12 Climate Change and Outdoor Recreation Participation in the Southern United States

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CONTENTS

In this chapter we begin to assess the potential effects of climate change on future outdoor recreation in the South, a region spanning 13 states from Virginia to Texas (Chapter 1). Our goal is to provide some useful insights about future natural resource-based recreation—an important nontimber product derived from southern forests—in the face of climate change. We develop and present projections of participation and consumption for 10 traditional natural resource-based recreation activities in the South. The work builds on previous outdoor recreation forecasts (Bowker et al. in press) by explicitly incorporating climate, along with population growth, land-use changes, and future socioeconomic conditions into demand models and projections.

The Intergovernmental Panel on Climate Change (2007) predicted that increases in the concentration of greenhouse gases in the atmosphere will further accelerate global warming, thereby resulting in significant climate change across the planet. The potential impacts of climate change have been projected within the context of various natural and biological systems. However, these impacts on human behavior and cultural interaction with nature remain largely unknown. Outdoor recreation opportunities rely heavily on natural settings, thus negative impacts on the quality and availability of forests and water bodies could negatively impact their long-term potential to provide recreational opportunities to humans (Morris and Walls 2009).

Mendelsohn and Markowski (1999) suggested that climate could affect recreation in direct and indirect ways including the effect of severe weather on physical comfort or convenience, the effect that varying season lengths could have on availability and suitability of certain outdoor opportunities, and the degree and pace of alterations to the natural resource base on which outdoor activities depend. Although many expect the impacts of climate change on outdoor recreation to be negative, Gregory (2011) has argued that the reverse could be more likely for some forms of adventure recreation and that rising temperatures could open new opportunities worldwide. For example, enough ice could melt in polar areas to make rowing in the Polar North possible. Similarly, rapid glacial recession in the high Andes of Peru would help open new trekking routes.

A handful of research articles and stories published in popular magazines have speculated on the mixed impacts of climate change on outdoor recreation, which could also go well beyond factors such as opportunity and participation. For example, the many dollars spent by recreation users generate billions in economic impacts, often in small rural economies. So, understanding the future impact of climate change on this industry would help communities take timely action on mitigation and adaptation. A few key questions facing planners and managers today are: (1) how climate change would impact demand for outdoor recreation; (2) whether certain types of activities would be impacted more than others; (3) whether certain places (such as regions or states) would experience higher impacts than others; (4) how the anticipated decrease in outdoor activity would translate into lost public welfare, which would allow mitigation or management decisions to take those costs/benefits into account; and (5) the appropriate analytical framework needed for assessing impacts (both in terms of demand/supply and welfare).

Literature on the relationship between climate change and outdoor recreation has slowly emerged. Available studies can be broadly classified into two types: individual survey-based studies and aggregate modeling studies. The individual survey approach has generally focused on a particular type of recreation, a limited area, or both together. For example, Cato and Gibbs (1973) found that the chance of rain and the expected air temperature could significantly affect the decision to go boating. Ahn et al. (2000) conducted a survey in North Carolina to determine how fishing behavior would be affected by a decline in trout habitat under global warming and found significant welfare loss. Similarly, Richardson and Loomis (2004) surveyed summer tourists at Rocky Mountain National Park in an effort to relate hypothetical climate scenarios to stated recreation trip behavior; they predicted a significant increase in park visitation under all climate change scenarios. Lise and Tol (2002), assessing the impacts of climate on tourist demand, found evidence that under a scenario of global warming, tourists would clearly alter their holiday patterns in Europe and that the effect of climate on tourism demand varied by age and income groups.

Individual survey-based approaches solicit perceptions of climate change and stated recreation behavior under contingent climate scenarios. However, using such survey data to develop a predictive model has some limitations. First, although respondents may accurately remember the number of trips they made or number of days they spent in a particular activity over a year, they might not remember the weather conditions for those days. Second, even if the survey explains the climate scenarios, respondents are still responding hypothetically. And third, linking individual surveys with regional averages of climate data generally means a mismatch on measurements (individual trip data versus state or county level climate data). For these reasons, an indirect approach to demand modeling, which measures observed participation and climate data on a seasonal basis for specific area units, can be more meaningful.

A few studies have adopted aggregate visitation modeling to evaluate the impacts of climate change on outdoor recreation. For example, Wake et al. (2006) combined annual time-series data on annual winter skiing and snowmobiling days with weather data (snow cover days, snowfall, winter temperature) to estimate their correlations. Results suggested a negative relationship with temperature, meaning that warming would have a negative impact on winter recreation. Arbel and Ravid (1985) estimated a time-series model of park visitation and found that weather variables negatively affected visitation in the short run. Mendelsohn and Markowski (1999) used state level data for the conterminous 48 states to assess the impacts of average temperature and precipitation on participation in various outdoor activities. Results revealed a mixed effect, and predicted an overall welfare gain. Loomis and Crespi (1999) also examined state-level data such as total park visits and rounds of golf played in relation to climate variables; they found that many outdoor activities would be negatively affected by climate change, but activities like golf and freshwater recreation would benefit.

In an aggregate modeling study, Whitehead et al. (2009) used data from the National Survey of Recreation and Environment (NSRE) to develop a participation model that he expanded to include some climate variables measured at state level. Their findings showed a significant and negative impact of climate variables, such as monthly temperature and precipitation, for certain months (such as June temperature and January precipitation). More recently, Bowker et al. (2012) also used the NSRE dataset (U.S. Department of Agriculture Forest Service 2009) to model national outdoor recreation participation rates and annual participation days for 17 common activities, and then projected recreation days under various climate change scenarios. They generally found that projections of climate change (U.S. Department of Agriculture Forest Service 2012) had marginally negative effects but that downturns were dramatic for two winter activities, snowmobiling and undeveloped skiing, under some of the climate alternatives.

Aggregated visitation approaches also have limitations. First, the models are usually simple and parsimonious, meaning that important variables are often missing, leading to potential biases in estimation. Second, many models used one-dimensional data, either cross-sectional data for a brief period in time, or time-series data for a limited area; parameters estimated from cross-sectional models are not stable over time, and thus may have limited forecasting accuracy and those estimated with the time-series data are not always applicable to other regions. And third, many studies used standardized or direct measurement of climate data. A variety of indirect but equivalent measurements are available—such as level of thermal comfort, and humidity resistance—that could more effectively capture the climate conditions perceived by people.

PARTICIPATION AND USE

We define participation in an outdoor recreation activity as engaging in that activity at least once in the preceding 12 months. Participation is an indicator of the size of a market and can also be a gauge of public interest. For example, if over 80% of the population engages in day hiking and only 4% engage in snowmobiling, public resource management agencies and private land managers would benefit from knowing that demand for hiking trails could be outpacing that for snowmobiling opportunities. This demonstrates the importance of knowing how many people participate in a given activity, and how this measure could change over time. Participation statistics, either per capita or in absolute numbers of participants, provide the broadest measure of a recreation market.

A second measure of recreation use or quantity demanded is consumption (also known as participation intensity), which can be measured as number of times, days, visits, or trips within a year or other time span; for example, the U.S. Forest Service has used recreation visitor days and national forest visits per year. Consumption measures provide an important additional dimension for resource managers, whose decisions depend on knowing how often and for how long people engage in an activity. This information can be critical to allocating campsites and other existing resources, and is also useful in planning the development of new venues. At the regional level, participation and consumption together provide the broadest measures of an outdoor recreation market. The consumption measure used in this chapter is the number of different days in the previous year that an American adult engaged in a specific activity. Our definition of a day follows the NSRE definition of an activity day: any amount of time spent on an activity on a given day, regardless of the number of hours or whether the activity was the primary reason for the outdoor visit.

The preceding two metrics are origin based—that is, they result from household-level surveying—but they do not specify the location of any activity. Research has shown, however, that the vast majority of outdoor recreation takes place within a few hours' drive of the visitor's residence (Hall and Page 1999). Number of participants and participation rates for 2008, along with total days spent participating, for 10 outdoor recreation activities are reported in Table 12.1. Short- and long-term trends can be important indicators of what could happen with outdoor recreation in the near future (Cordell 2012; Hall et al. 2009). However, simple descriptive statistics or trends do not formally address the underlying factors and associations that could be driving the trends. Thus, a trend could be of limited value if the time horizon is long or if its driving factors are expected to deviate substantially from their historical levels. Trend analysis can be supplemented by projection models that

TABLE 12.1
Outdoor Recreation Activity by Adults in the Southern United States, 2008

Activity	Participation Rate (%)	Participants (millions)	Days
Land based			
Developed site use (family gathering, picnicking, camping)	80	63.2	672
Horseback riding on trails	7	5.7	99
Day hiking	25	20.3	463
Motorized off-road driving	21	16.9	562
Primitive (visiting a wilderness, primitive camping/backpacking)	35	28.2	412
Water based			
Motorized water (motor boating, water skiing, personal water craft)	27	21.3	384
Nonmotorized (canoeing, kayaking, rafting)	15	12.2	80
Wildlife			
Birding (viewing or photographing)	34	27.0	2,862
Fishing	36	28.0	573
Hunting	14	10.8	230

Source: Adapted from National Survey on Recreation and the Environment, 2005 to 2009 ($n = 30{,}394$) (U.S. Department of Agriculture Forest Service 2009).

relate recreation participation directly to the factors that are known to influence behavior. Projection models can then be used with external forecasts of influential factors, including population growth, to simulate future participation. Such modeling allows changes over time to be assessed in light of previously unseen changes in factors that drive the behavior, such as demographics, economic conditions, climactic conditions, and land uses.

Previous research (Bowker et al. 1999, 2006; Cicchetti 1973; Hof and Kaiser 1983b, Leeworthy et al. 2005) has established that race, ethnicity, gender, age, income, and supply or proximity to settings all affect outdoor recreation participation as well as consumption. Similarly, these factors along with others, including distance and quality descriptors, have been used to explain visitation to specific sites (Bowker et al. 2007, 2010; Englin and Shonkwiler 1995). Reliable information about these factors is often available from external sources, like the U.S. Census or parallel research efforts aimed at modeling and simulating influential variables into the future. Such information can thus be available long before results from recreation surveys.

We used a two-step approach to develop projections for participation and consumption of 10 traditional outdoor recreation activities (Table 12.1). The model estimation step focused on developing statistical models of southern adult per capita participation and days-of-participation (conditional on being a participant) for each activity. The models describe the probability of participating in an activity. For those participating, the consumption model describes the number of days. This information provides an understanding of the factors that influence individual recreation choices or behavior and a process for examining individual behavior changes over time in response to changes in underlying factors such as demographics, climate, and resource availability.

