -4]	1,987	[54, 87]	[-28, -6]	35.00	[-11, 10]	[-4, 3]	69	[44, 106]	[-30, -4]
Day hiking	0.461	[7, 12]	[-6, 7]	9,951	[85, 129]	[-12, 14]	20.38	[-7, -4]	[2, 8]	202	[78, 113]	[-3, 25]
Primitive area use	0.541	[-4, 1]	[-13, -4]	11,589	[67, 104]	[-26, -6]	13.97	[-16, -14]	[-2, 4]	163	[44, 71]	[-19, -2]
Motorized off-roading	0.271	[-13, 4]	[-4, 4]	5,775	[61, 100]	[-7, 7]	16.91	[-11, -6]	[-3, 0]	97	[52, 84]	[-7, 0]
Snowmobiling	0.06	[-37, -28]	[-13, 4]	1,290	[17, 38]	[-27, 7]	4.82	[-18, -11]	[-2, 3]	6	[4, 18]	[-22, 7]
Motorized water activities	0.259	[0, 15]	[-19, -5]	5,480	[73, 122]	[-37, -9]	13.21	[-1, 9]	[-2, 2]	72	[75, 141]	[-45, -8]
Hunting	0.162	[-39, -26]	[-17, -1]	3,405	[23, 43]	[-32, -2]	13.99	[-10, -5]	[-3, 1]	47	[12, 35]	[-32, -3]
Fishing	0.337	[-13, -4]	[-23, -7]	7,123	[57, 86]	[-44, -12]	13.77	[-9, -7]	[-3, 1]	97	[46, 70]	[-45, -11]
Developed skiing	0.131	[13, 40]	[-8, 8]	2,838	[94, 169]	[-16, 16]	7.90	[7, 18]	[-8, 4]	23	[110, 218]	[-40, 31]
Undeveloped skiing	0.045	[-12, 6]	[-28, 17]	962	[69, 103]	[-54, 33]	7.16	[-5, -2]	[-12, -5]	7	[65, 96]	[-71, 20]
Swimming	0.522	[2, 8]	[2, 9]	11,085	[75, 119]	[3, 18]	20.06	[-5, 1]	[-1, 1]	223	[69, 110]	[3, 16]
Whitewater activities	0.16	[-15, -5]	[-3, 4]	3,401	[50, 83]	[-7, 8]	5.07	[-10, -6]	[-5, 0]	17	[41, 68]	[-15, 8]

Days-per-participant for the Rocky Mountain region varied no more than 12% (Table 6). For birding this measure may shift downwards with increasingly warmer summers (50-mile zone). Rising yearly potential evapotranspiration (200-mile zone) could induce declines in undeveloped skiing days-per-participant. Hiking days-per-participant responded positively to increasing winter potential evapotranspiration (200-mile zone). Including population effects for participant-days, some activities showed large negative and positive climate-related shifts, such as undeveloped skiing (-71% to 20%) and developed skiing (-40% to 31%). The greatest declines in participant-days occurred for motorized water activities, fishing, hunting, horseback riding on trails, and birding. Fishing and motorized water activity intensities correlated positively with total precipitation; horseback riding on trails correlated negatively. The long-term climate outlooks for some climate proxies, such as total precipitation, were inconsistent among the CGMs. Hunting participant-days declined with increasing monthly maximum temperatures (winter, 200-mile zone). Swimming participant-days rose marginally with increasing monthly mean precipitation, but the CGMs were mixed as to whether this metric would increase or decrease long term.

Pacific Coast RPA Region

The Pacific Coast was the most stable region under climate change (Table 7). Per capita participation varied no more than 15% between scenarios without and with climate change. Undeveloped skiing and hunting grew due to increased total precipitation. The GCMs indicate a mixture of wet and dry futures for 2060. Depending on the RPA scenario and climate model, snowmobiling could undergo a large decline, due to the negative impact of yearly potential evapotranspiration (100-mile zone), but the interval extended into the positive domain, indicating ambiguity. Horseback riding on trails and hiking participation totals could also undergo downturns with climate change. Horseback riding on trails participation may decline with increasing total precipitation (100-mile zone). Day hiking participation decreased with warmer summers (200-mile zone).

