Effects of Climate Change on Outdoor Recreation Benefits in the Pike-San Isabel and Arapaho-Roosevelt National Forests

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Introduction

Millions of Americans enjoy recreating in the outdoors. In 2017, 49 percent of the United States (U.S.) population participated in at least one outdoor activity (Outdoor Foundation 2018). The U.S. Department of Agriculture, Forest Service (2017) estimates there were 148 million visits to national forests during fiscal year 2016. In 2018, there were more than 318.2 million visits to national parks (Ziesler 2019). Across all national park units in Colorado, recreation visits totaled more than 7.6 million in 2018, the largest proportion of which were to Rocky Mountain National Park in northern Colorado— which shares a border with the Arapaho-Roosevelt National Forests—with nearly 4.6 million visitors (Ziesler 2019).

Outdoor recreation provides significant economic contributions to the overall U.S. economy. The latest report from the U.S. Department of Commerce, Bureau of Economic Analysis (BEA) estimates the outdoor recreation economy accounted for 2.2 percent of gross domestic product (GDP) in 2016 (BEA 2019). The BEA (2019) also reports that the outdoor recreation economy grew slightly faster (1.7 percent) than the overall U.S. economy (1.6 percent). Boating and fishing were the outdoor recreation activities with the largest overall economic impact, accounting for $36.9 billion of real gross output, in other words, the industry's sales. The Outdoor Industry Association (2019) reports that the national outdoor recreation economy generates annually $887 billion in consumer spending and supports 7.6 million American jobs. Additionally, it provides $65.3 billion in Federal tax revenue and $59.2 billion in state and local tax revenue.

Colorado's outdoor recreation also provides a substantial contribution to the State economy. The Outdoor Industry Association (2019) reports that 71 percent of Colorado residents participate annually in outdoor recreation. Additionally, they report that outdoor recreation generates $28 billion in consumer spending and provides $2 billion in State and local tax revenue. Outdoor recreation also supports 229,000 jobs in Colorado. The Statewide Comprehensive Outdoor Recreation Plan (2018) uses a broader definition of outdoor recreation to estimate economic output; for example, their definition includes activities such as team sports, golf, and playground activities. The implications of including a wider range of activities will result in larger estimated economic contributions from consumer spending. This report estimated that outdoor recreation contributes $62.5 billion in total economic output (value of all sales of goods and services) and $35 billion in value added (in other words, gross domestic product, or GDP). Furthermore, the Statewide Comprehensive Outdoor Recreation Plan (2018) report finds that outdoor recreation supports over 511,000 jobs in Colorado, when considering a broader definition of recreation activities.

According to the U.S. Census Bureau, Colorado has one of the fastest growing populations among U.S. States, increasing 14.8 percent in population size between 2010 and 2020 (U.S. Census Bureau 2021). In 2020, Colorado's population was more than 5.7 million residents (U.S. Census Bureau 2020); the Colorado State Demography Office predicts the State's population to increase to more than 7.4 million people by 2050 (Colorado State Demography Office 2022; Colorado State Demography Office, n.d.). Most of the State's population (more than 83 percent in 2020) lives along the Front Range, a relatively concentrated urban area situated near the foothills where the Great Plains meet the Rocky Mountains. This urban corridor takes its name from the nearby mountain range called the "Front Range" and spans roughly from Fort Collins (Larimer County) and Greeley (Weld County) in northern Colorado to Pueblo (Pueblo County) in the south. Most of the State's projected population growth is expected to be concentrated along the Front Range urban corridor, with an estimated addition of more than 1.4 million people between 2010 to 2050 (Colorado State Demography Office 2022). With expected population growth, recreation visitation to national forests and other nearby public lands is expected to increase.

Considering outdoor recreation's role of being economically and culturally important to Colorado, the State faces a series of challenges to forest management in the coming decades. Among these challenges are an expected increase in state population, effects of crowding, and the effects from a changing climate on availability of and access to outdoor recreation opportunities. Specifically, climate change is expected to have an impact to the region as temperatures are projected to increase in the future by 2.5 to 5.5 ^{o}F as well as a snowpack decrease in the range of 10 to 40 percent (see Chapter 3 in this report). As a result, it can be expected that outdoor recreation may be affected by climate change via two drivers: first, through a direct effect on recreation demand, and second, through an indirect effect from the quantity and quality of environmental goods and services (Loomis and Crespi 1999; Mendelsohn and Markowski 1999; Shaw and Loomis 2008; White et al. 2016).

The overarching objective of this report is to investigate, from an economic perspective, current outdoor recreation use on the Arapaho-Roosevelt and Pike-San Isabel National Forests, and to consider what future outdoor recreation use may look like under the conditions of changing climate and a growing state population. In the next section of this report, supply of outdoor recreation on the AR and PSI National Forests is discussed. This is subsequently followed by an investigation into current outdoor recreation visitor statistics for these four Forests. Next, we discuss two different concepts of the economic significance of outdoor recreation: first, how communities benefit economically from tourism and visitor expenditures and second, the economic benefits to individual recreators. We pay special attention to how visitors demand the various outdoor recreation uses on these forests and estimate a total economic benefit of current recreation use. Next, we investigate future recreation use into the year 2060 under the scenario of a changing climate. Lastly, findings are summarized, and management implications are documented.

Outdoor Recreation Supply

Outdoor recreation is a prominent use of the Arapaho-Roosevelt and Pike-San Isabel National Forests in Colorado. The Pike and San Isabel National Forests (PSI-NF) are in central Colorado, while the Arapaho-Roosevelt National Forests (AR-NF) are situated in northcentral Colorado (fig. 1). Proximity to these Forests is the expanding metropolitan Front Range, and the variety of types of recreation uses makes these Forests among the most popular outdoor recreation destinations in Colorado. Outdoor recreation on the PSI-NFs and the AR-NFs encompasses a spectrum of uses, including hunting, fishing, mountain biking, sight-seeing, hiking, backpacking, and skiing and snowboarding, among many others.

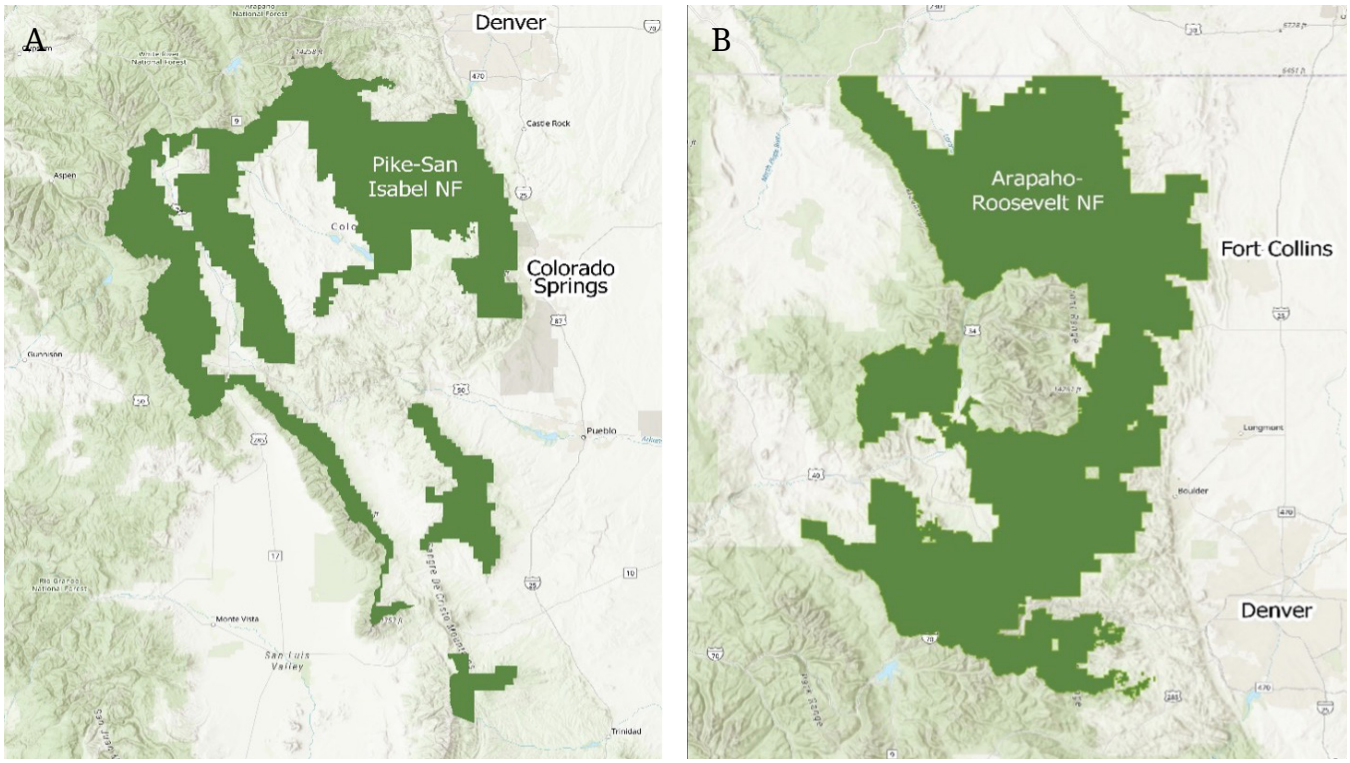

Figure 1a-b—Boundaries for Pike-San Isabel and Arapaho-Roosevelt National Forests.