The second or simulation step, combined the estimated models with external projections of explanatory variables to generate participation probabilities and days-of-participation for each activity at 10-year intervals to 2060. Per capita estimates for participation and days were combined with population projections to derive estimates of regional adult participants and days-of-participation for each activity. These estimates are then used to create indices by which 2008 estimates of participants and days-of-participation could be scaled.

STORYLINES AND GENERAL CIRCULATION MODELS

Indices of adult participants for each of the 10 activities and days of annual participation are presented across three storylines developed by the Forest Service for the 2010 Resources Planning Act (RPA) assessment. The three storylines, considered equally likely, are globally consistent and well documented by the Intergovernmental Panel on Climate Change (2007). They describe a range of future global and U.S. socioeconomic conditions that are likely to have different effects on future conditions and trends of U.S. forests and grasslands (U.S. Department of Agriculture Forest Service 2010). The global data were scaled to the U.S. national and regional levels and U.S. gross domestic product, and population projections were updated and the updated data were downscaled to county levels for the South (U.S. Department of Agriculture Forest Service 2010; Zarnoch et al. 2010).

As shown in Table 12.2 and Figures 12.1 and 12.2, storyline A1B corresponds to mid-range population growth and the highest household income growth levels. Under these conditions, the South

TABLE 12.2
Key Characteristics of Emissions Storylines Developed by the Intergovernmental Panel on Climate Change (2007)

	Storyline[a]		
Characteristics	**A1B**	**A2**	**B2**
General description	Global economic convergence	Regionalism less trade	Slow change, localized solutions
Global real gross domestic product growth (2010–2060)	High (6.2x)	Low (3.2x)	Low-medium (3.5x)
Global population growth (2010–2060)	Medium (1.3x)	High (1.7x)	Medium (1.4x)
U.S. real gross domestic product growth	High (3.3x)	Low-medium (2.6x)	Low (2.2x)
U.S. population growth	Medium (1.5x)	High (1.7x)	Low (1.3x)
Global expansion of primary biomass energy production	High	Medium	Low

[a] Numbers in parentheses (for example, 6.2x) are factors of change during the projection period.

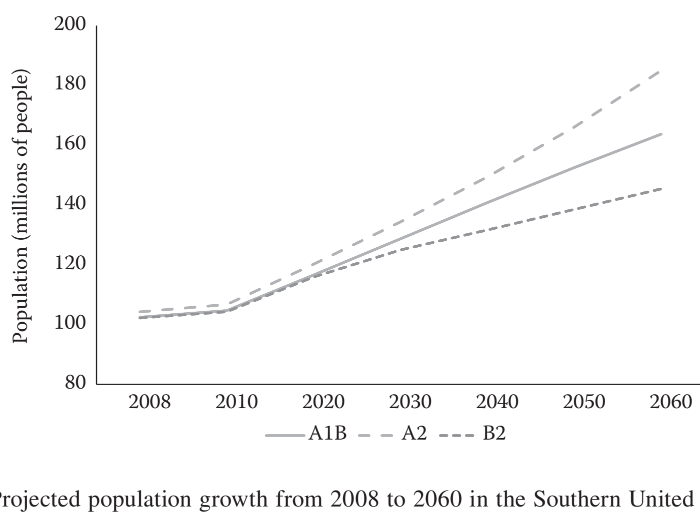

FIGURE 12.1 Projected population growth from 2008 to 2060 in the Southern United States based on an expectation of moderate population growth and high income growth (storyline A1B), high population growth and low income growth (storyline A2), or low population growth and moderate income growth (storyline B2); emissions storylines developed by the Intergovernmental Panel on Climate Change (2007).

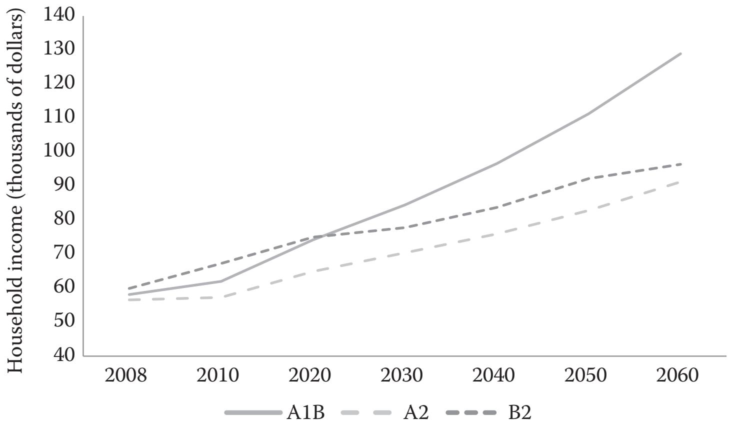

FIGURE 12.2 Projected average household real income (inflation adjusted) growth in the Southern United States based on an expectation of moderate population growth and high income growth (storyline A1B), high population growth and low income growth (storyline A2), or low population growth and moderate income growth (storyline B2); source: National Survey on Recreation and the Environment, emissions storylines developed by the Intergovernmental Panel on Climate Change (2007).

could expect to see about 164 million people (135 million adults) and an average household income of $129,000 by 2060. Storyline A2 projects the highest population growth, reaching about 185 million people (152 million adults) by 2060, and the lowest household income, about $91,000. Storyline B2 projects the lowest population growth and mid-level personal income, predicting a population of 145 million people (120 million adults) with average household income of about $96,000.

Projected land-use changes from Wear (2011) were used to develop the supply variables listed in Table 12.3. Nationally, urban area is expected to increase by 1–1.4 million acres per year from 1997 to 2060, with corresponding decreases of 24–37 million acres in forest area and 19–28 million acres in cropland. About 90% of forecasted losses would be in the Eastern United States with more than half of those losses occurring in the South. For the South, Wear (2011) forecasts forest acreage losses of 11 and 23 million acres (about 7–13%). Based on forecasts of land-use change from 2008 to 2060 by Cordell et al. (2013), southern forest and rangeland per capita is expected to decrease about 45% under A1B, 50% under A2, and about 37% under B2. Federal lands and areas covered by water are assumed static throughout the projection period. Further details about all explanatory variables and their values can be found at: www.forestthreats.org/research/projects/project-summaries/ccammo/Chapter12appendix.

Although not much large-scale work has been done relating climate to outdoor recreation, the general consensus is that long-term changes in climate could affect recreation demand. Walls et al. (2009) assert that the single most important new challenge to recreation supply will be mitigating the adverse effects of climate change, particularly in coastal areas and on western public lands. Disentangling the effects of the climate variables on recreation participation is difficult. Further exploration of these direct and indirect relationships, at both local and macro levels, will be fundamental to improving forecasts of recreation behavior in the future.

Each Intergovernmental Panel on Climate Change storyline had multiple associated climate projections based on levels of greenhouse gas emissions. For this chapter, we linked the three storylines with six general circulation models (Table 12.4) that differ in their approaches to modeling climate dynamics (MIROC3.2, CSIROMK2, CSIROMK3.5, HadCM3, CGCM2, and CGCM3.1), three of which were used to capture a range of future climates for the 2010 RPA assessment (U.S. Department of Agriculture Forest Service 2012).

The Intergovernmental Panel on Climate Change climate projections were first downscaled to the approximately 10 km scale, and then aggregated to the county scale. Detailed documentation

TABLE 12.3
Socioeconomic and Supply Variables for Modeling and Forecasting Outdoor Recreation Participation and Days-of-Participation by Adults in the Southern United States

Variable	Description
Gender	1 = male, 0 = otherwise
American Indian	1 = American Indian, non-Hispanic, 0 = otherwise
Asian/Pacific Islander	1 = Asian/Pacific Islander, 0 = otherwise
Hispanic	1 = Hispanic, 0 = otherwise
Black	1 = African-American, non-Hispanic, 0 = otherwise
Bachelor's	1 = Bachelor degree, 0 = otherwise
Below high school	1 = Less than high school, 0 = otherwise
Post graduate	1 = Post-graduate degree, 0 = otherwise
Some college	1 = Some college or technical school, 0 = otherwise
Age	Respondent age in years
Age squared	Respondent age squared
Income	Respondent household income (2007 dollars)
Population density	County area divided by population (base 1997)
Coastal	1 = County on coast, 0 otherwise
For_ran_pcap	Sum of forest land acres and rangeland acres divided by population at county level and at 50-, 100-, 200-mile radii (base 1997)
Water_pcap	Water acres divided by population at county level and at 50-, 100-, 200-mile radii (base 1997)
Mtns_pcap	Mountainous acres divided by population (base 1997)
Pct_mtns_pcap	Percentage of county acres in mountains divided by population multiplied by 100.000 (base 1997)
Natpark_pcap	Number of nature parks and similar institutions divided by population multiplied by 100,000 (base 1997)
Fed_land_pcap	Sum U.S. Forest Service, National Park Service, U.S. Fish and Wildlife Service, Bureau of Land Management, U.S. Bureau of Reclamation, Tennessee Valley Authority, and U.S. Army Corps of Engineers acreage divided by population (base 1997)
Avg_elev	Average elevation in meters at county level and 50-, 100-, 200-mile radii (base 1997)

TABLE 12.4
Intergovernmental Panel on Climate Change (2007) Emissions Storylines Paired with General Circulation Model Climate Projections

Storyline	General Circulation Model	Model Vintage[a]
A1B	CGCM3.1 (T47) CSIROMK3.5 MIROC3.2 (medres)	AR4
A2	CGCM3.1 (T47) CSIROMK3.5 MIROC3.2 (medres)	AR4
B2	CGCM2 CSIROMK2 HadCM3	TAR

[a] AR4 models were downloaded from the Program for Climate Model Diagnosis and Intercomparison Project 3 (www-pcmdi.llnl.gov/), and TAR 47 models were downloaded from the Intergovernmental Panel on Climate Change Data Distribution Centre (www.ipcc-data.org/).

