USDA Forest Service
U.S. DEPARTMENT OF AGRICULTURE

Southern Research Station | Research Paper SRS-67 | September 2023

# Estimating Recreation Use in Bent Creek Experimental Forest

**W. Henry McNab, Julia K. O'Shields, J. M. Bowker, and Stanley J. Zarnoch**

**W. Henry McNab:** Research Forester, U.S. Department of Agriculture Forest Service, Southern Research Station, Bent Creek Experimental Forest, 1577 Brevard Road, Asheville, NC 28806.

**Julia K. O'Shields:** Technology Transfer Specialist (retired), U.S. Department of Agriculture Forest Service, Southern Research Station, Bent Creek Experimental Forest, 1577 Brevard Road, Asheville, NC 28806.

**J. M. Bowker:** Research Social Scientist (retired), U.S. Department of Agriculture Forest Service, Southern Research Station, Forestry Sciences Laboratory, 320 Green Street, Athens, GA 30602.

**Stanley J. Zarnoch:** Mathematical Statistician (retired), U.S. Department of Agriculture Forest Service, Southern Research Station, Clemson University, Lehotsky Hall, Clemson, SC 29634.


## ABSTRACT

Dispersed recreation is an important use of national forests, including in experimental forests where long-term research is conducted to evaluate effects of environment and disturbances on ecosystems. Recreation has markedly increased in Bent Creek Experimental Forest since it was established in 1925. The objective of this investigation was to quantify visitors, their activities, and associated vehicular traffic to provide a baseline for evaluating the effects of recreation on the experimental forest environment and to identify potential research opportunities. In a core study conducted from 2005 to 2007, one person in each of 4,170 vehicles entering the experimental forest was interviewed to determine visitor numbers and intended recreational activities. A followup telephone subsample of 1,106 interviewed visitors was conducted to determine their demographics and travel expenses. Visitation averaged 145,570 people annually. The predominant recreation activities were hiking and bicycling. A typical visitor was a white male between 26 and 40 years of age with a bachelor's degree, who had travelled less than 10 miles oneway. Average cost per visit was between $18 and $36. Vehicle occupancy averaged 1.57 people and 0.24 pet dogs. Significant temporal influences affecting the rate of hourly traffic volume included season of year, day of week and time of day, but not whether the day was a holiday. Vehicle traffic was reduced in fall when deer hunting was permitted. Study results suggest that the large population of visitors using the experimental forest offers opportunities for social science research on ecosystem disturbances related to recreation. Data from the core study were archived and are available for further use.

**Keywords:** Dispersed recreation, economic analysis, pet dogs, recreation survey, temporal sampling strata, traffic trends, vehicle counts.


**LEFT:** Campsite at Lake Powhatan Recreation Site in Bent Creek Experimental Forest; **RIGHT:** Sign identifying a designated trail and the allowed types of uses.

# PREFACE

This publication documents findings from a research project to determine the amount and types of recreation in the Bent Creek Experimental Forest. The experimental forest was formally established in 1927 as an area in the Pisgah National Forest designated primarily for silviculture research that was also open for public access. Recreation then consisted largely of traditional, seasonal fishing and hunting activities that attracted few visitors. Now, nearly 100 years later, the Bent Creek area has become a mecca for dispersed recreation that serves a large metropolitan population as a place for mostly nontraditional activities, such as bicycling and pet exercise. Over time, increased recreational use was noted but received no formal attention until associated environmental effects became apparent and conflicts with requirements of forest research emerged. This study is the first to document the amount and types of recreation in this experimental forest. It provides a demographic profile of the population of visitors and examines temporal factors associated with their decision to visit. We summarize history of recreation in Bent Creek to provide context for the study. Results provide a baseline of visitation and traffic for measuring future changes. Equally important, this report describes opportunities for increasing value of the experimental forest as an outdoor laboratory for social science research on issues associated with dispersed recreation and resource management in national forests.