Eldora (680 acres)[1], Loveland Ski Area (1,800 acres)[2], and Winter Park Resort (3,081)[3] are ski areas situated in the AR-NFs and are among the closest ski areas to Denver and the Front Range urban corridor. (Echo Mountain Resort is another ski area close to Denver within the AR-NFs management boundary but is located on private land.) Ski Cooper (470 acres)[4], near Leadville, Colorado, is in the PSI-NFs and is one of the oldest ski areas in the U.S. and began as Camp Hale, a mountaineering training ground for the U.S. Army's 10th Mountain Division during World War II. In addition to in-bounds skiing, Ski Cooper also operates snowcat tours on 2,600 acres of backcountry skiing in the Pike-San Isabel and White River National Forests. Monarch Mountain (800 acres)[5] near Salida,

Colorado, maintains both in-bounds and guided backcountry skiing via snowcat tours in the PSI-NFs. The AR-NFs and PSI-NFs also provide opportunities for backcountry skiing and snowboarding, cross-country skiing, and snowshoeing in accessible winter locations such as Cameron Pass west of Fort Collins, Berthoud Pass near Winter Park, and Indian Peaks Wilderness west of Boulder.

Both the AR-NFs and the PSI-NFs have unique places for camping, hiking, scenic drives, and trails (USDA FS, n.d.-a). In total, the PSI-NFs maintains 94 developed campgrounds: eight are managed by the Pikes Peak Ranger District; 11 are managed by the San Carlos Ranger District; 16 are managed by the Salida Ranger District; 17 are managed by the Leadville Ranger District; 21 are managed by South Park Ranger District; and 21 are managed by the South Platte Ranger District (USDA FS, n.d.-b). The AR-NFs maintain 54 developed campgrounds: seven of which are managed by the Boulder Ranger District west of Boulder; 24 are managed by the Canyon Lakes Ranger District west of Fort Collins and Loveland; eight are managed by the Clear Creek Ranger District near Idaho Springs; and 15 are managed by the Sulphur Ranger District near Winter Park, Grand Lake, and Granby (USDA FS, n.d.-c).

In terms of the total number of trails available in these Forests, the PSI-NFs and AR-NFs have approximately 411 miles and 478 miles of trails, respectively, for hiking and horseback riding (Furniss and Howe 2016). Well-known trails include the Colorado Trail and the Continental Divide Trail. The Colorado Trail includes a total of 485 trail-miles, crossing six wilderness areas and six national forests from Denver to Durango (TCTF, n.d.). The trail is maintained and administered by both the Forest Service and the Colorado Trail Foundation. This continuous trail is known as one of the premier long-distance trails in the country for hiking, horseback riding, and mountain biking. Leadville Ranger District hosts several sections of the Colorado trail, providing views of beautiful mountains and gorgeous forest landscape (USDA FS n.d.-d). The Continental Divide Trail totals 3,100 miles that cross five U.S. States and is advertised as one of the world's greatest long-distance trails (CDTC n.d.). Nearly a quarter of the trail's total length (740 miles) is in the State of Colorado and crosses both the AR-NFs and PSI-NFs. Recreationists use the trail for fishing access, hiking, horseback riding, hunting, mountain biking, and skiing. Another unique hiking trail is the Devil's Head Lookout Tower in Douglas County, which is the last operational lookout tower on the Front Range and sits on the highest point of the Rampart Range between Colorado Springs and Denver.

In addition to hiking in general, climbing Colorado's "Fourteeners" (mountain peaks over 14,000 feet) is a popular activity in this region. The AR-NFs contains three Fourteeners partially or fully within the forest boundary. PSI-NFs contains an additional 23 of the total 54 Fourteeners in the State of Colorado (USDA FS n.d.-a). Hiking Fourteeners can be challenging but provides unique climbing and viewing experiences. The Colorado Fourteeners Initiative estimates that the closest Fourteeners to Denver collectively see hundreds of thousands of hiker use days per year (CFI n.d.). Among all

Colorado Fourteeners, the Fourteener with the highest amount of hiking use is Mount Bierstadt at 35,000 to 40,000 hiker-days per year; it is located in the PSI-NFs but can be accessed at the Guanella Pass Trailhead in the AR-NFs.

There are other recreation opportunities in the area that include nonmotorized water recreation, such as rafting, kayaking, and recreational fishing. In terms of stream reach lengths, the AR-NFs contains 3,186 miles (or 5,128 km) of streams and the PSI-NFs contains 4,577 miles (or 7,366 km) of streams throughout the respective forests (USGS 2019). Although not all streams can be boated, many can be fished by anglers for recreational fishing purposes. Those that can be boated can represent exciting whitewater experiences. For example, the Arkansas River runs through Browns Canyon National Monument (jointly managed by the Forest Service and Bureau of Land Management) and provides unique boating opportunities including scenic views from the river. Each year more than 175,000 recreationists visit the upper section of Arkansas River for nonmotorized water recreation (one of the most heavily used rivers for whitewater rafting in the U.S.) ranging from scenic float trips to class V rafting (Arkansas River Outfitters Association 2019).

Viewing scenery is also an important recreation use year-round especially during the fall foliage season from September through October. Some well-known places during the autumn include Kenosha Pass near Grant and Jefferson, Colorado (USDA FS, n.d.-e), and the Peak-to-Peak Scenic Byway (55 miles) situated between Estes Park and Black Hawk, Colorado (CDOT, n.d.). Located near Browns Canyon National Monument between Granite and Poncha Springs and Salida is the Collegiate Peaks Scenic Byway (57 miles), which parallels the Sawatch Range containing the highest concentration of Fourteeners in the U.S. People can also drive to the top of Pikes Peak, a Fourteener managed by the PSI-NFs near Colorado Springs. Other notable scenic driving routes in the AR-NFs and PSI-NFs include the Highway of Legends Scenic Byway (110 miles) and the Colorado River Headwaters (80 miles), Lariat Loop (40 miles), and Top of the Rockies (115 miles) National Scenic Byways. Frontier Pathways National Scenic Byway, located on the southern end of the PSI-NFs near the Spanish Peaks and Sangre de Cristo mountain ranges, is also a notable scenic drive (103 miles). The Cache La Poudre (101 miles in length) and Guanella Pass (22 miles) Scenic Byways are other notable scenic driving routes near the Front Range (CDOT, n.d.).

The PSI-NFs fully or partially contains nine wilderness areas. These wilderness areas range in size from the Spanish Peaks Wilderness at 1,937 acres to the Sangre de Cristo Wilderness at 179,304 acres (table 1) (Landres and Meyer 2000; Wilderness Connect 2019). For the PSI-NFs, the combined size of the nine designated wilderness areas totals 746,738 acres. The AR-NFs fully or partially maintains 10 areas designated as wilderness and that range in size from the Byers Peak Wilderness at 8,801 acres to the Indian Peaks Wilderness at 74,973 acres (Landres and Meyer 2000; Wilderness Connect 2019). The total combined size for wilderness areas in the AR-NFs is 370,031 acres. These wilderness areas provide important ecosystem services to society, such as maintaining

critical habitat for wildlife, supplying clean water for downstream users (Meldrum and Huber 2019), and providing unique outdoor recreation opportunities, including hiking, backpacking, and solitude-oriented experiences (Loomis and Richardson 2006; Walsh et al. 1984).

Table 1—Number of acres by Wilderness Area for the Pike-San Isabel and the Arapaho-Roosevelt National Forests.

Pike-San Isabel NF	Acres[a]
Buffalo Peak Wilderness	41,281
Collegiate Peaks Wilderness	165,864
Greenhorn Mountain Wilderness	23,116
Holy Cross Wilderness	122,446
Lost Creek Wilderness	114,864
Mount Evans Wilderness	73,459
Mount Massive Wilderness	24,467
Sangre de Cristo Wilderness	179,304
Spanish Peaks Wilderness	1,937
Total acres:	**746,738**

Arapaho-Roosevelt NF	Acres[a]
Byers Peak Wilderness	8,801
Cache la Poudre Wilderness	9,482
Comanche Peak Wilderness	68,025
Indian Peaks Wilderness	74,973
James Peak Wilderness	17,109
Mount Evans Wilderness	73,459
Neota Wilderness	9,927
Never Summer Wilderness	20,847
Rawah Wilderness	74,408
Vasquez Peak Wilderness	13,000
Total acres:	**370,031**

[a]Landres and Meyer 2000; Wilderness Connect 2019.