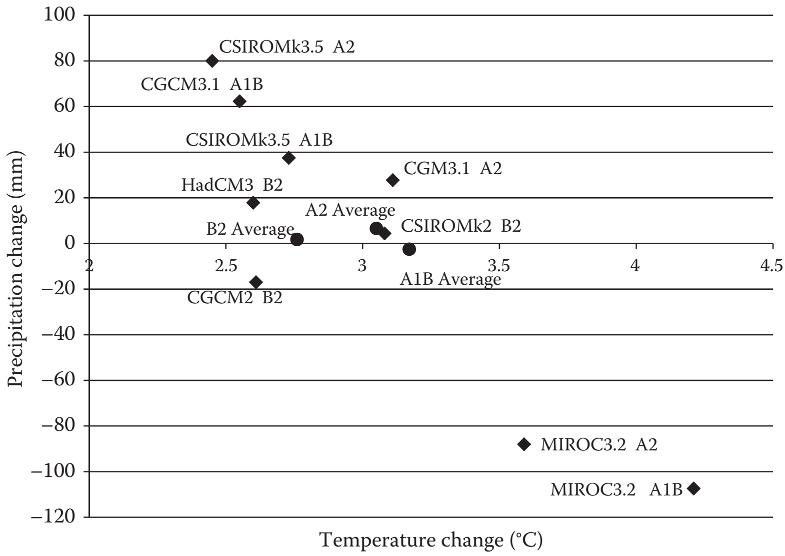

FIGURE 12.3 U.S. temperature and precipitation changes from the reference period (1961–90) to the decade surrounding the year 2060 (2055–64).

of the development of the RPA climate scenario-based projections and downscaling process can be found in U.S. Department of Agriculture Forest Service (2012) and Joyce et al. (in press). At the scale of the conterminous United States, the A1B storyline predicts the warmest and the driest climate of all storylines at 2060 (Figure 12.3), A2 the wettest, and B2 the coolest, although the precipitation changes at the scale of the United States are small to 2060. The individual climate model combinations highlight the variation within each storyline of the individual climate model projections. For example, within the A2 storyline, the CSIROMK3.5 model projects the least warming and the MIROC3.2 model projects the most warming. Although all areas of the United States show increases in temperature, the rate of change varies, and regional precipitation projections vary greatly (U.S. Department of Agriculture Forest Service 2012).

SUMMARY

The objectives of this chapter are to evaluate how population growth, changing demographics and economic conditions, changing land use, and changing climate are likely to affect participant numbers and days-of-participation for an array of 10 natural resource-based recreation activities in the South. The socioeconomic, climate, and land-use projections that are described above were used to develop projections of future resource uses and conditions. Not all of the projected variables are used in all models, but all of the projection models used some subset of these variables. Because the baseline models and orecasts (without climate change) are discussed in detail elsewhere (Bowker et al. in press), the main goal for this chapter is to identify the differences between the baseline recreation forecasts developed for the 2010 RPA assessment and those for which climate futures are explicitly incorporated.

This chapter proceeds as follows. First, we present the statistical methods and previous research on which per capita participation and consumption models were based. Next, we describe the data used in the estimation step—including projections of the various income and population growth factors and relevant assumptions—and present estimation and simulation steps for regional projections of participation and days by activity and climate scenario to 2060. Finally, we discuss some of the key findings within and across activity categories with respect to the factors driving change

over the projection period, while focusing particular attention on the effects of climate change and its relation to management options and activities.

METHODS AND DATA

Recreation demand models fall into three categories: site-specific user models, site-specific aggregate models, and population-level models (Cicchetti 1973). Cicchetti (1973) pioneered the use of cross-sectional population-level models with the household-based 1965 National Survey of Recreation. Estimated models and Census Bureau projections of socio-demographic variables and population were then used to forecast recreation participation and use to 2000. Cicchetti's approach has been used to estimate and project participation and use for recreation activities at national and regional levels (Bowker 2001; Hof and Kaiser 1983a; Leeworthy et al. 2005; Walsh et al. 1992) and for previous RPA assessments (Bowker et al. 1999; Hof and Kaiser 1983b). Alternative approaches, wherein population data were combined with individual site-level data or county-level data to project participation or consumption, have also been used to project national or regional recreation demand (Bowker et al. 2006; Cordell and Bergstrom 1991; Cordell et al. 1990; Englin and Shonkwiler 1995; English et al. 1993; Poudyal et al. 2008). A drawback of cross-sectional models is that the estimated model parameters remain constant over the projection period (Bowker et al. in press). A further drawback of these models is that it is difficult to account for future congestion, supply limitations, and relative price changes on growth in participation and use. Moreover, projections of external variables like population and economic growth, used as inputs for simulations across time, may not include the same assumptions as the estimated statistical models.

Logistic models used to describe the probability of adult participation in each of the 10 activities were specified as

$$P_i = \frac{1}{[1 + \exp(-X_i' B_i)]} \tag{12.1}$$

where P_i is the probability that an individual participated in recreation activity i in the preceding year. The vector X_i contains sociodemographic characteristics, supply, and climate variables for activity i, and at least one climate variable related to conditions at or near the individual's residence; B_i represents a vector of parameters that were estimated using NLOGIT 4.0. Models for each activity, based on NSRE data (U.S. Department of Agriculture Forest Service 2009) for the 13 southern states from 1999 to 2008, were combined with 2008 baseline population-weighted sample means for the explanatory variables to create an initial predicted per capita participation rate for each activity. The per capita participation rates were recalculated at 10-year intervals using projected changes in the explanatory variables. Indices were then created for the participation rates by which the NSRE 2005-2009 average population-weighted participation frequencies (baselines) were scaled, leading to indexed per capita participation rates for each of the 10 activities. Indexing the 2005–2009 averages by changes in model-predicted rates was judged to be superior in terms of mitigating potential nonlinearity biases associated with complete reliance on logistic predicted values (Souter and Bowker 1996). The indexed participation rate estimates were then combined with projected changes in population, according to each of the three storylines to yield indexed values for total adult participants across the 10 activities.

Consumption models were similar to the participation models except that an integer metric represented use, for example, the number of times, days, visits, trips, or events is modeled rather than decision to participate. The general specification for the consumption model was

$$Y_i = f(X_i) + u_i \tag{12.2}$$

where Y_i represents the annual number of days that an individual participated in activity i, X_i is a vector of sociodemographic characteristics, supply, and climate variables associated with activity i, and u_i is a random error term. These count data models are often estimated using negative binomial specifications with a semilogarithmic link function (Bowker 2001; Bowker et al. 1999; Zawacki et al. 2000). Variations of these consumption models have been used in onsite applications, where all observed visits are greater than or equal to one, as data are only obtained from actual visitors (Bowker and Leeworthy 1998). Such zero-truncated models have been applied extensively in onsite recreation-demand estimation and valuation research (Ovaskainen et al. 2001). In some situations the estimated models have been extrapolated to general populations (Englin and Shonkwiler 1995). This approach, wherein population data are combined with individual site-level data, was suggested by Cordell and Bergstrom (1991) and used in a previous RPA assessment by Cordell et al. (1990) with linear models to estimate outdoor recreation trips nationally for 31 activities and to project the number of trips by activity from 1989 to 2040. English et al. (1993) extended the Cordell et al. (1990) models and projections to the regional level by combining parameter estimates from national models with regional explanatory variable values. However, others have questioned the efficacy of extrapolating parameter estimates from the onsite demand models to the population at large (Hagerty and Moeltner 2005).

Because household data, like those obtained using the NSRE, may report zero visits, problems related to onsite samples and extrapolating onsite models to general populations are not serious impediments. In a previous RPA assessment analysis, Bowker et al. (1999) used data from the 1994 to 1995 NSRE, the U.S. Census, and the 1997 NORSIS database to project participation and consumption (annual days and trips) for more than 20 natural resource-based outdoor activities, both nationally and for the four geographical regions of the United States, from 2000 to 2050. The scope of his work was broader than participation modeling, including the use of negative binomial count models to estimate consumption (days and trips annually) and the projection of these measures over the same time period. Bowker (2001) followed the same approach using NSRE and state-level SCORP data to project participation and consumption for Alaskans from 2000 to 2020. Moreover, Leeworthy et al. (2005) used NSRE 2000 data to project participation and consumption of marine-related outdoor recreation from 2000 through 2010. Finally, Bowker et al. (2006) applied similar methods with NSRE 2000 and NVUM (National Visitor Use Monitoring) data (English et al. 2002) to project wilderness and primitive-area recreation participation and consumption from 2002 through 2050.

Alternatively, if observed zeros for the dependent variable (days-of-participation) seem excessive or not entirely caused by the same data-generating process as the positive values, a hurdle model structure or a zero-inflated count procedure is recommended (Cameron and Trivedi 1998). The hurdle model, employed in this analysis, combines the probability of participation (threshold) with the estimated number of days for those participating:

$$E\left[Y_i|X_i\right] = Pr\left[Y_i > 0|X1_i\right] * EY_i > 0[Y_i|Y_i > 0, X2_i] \tag{12.3}$$

where Y_i represents days of participation in activity i, and X_i, $X1_i$, and $X2_i$ represent vectors of sociodemographic characteristics, supply, and climate variables associated with activity i. The hurdle model allows different vectors of explanatory variables for the respective products of the expectation in Equation 12.3, with the probability estimated as a logistic and conditional-days portions estimated as a truncated negative binomial, thus leading to two unique sets of estimated parameters. Parameter estimates for each of the 10 regional recreation activity-day hurdle models were estimated with NLOGIT 4.0 (Greene 2009) using NSRE data from southern households from 1999 to 2008 (U.S. Department of Agriculture Forest Service 2009; Cordell 2012), county level climate data (Joyce et al. in press), county land-use data (Wear 2011), and recreation supply data (Cordell et al. 2013).

Similar to the procedure with the participation models and indices, hurdle model parameter estimates are combined with 2008 NSRE baseline participation and days estimates, projected explanatory variables, and projected population changes under each of the storylines to provide indices of projected growth of annual days-of-participation for the activities listed in Table 12.1. Three climate alternatives (Table 12.4) are used for each of the storylines.

Socioeconomic and supply variables for the various models and projections are listed in Table 12.3. The preponderance of these variables was included in the NSRE database (U.S. Department of Agriculture Forest Service 2009; Cordell 2012). Addition variables related to supply were obtained from Cordell et al. (2013). Projections of land-use change variables are from Wear (2011).

Historical as well as projected climate data are from Joyce et al. (in press). As little or no literature was available on linking climate to household participation and consumption of recreation activities, an ad hoc approach was followed during the model estimation stage wherein climate variables were created based on 6-year moving averages and arbitrary distances from county centroids. Climate variables are listed in Table 12.5. Each estimated model was limited to one climate variable to avoid multicollinearity.