Consumption mirrored participation. Days-per-participant varied no more than 11% for any given scenario. Participant-days shifted no more than 26% factoring in population growth and participation changes. Population growth made some intervals ambiguous. For example, day hiking days-per-participant could be 0% to 4% greater than without climate change, as warmer spring temperatures (100-mile zone) increase consumption. With population changes, day-hiking participant-days ranged from -6% to 3%. Challenge activities responded positively to climate change for days-per-participant (1% to 3%) and participant-days (1% to 11%), with potential evapotranspiration (winter, 200-mile zone) increasing through 2060. Undeveloped skiing decreased in days-per-participant. However, the results were mixed for participant-days, ranging from moderate declines to greater growth with increasing potential evapotranspiration (fall, 100-mile zone). Horseback riding on trails had the widest intervals for consumption measures. The greatest declining interval was for visiting interpretative sites with hotter summers (50-mile zone), followed by nature viewing with increasing summer potential evapotranspiration. Participant-days for visiting interpretative sites responded negatively (-12% to -4%) to increasing summer potential evapotranspiration.

Table 7

Participation and Consumption with 2008 Values, Intervals of Change from 2008 Levels under Climate-Static Outlooks, and Ranges of Climate-Induced Shifts for the Pacific Coast.

Pacific Coast	Per capita participation			Total participants (1,000s)			Days-per-participant			Participant-days (Millions)		
Activity	2008	Without CC (%)	CC versus No CC, % Change	2008	Without CC (%)	CC versus No CC, % Change	2008	Without CC (%)	CC versus No CC, % Change	2008	Without CC (%)	CC versus No CC, % Change
Visiting developed sites	0.812	[0, 2]	[-1, 0]	30,775	[49, 85]	[-1, 0]	12.59	[5, 13]	[-3, -1]	389	[58, 95]	[-5, -2]
Visiting interpretative sites	0.696	[2, 5]	[-1, 0]	26,435	[52, 89]	[-2, 0]	8.62	[14, 25]	[-5, -2]	228	[75, 119]	[-12, -4]
Birding	0.343	[1, 2]	[-1, 3]	12,980	[51, 86]	[-1, 6]	85.92	[-8, -6]	[-4, 0]	1,110	[42, 71]	[-2, -1]
Nature viewing	0.817	[-1, 2]	[-1, 0]	30,993	[48, 82]	[-2, 0]	157.01	[-13, -9]	[-3, -1]	4,851	[35, 59]	[-7, -2]
Challenge activities	0.135	[-10, -6]	[-1, 4]	5,176	[34, 71]	[-2, 6]	4.25	[-2, -2]	[1, 3]	23	[31, 67]	[1, 11]
Horseback riding on trails	0.072	[2, 17]	[-5, 1]	2,718	[54, 94]	[-10, 1]	8.27	[19, 56]	[-8, 6]	22	[90, 201]	[-26, 10]
Day hiking	0.447	[-1, 2]	[-4, 0]	17,230	[49, 83]	[-7, -1]	25.69	[-4, 3]	[0, 4]	440	[47, 75]	[-6, 3]
Primitive area use	0.46	[-11, -4]	[-1, 4]	17,592	[37, 64]	[-1, 7]	13.84	[5, 17]	[-5, -2]	245	[47, 85]	[-8, 2]
Motorized off-roading	0.224	[-21, -1]	[0, 2]	8,546	[32, 64]	[1, 3]	12.59	[-13, -7]	[-2, 3]	107	[22, 47]	[-1, 6]
Snowmobiling	0.034	[-21, 4]	[-11, 2]	1,302	[36, 73]	[-16, 4]	9.43	[-22, -10]	[-3, 0]	12	[14, 45]	[-17, 3]
Motorized water activities	0.256	[0, 21]	[-1, 0]	9,681	[54, 101]	[-3, 0]	12.42	[-2, 16]	[-1, 1]	119	[57, 133]	[-4, 1]
Hunting	0.067	[-41, -29]	[0, 13]	2,521	[5, 13]	[0, 25]	19.65	[-21, -17]	[-4, 0]	49	[-15, -9]	[-3, 19]
Fishing	0.264	[-13, -3]	[0, 2]	9,976	[36, 62]	[0, 4]	18.04	[-9, -7]	[-1, 1]	178	[26, 48]	[-1, 5]
Developed skiing	0.14	[6, 32]	[-1, 6]	5,420	[60, 119]	[-1, 11]	8.53	[5, 19]	[0]	47	[70, 160]	[-1, 12]
Undeveloped skiing	0.035	[-29, -22]	[-1, 15]	1,364	[15, 30]	[-1, 27]	7.06	[-7, -2]	[-11, -1]	10	[13, 21]	[-10, 23]
Swimming	0.661	[4, 8]	[-1, 0]	25,063	[54, 93]	[-1, 0]	29.91	[4, 13]	[-1, 0]	752	[61, 102]	[-2, -1]
Whitewater activities	0.165	[-13, 2]	[-2, 0]	6,270	[36, 70]	[-3, -1]	6.35	[-2, -1]	[-1, 0]	40	[35, 67]	[-4, -1]