# INTRODUCTION

## Developed, Dispersed, and Unmanaged Recreation

Recreation has long been recognized as both an important use of national forests and a challenge to manage (Kneipp 1930). Outdoor recreation management on national forest lands is grouped into two categories based on the level of administration: developed or dispersed. Developed recreation includes staffed facilities such as campgrounds and recreation areas where a range of services are provided and policies regulating visitor capacity and use are actively enforced. Dispersed recreation includes activities that take place in the general forest area, such as fishing, hiking, horseback riding, biking, hunting, scenic driving, and camping. Dispersed recreation is managed but to a lesser degree, usually passively with signage stating rules of use and other information (e.g., restricting biking to designated trails, and trail difficulty). Enforcement of rules for dispersed recreation largely depends on awareness of and conformance with societal environmental ethics by users; visitor capacity is largely unregulated except perhaps for wilderness areas where relative solitude is expected (Wagar 1974). As examples, trail running and hiking have increased nationally by 23.8 and 67.5 percent, respectively, since 2011 (Outdoor Foundation 2021). Also, the increasing popularity of mountain biking since the 1980s (Bowker and English 2002, Cordell 2008, Meyer 1985) has added to the complex nature of managing dispersed recreation and its effects on natural resources in national forests (Savre and others 2010).

**LEFT:** Soil erosion from bike traffic on an illegal, user-created trail; **RIGHT:** Bent Creek kiosk at low-elevation entrance.

Occurring with developed and dispersed recreation are unmanaged activities. Unmanaged recreation describes nontraditional visitor activities or activities occurring at unauthorized locations that can result in soil erosion, conflicts among users, damage to cultural sites, and disturbance to wildlife. Unmanaged recreation can be difficult to define because it resembles dispersed recreation; it has been described as "inappropriate dispersed recreation" (Santa Maria 2014) or "unmonitored nontraditional activities growing in popularity" (Brooks and Champ 2006). Because of its rapidly increasing impacts on natural resources and the environment, Dale Bosworth, former Chief of the U.S. Department of Agriculture Forest Service, included unmanaged outdoor recreation as one of the "four threats" that must be addressed on national forest lands to maintain their quality and enjoyment for both current and future public use (Bosworth 2004). Bosworth stated that effects of unmanaged dispersed recreation may be manifested by soil erosion from unauthorized trails, disturbance of sensitive vegetation, and conflicts among user groups. These and other issues related to public use are important in areas of national forests designated for research activities because disturbances associated with some visitor activities could affect results of study treatments. Issues such as these are particularly relevant for highly visited experimental forests near urban areas (Adams and others 2004, Cerveny and Charnley 2014), such as the Fraser Experimental Forest near Denver, CO (Yung and others 2012) and the Bent Creek Experimental Forest (BCEF) in the southern Appalachian Mountains of western North Carolina, located 10 miles south of Asheville, in the Pisgah National Forest (fig. 1).

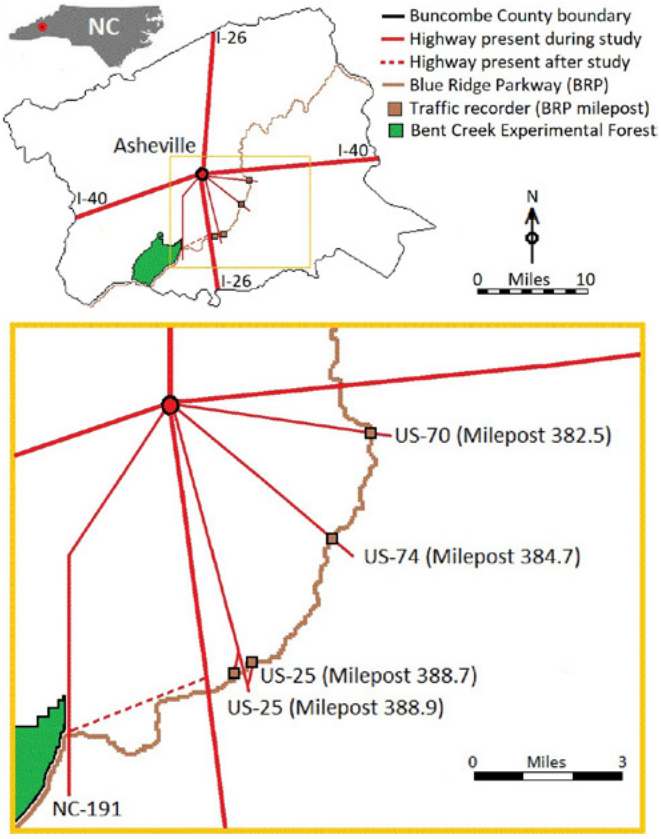



Figure 1—Vicinity map of Buncombe County, North Carolina, showing location of Bent Creek Experimental Forest in relation to Asheville and the Blue Ridge Parkway (BRP). Major highways intersecting the BRP are identified by Federal (U.S.), State (North Carolina) route numbers, and Parkway mile post (mp) markers. The connector road (broken line) between the BRP entrance at NC-191 (mp 393.6) and Interstate 26 was not present when the study was conducted (Boyle 2022).