Results were estimated for 10 logistic participation models, without and then with climate variables (www.forestthreats.org/research/projects/project-summaries/ccammo/Chapter12-appendix). Reported results for the logistic participation models include parameter estimates for each activity, values for explanatory variables by scenario and year, odds ratios that indicate the odds of participation occurring in one group compared to the odds of occurrence in another group, fit statistics, and graphics of overall participant growth by activity and assessment scenario. Climate variables used in the participation models are reported in Table 12.6.

Parameter estimates were then combined with available projections of explanatory variables to create indexed per capita participation estimates at 10-year intervals through 2060. These indices were in turn combined with population projections for each of the storylines to develop estimated participant indices. The participant indices were then applied to a beginning baseline estimate of participants for each activity based on weighted national averages calculated from 2005 to 2009 NSRE data to yield projection of adult participants. The four-year average around 2008 was chosen to avoid any aberration associated with a single year.

The hurdle model combines probability of participation in an activity with the expected value of days participating, given one actually participated (Equation 12.3). The estimated logistic models (www.forestthreats.org/research/projects/project-summaries/ccammo/Chapter12-appendix) are thus combined with conditional participation-days models to complete the hurdle model. Given that only those participating are included in the conditional days portion of the model, thus eliminating observations of zero for days, a truncated negative binomial model was employed for estimation. Like the participation models above, the days models were estimated for each of the 10 activities, with and without climate variables (www.forestthreats.org/research/projects/project-summaries/ccammo/Chapter12-appendix). Climate variables used in the days models are reported in Table 12.6.

Total days for each activity were estimated following a procedure that is similar to the one used for estimating participants and that uses the same data. First, days-of-participation per participant were regressed on relevant explanatory variables without and then with climate variables (www.forestthreats.org/research/projects/project-summaries/ccammo/Chapter12-appendix). Parameter estimates from the respective negative binomial models were then combined with projected explanatory variables at 10-year intervals to create indexed per capita days-of-participation for each activity. These indices were in turn combined with population projections for each of the storylines to develop estimated per participant-days indices. The participant-days indices were then applied to a beginning baseline estimate of participation days for each activity, based on weighted regional averages calculated from 2005 to 2009 NSRE data, to yield projections of southern adult participation days. Like the participant estimates, the four-year average around 2008 was chosen to avoid any aberration associated with a single year.

TABLE 12.5
Climate Variables Used for Estimating and Forecasting Outdoor Recreation Participation and Days-of-Participation by Adults in the Southern United States

Variable	Description[a]
Ppt_monthly_mean100	Daily average of precipitation for all months for resident county and counties within 100 miles of resident county centroid
Ppt_monthly_mean200	Daily average of precipitation for all months for resident county and counties within 200 miles of resident county centroid
Spring_PET_d200	Spring average daily potential evapotranspiration for resident county and counties within 200 miles of resident county centroid
Tmax_fall50	Average monthly maximum autumn temperature for resident county and counties within 50 miles of resident county centroid
Tmax_geq_25_d200	Percentage of the month when average monthly maximum temperature exceeded 25°C for resident county and counties within 200 miles of resident county centroid
Tmax_geq_35	Percentage of months when average monthly maximum temperature exceeded 35°C in the resident county
Tmax_geq35_d100	Percentage of month when average monthly maximum temperature exceeded 35°C for resident county and counties within 100 miles of resident county centroid
Tmax_geq35_d200	Percentage of month when average monthly maximum temperature exceeded 35°C for resident county and counties within 200 miles of resident county centroid
Tmax_spring	Average of the monthly maximum temperature averages in spring in the resident county
Tmax_spring100	Average of the monthly maximum temperature averages in spring for the resident county and counties within 100 miles of resident county centroid
Tmax_summer	Average of the monthly maximum temperature averages in summer in the resident county
Tmax_summer50	Average of the monthly maximum temperature averages in summer for the resident county and counties within 50 miles of resident county centroid
Tmax_summer100	Average of the monthly maximum temperature averages in summer for the resident county and counties within 100 miles of resident county centroid
Tmax_summer200	Average of the monthly maximum temperature averages in summer for the resident county and counties within 200 miles of resident county centroid
Tmax_winter	Average of the monthly maximum temperature averages in winter in the resident county
Tmax_winter100	Average of the monthly maximum temperature averages in winter for the resident county and counties within 100 miles of resident county centroid
Tmin_leq_0	Percentage of month when average monthly minimum temperature was below 0°C in the resident county
Tmin_leq_neg10	Percentage of month when average monthly minimum temperature was below −10°C in the resident county
Total_ppt100	Monthly average of total monthly precipitation in resident county and counties within 100 miles of resident county centroid
Total_ppt200	Monthly average of total monthly precipitation in resident county and counties within 200 miles of resident county centroid
Tinter_PET_d50	Average of daily potential evapotranspiration averages in winter for resident county and counties within 50 miles of resident county centroid
Tinter_PET_d200	Average of daily potential evapotranspiration averages in winter for resident county and counties within 200 miles of resident county centroid
Tearly_PET_d200	Average of daily potential evapotranspiration averages for resident county and counties within 200 miles of resident county centroid

[a] All averages were calculated over six-year periods, for example, historic data are based on 2000 to 2006 data, 2060 projections are based on averages from 2055 to 2060. Seasons were divided into three-month periods based on the following categories: winter (December, January, and February), spring (March, April, and May), summer (June, July, and August), and autumn (September, October, and November).

TABLE 12.6
Climate Variables for Modeling Activity Participation and Days-of-Participation

Recreation Activity	Model Type	Climate Variable
Land based		
Developed site use (family gathering, picnicking, camping)	Participation	tmax_summer
	Days	tmax_geq_25_d100
Equestrian (horseback riding on trails)	Participation	tmin_leq_0_d200
	Days	tmax_geq_35
Day hiking	Participation	tmax_geq_35_d200
	Days	tmin_leq_0
Off-road driving	Participation	tmax_geq_25
	Days	tmax_geq_35_d200
Primitive area use (visiting wilderness, camping/backpacking)	Participation	tmax_geq25
	Days	tmax_geq_25_d100
Water based		
Motorized water (motorboating, water skiing, jetskiing)	Participation	tmax_geq_25
	Days	tmin_leq_0_d200
Floating (canoeing, kayaking, rafting)	Participation	tmax_summer
	Days	spring_PET_d50
Wildlife		
Birding (viewing or photographing)	Participation	winter_PET_d50
	Days	tmax_geq_35
Hunting	Participation	tmax_winter_d100
	Days	tmin_leq_neg5_d100
Fishing	Participation	tmax_geq_35
	Days	tmax_geq_35

RESULTS

Below, we present per capita and overall changes, from 2008 to 2060, in participation and days-of-participation by storyline for land-based activities (developed site use, hiking, horseback riding on trails, motorized off-road driving, and primitive site use), water-based activities (motorized and nonmotorized), and wildlife-based activities (birding, fishing, and hunting).

Developed site use: Developed site use is the most popular of the land-based outdoor recreation activities, both nationally and in the South. This composite activity includes family gatherings, picnicking, and developed camping. On average, from 2005 to 2009, this activity was practiced by about 80% of southern adults, or more than 63 million people, accounting for 672 million days-of-participation in 2008 (Table 12.1). Moreover, our projections only relate to adults; because many children participate in these activities, participation totals that include all age groups should be much higher than the numbers reported in this chapter. As Table 12.7 indicates, per capita participation growth in this activity is expected to be static over the next 50 years across all storylines; with the moderate population/high income growth-focused A1B—at 2%—showing the most change. This composite activity is already highly popular, and the static participation rate means that overall participant growth is likely to mirror general population increases for all storylines. Thus, under A2, which has the highest expected population growth, participation would increase by nearly 90% to approximately 122 million adults per year. Days-per-participant is projected to remain constant across all storylines. Hence, the total for days is expected to follow growth in participant numbers and is expected to range from 53% to 90% over the next five decades.

TABLE 12.7
Forecasted Developed Site Use (Family Gatherings, Picnicking, or Camping) by Adults in the Southern United States

	Year		Projected Change from 2008 (%)			
Storyline[a]	2008	2060[b]	Baseline[b]	Climate1[c]	Climate2[d]	Climate3[e]
	Per capita participation (%)					
A1B	79.9	81.5	2	1	0	(2)
A2	79.9	80.7	1	(1)	(1)	(2)
B2	79.9	80.7	1	(1)	0	(1)
	Adult participants (millions)					
A1B	63.2	109.9	74	72	70	67
A2	64.2	122.1	90	88	86	84
B2	63.0	96.4	53	50	51	50
	Days per participant					
A1B	10.61	10.61	0	1	3	4
A2	10.61	10.61	0	2	3	3
B2	10.61	10.61	0	2	1	1
	Total days (millions)					
A1B	672	1,170	74	74	76	73
A2	684	1,299	90	91	92	89
B2	670	1,026	53	52	53	52

Note: Based on an expectation of moderate population growth and high income growth (storyline A1B), high population growth and low income growth (storyline A2), or low population growth and moderate income growth (storyline B2) under alternative climate futures derived from general circulation models.

[a] Emissions storylines developed by the Intergovernmental Panel on Climate Change (2007).

[b] Climate variable omitted from model and projection.

[c] Climate1 uses forecast data from CGCM3.1 for storylines A1B and A2; CGCM2 for storyline B2.

[d] Climate2 uses forecast data from CSIROMK3.5 for storylines A1B and A2; CSIROMK2 for storyline B2.

[e] Climate3 uses forecast data from MIROC3.2 for storylines A1B and A2; HadCM3 for storyline B2.

Adding climate projections across the storylines produced only marginal changes in participants and days-of-participation (Table 12.7). Generally, participation rates decreased ≤4 percentage points from the baseline leading to a potential decrease of ≤10 million participants in 2060 under storyline A1B. Alternatively, despite climate change from the baseline, days-per-participant increased from 1 to 4 percentage points across the storylines. This change offset the slight decrease in participant numbers and thus the days total appears largely unaffected by climate change, depending far more on population and income changes.