Nation

National models were estimated rather than regionally aggregated. Climate change had mixed effects on participation and consumption (Table 8). Undeveloped skiing and snowmobiling were most negatively impacted, due to warmer futures. Decreases in per capita participation for these two winter activities ranged from 19% to 69%, while total participants decreased by 31% to 109%. Fishing, whitewater activities, and motorized water activities saw participation reductions under increasingly warmer futures, but far less than snowmobiling and undeveloped skiing.

A positive relationship between equestrian participation and warmer conditions implied higher participation rates and riders by 2060. Participation in swimming, nature viewing, visiting interpretative sites, motorized off-roading, and visiting developed sites were largely unaffected by climate change.

Climate impacted participation positively and consumption negatively for horseback riding on trails. With warmer futures, participation rates and equestrian rider totals increased, but riders recreated fewer days, decreasing participant-days. The biggest decreases in days-per-participant were for horseback riding on trails (due to warming) and snowmobiling (increasing yearly potential evapotranspiration in a 200-mile zone). Increasing evaporation generally indicates less favorable snow cover conditions. Snowmobiling, undeveloped skiing, and whitewater activities showed fewer participant-days annually. Undeveloped skiing participant-days responded negatively to increasing potential evapotranspiration (winter, 200-mile zone). Whitewater activity participant-days responded negatively to climate change. Consumption was positively linked to monthly mean precipitation (100-mile zone), but GCM projections vary as to whether 2060 will be wetter or drier. Positive consumption impacts could occur for visiting interpretative sites, specifically nature centers, zoos, historic sites, and/or prehistoric sites. Participation intensity was positively linked to increasing percentages of months with maximum temperatures above 35°C (200-mile zone). Projected changes due to climate were generally positive and small for challenge activities, driven by increasing potential evapotranspiration (winter, 50 mile-zone). Motorized off-roading responded positively to warmer futures.

Discussion

A major question facing policy makers and land managers is how climate change will affect outdoor recreation. Looking to 2060, we projected outdoor recreation participation and consumption for four RPA regions and the nation, detailed in previous publications for RPA scenarios A1B, A2, and B2. Here, we focused on whether climate change positively or negatively influences participation and use for 17 activities. Climate change effects were quantified as the percentage difference in projected metrics, relative to 2008, for 2060 with and without climate change. For three RPA scenarios, each with three respective climate models, the range of values indicated the possible futures.

The directly estimated measures (per capita participation and days-per-participant) varied less across the RPA and climate scenarios than the simulated measures (total participants and participant-days) which included population growth. Response to climate change was often qualitatively the same for participation and use, but there were region/activity combinations where climate effects differed for participation and

Table 8

Participation and Consumption with 2008 Values, Intervals of Change from 2008 Levels Under Climate-Static Outlooks, and Ranges of Climate-Induced Shifts for the Nation