Outdoor Recreation Use Statistics - Current and Projected

Outdoor Recreation on the Arapaho-Roosevelt and Pike-San Isabel National Forests

People participate in a wide range of outdoor recreation activities on the AR-NFs and the PSI-NFs. To better understand people's satisfaction and use of these national forests, the Forest Service conducts the National Visitor Use Monitoring (NVUM) survey, which rotates sampling on all forests and grasslands throughout the National Forest System every 5 years.[6] For this analysis, we use data collected in 2015 and 2016 for the AR-NFs and PSI-NFs, respectively. A two-step process is used to arrive at total number of days of participation by recreation activity per year. First, total annual visitation is multiplied by percent main activity participation, both of which are drawn from the NVUM survey, to arrive at annual visits by main activity per year (tables A-1 and A-2 in the Appendix). Main activity participation is defined by NVUM as the primary activity for this recreation visit to the national forest. The second step is to account for length of stay per visit by main activity. Here, conversion factors for Region 2 of the Forest Service (Rocky Mountain Region) in the Rosenberger et al. (2017) outdoor recreation use values report are used to convert "visits" into "days." The conversion factor is defined as "the average number of calendar days per national forest visit" and were imputed by Rosenberger et al. (2017) using NVUM survey results. For each activity, "visitation" is multiplied by the "conversion factor" to arrive at "days" (table A-3 in the Appendix), which are the relevant units for the economic valuation. Days by main activity are summarized for the PSI-NFs and AR-NFs into five climate-sensitive categories of activities (categorized the same as Winter et al. 2021): warm-weather activities, winter activities, wildlife activities, gathering forest products, water-based activities (not including fishing), and other activities (table 2). Each of the five climate-sensitive categories combine recreation activities that are expected to be similarly affected by environmental conditions (Hand and Lawson 2018; Hand et al. 2018).

These calculations show more than 5,377,000 days per year across all outdoor recreation activities for the PSI-NFs. Warm-weather activities collectively have the most visitor days (2,713,000), with viewing natural features having the highest number of days per year (960,000) when looking at the individual activity level (shown graphically in fig. 2). This is followed by hiking/walking (926,000) and developed camping (351,000). Additional warm-weather activities contributing to this category include primitive camping, bicycling, backpacking, other nonmotorized use, picnicking, and horseback riding. The bundled other activities grouping had the next highest amount of total days as a category (1,647,000). Within this climate-sensitive category, driving for pleasure (704,000) had the highest number of activity days, followed by motorized trail activity (403,000) and relaxing (221,000). Wildlife activities collectively have the third most visitor days (661,000), with fishing (552,000) being the most popular activity in this category followed by viewing wildlife (69,000). Downhill skiing (224,000 days) was the most popular activity in the winter activity category.

Table 2—Activity days per year (1,000s) by main activity for the Arapaho-Roosevelt and Pike-San Isabel National Forests.

Activity	Pike-San Isabel NF Days (1,000s)	Arapaho-Roosevelt NF Days (1,000s)
Warm-weather activities		
Hiking/walking	926.9	817.9
Viewing natural features	960.2	818.9
Other nonmotorized	39.1	34.1
Bicycling	154.6	84.0
Developed camping	351.4	719.4
Picnicking	29.4	9.7
Backpacking	53.5	38.6
Horseback riding	9.6	0.0
Primitive camping	189.2	74.0
Total	**2,713.8**	**2,596.5**
Winter activities		
Downhill skiing	224.9	1191.0
Cross-country skiing/snowshoeing	17.1	87.9
Snowmobiling	32.2	42.5
Total	**274.3**	**1,321.4**
Wildlife activities		
Fishing	552.6	228.7
Hunting	38.7	480.9
Viewing wildlife	69.7	29.7
Total	**661.1**	**739.3**
Gathering forest products		
Gathering forest products	27.2	4.9
Total	**27.2**	**4.9**
Water-based activities, not including fishing		
Motorized water activities	0.0	5.2
Non-motorized water	54.3	15.2
Total	**54.3**	**20.4**
Other activities		
Relaxing	221.2	110.9
Driving for pleasure	704.7	398.9
Some other activity	120.1	64.0

Table 2 continued.

Activity	Pike-San Isabel NF Days (1,000s)	Arapaho-Roosevelt NF Days (1,000s)
Off-highway vehicle use	170.0	92.1
Nature center activities	7.1	0.0
Motorized trail activity	403.1	48.9
Nature study	9.0	0.0
Resort use	0.2	0.0
Visiting historic sites	11.6	3.1
Other motorized activity	0.0	0.0
Total	**1,647.0**	**717.8**
Total days (1,000's)	**5377.6**	**5400.4**

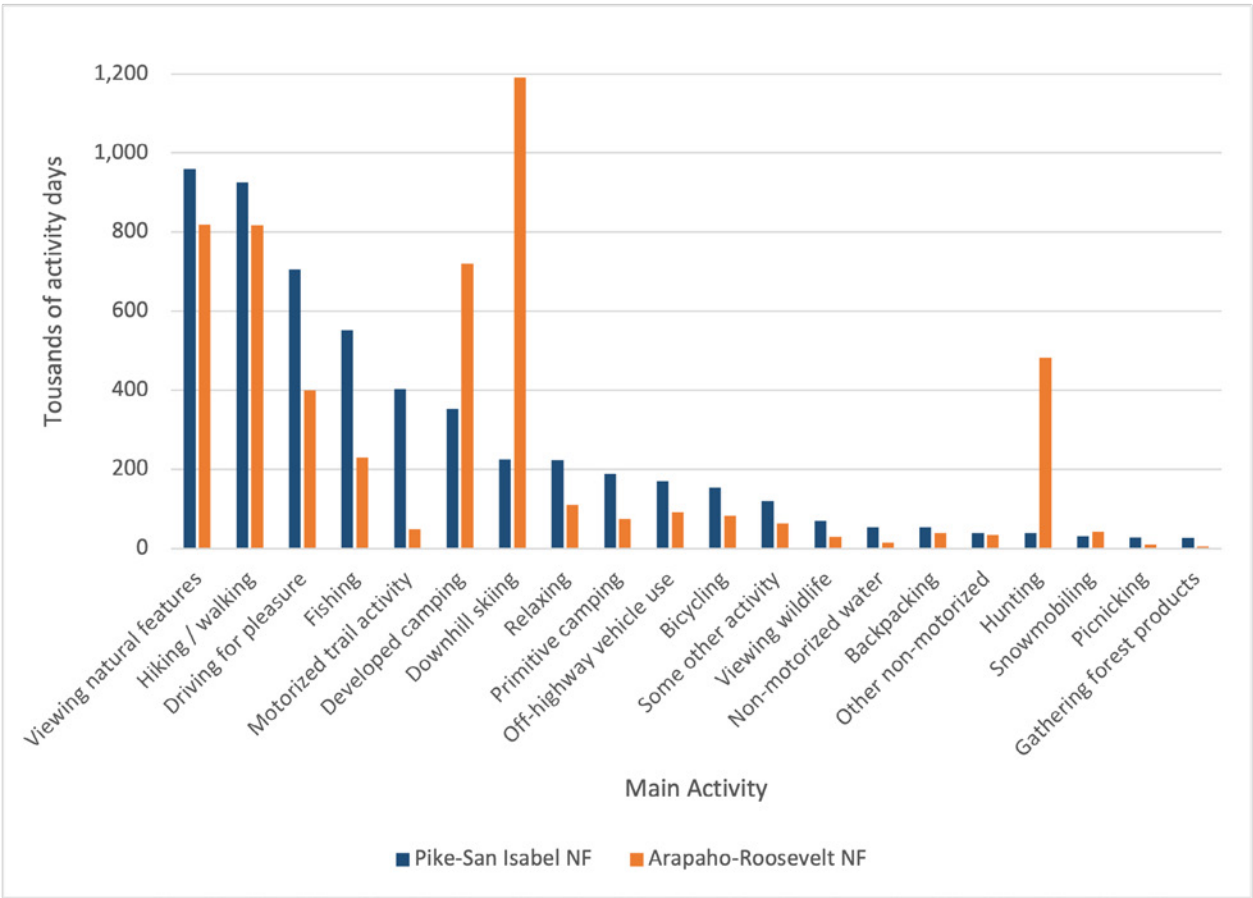

Figure 2—Top 20 activity days per year (1,000s) by main activity for the Arapaho-Roosevelt and Pike-San Isabel National Forests.

The AR-NFs have a similar number of total days per year at 5,400,000 across all outdoor recreation activities (table 2). However, there are noticeable differences in numbers of activity days by main activity when comparing the AR-NFs to the PSI-NFs. The most striking difference is the annual number of days downhill skiing (1,191,000), which has the highest number of activity days across all activities for the AR-NFs (fig. 2). The warm-weather activities grouping has the most activity days (2,596,000), with viewing natural features (818,000) having the largest number of activity days per year, followed by hiking/walking (817,000) and developed camping (719,000). Hunting (480,000) has the highest number of activity days in the wildlife activities category, while driving for pleasure (398,000) is the most popular activity in the other activities category.

As an aside, we can use NVUM reported data on the number of annual visitors to wilderness areas to investigate a rough approximation of intensity of wilderness use. (These data are implicitly captured in table 2 and are imbedded in the total activity counts at the Forest level.) Based on the 2016 NVUM data, there are approximately 297,338 visits to wilderness areas in the PSI-NFs each year, yielding a result of 2.5 wilderness visits per acre per year. For the AR-NFs, there are 271,867 Wilderness visits, based on 2015 NVUM data, yielding a result of 1.4 Wilderness visits per acre per year. Compared to other Wilderness Areas, the PSI-NFs and AR-NFs wilderness areas are highly visited when evaluating use on a per acre basis. For example, in California, which is the most populous State and has the second most wilderness acres in the U.S., the Angeles National Forest has approximately 122,557 acres with 291,649 visits across its five designated wilderness areas. The San Bernardino National Forest has 151,341 acres with 40,334 visits across its eight designated wilderness areas. The wilderness visits per acres are 0.42 and 3.75 for the Angeles and San Bernardino National Forests, respectively. These estimates show the intensity of use to otherwise “pristine” wilderness environments.