Hiking: Day hiking is perhaps the single most popular backcountry activity. In 2008 about 33% of adults nationally participated in hiking. In the South, 25.2% of adults participated in hiking, totaling about 20 million participants and 463 million days annually (Table 12.1). For all storylines in the absence of climate change, hiking participation per capita is expected to increase by 12% to 16% by 2060 (Table 12.8). Participant numbers increase the most under A2 at nearly 113% (resulting in about 44 million hikers), followed by A1B at about 96% and B2 at about 70%. Hiking days are expected to increase by slightly more than participants. A notable result for hiking is that it is the only activity for which Hispanic ethnicity is associated with a higher participation rate and higher days-per-participant than other Caucasians (www.forestthreats.org/research/projects/project-summaries/ccammo/Chapter12-appendix).

Projected climate changes appear to have negative impacts across all storylines. For example, relative to the baseline, participation rates decreased by ≤16 percentage points for storyline A1B,

TABLE 12.8
Forecasted Hiking Use by Adults in the Southern United States

	Year		Projected Change from 2008 (%)			
Storyline[a]	**2008**	**2060**[b]	**Baseline**[b]	**Climate1**[c]	**Climate2**[d]	**Climate3**[e]
	Per capita participation (%)					
A1B	25.2	29.2	16	13	10	0
A2	25.2	28.5	13	10	8	1
B2	25.2	28.2	12	5	8	7
	Adult participants (millions)					
A1B	20.3	39.8	96	91	86	70
A2	20.6	44.0	113	107	104	91
B2	20.2	34.4	70	59	63	62
	Days per participant					
A1B	22.93	23.62	3	(5)	(5)	(5)
A2	22.93	23.16	1	(6)	(6)	(7)
B2	22.93	24.08	5	(4)	(3)	(3)
	Total days (millions)					
A1B	463	935	102	82	77	62
A2	471	1,017	116	95	91	78
B2	461	817	77	53	59	57

Note: Based on an expectation of moderate population growth and high income growth (storyline A1B), high population growth and low income growth (storyline A2), or low population growth and moderate income growth (storyline B2) under alternative climate futures derived from general circulation models.

[a] Emissions storylines developed by the Intergovernmental Panel on Climate Change (2007).

[b] Climate variable omitted from model and projection.

[c] Climate1 uses forecast data from CGCM3.1 for storylines A1B and A2; CGCM2 for storyline B2.

[d] Climate2 uses forecast data from CSIROMK3.5 for storylines A1B and A2; CSIROMK2 for storyline B2.

[e] Climate3 uses forecast data from MIROC3.2 for storylines A1B and A2; HadCM3 for storyline B2.

≤12 percentage points for A2, and ≤7 percentage points for B2. The biggest decreases are associated with the MIROC3.2 climate projection, which is characterized by higher temperatures and lower participation. Nevertheless, at the very least, the same percentage of southerners will likely be participating in hiking in 2060 as today, even under the most negative climate alternative. Climate change would also have a downward effect on the annual hiking days-per-participant, accounting for a 7- to 9-percentage point decrease from the baseline across storylines. Despite these decreases, increased population is expected to cause increases, both in participant numbers (59–107%) and days-of-participation (53–95%). On average, projected annual hiking days across storylines will likely be ≤25% points lower in 2060 than if climate remained unchanged.

Horseback riding on trails: Although the least popular of the land based activities, horseback riding is nevertheless enjoyed by 7.1% of southern adults annually (Table 12.9). Unlike developed use and hiking, per capita participation in horseback riding on trails is projected to decrease by 5–8% in B2 and A2 over the next 50 years. In A1B, however, per capita participation is expected to increase by 9%. The number of participants in this activity increases under A1B (a function of high income growth) from about 5.6 million in 2008 to between 10 and 11 million by 2060, followed by a similar increase under A2 (driven by high population growth). Annual riding days-per-participant is static under A2, but increases by 9% under the low population/moderate income growth of B2, and by 26% under A1B. Combined with the participation rate changes and population growth, horseback riding on trails is projected to increase from a total of about 100 million days in 2008 to between 155 and 231 million days annually by 2060.

TABLE 12.9
Forecasted Horseback Riding-on-Trails Use by Adults in the Southern United States

	Year		Projected Change from 2008 (%)			
Storyline[a]	**2008**	**2060[b]**	**Baseline[b]**	**Climate1[c]**	**Climate2[d]**	**Climate3[e]**
	Per capita participation (%)					
A1B	7.1	7.7	9	8	7	8
A2	7.1	6.5	(8)	(9)	(10)	(11)
B2	7.1	6.7	(5)	(7)	(3)	(5)
	Adult participants (millions)					
A1B	5.6	10.5	85	83	82	84
A2	5.7	9.9	73	71	69	67
B2	5.6	5.4	44	41	47	44
	Days per participant					
A1B	17.67	22.26	26	(15)	(18)	(65)
A2	17.67	17.49	(1)	(59)	(40)	(60)
B2	17.67	19.26	9	(36)	(28)	(31)
	Total days (millions)					
A1B	99	231	133	55	31	(35)
A2	101	172	71	(30)	2	(34)
B2	99	155	57	(10)	6	(1)

Note: Based on an expectation of moderate population growth and high income growth (storyline A1B), high population growth and low income growth (storyline A2), or low population growth and moderate income growth (storyline B2) under alternative climate futures derived from general circulation models.

[a] Emissions storylines developed by the Intergovernmental Panel on Climate Change (2007).

[b] Climate variable omitted from model and projection.

[c] Climate1 uses forecast data from CGCM3.1 for storylines A1B and A2; CGCM2 for storyline B2.

[d] Climate2 uses forecast data from CSIROMK3.5 for storylines A1B and A2; CSIROMK2 for storyline B2.

[e] Climate3 uses forecast data from MIROC3.2 for storylines A1B and A2; HadCM3 for storyline B2.

Accounting for associated climate change alternatives has very minor effects on the participation rate and the number of participants by 2060, falling within a few percentage points of the baseline for all storylines (Table 12.9). However, climate seems to have dramatic dampening effects on annual days-per-participant, leading to decreases of 15–65% (2.7–10.6 days). The largest decreases appear for the MIROC3.2 climate projections. Combined with population growth under each storyline, the effect of climate change on total days-of-participation for riding ranges from a 55% increase (A1B with CGCM3.1) to a 35% decrease (A1B with MIROC3.2). Including climate would likely cause substantially fewer riding days per year in 2060 than the baseline. Moreover, in five of nine storyline/climate alternatives, the annual days total decreases compared to 2008.

Motorized off-road driving: Off-road driving increased in popularity among southerners by 42% from 1999 to 2009 (Cordell et al. in press). In 2008, approximately 21% or 17 million adults took part in off-road driving, accounting for more than 560 million days (Table 12.10). This makes motorized off-roading second only to visiting developed sites for days-of-use among the land-based activities. Over the next 50 years, participation rates are projected to decrease by 11–25% across all storylines, meaning that the growth of participant numbers would be lower than the population growth rate, or 26–51%. Annual days-per-participant is expected to decrease by ≤3%; therefore, the total number of days for this activity is expected to grow slightly less than participants, or from 24% to 48%. Although off-roading days will likely increase less than population growth, southerners would nevertheless increase their off-roading days by 135–269 million annually by 2060.

TABLE 12.10
Forecasted Motorized Off-Road Use by Adults in the Southern United States

	Year		Projected Change from 2008 (%)			
Storyline[a]	**2008**	**2060[b]**	**Baseline[b]**	**Climate1[c]**	**Climate2[d]**	**Climate3[e]**
	Per capita participation (%)					
A1B	21.3	19.0	(11)	(12)	(15)	(15)
A2	21.3	16.0	(25)	(25)	(27)	(27)
B2	21.3	17.9	(16)	(18)	(17)	(17)
	Adult participants (millions)					
A1B	16.9	25.5	51	50	45	44
A2	17.2	24.4	42	41	37	37
B2	16.9	21.2	26	25	25	26
	Days per participant					
A1B	33.30	32.63	(2)	(13)	(20)	(39)
A2	33.30	32.30	(3)	(31)	(18)	(32)
B2	33.30	32.63	(2)	(21)	(15)	(32)
	Total days (millions)					
A1B	562	831	48	30	16	(12)
A2	571	788	38	(2)	13	(7)
B2	560	695	24	(1)	6	3

Note: Based on an expectation of moderate population growth and high income growth (storyline A1B), high population growth and low income growth (storyline A2), or low population growth and moderate income growth (storyline B2) under alternative climate futures derived from general circulation models.

[a] Emissions storylines developed by the Intergovernmental Panel on Climate Change (2007).
[b] Climate variable omitted from model and projection.
[c] Climate1 uses forecast data from CGCM3.1 for storylines A1B and A2; CGCM2 for storyline B2.
[d] Climate2 uses forecast data from CSIROMK3.5 for storylines A1B and A2; CSIROMK2 for storyline B2.
[e] Climate3 uses forecast data from MIROC3.2 for storylines A1B and A2; HadCM3 for storyline B2.

Through 2060, climate is expected to have very minor negative effects on participation rates compared to the baseline (Table 12.10). Similarly, the effect on participant numbers is marginal. However, because days-per-participant decreases from 13% to 39% annually compared to 2008, total days-of-participation for off-road driving is expected to be noticeably less than for the no climate change baseline. With four out of nine storyline/climate alternatives, the number of off-road driving days in 2060 is forecasted to be ≤12% lower than in 2008, suggesting that climate change could strongly dampen off-road driving days in the future.

Visiting primitive areas: This activity is an aggregate that consists of activities such as backpacking, primitive camping, and visiting a designated or undesignated wilderness. This composite accounted for over 28 million participants in 2008, or about 35% of all adults in the South (Table 12.11). Participants visited primitive areas on over 411 million days in 2008. Under the baseline with no climate change, annual per capita participation is expected to decrease by ≤7% over the next 50 years. Increased population density, decreases in forest and rangeland per capita, and changing demographics appear to be factors influencing the participation rate decrease (www.forestthreats.org/research/projects/project-summaries/ccammo/Chapter12-appendix). However, overall participation is expected to increase by 44–76% across all storylines by 2060 because population growth would offset the small decrease in participation rates. Annual days-of-participation for visiting primitive areas per participant is projected to remain nearly constant throughout the simulation period; therefore, the growth in total days per year is expected to closely follow adult population growth and range from 43% to 77% across all baselines.