Nation	Per capita participation			Total participants (1,000s)			Days-per-participant			Participant-days (Millions)		
Activity	**2008**	**Without CC (%)**	**CC versus No CC, % Change**	**2008**	**Without CC (%)**	**CC versus No CC, % Change**	**2008**	**Without CC (%)**	**CC versus No CC, % Change**	**2008**	**Without CC (%)**	**CC versus No CC, % Change**
Visiting developed sites	0.819	[1, 3]	[-2, -1]	193,681	[42, 77]	[-3, -1]	11.67	[-2, -1]	[-3, 0]	2,246	[40, 74]	[-7, -2]
Visiting interpretative sites	0.669	[5, 9]	[-2, 0]	158,173	[48, 84]	[-2, 0]	7.81	[3, 8]	[1, 6]	1,249	[53, 90]	[1, 7]
Birding	0.346	[4, 8]	[-10, -2]	81,847	[46, 81]	[-16, -3]	97.71	[-6, -2]	[-2, 1]	8,255	[43, 71]	[-18, -3]
Nature viewing	0.805	[1, 3]	[-1, 0]	190,345	[42, 76]	[-2, 0]	169.59	[-11, -8]	[-2, -1]	32,461	[30, 61]	[-5, -1]
Challenge activities	0.107	[7, 18]	[-3, 3]	25,257	[50, 86]	[-5, 4]	4.77	[-2, -1]	[1, 3]	120	[49, 83]	[-2, 9]
Horseback riding on trails	0.070	[1, 19]	[3, 15]	16,473	[44, 86]	[5, 24]	16.28	[3]	[-23, -7]	263	[49, 92]	[-23, -7]
Day hiking	0.333	[7, 10]	[-6, -2]	78,639	[50, 88]	[-9, -3]	22.89	[6]	[0, 1]	1,834	[59, 98]	[-9, -1]
Primitive area use	0.383	[-5, -1]	[-5, -1]	90,605	[33, 65]	[-7, -2]	13.22	[-1]	[-4, -2]	1,239	[33, 63]	[-13, -5]
Motorized off-roading	0.204	[-18, 0]	[-1, 1]	48,171	[29, 56]	[-2, 1]	21.65	[-7, -6]	[1, 4]	1,053	[21, 46]	[0, 7]
Snowmobiling	0.04	[-23, -13]	[-60, -19]	9,487	[10, 37]	[-94, -31]	7.25	[-4, -2]	[-22, -8]	69	[8, 33]	[-101, -39]
Motorized water activities	0.263	[-2, 15]	[-10, -2]	62,263	[41, 81]	[-16, -3]	15.27	[-6, 4]	[-5, -1]	958	[37, 89]	[-24, -5]
Hunting	0.119	[-31, -22]	[-6, -1]	28,045	[8, 23]	[-10, -1]	19.13	[-12]	[-2, 0]	538	[-5, 8]	[-10, -1]
Fishing	0.309	[-10, -3]	[-12, -3]	73,069	[28, 56]	[-18, -4]	18.48	[-7, -4]	[-2, 1]	1,369	[22, 46]	[-19, -3]
Developed skiing	0.101	[11, 45]	[-8, 2]	23,845	[58, 127]	[-14, 3]	7.19	[1, 10]	[-2, 0]	171	[61, 150]	[-18, 3]
Undeveloped skiing	0.033	[-8, 6]	[-69, -23]	7,816	[32, 67]	[-109, -38]	6.58	[2]	[-9, -3]	51	[35, 70]	[-115, -42]
Swimming	0.609	[5, 11]	[0]	143,904	[47, 85]	[0, 1]	23.98	[-1, 4]	[-4, -1]	3,476	[46, 83]	[-6, -2]
Whitewater activities	0.169	[-11, 3]	[-23, -4]	39,995	[30, 62]	[-37, -7]	6.50	[0]	[-1, 0]	262	[30, 62]	[-38, -6]

use. In the North, climate positively affected horseback riding on trails participation, while negatively impacting days-per-participant.

Across regions the climate change effects were not always negative. For many activity/region combinations, the effects spanned from negative to positive, indicating uncertainty about the future. This uncertainty often occurred because the GCMs provided conflicting projections for climate variables. Overall, winter activities were the most negatively impacted from climate change, primarily due to warmer futures. Important climate measures to consider were maximum temperatures, potential evapotranspiration, and precipitation. While some effects on recreation can be mitigated (e.g., improving the quality of a nature center), future climate conditions will likely require anticipation and adaptation.