**LEFT:** Bent Creek Experimental Forest 1956 sign; **RIGHT:** The Shut-In Ridge trail provided access to a rain gauge near Glenn Bald in 1936.

## Recreation at Bent Creek Experimental Forest

Perceived public use of BCEF increased rapidly during the late 1900s, as mountain economies shifted from rural agriculture-based to urban manufacturing and service (Yarnell 1998). The type of visitor uses in BCEF also changed, from traditional fishing and hunting, which was low volume, seasonal, and somewhat sedentary to high volume, action-oriented recreational activities, such as hiking and biking (Crittenden 1997). BCEF became better known as a place for recreation rather than forest research (Crane 1998a). Increased public use, however, brought new issues, such as requests for additional trails, expanded vehicle parking, unintended disturbance of research installations, and questions about the carrying capacity and sustainability of recreation in the experimental forest (Asheville Citizen-Times 2002). To better understand the amount and types of contemporary recreation, a study was designed with the objectives of measuring: (1) the number of annual visitors and the activities they pursued, and (2) the volume of vehicular traffic and its temporal variation. Although forest silviculture and wildlife research have been the primary activities in the experimental forest for nearly 100 years, this was the first study designed to assess the number of visitors and type of recreation activities.

## History of Land Use and Recreation at Bent Creek

The experimental forest is situated in a 6,000-acre watershed drained by a third-order stream, 5 miles in length, named Bent Creek that empties into the French Broad River. Regional climate is humid-temperate, with short, cool winters and warm summers. Precipitation averages 50 inches annually and is well distributed among seasons. Forest vegetation consists of more than 100 tree species that are distributed across the landscape in communities associated primarily in relation to available soil moisture during the growing season. Variation of soil moisture is associated with mountainous topography, ranging from relatively dry upper slopes and convex ridges to moist lower slopes and concave coves. Dry and intermediate sites are dominated by an overstory of mixed species of xerophytic oaks (*Quercus* spp.) and hickories (*Carya* spp.). Mixed mesophytic species, dominated by yellow-poplar (*Liriodendron tulipifera*) occupy moist sites. The midstory of most stands is occupied by shade-tolerant species, such as red maple (*Acer rubrum*) and sourwood (*Oxydendrum arboreum*). Climate-related disturbances include winter ice storms, summer droughts, and windstorms. Lightning-ignited fires are uncommon in this humid environment, but fire became an increased form of disturbance associated with human occupation of the watershed (Yarnell 1998).

Human presence in the watershed likely began around 12,000 years ago (Yarnell 1998). Evidence of prehistoric use of the area by the Cherokee Nation dates from 1600 based on excavation of a mound site several miles east of the watershed, on the Biltmore Estate (Kimball and others 2010). Historic evidence of Native American presence in the watershed was documented by Nesbitt (1941) who reported two Cherokee camps, occupied by several hundred people when European settlement of the Bent Creek watershed began in the late 1700s.

Early recreation in the watershed can be grouped by type of land ownership: private or public. Private ownership began in 1796 when the North Carolina State Government began issuing grants to European pioneer settlers for large tracts of former Cherokee lands (Arthur 1914), which included about half of the watershed (Nesbitt 1941). Those tracts were subsequently subdivided and sold to other settlers who entered the Bent Creek watershed and practiced subsistence agriculture for nearly 100 years (Nesbitt 1941). By 1900, the watershed had been subdivided into many privately owned tracts used for farming, wood production, livestock grazing, a sawmill and a grist mill, which supported a general store, school, and church. Recreation was community oriented, consisting of weekend gatherings for activities such as square dancing and church attendance. Summer baseball games were held on a sediment-filled mill pond. Hunting and fishing were not considered as recreation, rather as utilization of a land resource. In 1890, George Vanderbilt began purchasing land in the Bent Creek watershed and beyond for his Pisgah Forest, part of the Biltmore Estate. For the next 2 decades, until Vanderbilt's death in 1914, access in the watershed was limited, intentional woods burning

**LEFT:** Bent Creek campground pavillion, approximately 1942; **RIGHT:** Lodge at drained Deer Lake, approximately 1980.

was reduced, and hunting and fishing were controlled by his game wardens.