The estimated number of activity days by main outdoor recreation activity on the PSI-NFs and the AR-NFs shown in table 2 were then used to investigate the economics of outdoor recreation use and projected changed in activity days in response to a changing climate.

Economics of Outdoor Recreation

There are two common ways to think about the economic significance of outdoor recreation to these national forests. The first—a regional economic analysis—measures how jobs and business activities are supported by expenditures made by national forest visitors to the regional economy (Loomis and Walsh 1997; White 2017). The second—economic valuation—measures the value or benefits to individual recreators (Segerson 2017). The two concepts and approaches—regional economic analyses and economic valuation—measure the economic significance of outdoor recreation from different perspectives. The following subsections discuss these concepts and describe regional

economic effects from visitor spending on jobs and business activities and economic valuation of outdoor recreation to individual recreators.

Outdoor Recreation Expenditures and an Overview of Regional Economic Effects Analyses

There are two subtly different ways to consider how regional economies, employment, and business activities are affected by outdoor recreation and tourism dollars. The first is an economic contributions analysis, which measures the gross economic activity of the regional economy from total visitor expenditures, including both local and nonlocal visitor expenditures (Cullinane Thomas et al. 2019). In a contributions analysis, results can be interpreted as the relative importance of all forest visitor spending to the regional economy. This is contrasted with the second type of regional economic analysis called an economic impact analysis, which focuses on net changes to the regional economy from "new" money brought in exclusively from nonlocal visitor expenditures (Cullinane Thomas et al. 2019). For this report, we investigate the expenditures made by both types of forest visitors but do not estimate the economic effects to the broader regional economy. In particular, expenditures are separated by both local and nonlocal visitors to gain a foundational understanding of how local economies may be affected by local and nonlocal tourism dollars.

To begin to understand how tourism affects local economic activities in and near these Forests, the local economic region must be defined, and the amount of money spent by local and nonlocal forest visitors within the defined regional economy must be quantified. It is important to distinguish between local and nonlocal forest visitors because their trip behaviors, characteristics, and expenditures can be different. For this report, the local region is defined as a 50-mile boundary around each forest (PSI-NFs and AR-NFs, respectively). This 50-mile boundary is a standard approach used by the Federal agencies to define which economies and their associated activities can be counted as part of the local economic region near the forest (White et al. 2016). Using this definition, people who live inside the 50-mile boundary around the forest are considered locals and their associated spending to make an outdoor recreation trip to the forest would be classified as local spending. In contrast, people who live outside the 50-mile buffer are considered nonlocals to the forest. Their associated spending is bringing new money into the defined local region and is generating new economic activity (i.e., jobs and business activities). Total expenditures within 50 miles of each forest are estimated for local and nonlocal visitation using the procedures outlined in White (2017). For the PSI-NFs, total annual spending is considerably higher among those traveling from outside a 50-mile radius, than for locally originating visitation (table 3). Lodging expenditures account for 25.2 percent of expenditures among nonlocal visitation, followed by gas and oil at 20.2 percent, and then by restaurants at 18.8 percent. Gas and oil is the primary spending category for local visitors, followed by groceries at 24.7 percent. The average total spending per party per trip is $255 for nonlocals and $131 for locals.

Table 3—Total annual expenditures within 50 miles of the survey site by nonlocal and local visitation to the Pike-San Isabel National Forest, by spending category.

Spending category	Nonlocal spending[a,b]		Local spending	
	Total annual expenditures Thousands of dollars ($2018)[c]	Spending for each category Percent	Total annual expenditures Thousands of dollars ($2018)[c]	Spending for each category Percent
Lodging	49,227	25.2	2,712	4.3
Camping fees	5,596	2.9	3,698	5.8
Restaurant	36,703	18.8	7,757	12.2
Groceries	27,577	14.1	15,639	24.7
Gas and oil	39,603	20.2	21,707	34.3
Local transportation	1,379	0.7	203	0.3
Entry fees	9,103	4.7	3,726	5.9
Recreation and entertainment	12,153	6.2	1,647	2.6
Sporting goods	7,026	3.6	5,136	8.1
Souvenirs and other expenses	7,292	3.7	1,141	1.8
Total	**195,659**	**100**	**63,366**	**100**

Spending totals were calculated using the procedures outlined in White (2017) and parameters and spending averages used by the USDA Forest Service office of Ecosystem Management Coordination.
[a]Nonlocal refers to trips that required traveling more than 50 miles to the survey site.
[b]National Visitor Use Monitoring (NVUM) data source is the fourth round of the NVUM surveys.
[c]NVUM data, 2016.

For the AR-NFs, the total annual expenditure is similar for those traveling from outside a 50-mile radius and for locally originating visitation (table 4). Gas and oil expenditures account for 23.8 percent of expenditures among nonlocal visitation, followed by restaurant at 17.7 percent, and then by lodging expenses at 15.5 percent. For the PSI-NFs, gas and oil is also the primary spending category for local visitation, followed by groceries at 23.4 percent. The total spending (per party/trip) is $285 for nonlocals and $119 for locals.

Table 4—Total annual expenditures within 50 miles of the survey site by nonlocal and local visitation to the Arapaho-Roosevelt National Forests, by spending category.

Spending category	Nonlocal spending[a,b]		Local spending	
	Total annual expenditures Thousands of dollars ($2018)[c]	Spending for each category Percent	Total annual expenditures Thousands of dollars ($2018)[c]	Spending for each category Percent
Lodging	13,717	15.5	1,795	2.1
Camping fees	2,597	2.9	5,111	6.0
Restaurant	15,672	17.7	9,468	11.1
Groceries	12,464	14.1	19,855	23.4
Gas and oil	21,063	23.8	26,769	31.5
Local transportation	188	0.2	91	0.1
Entry fees	9,989	11.3	9,801	11.5
Recreation and entertainment	7,080	8.0	4,494	5.3
Sporting goods	3,732	4.2	6,621	7.8
Souvenirs and other expenses	1,950	2.2	915	1.1
Total	**88,452**	**100**	**84,920**	**100**

Spending totals were calculated using the procedures outlined in White (2017) and parameters and spending averages used by the USDA Forest Service office of Ecosystem Management Coordination.
[a]Nonlocal refers to trips that required traveling more than 50 miles to the survey site.
[b]National Visitor Use Monitoring (NVUM) data source is the fourth round of the NVUM surveys.
[c]NVUM data, 2015.

Economic Valuation of Outdoor Recreation

Understanding the economic benefits of outdoor recreation, as opposed to the regional economic effects from visitor spending, provides a useful framework for evaluating tradeoffs because: (1) maximizing net economic benefits can be an important objective when facing limited resources and competing uses; (2) it provides a way to weigh the outcome competing projects or objectives in commensurate units (dollars); and (3) it provides a measure of the net benefits across all recreators (Young and Loomis 2014). Since there are no market-driven entrance fees required to participate in outdoor recreation on the PSI-NFs and the AR-NFs, meaning there are little to no entrance fees to access the National Forest, nonmarket valuation techniques must instead be relied upon to quantify the economic value of outdoor recreation activities (Loomis and Walsh 1997). Nonmarket valuation methods can be generally grouped into two broad categories: revealed preference methods and stated preference methods (Champ et al. 2017), both of which have been widely used as standard approaches to valuing outdoor recreation (Loomis and Walsh 1997). The basic approach to revealed preference methods includes estimating value from observed behaviors in related markets. These

techniques infer value from observed data, such as number of trips or site visits, and travel related expenditures incurred during the visit, which are then used in estimating a travel cost model. The number of trips a visitor takes over a period of time and their travel related expenditures allow estimation of the overall demand function to visit a given site. From this demand function the consumer surplus or the amount the visitor would pay in excess of their travel costs (i.e., their net willingness to pay—WTP) is obtained. In contrast, the basic approach to the second broad grouping of nonmarket valuation techniques, stated preference methods, is to ask people via a survey or interview to state their value based on a hypothetical change to a good or service (Johnston et al. 2017). Stated preference techniques include the contingent valuation method (Boyle 2017) and choice models (conjoint or choice experiments; see Holmes et al. [2017] for background on these types of approaches), both of which are flexible enough to accommodate use values (e.g., outdoor recreation) as well as nonuse (or passive use) values (e.g., existence value).