The Pacific Coast was the most stable region, with most deviations less than 10% and ranges often bracketing zero. The North and South appeared more affected by climate shifts. The most negative impact from climate change occurred for participant-days of horseback riding on trails in the South. The greatest projected increase from climate change occurred for participant-days of fishing for the North.

Snowmobiling participation and consumption, mainly in the North, will be impacted negatively by climate change. Undeveloped skiing is also at risk across participation and consumption measures for the North and nation. Climate change had a positive impact on undeveloped skiing participation in the Pacific Coast region, while having negative effects on days-per-participant for the Rocky Mountain and Pacific Coast regions. Whitewater participation could be at risk in the North and South, as well as the nation. Additionally, consumption measures may be susceptible to climate change for whitewater participants in the North and the nation. Days-per-participant in whitewater activities for the South increased from climate change. Primitive area use decreased in participation and consumption from climate change in the North, as well as for South consumption and Rocky Mountain participation measures.

Climate change had mixed impacts on horseback riding on trails. Participation metrics showed a positive shift for the North and nation, with negative impacts on consumption for the nation and the South. Equestrian activities generally had negative climate-induced impacts within the Rocky Mountain region. The only metric in the Pacific Coast region where equestrian activities decreased because of climate was total participants. Lastly, equestrian participant-days in the North increased with climate change.

Swimming showed mixed responses to climate change. Participation decreased in the North, while participation and consumption increased in the Rocky Mountain region. Negative climate change effects were seen for participant-days from swimmers in the South and Pacific Coast regions, as well as for swimming participants in the South. Climate change had a positive impact on visiting interpretative sites consumption in the North and nation. The activity could see downturns in participant-days for the Pacific Coast region. Challenge activities had an interesting dynamic for the South: while climate change was negative for participation, the impact was positive in terms of consumption. Challenge activities consumption responded positively to climate in the Pacific Coast region.

Hunting and fishing showed mixed impacts from climate change. Understanding the geographic variations among targeted and prey species may better equip regional managers for strategic planning. In the North, hunting participation and consumption was negatively impacted by climate change, while fishing participation and consumption were positively influenced. Total anglers and fishing participant-days in the South responded negatively to warmer futures, while hunting participant-days increased. Fishing and hunting in the Rocky Mountain region will most likely be negatively influenced from climate change, while the opposite effect is expected for the Pacific Coast region. Climate effects were mixed for motorized water activities, which could be at risk in the Rocky Mountain region under climate change, while seeing beneficial responses in the North and South. Day hiking could be an at-risk activity for participation in the South. Days-per-hiker increased from climate change in the Rocky Mountain region but not for the Pacific Coast region, an area also showing negative impacts on total hiking participants.

The climate variables used in the recreation models were limited to those from the RPA Assessment climate projections because long-term simulation is a fundamental objective of the RPA Assessment. Generally, the climate variables used in these recreation models were presumed to affect willingness to participate and frequency of participation directly. For many activities this is probably sufficient, but for others such a presumption can be limiting. For example, increasing temperatures could have impacts on the underlying ecosystem and alter the abundance to the targeted species for hunters and anglers. A change in species abundance or population structure could very well affect the decision to participate and, if so, how often. Until sufficient data on such relationships become available, modeling approaches like ours will be limited.

One direction for improving the projections of climate-change-related impacts would be to construct indices based on climate effects because of high correlations among many climate measures. In this study, we used an ad hoc procedure including a single climate variable. A next step would be to refine the climate variables factoring into the model, permitting more thorough modeling of their complex dynamics. Another limitation is that data were origin-based as opposed to destination-based. With respondents' FIPS codes from NSRE, modeling and projections focused on climate at or near the origin. While the majority of outdoor recreation takes place within a few hours' drive of home (Hall & Page, 1999), considering not only climate change outlooks at origins but also destinations could be informative, especially when longer trips are planned around destination climate conditions.

Implications for Practice

Although managers cannot directly manage climate conditions, they can strategize around potential impacts of climate change for quality outdoor recreation. Our results, being macro-level at the regional and national scales, are not intended to be directly applicable by managers, particularly at a specific locale. The take-away for such managers should be that across a broad range of future socioeconomic and population growth scenarios, each associated with three credible climate models, there is considerable ambiguity about just how much climate change could impact participation and use across many outdoor recreation activities.