Public ownership began in 1914. Using provisions of the Weeks Act, the Forest Service purchased Vanderbilt's 88,700-acre Pisgah Forest from his widow, Edith, for $5 per acre (Asheville Gazette News 1914), which included the Bent Creek watershed (Alexander 2005). The Pisgah National Forest was established on October 17, 1916 (Lewis 2016). Its land and wildlife resources were soon made available for public use as described in articles appearing in Asheville newspapers. For example, Pisgah National Forest supervisor Verne Rhoades issued the first fishing permit in March 1917 (Asheville Citizen 1917). Trail construction was emphasized by the Forest Service as a cost-effective way to encourage public access for recreation (Hall 1919). Sightseeing by automobile was rapidly increasing and encouraged in the Pisgah National Forest, using Vanderbilt's formerly private road to his Buck Spring Lodge at Mt. Pisgah (Asheville Citizen 1919, 1921a; Hall 1919). Hunting was permitted in the national forest, but before wildlife management began in the late 1930s (N.C. Department of Conservation and Development 1937) regulations were established and enforced by county game wardens (Asheville Citizen 1920).

Developed recreation in the watershed began in 1921. The Pisgah National Forest issued a permit to the Asheville Young Men's Christian Association (YMCA) to build a campground (Camp Powhatan) and reconstruct a nearby earthen dam to form a lake at the 1865 site of a water-powered sawmill (Asheville Citizen 1921b, 1922; Nesbitt 1941: 36) (fig. 2). The Boy Scout organization also developed a campground with a small lake (Lake Daniel Boone) and cabins a short distance upstream from Camp Powhatan (Asheville Citizen 1925, Asheville Citizen-Times 1931b, Neufeld 2018) at the former mill pond site previously used for ball games by the Bent Creek community. The two campgrounds were used primarily during the summer months for managed outdoor recreation activities by urban youth groups and were popular because the Bent Creek watershed was near Asheville.

A third lake was constructed around 1927 on the privately owned Nichols property (Nesbitt 1941) by damming Wolf Branch (Royall 2003) (fig. 2). Use of the unnamed lake and the surrounding 40 acres of forest and cleared land is unknown except that the property was later described as a private fishing and hunting estate (Asheville Citizen 1959a). A large, lodge-type structure was built there in 1950 (USDA Forest Service 2001). The lake was named Deer Lake in 1959 when the property was purchased from the private estate by an organization for use as a children's day camp (Asheville Citizen 1959a, 1959b, 1960). The privately owned Deer Lake property was purchased by the Forest Service in 1966 for inclusion in the Pisgah National Forest and later used for environmental education programs between 1971 and 1977 (Asheville Citizen 1977, Slater 1971) (app. H).

The history of BCEF begins with establishment of the Appalachian Forest Experiment Station in 1921 (Asheville Citizen 1921c), headquartered in Asheville and under the direction of pioneer Forest Service researcher Earl Frothingham (Frothingham 1921). Although early Forest Service research had been ongoing for many years in plantations established by Carl Schenck at the Biltmore Estate (Haasis 1930), field research in the future BCEF area began around 1925. There, on about 150 acres of the Pisgah Ranger District of the National Forest, near where Bent Creek joins with the French Broad River, a small building was constructed for use as a laboratory by field staff of the Station and the Bureau of Entomology, which was conducting research on the southern pine beetle (*Dendroctonus frontalis*) (Asheville Citizen 1926, Caird 1935) (fig. 2). The experimental forest was formally established in 1927 on 1,042 acres extending from the laboratory area southward into the watershed between Shut-in Ridge and Bent Creek (Asheville Citizen 1929, USDA Forest Service 1927) nearly to Camp Powhatan (fig. 2).

An appropriation of unemployment relief funds was obtained by the Forest Service from the Hoover administration in 1931 for construction of offices, additional laboratories, and maintenance facilities near the first laboratory at BCEF (Asheville Citizen-Times 1931a). Those funds were also used for building Hard Times Road to provide vehicular access into the new experimental forest (Abell 1933). The purpose of the experimental forest was to

**LEFT:** Work crew building Hard Times Road; **RIGHT:** The small building that served as the original 1925 laboratory/office at Bent Creek.