When circumstances preclude conducting an original nonmarket valuation study, the benefit transfer method uses existing nonmarket valuation estimates from previously conducted revealed and stated preference studies and applies them new context (Boyle and Bergstrom 1992; Johnston et al. 2015; Richardson et al. 2015; Rosenberger and Loomis 2017). For example, a benefit for hiking/walking at one site might be used to estimate benefits at another site. There are four different types of benefit transfer: (1) a unit value transfer using a single estimate from the recreation site most similar to the site we are trying to value (the value estimated at Site A applied to Site B); (2) an average value transfer of several existing estimates drawn from the literature (the average value estimated at all sites in a region applied to Site B; (3) a function transfer that applies an estimated site demand or willingness to pay function from a past study to the new unstudied site or context; and (4) using a meta-regression demand or valuation equation estimated from a pool of past valuation studies at several sites (see Johnston et al. [2015] and Rosenberger and Loomis [2017] for comprehensive discussions of benefit transfer methods). The ideal situation for benefit transfer would be to use an existing value estimate drawn from a study that was conducted in the same location (e.g., AR-NFs) for the same type of good or service (e.g., deer hunting) being examined in this new policy context. Rosenberger et al. (2017) offer that the error when conducting a benefit transfer is likely to be smallest when the original study site and new policy site are similar. One measure of reliability between different benefit transfer approaches is the absolute percent transfer error (PTE), which compares the degree of difference between the transferred value estimate with a known policy value estimate (Rosenberger 2015). Rosenberger (2015) and Rosenberger and Loomis (2017) cataloged estimates of absolute PTE from value (unit or average) transfers and function transfers. They found that value transfers had mean absolute PTE of 140 percent (median = 45 percent), while benefit function transfers (including meta-analyses) performed better

with a mean absolute PTE of 65 percent (median = 36 percent) (Rosenberger, 2015), suggesting that function transfers offer an improvement over unit or average value transfers.

For this analysis, we conduct a benefit transfer by relying on the per person, per day average value estimates for Region 2 of the National Forest System generated by Rosenberger et al. (2017). Their predicted average values are based on a meta-analysis of pooled economic valuation studies on outdoor recreation across the United States and Canada over the period 1958 to 2015 (see the Recreation Use Values Database [RUVD 2016] for a complete list of studies used in their meta-analysis). Several of the Rosenberger et al. (2017) primary activity groupings are aggregated into two or more NVUM activities. For example, NVUM includes a "primitive camping" category and a "backpacking" category, both of which are aggregated into the "backpacking" primary activity in the Rosenberger et al. (2017) meta-analysis (see table 1 on page 5 of their report). We follow their categorization scheme provided to apply a value to these aggregated activity types. Table 5 summarizes the estimated per person, per day economic benefits (or WTP) by activity type.

Table 5—Estimates per person, per day and total economic benefits by activity type for the Pike -San Isabel and Arapaho-Roosevelt National Forests (adapted from Rosenberger et al. 2017; and based on visitation data collected in 2016 for PSI-NF and 2015 for AR-NF).

Activity	Average value estimate (2016, $ per person, per day)	Total annual value estimate ($1,000s; 2016)	
		Pike-San Isabel NFs	Arapaho-Roosevelt NFs
Warm-weather activities			
Hiking/walking	84.12	77,972	68,803
Viewing natural features	59.79	57,408	48,964
Other nonmotorized	64.67	2,528	2,203
Bicycling	86.40	13,357	7,254
Developed camping	35.28	12,396	25,380
Picnicking	48.84	1,435	475
Backpacking	32.81	1,755	1,267
Horseback riding	64.67	620	—
Primitive camping	32.81	6,208	2,427
Total	—	**173,679**	**156,772**
Winter activities			
Downhill skiing	81.89	18,417	97,532
Cross-country skiing/Snowshoeing	56.18	962	4,941

Table 5 continued.

Activity	Average value estimate (2016, $ per person, per day)	Total annual value estimate ($1,000s; 2016)	
		Pike-San Isabel NFs	Arapaho-Roosevelt NFs
Snowmobiling	50.11	1,616	2,128
Total	—	**20,995**	**104,601**
Wildlife activities			
Fishing	71.18	39,336	16,280
Hunting	77.08	2,985	37,070
Viewing wildlife	59.79	4,169	1,774
Total	—	**46,490**	**55,124**
Gathering forest products			
Gathering forest products	64.67	1,759	316
Total	—	**1,759**	**316**
Water-based activities, not including fishing			
Motorized water activities	58.04	—	304
Non-motorized water	108.59	5,894	1,651
Total	—	**5,894**	**1,955**
Other activities			
Relaxing	64.67	14,305	7,170
Driving for pleasure	64.67	45,576	25,798
Some other activity	64.67	7,768	4,136
Off-highway vehicle use	50.11	8,520	4,613
Nature center activities	59.79	422	—
Motorized trail activity	50.11	20,200	2,448
Nature study	59.79	535	—
Resort use	64.67	10	—
Visiting historic sites	59.79	696	186
Other motorized activity	50.11	—	—
Total	—	**98,033**	**44,352**
Total for all activities	—	**346,850**	**363,121**

— indicates no data

The per person, per day economic WTP estimates are then multiplied by the number of days (table 2) to arrive at the total annual value by activity for the PSI-NFs and the AR-NFs (table 5). Results for the PSI-NFs show the total estimated economic benefit across all recreation activities to be more than $346 million per year. The results for the AR-NFs show a similar magnitude in total estimated benefits at more than $363 million per year. When comparing among the climate-sensitive groupings (warm-weather activities, winter activities, wildlife activities, gathering forest products, water-based activities [not including fishing], and other activities), it becomes clear that warm-weather activities (e.g., bicycling, hiking/walking, picnicking) are the most-highly valued type of recreation use per year for both Forests ($173 million for the PSI-NFs and $156 million for the AR-NFs). Winter activities (e.g., skiing, snowmobiling) are the next most valued recreation use for the AR-NFs at $104 million per year and are primarily driven by the estimated value of downhill skiing ($97 million per year). For the PSI-NFs, the next most valuable grouping is other activities ($98 million per year), which includes activities such as off-highway vehicle use, motorized trail activity, and driving for pleasure.

The main limitation of our results arises from fact that the underlying meta-analysis does not provide confidence intervals or other measures of uncertainty for the per person, per activity day values. This means our aggregated total economic benefits shown in table 5 suggest a certain level of precision not acknowledged in the results. Furthermore, some of the studies in the meta-analysis do not consider substitution effects, which can lead to overestimation of values.

Climate Change Vulnerability Assessment: Relationships Between Climate Change and Outdoor Recreation

Climate change is expected to influence the region's temperature as climate models forecast an increase of 2.5 to 5.5 °F as well as a decrease in snowpack of 10 to 40 percent (see Chapter 3 in this report). Outdoor recreation may be affected by climate change via two drivers: first, through a direct effect on recreation demand, and second, through an indirect effect from the quantity and quality of environmental goods and services (Loomis and Crespi 1999; Mendelsohn and Markowski 1999; Shaw and Loomis 2008). In a study focusing on national parks, Fisichelli et al. (2015) examined the relationship between climate and future park visitation by evaluating historical monthly mean air temperatures and historical National Park Service visitation from 340 parks since 1979. They found visitation increased with increasing average monthly temperature but decreased with temperature greater than 25 degrees Celsius. As a result of higher temperatures under alternative climate scenarios, they predict future visitation to generally increase across the park system. Their findings indicate increased temperatures could increase visitation during the nonpeak shoulder seasons, as well as other public lands that are in either higher-latitude and/or high-altitude environments, such as the AR and PSI National Forests. Similarly, Loomis and Richardson (2006) investigated changes in Rocky Mountain National Park visitation behavior from climate

change. The authors conclude that climate change is expected to benefit traditional recreationists, such as hikers and campers, due to warmer temperature and a longer season, while winter recreation uses would decline in visitation. However, there have been some climactic changes in the study area since 2006, such as the Cameron Peak and East Troublesome Fires, that have resulted in extended trail closures (e.g., Roaring Creek Trail; USDA FS, n.d.-g). Furthermore, for the same study area, Richardson and Loomis (2004) found that there is a decrease in visitation under the extreme heat climate conditions. Askew and Bowker (2018) found that recreation will respond differently to climate change, depending on location and activity. For example, in the Rocky Mountain Region, climate change is expected to negatively impact fishing, hunting, and motorized water activities, while having a positive impact on swimming. Scott et al. (2008) investigated climate change implications for snowmobiling in the U.S. northeast region and found that it was more vulnerable than skiing due to greater dependence on natural snowfall. Similarly, White et al. (2016) reports that on Federal lands, snowmobiling and undeveloped skiing are the outdoor recreation activities likely to have the greatest decline in participation under climate change.

We are interested in the potential impacts to outdoor recreation use on the AR-NFs and the PSI-NFs from climate change, and to quantify these projected changes, we rely on forecasts published in Chapter 12 of the "Update to the Forest Service 2010 Resources Planning Act Assessment" (USDA FS 2016). This referenced report provides modeled regional recreation participation projections at the four Resources Planning Act (RPA) regions, including the Rocky Mountain RPA that contains the AR-NFs and PSI-NFs. The report provides percent change in number of recreation days by activity projected to the year 2060 under two scenarios: with and without climate change (table 6). The analysis uses external projections of demographics, economic conditions, land use, and climate factors to estimate future per capita participation and average annual days per participant on national forest units under climate change. The participation rate and average days per participant are multiplied by the RPA population projections to calculate total participants and total annual days for the Rocky Mountain RPA region. To incorporate uncertainty about future recreation use, the RPA assessment developed multiple scenarios based on future economic, social, economic, and environmental conditions (see Bowker et al. 2012 and USDA FS 2016 for additional details). There are several limitations to these forecasts, which leads to population growth being a driving factor in forecasted results changes (Bowker et al. 2012). Emerging activities brought about by new technologies and changing tastes and preferences may not be accurately reflected in the models and, to the extent that data were collected during periods of participation growth, may overestimate future use. Bowker et al. (2012) state that another drawback to their analysis is the challenge in accounting for future congestion, limited supply, and relative price changes on growth in participation.