While most frontline managers must first focus on their immediate surroundings and markets, longer-term planners at the agency levels should be able to use our results to inform more strategic decisions and responses. While considerable ambiguity arises when multiple factors come together, clearly some activities will be adversely affected by projected climate changes that include warmer futures. Management should thus be preparing mitigation and adaptation strategies for potential downturns in winter sports like undeveloped skiing and snowmobiling. Alternatively, for activities expected to see growth under climate change, such as fishing and motorized water activities in the North, managers will also have to prepare adaptation strategies, albeit in a different direction.

References

Ahn, S., DeSteiguer, J. E., Palmquist, R. B., & Holmes, T. P. (2000). Economic analysis of the potential impact of climate change on recreational trout fishing in the southeastern Appalachian Mountains: An application of a nested multinomial logit model. *Climate Change, 45*, 493–509.

Alcamo, J., Ash, N.J., Butler, C. D., Callicot, J. B., Capistrano, D., Carpenter, S. R., … Zurek, M. B. (2003). *Ecosystems and human well-being.* Washington, DC: Island Press.

Bark, R. H. & Colby, B. G. (2011). Climate, changing snowpack, and the future of winter recreation. In B. G. Colby & G. B. Frisvold (Eds.), *Adaptation and resilience: The economics of climate, water, and energy challenges in the American Southwest* (pp. 145–162). Washington, DC: RFF Press.

Bowker, J. M. (2001). *Outdoor recreation participation and use by Alaskans: Projections 2000-2020.* Gen. Tech. Rep. PNW–GTR–527. Portland, OR: U.S. Department of Agriculture Forest Service, Pacific Northwest Research Station. 28 p.

Bowker, J. M., & Askew, A. (2012). U.S. outdoor recreation participation projections to 2060. In H. K. Cordell (Ed.), *Outdoor recreation trends and futures: A technical document supporting the Forest Service 2010 Resources Planning Act Assessment*. Gen. Tech. Rep. SRS-150. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station, 105-124.

Bowker, J. M., & Askew, A. E. (2013). *Outlook for outdoor recreation in the North United States: A technical document supporting the Northern Forest Futures Project with projections through 2060.* Gen. Tech. Rep. NRS-120. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 62 p.

Bowker, J. M., Askew, A., Cordell, H. K., & Bergstrom, J. C. (2013). Outdoor recreation. In D. N. Wear & J. G. Greis (Eds.), *The Southern Forest Futures Project: Technical report.* Gen. Tech. Rep. *SRS-GTR-178.* Asheville, NC: USDA-Forest Service, Southern Research Station. 161-182.

Bowker, J. M., Askew, A. E., Cordell, H. K., Betz, C. J., Zarnoch, S. J., & Seymour, L. (2012). *Outdoor recreation participation in the United States: Projections to 2060: A technical document supporting the Forest Service 2010 RPA Assessment.* Gen. Tech. Rep. SRS-160. Asheville, NC: U.S. Department of Agriculture Forest Service, South Research Station. 34 p.

Bowker, J. M., Askew, A. E., Poudyal, N., Zarnoch, S. J., Seymour, L., & Cordell, H. K. (2014). Climate change and outdoor recreation participation in the Southern United States. In J. M. Vose & K. D. Klepzig (Eds.), *Climate change adaptation and mitigation management options: A guide for natural resource managers in South forest ecosystems* (pp. 421–450). Boca Raton, FL: CRC Press - Taylor and Francis.

Bowker, J. M., English, D. B. K., & Cordell, H. K. (1999). Outdoor recreation participation and consumption: Projections 2000 to 2050. In H. K. Cordell, C.

J. Betz, & J. M. Bowker (Eds.), *Outdoor recreation in American life: A national assessment of demand and supply trends* (pp. 323–350). Urbana, IL: Sagamore.

Bowker, J. M., & Leeworthy, V. R. (1998). Accounting for ethnicity in recreation demand: A flexible count data approach. *Journal of Leisure Research, 30*(1), 64–78.