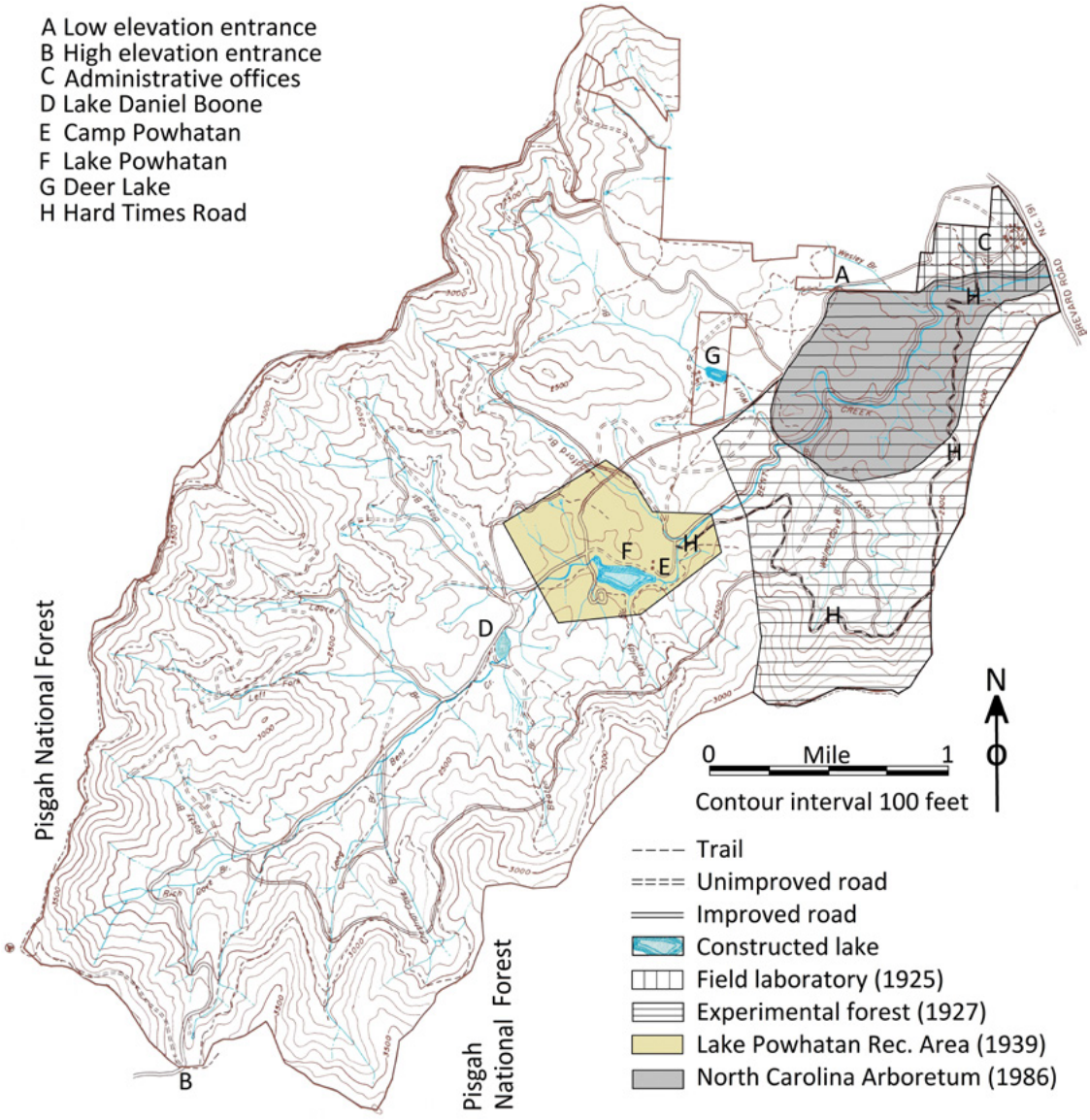



Figure 2—Map of Bent Creek Experimental Forest with locations of features identified in the text.