Table 6—Percent change in recreation days by recreation activity for the Rocky Mountain Region projected to 2060 (adapted from table 12-20 in USDA FS 2016).

Activity	Outdoor recreation activity group (USDA FS 2016)	2060 average change in total participants (%)	
		Without climate change	With climate change
Warm-weather activities			
Hiking/walking	Day hiking	98	110
Viewing natural features	Nature viewing	79	78
Other nonmotorized	Nature viewing	79	78
Bicycling	Challenge activities	97	101
Developed camping	Visiting developed sites	92	86
Picnicking	Visiting developed sites	92	86
Backpacking	Primitive area use	60	48
Horseback riding	Horseback riding	69	54
Primitive camping	Primitive area use	60	48
Winter activities			
Downhill skiing	Developed skiing	162	161
Cross-country skiing	Undeveloped skiing	80	53
Snowmobiling	Motorized snow activities	11	3
Wildlife activities			
Fishing	Fishing	62	35
Hunting	Hunting	22	5
Viewing wildlife	Nature viewing	79	78
Gathering forest products			
Gathering forest products	Nature viewing	79	78
Water-based activities, not including fishing			
Motorized water activities	Motorized water activities	109	86
Nonmotorized water	Floating	57	54
Other activities			
Relaxing	Visiting developed sites	92	86
Driving for pleasure	Nature viewing	79	78
Some other activity	Nature viewing	79	78
Off-highway vehicle use	Motorized off road	68	65

Table 6 continued.

Activity	Outdoor recreation activity group (USDA FS 2016)	2060 average change in total participants (%)	
		Without climate change	With climate change
Nature center activities	Visiting interpretative sites	116	113
Motorized trail activity	Motorized off road	68	65
Nature study	Nature viewing	79	78
Resort use	Visiting developed sites	92	86
Visiting historic sites	Visiting interpretative sites	116	113
Other motorized activity	Motorized off road	68	65

For our analysis, we multiply the average percent change in number of days across all RPA scenarios for the Rocky Mountain RPA (table 12-20, USDA FS 2016) with activity days per year (table 2); this yields average annual projected number of days with and without climate change in 2060 for both the PSI-NFs (table 7) and AR-NFs (table 8). Taking the difference between the two climate change scenarios provides a net change in the number of days by activity resulting from climate change for each national forest. The net change in number of days is summed by climate-sensitive groupings (warm-weather activities, winter activities, wildlife activities, gathering forest products, water-based activities [not including fishing], and other activities) to investigate the general effects from climate change impacts on similar outdoor recreation activity types. In the next subsections, we discuss the potential climate impacts to each climate-sensitive grouping. The other activities category (e.g., off-highway vehicle use, motorized trail activity, driving for pleasure) is omitted from further discussion because, although climate change may impact these uses implicitly, other important factors such as infrastructure and interpretive materials are likely to be more important determinates in their projected recreation uses.

Table 7—Projected and net changes in recreation days at the Pike-San Isabel National Forests with and without climate change in 2060.

Activity	Projected days in 2060 (1,000s)		Net effects of climate change
	without climate change	with climate change	
Warm-weather activities			
Hiking/walking	1,835.3	1,946.5	111.2
Viewing natural features	1,718.7	1,709.1	-9.6
Other nonmotorized	70.0	69.6	-0.4
Bicycling	304.5	310.7	6.2
Developed camping	674.6	653.5	-21.1

Table 7 continued.

Activity	Projected days in 2060 (1,000s)		Net effects of climate change
	without climate change	with climate change	
Picnicking	56.4	54.7	-1.8
Backpacking	85.6	79.2	-6.4
Horseback riding	16.2	14.8	-1.4
Primitive camping	302.7	280.0	-22.7
Total	**5,064.1**	**5,118.1**	**54.0**
Winter activities			
Downhill skiing	589.2	587.0	-2.2
Cross-country skiing/ snowshoeing	30.8	26.2	-4.6
Snowmobiling	35.8	33.2	-2.6
Total	**655.9**	**646.4**	**-9.5**
Wildlife activities			
Fishing	895.3	746.0	-149.2
Hunting	47.2	40.7	-6.6
Viewing wildlife	124.8	124.1	-0.7
Total	**1067.3**	**910.8**	**-156.5**
Gathering forest products			
Gathering forest products	48.7	48.4	-0.3
Total	**48.7**	**48.4**	**-0.3**
Water-based activities, not including fishing			
Motorized water activities	—	—	—
Nonmotorized water activities	85.2	83.6	-1.6
Total	**85.2**	**83.6**	**-1.6**
Other activities			
Relaxing	424.7	411.4	-13.3
Driving for pleasure	1,261.5	1254.4	-7.0
Some other activity	215.0	213.8	-1.2
Off-highway vehicle use	285.7	280.6	-5.1
Nature center activities	15.2	15.0	-0.2
Motorized trail activity	677.2	665.1	-12.1
Nature study	16.0	15.9	-0.1

Table 7 continued.

Activity	Projected days in 2060 (1,000s)		Net effects of climate change
	without climate change	with climate change	
Resort use	0.3	0.3	0.0
Visiting historic sites	25.2	24.8	-0.3
Other motorized activity	—	—	—
Total	**2,920.8**	**2,881.4**	**-39.4**
Total days (1,000s)	**9,842.0**	**9,688.8**	**-153.2**

— Indicates no data

Table 8—Projected and net changes in recreation days at the Arapaho-Roosevelt National Forests with and without climate change in 2060.

Activity	Projected days in 2060 (1,000s)		Net effects of climate change
	without climate change	with climate change	
Warm-weather activities			
Hiking/walking	1,619.5	1,717.6	98.1
Viewing natural features	1,465.9	1,457.7	-8.2
Other nonmotorized	61.0	60.6	-0.3
Bicycling	165.4	168.8	3.4
Developed camping	1,381.2	1,338.0	-43.2
Picnicking	18.7	18.1	-0.6
Backpacking	61.8	57.1	-4.6
Horseback riding	—	—	—
Primitive camping	118.4	109.5	-8.9
Total	**4,891.7**	**4,927.5**	**35.7**
Winter activities			
Downhill skiing	3,120.5	3,108.5	-11.9
Cross-country skiing/snowshoeing	158.3	134.6	-23.7
Snowmobiling	47.1	43.7	-3.4
Total	**3,325.9**	**3,286.9**	**-39.1**

Table 8 continued.

Activity	Projected days in 2060 (1,000s)		Net effects of climate change
	without climate change	with climate change	
Wildlife activities			
Fishing	370.5	308.8	-61.8
Hunting	586.7	505.0	-81.8
Viewing wildlife	53.1	52.8	-0.3
Total	**1,010.4**	**866.6**	**-143.8**
Gathering forest products			
Gathering forest products	8.8	8.7	-0.05
Total	**8.8**	**8.7**	**-0.05**
Water-based activities, not including fishing			
Motorized water activities	10.9	9.7	-1.2
Nonmotorized water	23.9	23.4	-0.5
Total	**34.8**	**33.2**	**-1.7**
Other activities			
Relaxing	212.9	206.2	-6.7
Driving for pleasure	714.1	710.1	-4.0
Some other activity	114.5	113.8	-0.6
Off-highway vehicle use	154.6	151.9	-2.8
Nature center activities	—	—	—
Motorized trail activity	82.1	80.6	-1.5
Nature study	—	—	—
Resort use	—	—	—
Visiting historic sites	6.7	6.6	-0.1
Other motorized activity	—	—	—
Total	**1,284.9**	**1,269.3**	**-15.6**
Total days (1,000s)	**10,556.5**	**10,392.0**	**-164.4**

— Indicates no data

Warm Weather Activities

Warm-weather activities are currently the most common recreation use in PSI-NFs (50 percent of total days) and AR-NFs (48 percent of total days). Within the warm-weather activities group for the PSI-NFs, viewing natural features and hiking/walking are the most popular recreation activities, 17.9 percent and 17.2 percent of total days, respectively. For the AR-NFs, viewing natural features and hiking receive the most days per year at 15.1 percent and 15.2 percent, respectively, followed by developed camping at 13.3 percent. Using the projected changes from the U.S. Forest Service 2010 RPA Assessment (USDA FS 2016; table 6), total recreation days are expected to increase by a combined net effect of 54,000 days for the PSI-NFs and 35,700 for the AR-NFs across all warm-weather recreation activities by 2060 as a result of climate change (tables 7–8).