Bowker, J. M., Murphy, D., Cordell H. K., English, D. B. K., Bergstrom, J. C., Starbuck, C.M., . . . Green, G.T. (2006). Wilderness and primitive area recreation participation and consumption: An examination of demographic and spatial factors. *Journal of Agricultural and Applied Economics, 38*(2), 317–326.

Brice, B., Fullerton, C., Hawkes, K. L., Mills-Novoa, M., O'Neill, B. F., & Pawlowski, W. M. (2017). The impacts of climate change on natural areas recreation: A multi-region snapshot and agency comparison. *Natural Areas Journal, 37*(1), 86–97.

Cameron, C. A., & Trivedi, P. K. (1998). *Econometric society monographs: Regression analysis of count data.* New York, NY: Cambridge University Press.

Cicchetti, C. J. (1973). *Forecasting recreation in the United States.* Lexington, MA: D.C. Heath and Co.

Cordell, H. K. (2012). *Outdoor recreation trends and futures: a technical document supporting the Forest Service 2010 RPA Assessment.* Gen. Tech. Rep. SRS-150. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station, 167 p.

Cordell, H. K., & Bergstrom, J. C. (1991). A methodology for assessing national outdoor recreation demand and supply trends. *Leisure Sciences, 13*(1), 1–20.

Cordell, H. K., Bergstrom, J.C., Hartmann, L. A., & English, D. B. K. (1990). *An analysis of the outdoor recreation and wilderness situation in the United States: 1989-2040.* Gen. Tech. Rep. RM–189. Fort Collins, CO: U.S. Department of Agriculture Forest Service, Rocky Mountain Forest and Range Experiment Station. 112 p.

Cordell, H. K., Betz, C. J., & Mou, S. H. (2013). Outdoor recreation in a shifting societal landscape. In D. N. Wear, & J. G. Greis (Eds.), *The Southern Forest Futures Project: technical report.* Gen. Tech. Rep. SRS-GTR-178. Asheville, NC: USDA-Forest Service, Southern Research Station. 123-160.

Englin, J. E., & Shonkwiler, J. S. (1995). Estimating social welfare using count data models: An application to long-run recreation demand under conditions of endogenous stratification and truncation. *Review of Economics and Statistics, 77*(1), 104–112.

English, D. B. K., Betz, C. J., & Young, J. M. (1993). *Regional demand and supply projections for outdoor recreation.* Gen. Tech. Rep. RM–230. Fort Collins, CO: U.S. Department of Agriculture Forest Service, Rocky Mountain Forest and Range Experiment Station. 44 p.

English, D. B. K., Kocis, S. M., Zarnoch, S. J., & Arnold, J. R. (2002). *Forest Service National Visitor Use Monitoring process: Research method documentation.* Gen. Tech. Rep. SRS–57. Asheville, NC: U.S. Department of Agriculture Forest Service, Southeastern Forest Experiment Station. 14 p.

Forest and Rangeland Renewable Resources Planning Act of 1974, Pub. L. No. 93-378, 88 Stat 475, as amended (1974).

Frisvold, G. B., Ma, X., & Ponnaluru, S. (2011). Climate, water availability, energy costs, and national park visitation. In: B. G. Colby & G. B. Frisvold (Eds.), *Adaptation and resilience: The economics of climate, water, and energy challenges in the American Southwest* (pp. 120–144). Washington, DC: RFF Press.

Greene, W. H. (2009). *NLOGIT 4.0.* Plainview, NY: Econometric Software, Inc.

Gregory, S. (2011). Go with the Floe: Adventure travel's love-hate relationship with climate change. *TIME Magazine*, August 29, 2011.

Hall, T. E., Heaton, H., & Kruger, L. E. (2009). *Outdoor recreation in the Pacific Northwest and Alaska: Trends in activity participation.* Gen. Tech. Rep. PNW–GTR–778. Portland, OR: U.S. Department of Agriculture Forest Service, Pacific Northwest Research Station. 108 p.

Hall, C. M., & Page, S. J. (1999). *The geography of tourism and recreation.* New York, NY: Routledge.

Hof, J. G., & Kaiser, H. F. (1983a). *Projections of future forest recreation use.* Resour. Bull. WO–2. Washington, DC: U.S. Department of Agriculture Forest Service.