**LEFT:** Lake Powhatan; **RIGHT:** Bent Creek Experimental Forest "Experimental Area" sign.

provide an area for investigating methods for rehabilitating cutover and unmanaged forests and demonstrating sound forest management practices. In 1935, BCEF was expanded by 4,800 acres, which included much of the Bent Creek watershed (USDA Forest Service 1935). Specifically excluded from the enlarged experimental forest were 600 acres including "…the Boy Scout Lake and the Y.M.C.A. Lake [that] may have a higher use for recreational purposes." The BCEF is part of the Forest Service's network of experimental forests that are designated primarily for research purposes, where each represents a major forest ecosystem type in the United States (Adams and others 2004). BCEF is an area typical of the southern extent of the central hardwood forest region in the southern Appalachian Mountains, from central Virginia to northeastern Georgia.

A Civilian Conservation Corps (CCC) camp, F-22, was established in BCEF in 1935 to develop field facilities for the larger experimental forest (Jolley 2007). CCC work at BCEF was not on recreation-related projects, which was typical for national parks (McCoy 1934), but was directed toward forest management activities, such as road maintenance, clearing lanes for fire control, and assisting with installation of research areas (Asheville Citizen 1934). Some work, however, was indirectly related to recreational hunting through association with white-tailed deer (*Odocoileus virginianus*), which had increased rapidly in the Pisgah National Forest through enforcement of hunting regulations (Asheville Citizen 1932, Padgitt 1927). For example, CCC personnel were used to conduct annual censuses of the deer population (Asheville Citizen 1935a), where up to 175 men were needed per square mile (Erickson 1940). The CCC also assisted in finding orphaned deer fawns that were raised and released in other national forests to restore the species (Asheville Citizen-Times 1934, Jolley 2007), which had been hunted nearly to extinction by early settlers (Ellsworth and others 1994). The CCC camp in BCEF was closed in late 1937 (Asheville Citizen 1937c).

The first reference to hiking as dispersed recreation in BCEF occurred in 1931 (Naves 1931). In early February, M.A. Mattoon, Forest Supervisor of the Pisgah National Forest, led members of the Carolina Appalachian Trail Club into BCEF using the Shut-In Ridge Trail. The Shut-In Trail, along the southwest boundary of BCEF, was likely one of several established by George Vanderbilt for access by horseback to Buck Springs Lodge. It is an example of other existing trails, likely kept open by hunters, which would be used in later years for other types of dispersed recreation.

Forest Service management of developed recreation began around 1940, following a series of storm events that had damaged the YMCA and Scout campgrounds in the mid-1930s. In 1935, the YMCA lake at Camp Powhatan was drained for removal of sediments and to allow repairs to the 1921 earthen dam (Asheville Citizen 1935b). A winter storm in early January 1937 caused record flooding in Asheville (Asheville Citizen 1937a) and likely damaged the log and earthen dam at Camp Powhatan because it was soon condemned by the Forest Service (Asheville Citizen 1937b). A similarly constructed dam at Camp Daniel Boone was also probably breached by the 1937 storm because the Boy Scouts relocated their campground outside of BCEF in 1938 (Asheville Citizen-Times 1938). In mid-August 1940, more severe flooding resulted from a lengthy summer storm event that was followed by a subtropical hurricane 2 weeks later (Tennessee Valley Authority 1973), destroying the YMCA's Camp Powhatan (Asheville Citizen 1940, Nesbitt 1941). Following plans developed in 1939 (Asheville Times 1939), the Forest Service contracted for construction of a larger, concrete dam and improved campground facilities at the present site of the Lake Powhatan Recreation Area, which was funded under the Works Progress Administration program (WPA) (Asheville Citizen 1941). An early reference to hunting safety occurred in late November 1941, when the WPA employees did not work for several days during Thanksgiving weekend "… for fear some of the hunters will mistake them for deer or bear and shoot them." (Asheville Times 1941). The recreation area was scheduled for opening in early October 1942 (Asheville Citizen 1942).

Traditional dispersed recreation in BCEF, including driving on the ungated road system, continued at a low level into the late 1980s and was welcomed by Forest Service research staff because visitors were an audience for viewing forest management and other research activities (Morrison 1990).