TABLE 12.11
Forecasted Primitive area Use by Adults in the Southern United States

Storyline[a]	Year		Projected Change from 2008 (%)			
	2008	2060[b]	Baseline[b]	Climate1[c]	Climate2[d]	Climate3[e]
	Per capita participation (%)					
A1B	35.3	34.9	(3)	(3)	(4)	(4)
A2	35.3	32.8	(7)	(7)	(8)	(8)
B2	35.3	33.5	(6)	(6)	(6)	(6)
	Adult participants (millions)					
A1B	28.2	47.0	67	65	63	63
A2	28.6	50.4	76	75	74	73
B2	28.1	40.4	44	42	42	43
	Days per participant					
A1B	14.55	14.70	1	(4)	(10)	(11)
A2	14.55	14.70	1	(5)	(9)	(8)
B2	14.55	14.70	1	(5)	(4)	(3)
	Total days (millions)					
A1B	412	697	67	59	47	45
A2	419	751	77	66	58	59
B2	411	592	43	36	37	38

Note: Based on an expectation of moderate population growth and high income growth (storyline A1B), high population growth and low income growth (storyline A2), or low population growth and moderate income growth (storyline B2) under alternative climate futures derived from general circulation models.

[a] Emissions storylines developed by the Intergovernmental Panel on Climate Change (2007).
[b] Climate variable omitted from model and projection.
[c] Climate1 uses forecast data from CGCM3.1 for storylines A1B and A2; CGCM2 for storyline B2.
[d] Climate2 uses forecast data from CSIROMK3.5 for storylines A1B and A2; CSIROMK2 for storyline B2.
[e] Climate3 uses forecast data from MIROC3.2 for storylines A1B and A2; HadCM3 for storyline B2.

Amending the storylines with related climate forecasts would lead to virtually no changes in participation rates or the number of participants visiting primitive areas to 2060. However, climate change would produce a 5- to 22-percentage point decrease from the baseline across the storylines, yielding 36–66% more primitive visit days than in 2008.

Motorized water use: In 2008, 27%, or about 21 million southern adults, engaged in motor boating, waterskiing, and personal watercraft use; and spent approximately 384 million days in this activity. Taken separately, these activities all experienced relatively strong growth in participants from 1999 to 2009, both regionally and nationally (Cordell et al. in press; Cordell 2012). The participation rate for motorized water use is projected to increase by 10% to 2060 under A1B, but decreases by ≤5% under A2 and B2 (Table 12.12). The difference can be attributed to higher growth rate for household income, which is an important driver for this activity (www.forestthreats.org/research/projects/project-summaries/ccammo/Chapter12-appendix). Including population growth yields a 48- to 87-percent increase in total participants by 2060. Days-per-participant is expected to be stable at 18 days per year under A1B (faster than population growth), but decrease slightly under the others for a rate that is somewhat slower than population growth. By 2060, days-of-participation for motorized water use are expected to grow by 38–86%, to between 529 and 715 million days annually.

Climate change would add about a 3 percentage points to the participation rate for A1B and A2, and no change for B2 (Table 12.12). Thus, motor boating participant numbers can be expected to increase by zero to 8 percentage points more than the baselines when climate forecasts are included.

TABLE 12.12

Forecasted Recreational Motorized Water Use (Motor Boating, Waterskiing, Using Personal Watercraft) by Adults in the Southern United States

	Year		Projected Change from 2008 (%)			
Storyline[a]	**2008**	**2060[b]**	**Baseline[b]**	**Climate1[c]**	**Climate2[d]**	**Climate3[e]**
	Per capita participation (%)					
A1B	27.0	29.7	10	10	15	15
A2	27.0	25.7	(5)	(4)	(2)	(2)
B2	27.0	26.5	(2)	(2)	(2)	(2)
	Adult participants (millions)					
A1B	21.3	39.8	87	88	95	95
A2	21.6	38.9	80	80	85	86
B2	21.2	31.4	48	49	48	48
	Days per participant					
A1B	18.21	18.03	(1)	(1)	(1)	(2)
A2	18.21	16.57	(9)	(10)	(9)	(8)
B2	18.21	17.12	(6)	(7)	(8)	(7)
	Total days (millions)					
A1B	384	715	86	85	92	92
A2	391	645	65	63	69	70
B2	383	529	38	39	37	37

Note: Based on an expectation of moderate population growth and high income growth (storyline A1B), high population growth and low income growth (storyline A2), or low population growth and moderate income growth (storyline B2) under alternative climate futures derived from general circulation models.

[a] Emissions storylines developed by the Intergovernmental Panel on Climate Change (2007).

[b] Climate variable omitted from model and projection.

[c] Climate1 uses forecast data from CGCM3.1 for storylines A1B and A2; CGCM2 for storyline B2.

[d] Climate2 uses forecast data from CSIROMK3.5 for storylines A1B and A2; CSIROMK2 for storyline B2.

[e] Climate3 uses forecast data from MIROC3.2 for storylines A1B and A2; HadCM3 for storyline B2.

Annual days-per-participant is expected to remain virtually unchanged from baseline conditions. Hence, for total days for motorized water use can be expected to increase by ≤6 percentage points over the baselines.

Nonmotorized water use: Approximately 15.4% or 12.2 million adults in the South participated in canoeing, kayaking, or rafting in 2008, resulting in 80 million days of use (Table 12.1). Although rafting grew by only 5% from 1999 to 2009, canoeing (39%) and kayaking (154%) grew dramatically (Cordell 2012). Despite rapid growth over the past decade, per capita adult participation is projected to be stable out to 2060, resulting in participant numbers growing at the same rate as the population, or 45–81% (Table 12.13). This activity is less affected by income than its motorized counterpart. Hence, A2 with higher population growth would yield the biggest increase in participants. Days-per-participant is expected to decrease minimally by 2060, meaning that the current 80 million days for this activity is forecasted to increase to 114 to 143 million days by 2060.

Climate change will likely negatively affect participation rates for nonmotorized water activities across all storylines. Participation rates are expected to drop 6–18 percentage points compared to the baseline (Table 12.13). The number of participants is thus expected to grow 33–70% by 2060, or about 10 percentage points less than when climate change is not considered. Conversely, climate change is expected to have a marginally positive effect on annual days-of-participation—2–11 percentage points over the baseline—depending on the particular storyline/climate alternative. Given

TABLE 12.13
Forecasted Recreational Nonmotorized Water Use (Canoeing, Kayaking, Rafting, Tubing) by Adults in the Southern United States

	Year		Projected Change from 2008 (%)			
Storyline[a]	2008	2060[b]	Baseline[b]	Climate1[c]	Climate2[d]	Climate3[e]
	Per capita participation (%)					
A1B	15.4	16.3	6	0	(5)	(12)
A2	15.4	14.8	(4)	(10)	(13)	(17)
B2	15.4	14.8	(4)	(12)	(11)	(12)
	Adult participants (millions)					
A1B	12.2	22.0	80	69	61	49
A2	12.4	22.5	81	70	65	57
B2	12.2	17.6	45	33	35	33
	Days per participant					
A1B	6.58	6.49	(2)	2	7	9
A2	6.58	6.38	(3)	6	5	6
B2	6.58	6.45	(2)	4	2	0
	Total days (millions)					
A1B	80	141	76	73	72	63
A2	81	143	76	80	72	67
B2	80	114	43	38	38	33

Note: Based on an expectation of moderate population growth and high income growth (storyline A1B), high population growth and low income growth (storyline A2), or low population growth and moderate income growth (storyline B2) under alternative climate futures derived from general circulation models.

[a] Emissions storylines developed by the Intergovernmental Panel on Climate Change (2007).

[b] Climate variable omitted from model and projection.

[c] Climate1 uses forecast data from CGCM3.1 for storylines A1B and A2; CGCM2 for storyline B2.

[d] Climate2 uses forecast data from CSIROMK3.5 for storylines A1B and A2; CSIROMK2 for storyline B2.

[e] Climate3 uses forecast data from MIROC3.2 for storylines A1B and A2; HadCM3 for storyline B2.

that the marginal decrease in participation rate is slightly greater than the marginal increase in days-per-participant, on average the total days-of-participation for nonmotorized water activities in 2060 ranges from slightly more (4 percentage points) to somewhat less (13 percentage points) than the baselines when climate change is included.

Birding: This nonconsumptive activity, which consists of viewing or photographing birds, involves 34.2% of the adult population (27 million people) in the South. Among all activities, birding has the highest annual days-per-participant (107) for an annual total of about 2.9 billion days (Table 12.14). This reflects the many levels or intensities of birding, from watching backyard feeders to pursuing sightings in remote forests. Cordell (2012) reports that birding participation increased by nearly 30% from 1999 to 2009. Per capita participation in birding is projected to increase 8–10% through 2060, meaning that birders would increase faster than the general adult population across all storylines, with total participants expected to be 44–56 million. Days-per-participant is expected to decrease 9–13%, meaning that the total number of days per year would increase marginally less than the population, or 47–76%.

Adding climate change to the storylines shows little or no effect on the participation rate or the number of birders. However, the 9–13% decrease in annual days-per-participant under the baselines becomes 20–37% when climate data are included, with the biggest decreases happening under A1B with the MIROC3.2 climate forecast (Table 12.14). Given the shortened participation periods, total

TABLE 12.14
Forecasted Birding Activity (Viewing or Photographing) by Adults in the Southern United States

	Year		Projected Change from 2008 (%)			
Storyline[a]	**2008**	**2060**[b]	**Baseline**[b]	**Climate1**[c]	**Climate2**[d]	**Climate3**[e]
	Per capita participation (%)					
A1B	34.2	37.6	10	11	12	11
A2	34.2	36.9	8	9	9	10
B2	34.2	36.9	8	9	8	8
	Adult participants (millions)					
A1B	26.0	50.4	87	88	90	89
A2	27.4	55.7	103	105	106	108
B2	26.9	43.9	63	65	63	64
	Days per participant					
A1B	106.65	94.92	(11)	(25)	(27)	(37)
A2	106.65	92.79	(13)	(30)	(24)	(31)
B2	106.65	97.05	(9)	(22)	(20)	(20)
	Total days (millions)					
A1B	2862	4752	66	42	39	19
A2	2912	5125	76	43	56	43
B2	2855	4197	47	29	30	30

Note: Based on an expectation of moderate population growth and high income growth (storyline A1B), high population growth and low income growth (storyline A2), or low population growth and moderate income growth (storyline B2) under alternative climate futures derived from general circulation models.

[a] Emissions storylines developed by the Intergovernmental Panel on Climate Change (2007).

[b] Climate variable omitted from model and projection.

[c] Climate1 uses forecast data from CGCM3.1 for storylines A1B and A2; CGCM2 for storyline B2.

[d] Climate2 uses forecast data from CSIROMK3.5 for storylines A1B and A2; CSIROMK2 for storyline B2.