Hof, J. G., & Kaiser, H. F. (1983b). Long-term outdoor recreation participation projections for public land management agencies. *Journal of Leisure Research, 15*(1), 1–14.

Intergovernmental Panel on Climate Change (IPCC). (2007). Climate change 2007, the fourth IPCC assessment report. Retrieved from http://www.ipcc.ch/ ipccreports/ index.htm

Joyce, L. A., Price, D. T., Coulson, D. P., McKenney, D. W., Siltanen, R. M., Papadopol, P., & Lawrence, K. (2014). *Projecting climate change in the United States: A technical document supporting the Forest Service RPA 2010 Assessment.* Gen. Tech. Rep. RMRS-GTR-320. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 85 p.

Leeworthy, V. R., Bowker, J. M., Hospital, J. D., & Stone, E. A. (2005). *Projected participation in marine recreation: 2005 & 2010.* Report prepared for U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Special Projects Division, Silver Spring, MD: 152 p. http://www.srs.fs.usda.gov/pubs/ja/ ja_leeworthy002.pdf

Leones, J., Colby, B., Cory, D., & Ryan, L. (1997). Measuring regional economic impacts of streamflow depletions. *Water Resources Research, 33*(4), 831–838.

Lise, W., & Tol, R. S. J. (2002). Impact of climate on tourist demand. *Climate Change, 55*(3), 429–449.

Loomis, J. B., & Crespi, J. (1999). Estimated effects of climate change on selected outdoor recreation activities in the United States. In R. Mendelsohn & J. E. Newmann (Eds.), The impact of climate change on the United States economy (pp. 283–314). Cambridge, NY: Cambridge University Press.

Mendelsohn, R., & Markowski, M. (1999). The impact of climate change on outdoor recreation. In R. Mendelsohn & J. E. Newmann (Eds.), *The impact of climate change on the United States economy* (pp. 267–288). Cambridge, NY: Cambridge University Press.

Morris, D., & Walls, M. (2009). *Climate change and outdoor recreation resources. Backgrounder.* Washington, DC: Resources for the Future.

Nakićenović, N., Alcamo, J., Davis, G., & de Vries, B. (2000). *Emissions scenarios.* Special report of working group III of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press. http://www.grida.no/climate/ipcc/emission/index.htm

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

SAS Institute Inc. (2004). *SAS/STAT 9.1 user's guide.* Cary, NC: SAS Institute Inc.

U.S. Census Bureau. (2004). Projected population by age, sex, race, and Hispanic origin: 2000-2050 [Dataset]. Washington, DC: U.S. Department of Commerce, Census Bureau. Retrieved from https://www.census.gov/data/datasets/2004/demo/popproj/2004-detailed-data.html

U.S. Department of Agriculture. (USDA) Forest Service. (2009). National survey on recreation and the environment [Dataset]. Retrieved from www.srs.fs.usda.gov/trends/nsre/nsre2.html

USDA Forest Service. (2010). National Visitor Use Monitoring Program: FY 2009 NVUM national summary report. Retrieved from www.fs.fed.us/recreation/programs/nvum/

USDA Forest Service. (2012). *Future scenarios: A technical document supporting the Forest Service 2010 RPA Assessment*. Gen. Tech. Rep. RMRS-GTR-272. Fort Collins, CO: U.S. Department of Agriculture Forest Service, Rocky Mountain Research Station. 34 p.

Wake, C., Burakowski, E., & Goss, L. (2006). *Winter recreation and climate variability in New Hampshire: 1984– 2006.* The Carbon Coalition and Clean Air-Cool Planet. Portsmouth, New Hampshire.

Walls, M., Darley, S., & Siikamaki, J. (2009). *The state of the great outdoors: America's parks, public lands, and recreation resources.* Washington, DC: Resources for the Future.

Walsh, R. G., Jon, K. H., McKean, J. R., & Hof, J. (1992). Effect of price on forecasts of participation in fish and wildlife recreation: an aggregate demand model, *Journal of Leisure Research, 21*, 140–156.

Zarnoch, S. J., Cordell, H. K., Betz, C. J., & Langner, L. (2010). *Projecting county-level populations under three future scenarios: A technical document supporting the Forest Service 2010 RPA assessment.* Gen. Tech. Rep. SRS–128. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station.