When considering the specific recreation activities in the warm-weather group, it becomes clear that the impacts from climate change are expected to disproportionally affect specific recreation activities. Specifically, one of the most popular recreation activities, hiking, will see net increases in the number of visitation days under climate change in both the PSI and AR NFs (tables 7-8). Under the no climate change scenario, the number of hiking days are also expected to increase and are predicted to nearly double (an increase of 98 percent) by 2060 (table 6). Comparatively, hiking days are expected to more than double (an increase of 110 percent) in the climate change scenario by 2060, yielding a net increase of 111,000 hiking days for the PSI-NFs and a net increase of 98,000 hiking days for the AR-NFs attributable to climate change. A net increase is also expected for days bicycling attributable to climate change for the PSI-NFs (6,200 days) and the AR-NFs (3,400 days). In contrast, for the remaining warm-weather recreation activities, the models predicted a slight net decrease in warm-weather activity days on both national forests as a result of climate change. Among warm-weather activities, the largest net decrease in warm-weather activity days resulting from climate change are predicted to be primitive camping (22,700 days for the PSI-NFs and 8,900 days for the AR-NFs) and developed camping (21,100 days for the PSI-NFs and 43,200 for the AR-NFs).

Keep in mind that these are net effects between the with and without climate change scenarios, and the gross number of days for all warm-weather activities are expected to increase by at least 48 percent (primitive camping forecasts from table 6) relative to the current recreation use estimates from 2015 and 2016 levels. An explanation for these rates of growth under each climate scenario is largely due to population growth (USDA FS 2016). Although higher minimum temperatures required for warm-weather activities are expected to increase use with climate change, higher maximum levels may dampen or shift demand to different locations or activities due to extreme heat events (Bowker et al. 2012; Richardson and Loomis 2004).

Winter Activities

Winter activities account for 24.5 percent of total activity days per year for the AR-NFs. Downhill skiing accounts 22.1 percent of total activity days, cross-country skiing comprise of 1.6 percent of total days, and snowmobiling comprises 0.8 percent of total days. For the PSI-NFs, the proportion of days in the winter activities grouping is comparatively lower at 5.1 percent of total forest days and is largely concentrated in downhill skiing (4.2 percent of total days). Generally, climate change is expected to have a negative effect on winter activities as warmer seasonal temperatures will cause relatively shorter winter seasons, with more precipitation as rain rather than snow, and a higher snow line in the mountains. Specifically, past research predicts that downhill skiing, snowboarding, cross-country skiing, and snowmobiling are each expected to decrease in number of days available for these winter activities (Wobus et al. 2017).

Using projected changes from the U.S. Forest Service 2010 RPA Assessment (USDA FS 2016) (table 6), winter activity recreation days are expected to decrease by 9,500 days on the PSI-NFs and 39,100 days on the AR-NFs in the climate change scenario (tables 7–8). The difference between each forest's predicted net change to winter activities is because the AR-NFs' current total recreation days is disproportionally higher for this climate-sensitive category (24.5 percent) compared to the PSI-NFs' (5.1 percent). Cross-country skiing (which includes snowshoeing) will have the largest net decrease in days (4,600 fewer days for the PSI-NFs and 23,700 fewer days for the AR-NFs) between the two climate change scenarios. Downhill skiing for each forest is expected to experience a net decrease in visitation days of 2,200 for the PSI-NFs and 11,900 for the AR-NFs as result of climate change. Wobus et al. (2017) argue that downhill skiing and snowboarding may be more resilient to climate change because resorts could rely on artificial snowmaking whereas cross-country skiing, snowshoeing, and snowmobiling must rely on natural snowfall. Despite the expected net decrease in number of days for winter activities, the climate change scenario predicts positive gross increases in the recreation days in 2060 relative to current levels. Specifically, downhill skilling is expected to increase by 161 percent, cross-country skiing by 53 percent, and snowmobiling by 3 percent for each Forest relative to the current number of days (table 6). However, because of shorter seasons, the number of days within a single year when winter activities are possible will decrease and winter activities may see an increase in congestion and crowding, thus reducing benefits to recreationists. For example, Fonner and Berrens (2014) found that U.S. downhill ski areas participants prefer some level of crowding, but higher levels of crowding become a negative experience for skiers. To reduce crowding for downhill skiing, Walsh et al. (1983) found that Colorado skiers would be willing to pay a premium for lift tickets with shorter lift line waiting times. A more recent study from Norway shows similar results; skiers are willing to pay more than the standard lift ticket for reduce wait times (Lien et al. 2022).

Wildlife Activities

Wildlife activities are distinct from other types of recreation as these activities depend on the distribution, abundance, and health of desired target species (Hand et al. 2018). Wildlife activities considered in this analysis include consumptive (hunting and fishing) and nonconsumptive (wildlife viewing) activities. Both the PSI-NFs and AR-NFs have the similar percentage of total days (12.3 and 13.7 percent) in the wildlife activities category. The most popular activities in this category are fishing for PSI-NFs (10.3 percent of total days) and hunting for AR-NFs (8.9 percent of total days). Using projected changes from the U.S. Forest Service 2010 RPA Assessment (USDA FS 2016) (table 6), wildlife activity recreation participation between the with and without climate change scenarios is expected to decline by a net 156,500 days for the PSI-NFs and 143,800 days for the AR-NFs (tables 7-8). For the PSI-NFs, most of the decline in wildlife activity days is concentrated in fishing which is predicted to have a net decline of 149,200 days by 2060. For the AR-NFs, hunting is expected to decrease by a net 81,800 days and fishing decrease by a net of 61,800 days. Factors for the expected decline in fishing are higher summer and annual temperatures and changes in water availability for fish habitat. For hunting, this decline is due to increases in human population density and a reduction in per capita access. Warmer and drier conditions affecting habitat are contributing factors to the net decrease in participation in hunting from climate change (USDA FS 2016). Viewing wildlife is also expected to experience a decrease in the number of days for each Forest but not as dramatically as fishing and hunting.

Forest Product Gathering

Forest product gathering consists of Christmas tree harvesting, mushroom gathering, wood collection for personal use, as well as other nontimber products. This broad category is among the least popular activities as <1 percent of PSI-NFs days fall into this activity category and <1 percent for AR-NFs. The U.S. Forest Service 2010 RPA Assessment (USDA FS 2016) indicates there will be a slight decrease in visits for forest product gathering with climate change (tables 7–8).

Water-Based Activities (Not Including Fishing)

For the water-based category, the recreation activities include nonmotorized water activities and motorized water activities. Nonmotorized water activities are 1.0 percent of total PSI-NFs visits and <1 percent of total AR-NFs visits. Motorized water activities account for <1 percent of total recreation days for the PSI-NFs and <1 percent in AR-NFs. These relatively low activity days might be due to high cost of rafting and motorized boating. Furthermore, streams, rivers, lakes, and reservoirs provide boating opportunities, but they may be commonly paired with fishing (Hand et al. 2018) or could be considered a relatively scarce resource compared to the high availability of other outdoor recreation opportunities on the Forest such as the number of trails for hiking or backpacking. The U.S. Forest Service 2010 RPA Assessment (USDA FS 2016) shows climate change will have a negative effect on activity days for water-based activities, which are predicted to experience a net decrease of 1,600 days for the PSI-

NFs and 1,700 for the AR-NFs by 2060 (tables 7–8). The timing of spring runoff and overall availability of water in rivers, lakes, and reservoirs may be key drivers for these changes.

Adapting Recreation to the Effects of Climate Change

Based on these modeled results, climate change is expected to affect future recreation participation on the PSI-NFs and AR-NFs. However, these forecasts do not account for emerging outdoor recreation activities brought about by new technologies and changing tastes and preferences (Bowker et al. 2012). Future congestion and limited supply place constraints on the amount of recreation use that Forest Service sites can accommodate with current infrastructure. Adaptation strategies may be needed by recreation participants and public land managers to ensure recreation activities can be accessible in the future. Dante-Wood and Hoang (2018) provide a general framework of adaptation strategies for landscape-scale land management for the Northern Rockies. Jardine and Long (2014) have outlined several approaches to promote climate change resilience in the Sierra Nevada and southern Cascade Range that can be adapted to the study area. They suggest focusing on longer time horizons for planning, setting adaptable objectives with the ability to revisit and modify as needed, and use of valuation tools, monitoring, and research. In addition, the Interagency Visitor Use Management Council has guidebooks that may be useful towards planning and monitoring of recreation use levels and selection of indicators (IVUMC 2019).

Adaptation by Recreation Participants

Increasing temperatures and shorter winter and longer summer seasons will impact the demand and supply of outdoor recreation. Recreationists may need to adjust the timing, location, and type of activity with a changing climate and environmental conditions. The timing of seasonal visitation patterns may shift to shoulder seasons, such as recreating earlier or later in the summer or winter. Where people choose to recreate may change as the result of hotter temperatures where they may decide to hike at higher elevations such as high-alpine areas, where temperatures are cooler. Recreationists may benefit from developing alternative visitation plans in case preferred recreation sites are no longer available. It's possible that alternative sites or activities might be available; however, the alternative location may be less appealing to individuals or family connection to a site or activity might be lost, or the lost activity and location may be viewed as irreplaceable due to its unique nature (Winter et al. 2014). In addition, recreationists have already been forced to adapt due to other indirect climate change effects. For example, recent wildfires have caused several trails to close for an extended period of time. Therefore, recreationists are force to find alternative recreation sites to engage in the same activity, switch activity, or forgo the activity by staying at home.