[e] Climate3 uses forecast data from MIROC3.2 for storylines A1B and A2; HadCM3 for storyline B2.

days-of-participation for birding will likely increase 19–56% to 2060; about 17- to 33-percentage points less, on average, than the baselines.

Fishing: Defined here, fishing includes various types of saltwater and freshwater pursuits. Fishing has the second highest participation rate (35.7%) for southerners. In 2008, approximately 28 million anglers accounted for 573 million days-of-participation (Table 12.1). According to Cordell (2012), fishing participants increased by >21% in the past decade. Across all storylines, the fishing participation rate is projected to decrease by 10–18% over the next 50 years (Table 12.15). Thus, the number of anglers is projected to grow somewhat slower than the regional population, with growth rates for participants of 32–54%. Days-per-participant are expected to decrease marginally, remaining at about 20 per year. Therefore, the number of days-of-participation for fishing is expected to grow slightly slower than the number of participants, or 30–51%. Nevertheless, fishing is expected to remain among the top recreation activities in the South, accounting for 742–874 million days annually in 2060.

Adding climate to the fishing forecasts would result in decreases from the baseline for both participation rates and annual fishing days-per-participant (Table 12.15). Across all storylines, participation rates in 2060 are expected to decrease 15–27% from 2008 levels. This implies that participant numbers would increase 24–46%, or about 8 percentage points less than when climate change is not considered. The fishing-days total increases under eight of nine storylines with climate included, but at rates far below the baselines. Increases range from 10% to 33%.

TABLE 12.15
Forecasted Recreational Fishing Activity (Warm-Water, Cold-Water, and/or Saltwater) by Adults in the Southern United States

	Year		Projected Change from 2008 (%)			
Storyline[a]	**2008**	**2060**[b]	**Baseline**[b]	**Climate1**[c]	**Climate2**[d]	**Climate3**[e]
	Per capita participation (%)					
A1B	35.7	32.1	(10)	(15)	(15)	(21)
A2	35.7	29.3	(18)	(23)	(23)	(27)
B2	35.7	31.1	(13)	(18)	(17)	(18)
	Adult participants (millions)					
A1B	28.0	42.9	53	46	44	35
A2	28.5	42.9	54	46	45	38
B2	28.0	36.9	32	24	25	24
	Days per participant					
A1B	20.58	20.17	(2)	(9)	(12)	(26)
A2	20.58	19.96	(3)	(20)	(12)	(21)
B2	20.58	20.37	(1)	(11)	(8)	(9)
	Total days (millions)					
A1B	573	864	51	33	26	(1)
A2	582	874	50	17	27	10
B2	571	742	30	10	15	13

Note: Based on an expectation of moderate population growth and high income growth (storyline A1B), high population growth and low income growth (storyline A2), or low population growth and moderate income growth (storyline B2) under alternative climate futures derived from general circulation models.

[a] Emissions storylines developed by the Intergovernmental Panel on Climate Change (2007).

[b] Climate variable omitted from model and projection.

[c] Climate1 uses forecast data from CGCM3.1 for storylines A1B and A2; CGCM2 for storyline B2.

[d] Climate2 uses forecast data from CSIROMK3.5 for storylines A1B and A2; CSIROMK2 for storyline B2.

[e] Climate3 uses forecast data from MIROC3.2 for storylines A1B and A2; HadCM3 for storyline B2.

Hunting: This activity includes all types of legal hunting including big game, small game, waterfowl, and varmint. Approximately 11 million adults in the South, over 13%, reported hunting in 2008 on a total of 230 million days (Table 12.1). Cordell (2012) reports that small game hunting participants increased by 16%, compared to 25% for big game hunters, from 1999 to 2009. Findings from our models suggest that per capita participation has peaked and is likely to decrease 26–41% over the next 50 years (Table 12.16). A number of factors appear to be driving the decrease including: increasing population density, growth in the Asian and Hispanic components of the general population, increasing levels of education, and declining forest and rangeland per capita (www.forestthreats.org/research/projects/project-summaries/ccammo/Chapter12-appendix). Despite the declining participation rate, the number of southern hunters out to 2060 is expected to increase by 8% under the low population/moderate income growth focused B2, compared to 25% under the moderate population/high income growth focused A1B. Days-of-participation per hunter, currently about 22, is projected to remain constant regardless of storyline. Total days-of-participation for hunting are forecasted to grow at about the same rate as hunter numbers: 8–24% for an annual total of 248–286 million days by 2060.

When climate change projections are included in the hunting forecasts, participation rates and participants remain largely unchanged from the baseline with participant numbers increasing 4–26% by 2060 (Table 12.16). However, climate change appears to have a positive influence on the

TABLE 12.16
Forecasted Recreational Hunting Activity by Adults in the Southern United States

	Year		Projected Change from 2008 (%)			
Storyline[a]	**2008**	**2060[b]**	**Baseline[b]**	**Climate1[c]**	**Climate2[d]**	**Climate3[e]**
	Per capita participation (%)					
A1B	13.7	10.1	(26)	(26)	(27)	(26)
A2	13.7	8.1	(41)	(41)	(42)	(43)
B2	13.7	9.7	(29)	(32)	(27)	(29)
	Adult participants (millions)					
A1B	10,786	13,482	25	26	23	25
A2	10,973	12,180	11	12	10	7
B2	10,758	11,618	8	4	10	7
	Days per participant					
A1B	21.68	21.46	(1)	5	4	1
A2	21.68	21.46	(1)	0	5	2
B2	21.68	21.68	0	12	7	1
	Total days (millions)					
A1B	230	286	24	32	28	26
A2	234	255	9	12	15	9
B2	230	248	8	16	18	9

Note: Based on an expectation of moderate population growth and high income growth (storyline A1B), high population growth and low income growth (storyline A2), or low population growth and moderate income growth (storyline B2) under alternative climate futures derived from general circulation models.

[a] Emissions storylines developed by the Intergovernmental Panel on Climate Change (2007).

[b] Climate variable omitted from model and projection.

[c] Climate1 uses forecast data from CGCM3.1 for storylines A1B and A2; CGCM2 for storyline B2.

[d] Climate2 uses forecast data from CSIROMK3.5 for storylines A1B and A2; CSIROMK2 for storyline B2.

[e] Climate3 uses forecast data from MIROC3.2 for storylines A1B and A2; UKMOHADCM3 for storyline B2.

annual hunting days-per-participant, leading to increases of zero to 12%. Thus, total hunting days increase with climate change across A1B by an average of 29%, and B2 by 14% compared to 2008. The increases average about 5 percentage points higher annually than the no-climate storyline baselines.

CONCLUSIONS

Despite continued losses in forests and rangeland per capita across the South and changing demographics, outdoor recreation activity is expected to continue growing—both in numbers of participants and days-of-participation—at a rate near to or somewhat below population growth rates. Details of participation and consumption forecasts related to population growth and changing demographics are available in Bowker et al. (2012) and at www.forestthreats.org/research/projects/project-summaries/ccammo/Chapter12-appendix. For a few activities, such as developed site use, hiking, and birding, participant numbers as well as days-of-participation are projected to grow faster than population. Other activities typically associated with higher income, such as horseback riding on trails, motorized water use, and non-motorized water use, would grow faster than the population if predictions of higher income eventuate. Otherwise, they would grow at rates slightly less than population. A few activities, such as fishing, hunting, and motorized off-road use, are projected to experience substantial decreases in participation rates; and thus, although increasing, are expected to grow much slower than population. Hunting and motorized off-road use, being relatively land intensive, would be adversely affected by the expected decrease in available forest and rangeland acreage per capita. Moreover, these activities are generally not considered widely popular to the growing numbers of ethnic minorities in the region (Poudyal et al. 2008).

Participant numbers and days-of-participation for southerners were projected for storylines with and without associated climate alternatives (Figure 12.3, Table 12.4). Details about climate effects on recreation participation and use can be found in Tables 12.7 through 12.16 and by examining the models and simulations that support predictions (www.forestthreats.org/research/projects/project-summaries/ccammo/Chapter12-appendix). No specific probabilities were assigned to either the individual storylines or any of the climate alternatives associated with them (U.S. Department of Agriculture Forest Service 2012). However, the general effects of climate change on each of the 10 outdoor recreation activities can be inferred by looking at the range of changes in the participation rates, participants, days-of-participation per participant, and total days-of-participation for each activity compared to the no-climate baseline.

Compared to projections without climate change, participation rates were either marginally decreased by including climate change into the models and simulations, as for developed site use (1–4 percentage points), motorized off-road use (0–4 percentage points), and visiting primitive areas (0–1 percentage points); or the participation rate decreased somewhat more relative to the baseline, as for hiking (3–16 percentage points), nonmotorized water use (6–18 percentage points), and fishing (4–11 percentage points). Motorized water use (0–5 percentage points) and birding (0–2 percentage points) were the only activities for which the participation rate rose as a result of including climate in the forecasts. Changes in the participation rate for hunting and horseback riding on trails were ambiguous, ranging from an increase of 2 percentage points to a decrease of 3 percentage points for both activities.

Adult participant numbers tracked relatively closely to the participation rates with and without climate. For example, activities for which participant numbers decreased slightly compared to the no-climate baseline included developed site use (2–7 percentage points), horseback riding on trails (1–6 percentage points), motorized off-road use (0–7 percentage points), and visiting primitive areas (1–4 percentage points). Larger decreases in participant numbers occurred for hiking (5–26 percentage points), nonmotorized water use (10–31 percentage points), and fishing (7–18 percentage points). For motorized water use (0–8 percentage points) and birding (0–5 percentage points), the number of participants remained constant or rose relative to the baseline. Hunting was the only activity to show mixed results for participant numbers that ranged from an increase of 2 percentage points to a decrease of 4 percentage points relative to the baseline.

Annual days-per-participant would be moderately less for hiking, primitive area use, and motorized water use when climate is considered in the storylines (Tables 12.7 through 12.16). A number of activities, including birding, horseback riding on trails, motorized off-road use, and fishing, would experience very large decreases in annual days-per-participant. For developed site use, hunting, and nonmotorized water use, including climate would slightly increase the average annual days-of-participation. Total activity days per year would generally mirror the effects seen with days-per-participant.

Table 12.17 shows forest and rangeland acres-per-participant, which is a measure of recreation resource availability. In places where congestion is a concern and recreation use can adversely impact theresource, a higher number is preferred. This measure is useful in demonstrating the potential differences between storylines with and without climate change. In the absence of climate change, forest and range acres-per-participant for all activities except hunting are projected to decrease by 24–54% by 2060 as participant numbers increase. For hunting the decrease is expected to be somewhat less, from 11% to 26%, because of slower growth in the number of hunters. Incorporating climate change, all other activities face decreases of 23–54%. The biggest single change is for storyline A1B where hiking is about 4 percentage points less impacted with climate change. Birding is the only land-based activity for which climate change spells a decrease in acres-per-participant by

2060 (about 1 percentage point). Across all activities and storylines the differences in this density of participation measure are minimal.

An alternative measure of congestion or land impact is annual days-of-use per forest or rangeland acre (Table 12.18). This measure is perhaps more accurate for assessing the impact of activities on naturebecause it combines the number of participants with participant intensity per unit of land area. The essential driver for this measure is activity days, or participation intensity. In places where congestion is a concern and recreation use can adversely impact the resource, a lower number is preferred. Over the next 50 years, congestion per unit of land area is expected to be highest for horseback riding on trails (151%) and hiking (130%), and lowest for hunting (13–34%). In general, adding climate change to the storylines would have a more noticeable mitigating effect on annual days-of-use per forest and rangeland acre: 18–36 percentage points lower for birding, 22–31 percentage points for hiking, and similar effects for motorized off-road and primitive area use. The most noticeable difference (nearly 100 percentage points) would be for horseback riding on trails. For hunting and developed site use, the changes would be negligible.

For developed site use and hiking, decreases in acres-per-participant could begin to strain existing infrastructure. Birding and hiking may not require expansive areas for quality experiences as they are often "edge dependent" or along linear corridors. Activities typically considered space intensive—horseback riding on trails, motorized off-road use, and especially hunting—could experience somewhat smaller decreases in acres-per-participant, but could actually "feel" more congested given the

TABLE 12.17
Forest-Based Recreation Acres per Participant Densities in the Southern United States

		Acres per Participant			Percent Increase (Decrease)	
Activity	Storyline	2008	2060 Baseline	2060 Climate Average	No Climate Change	With Climate Change
Birding	A1B	10.5	5.2	5.16	(50)	(51)
	A2	10.4	4.8	4.72	(54)	(54)
	B2	10.5	6.2	6.15	(41)	(42)
Developed site use	A1B	4.5	2.4	2.46	(47)	(45)
	A2	4.4	2.2	2.24	(51)	(49)
	B2	4.5	2.8	2.87	(37)	(36)
Hiking	A1B	14.0	6.6	7.11	(53)	(49)
	A2	13.8	6.1	6.46	(51)	(53)
	B2	14.0	7.9	8.30	(43)	(41)
Horseback riding on trails	A1B	50.2	25.2	25.50	(50)	(49)
	A2	49.4	26.8	27.46	(46)	(44)
	B2	50.2	33.4	33.41	(33)	(33)
Hunting	A1B	26.3	19.5	19.60	(26)	(25)
	A2	25.9	21.9	22.19	(15)	(14)
	B2	26.3	23.3	23.56	(11)	(10)
Motorized off-road	A1B	16.8	10.3	10.65	(38)	(37)
	A2	16.5	10.9	11.21	(34)	(32)
	B2	16.8	12.7	12.85	(24)	(23)
Primitive area use	A1B	10.1	5.6	5.71	(45)	(43)
	A2	9.9	5.3	5.36	(47)	(46)
	B2	10.1	6.7	6.78	(33)	(33)

Note: Based on an expectation of moderate population growth and high income growth (storyline A1B), high population growth and low income growth (storyline A2), or low population growth and moderate income growth (storyline B2) with and without climate change; emissions storylines developed by the Intergovernmental Panel on Climate Change (2007).

TABLE 12.18
Forest-Based Recreation Days per Acre Densities in the Southern United States

		Activity Days per Forest and Range Acre			Percent Increase (Decrease)	
Activity	**Storyline**	**2008**	**2060 Baseline**	**2060 Climate Average**	**No Climate Change**	**With Climate Change**
Birding	A1B	10.1	18.0	14.5	79	43
	A2	10.3	19.2	16.0	87	57
	B2	10.1	15.5	13.7	54	36
Developed site use	A1B	2.4	4.4	4.5	88	88
	A2	2.4	4.9	4.9	102	103
	B2	2.4	3.8	3.8	60	59
Hiking	A1B	1.6	3.6	3.1	118	87
	A2	1.7	3.8	3.3	130	100
	B2	1.6	3.0	2.7	85	63
Horseback riding on trails	A1B	0.3	0.9	0.4	151	26
	A2	0.4	0.6	0.3	82	(15)
	B2	0.3	0.6	0.4	63	3
Hunting	A1B	0.8	1.1	1.1	34	39
	A2	0.8	1.0	1.0	16	19
	B2	0.8	0.9	1.0	13	19
Motorized off-road	A1B	2.0	3.1	2.4	59	20
	A2	2.0	3.0	2.2	47	8
	B2	2.0	2.6	2.1	30	7

Note: Based on an expectation of moderate population growth and high income growth (storyline A1B), high population growth and low income growth (storyline A2), or low population growth and moderate income growth (storyline B2) with and without climate change; emissions storylines developed by the Intergovernmental Panel on Climate Change (2007).

nature of the activity. Notably, for storyline A1B, with or without climate change, the loss in acres-per-participant associated with high income growth, moderate land conversion, and moderate population growth would lead to the most "congestion" for the space intensive activities. Conversely, B2, characterized by the lowest population growth, would lead to the least amount of future congestion or pressure on resources.

Bowker et al. (2012) found that winter activities often done mostly at the local level, such as snowmobiling and undeveloped skiing, were more negatively impacted by projected changes in climate over the next 50 years, going from substantial increases in participants and days-of-participation to a high likelihood of dramatic decreases. Although often enjoyed by many southerners, these activities are obviously not major outdoor recreation activities region-wide.

Finally, although the effects of climate change are summarized as ranges, more often than not the most pronounced differences between the no-climate and climate forecasts occurred under storylines A1B and A2 under the Climate3 alternative (Tables 12.7 through 12.16), which employs the MIROC3.2 climate forecasts (Joyce et al. in press). As discussed in Chapter 2, the MIROC3.2 climate simulations project the highest temperatures and lowest precipitation of all of the models.

MANAGEMENT RESPONSES

In preparing this chapter, we developed models to explain outdoor recreation participation and days-of-participation for residents of the Southern United States. These models—combined with population, socioeconomic, land use, and climate projections from alternative futures—were employed to predict the number of outdoor recreation participants and days-of-participation and to estimate the degree to which projections differ based on the presence of climate change.

The results herein suggest that recreation participant numbers and days for southerners will continue to grow over the next 50 years under nearly all of the considered socioeconomic, land use, and climate conditions. Thus, the general outlook for recreation resources is for opportunities and access per person to decline. Assuming that the public land base for outdoor recreation remains stable into the future, an increasing population would result in decreasing per-person opportunities across most of the United States. Although many other factors are involved in recreation supply, recreation resources (both built and natural) will likely become less "available" as more people compete to use them. For privately owned land, this could mean rising access prices from increased demand relative to supply. On public lands, where access fees cannot be easily adjusted to market or quasi-market conditions, increased congestion and possible declines in the quality of the recreation experience are likely to present important challenges to management.

A major challenge for natural resource managers and planners will be to ensure that recreation opportunities remain viable and grow along with the population. This will probably have to be accomplished through creative and efficient management of site attribute inputs and plans, rather than through major expansions or additions to the natural resource base. Trends toward more flexible work scheduling and telecommuting would allow recreation users to allocate their leisure time more evenly across the seasons and through the week, thus facilitating less concentrated peak demands. In addition, technological innovations like GPS (Global Positioning System) units and light-weight plastic kayaks allow more people to find and get to places more easily and quickly, perhaps leading to overuse pressures not previously considered a threat.

Overall, the infrastructure that supports outdoor recreation opportunities in the South could be severely tested under most foreseeable circumstances. For activities like developed site use and day hiking, fewer acres or trail miles per participant could begin to strain the existing infrastructure as biological and social carrying capacities become strained. Activities like birding and hiking may not require expansive contiguous areas for quality experiences as they are often "edge dependent" or occur along linear corridors. However, activities typically considered space intensive—horseback riding on trails, hunting, and motorized off-road use—are likely to actually "feel" more congested given the nature of the activity, despite relatively slow growth.

Perhaps surprisingly, the effects of climate change on recreation demand by southerners appear to be moderately mitigating insofar as use density measures (like participants per forest and rangeland acre and activity days per acre) are concerned (Tables 12.17 and 12.18). Climate can affect individual willingness to participate in recreation activities, recreation resource availability and quality, or both. The climate variables used in the recreation models were limited to those coming directly from the RPA climate projections (U.S. Department of Agriculture Forest Service 2012), or variables derived from those basic variables. Generally, the climate variables used in these recreation models were presumed to affect willingness to participate and frequency of participation directly. However, despite the lack of existing data, climate change would undoubtedly affect resource availability directly and indirectly. For example, increasing temperatures will likely affect the distribution of plant and animal species, which are fundamental to maintaining fish and game populations. Moreover, changes in regional precipitation would influence stream and reservoir levels, affecting opportunities for fishing and boating. Disentangling the effects of the climate variables on recreation participation is difficult. However, understanding these direct and indirect relationships, at both local and macro levels, will be fundamental to improving forecasts of recreation behavior.

No one can know exactly how changes in income, socioeconomic factors, economic development, and climate change would affect the supply and demand for forest-based outdoor recreation because the assumptions that underlie forecasts are likely to change with time. As well, due to data limitations, the results presented here do not account for detailed interactions among many of the external variables over time. Moreover, people's preferences shift. New technologies alter, and occasionally curtail, enjoyment of the outdoors. Activities like snowboarding, mountain biking, and orienteering were not available options in 1973, the year that Cicchetti published his seminal forecasting work on national recreation use; nor were activities like video gaming and watching movies at home. As ethnic groups continue to acculturate over the course of the next five decades, differences in outdoor recreation and consumption could shift. But it is safe to say that as the population grows, outdoor recreation pressure will increase on the natural environment, public and private; and that management will need to find creative ways to mitigate this pressure, especially on the most pristine and potentially vulnerable areas. What is important to keep in mind is that the effects of climate change in the South are likely to be relatively minor compared to threats resulting from population growth.

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