Adaptation by Public Land Managers

Public land managers may need to adapt to changing environmental conditions and future demand for recreation opportunities. Regardless of the effects from a changing climate, as the absolute growth in visitor days (largely due to population growth) and demand for certain high-quality recreation opportunities increases, sufficient staffing and resources may be required to continue to manage these recreation sites. Limited supply constrains recreation use that Forest Service sites can accommodate with current infrastructure, and it is uncertain whether existing facilities will be able to accommodate increased demand in future recreation activities (White et al. 2016). With increased demand and limited supply, one implication is to consider planning for substitution effects between recreation activities. For example, people who would otherwise be camping may shift to day hiking or walking if campsites are full and they cannot stay overnight. One way this might be accomplished is for the Forest Service to consider maintaining and increasing partnerships and volunteer programs. Community involvement and partnerships have been instrumental in providing recreation opportunities and restoring recreation sites. Some examples of successful partnerships with Forest Service are the Colorado Trail Foundation (TCTF, n.d.) and the Continental Divide Trail Coalition (CDTC, n.d.). Through these partnerships, the Forest Service can acquire the additional labor needed to open developed campsites and national forest roads earlier especially if the season is expanded as is expected under climate change.

Further, the agency can build more campsites and trails at higher elevations that can be used during the hotter mid-summer temperatures that might make lower-elevation trails and campsites undesirable. The increasing technological capabilities of smartphones, apps, and other devices can potentially help public land managers communicate with recreationists for possible trail closures, types of recreation activities available, and safety information. For example, the U.S. Forest Service Interactive Visitor Map (USDA FS, n.d.-f) provides information on the types of recreation opportunities available on each national forest. National Forest apps can potentially help managers provide recreationists with trail information, possible trail closure, and substitute sites. Social media can also be useful for a subset of interested individuals seeking forest updates.

Conclusion and Implications

The biggest challenge for Forest Service managers on both the PSI-NFs and the AR-NFs is the substantial increase in visitor use expected due to the large population increases that are expected along the Front Range. Specifically, recreation days on both national forests are expected to double by 2060. While climate change will result in some recreation activities seeing larger increases, the biggest challenge will be designing plan alternatives to deal with general increases in visitor use. This might entail different alternatives such as: (1) building additional recreation infrastructure (e.g., campsites and trails, especially at higher elevations) along with the means to finance and maintain this expanded infrastructure (e.g., utilizing fee structures permissible under the Federal Lands Recreation Enhancement Act); or (2) imposing rationing mechanisms to balance the demand for recreation and limited supply of recreation opportunities. In any climate future, managers will need to manage congestion and its impacts to the recreational experience.

Notes

[1]https://www.eldora.com/the-mountain/mountain-stats-policies-faqs/mountain-stats
[2]https://skiloveland.com/the-mountain/trail-map-mountain-stats/
[3]https://www.winterparkresort.com/the-mountain/mountain-information/statistics
[4]https://www.skicooper.com/mountain-stats/
[5]https://www.skimonarch.com/hours-stats/
[6]National Visitor Use Monitoring Program (NVUM) web-application: https://www.fs.usda.gov/about-agency/nvum

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Appendix

Table A1—Participation frequency (%) and visits (1000s) by recreation activity at the Pike and San Isabel National Forests (National Visitor Use Monitoring sampling in 2016).

Activity	Main activity (%)	Visitation (1,000s)
Warm-weather activities		
Hiking/walking	19.0	842.6
Viewing natural features	19.7	872.9
Other nonmotorized	0.7	32.6
Bicycling	3.2	140.5
Developed camping	2.9	130.1
Picnicking	0.6	26.7
Backpacking	0.5	21.4
Horseback riding	0.2	7.4
Primitive camping	1.8	78.8
Total	**48.6**	**2,153.1**
Winter activities		
Downhill skiing	5.1	224.9
Cross-country skiing	0.4	17.1
Snowmobiling	0.6	26.9
Total	6.1	268.9
Wildlife activities		
Fishing	10.4	460.5
Hunting	0.7	29.8
Viewing wildlife	1.4	63.4
Total	**12.5**	**553.7**
Gathering forest products		
Gathering forest products	0.6	24.7
Total	**0.6**	**24.7**
Water-based activities, not including fishing		
Motorized water activities	0.0	0.0
Nonmotorized water	1.1	49.3
Total	**1.1**	**49.3**

Table A1 continued.

Activity	Main activity (%)	Visitation (1,000s)
Other activities		
Relaxing	3.3	147.5
Driving for pleasure	14.4	640.7
Some other activity	2.3	100.1
Off-highway vehicle use	3.2	141.7
Nature center activities	0.2	7.1
Motorized trail activity	7.0	310.1
Nature study	0.2	9.0
Resort use	0.0	0.1
Visiting historic sites	0.2	10.6
Other motorized activity	0.0	0.0
Total	**30.8**	**1,366.7**
Total Visits	—	**4,434.0**

— Indicates no data.
*Visits of each category does not sum to Total Visits due to rounding and excluding “No Activity Reported”.

Table A2—Participation frequency (%) and visits (1000s) by recreation activity at the Arapaho and Roosevelt National Forests (National Visitor Use Monitoring sampling in 2015).

Activity	Main activity (%)	Visitation (1,000s)
Warm-weather activities		
Hiking/walking	16.7	743.6
Viewing natural features	16.7	744.5
Other nonmotorized	0.6	28.4
Bicycling	1.7	76.3
Developed camping	6.0	266.4
Picnicking	0.2	8.8
Backpacking	0.3	15.4
Horseback riding	0.0	0.0
Primitive camping	0.7	30.8

Table A2 continued.

Activity	Main activity (%)	Visitation (1,000s)
Total	**42.9**	**1914.3**
Winter activities		
Downhill skiing	26.7	1191.0
Cross-country skiing	2.0	87.9
Snowmobiling	0.8	35.4
Total	**29.5**	**1314.4**
Wildlife activities		
Fishing	4.3	190.6
Hunting	8.3	369.9
Viewing wildlife	0.6	27.0
Total	**13.2**	**587.5**
Gathering forest products		
Gathering forest products	0.1	4.4
Total	**0.1**	**4.4**
Water-based activities, not including fishing		
Motorized water activities	0.1	4.8
Nonmotorized water	0.3	13.8
Total	**0.4**	**18.6**
Other activities		
Relaxing	1.7	73.9
Driving for pleasure	8.1	362.7
Some other activity	1.2	53.3
Off-highway vehicle use	1.7	76.7
Nature center activities	0.0	0.0
Motorized trail activity	0.8	37.6
Nature study	0.0	0.0
Resort use	0.0	0.0
Visiting historic sites	0.1	2.8
Other motorized activity	0.0	0.0
Total	**13.6**	**607.0**
Total Visits	—	**4,458.8**

— Indicates no data.
*Visits of each category does not sum to Total Visits due to rounding and excluding “No Activity Reported”.

Table A3—Days (1000s) and conversion factor by recreation activity per sampling year at the Pike and San Isabel National Forests and the Arapaho and Roosevelt National Forests.

Activity	Conversion factor (R2)	Days (1,000s)	
		Pike-San Isabel NF (2016)	Arapaho-Roosevelt NF (2015)
Warm-weather activities			
Hiking/walking	1.1	926.9	817.9
Viewing natural features	1.1	960.2	818.9
Other nonmotorized	1.2	39.1	34.1
Bicycling	1.1	154.6	84.0
Developed camping	2.7	351.4	719.4
Picnicking	1.1	29.4	9.7
Backpacking	2.5	53.5	38.6
Horseback riding	1.3	9.6	0.0
Primitive camping	2.4	189.2	74.0
Total	—	**2,713.8**	**2,596.5**
Winter activities			
Downhill skiing	1.0	224.9	1,191.0
Cross-country skiing	1.0	17.1	87.9
Snowmobiling	1.2	32.2	42.5
Total	—	**274.3**	**1,321.4**
Wildlife activities			
Fishing	1.2	552.6	228.7
Hunting	1.3	38.7	480.9
Viewing wildlife	1.1	69.7	29.7
Total	—	**661.1**	**739.3**
Gathering forest products			
Gathering forest products	1.1	27.2	4.9
Total	—	**27.2**	**4.9**
Water-based activities, not including fishing			
Motorized water activities	1.1	0.0	5.2
Nonmotorized water	1.1	54.3	15.2
Total	—	**54.3**	**20.4**

Table A3 continued.

Activity	Conversion factor (R2)	Days (1,000s)	
		Pike-San Isabel NF (2016)	Arapaho-Roosevelt NF (2015)
Other activities			
Relaxing	1.5	221.2	110.9
Driving for pleasure	1.1	704.7	398.9
Some other activity	1.2	120.1	64.0
Off-highway vehicle use	1.2	170.0	92.1
Nature center activities	1.0	7.1	0.0
Motorized trail activity	1.3	403.1	48.9
Nature study	1.0	9.0	0.0
Resort use	2.1	0.2	0.0
Visiting historic sites	1.1	11.6	3.1
Other motorized activity	1.2	0.0	0.0
Total	—	**1,647.0**	**717.8**
Total days (1,000s)	—	**5,377.6**	**5,400.4**

— Indicates no data.