In 1986, a site in BCEF was selected for the North Carolina Arboretum site, a North Carolina state facility for education and conservation of native vegetation (fig. 2) (Osborne 1986). Occupying 430 acres in the lower part of the original area of the experimental forest, it was a fenced, controlled-access area that provided a highly developed area for dispersed recreation of hiking and biking, where hunting was prohibited (Crane 1998c, Nivens 1989, Osborne 1989).

Awareness of the need to manage the increasing visitor use in BCEF beyond the developed arboretum and Lake Powhatan areas was an issue recognized by the Pisgah National Forest in the late 1990s (Crane 1998b). Earlier, reduced road maintenance funding caused the Pisgah District to issue a winter closure order for secondary system roads. This policy reduced road damage from rutting by vehicles during wet weather and reduced the recurring problem of roadside dumping of trash. The road closure did not affect hiking and camping but was an issue with some hunters because of reduced access to retrieve harvested deer during hunting seasons (W.H. McNab, personal observation). In the late 1990s, the national surge of dispersed recreation (Cordell and others 1999) was noted in BCEF, as evidenced by overflow parking at the only designated trailhead (Hard Times), an abundance of mountain bikes on system roads, and user-created trails through research areas (Crittenden 1997). Newspaper articles promoted the arboretum and BCEF areas as well suited for running and bicycling (Crane 1998a, 1998c). Lack of a designated trail system allowed Pisgah District Ranger, Art Rowe, to identify soil erosion from several unauthorized trails as an environmental issue (Crane 1998b). Even with increasing public use, BCEF was generally considered a safe place for recreation (Crane 1998d), although a nonhunting related death of a recreationist occurred in 1994 (O'Neal 1994).

The Pisgah District began an increased level of managing dispersed recreation in BCEF in 1999 with an environmental assessment of proposed actions, including designation of an authorized trail system, additional vehicle parking areas (i.e., Ledford and Rice Pinnacle trailheads) and restrictions on roadside camping (see sign p. 9, USDA Forest Service 1999). A March 2000 wildfire of undetermined origin in BCEF (Alexander 2000) burned through several research plots and reinforced the need for increased attention to dispersed recreation, particularly the undesirable effects of trash associated with roadside camping near Bent Creek, which flowed into Lake Powhatan. The proposed actions for managing recreation were the topics of several newspaper articles inviting public comments on the environmental assessment (Ball 2002a, 2002b). In July 2014, the Forest Service issued order 07-01-04 restricting horse and bicycle riding to designated trails and roadside camping to the Lake Powhatan Recreation Area.

## The Need for a Recreation Study

The first indication of the need to measure dispersed recreation appeared in a newspaper editorial that included a revealing comment by Project Leader David Loftis, the research manager at BCEF: "We can only meet a certain level of the demand for recreation use at Bent Creek" (Asheville Citizen-Times 2002). The decision notice of preferred actions for managing visitor use in Bent Creek was issued in May 2002 (USDA Forest Service 2002) and identified the need for increased management of dispersed recreation to reduce issues among user groups and with forest research requirements. Tension between research and some recreation groups surfaced in 2003, however, when strong opposition was voiced by trail users against reconstruction of a designated bike trail that followed a former logging road, which was needed to allow installation of several silviculture studies (Clark 2003). Noteworthy in the 2003 environmental assessment for the Bent Creek Complex timber harvest was a statement of the need to "conduct research projects that address the impact of recreation on the forest" (USDA Forest Service 2003). This was the basis for the soon-to-occur 2005 survey of visitor recreation activities. Evidence of the continuing increase of unmanaged recreation by mountain biking in BCEF was apparent from many illegal user-created trails, which prompted additional management actions for improved signage and enforcement of designated trail use (Morrison 2004). Although the designated trail system of 44 miles received considerable public attention, management of developed recreation continued by removing sedimentation in Lake Powhatan to improve water quality for fishing and swimming (Nash 2006).

Excluding the developed Lake Powhatan Recreation Area where visitation was recorded, little was known about the volume and types of dispersed recreation in BCEF, which would be useful for planning purposes as stated by Bosworth (2004). Related to the question of visitor volume was information on the evenness of daily and seasonal visitation at BCEF. In their study of visitor use of the Virginia Creeper Trail in Virginia, Bowker and others (2007) stratified sampling by seasons (i.e., winter, summer) and day types (i.e., weekday, weekend). A study in the Northeastern United States showed that the volume of outdoor recreation surged on weekends compared to weekdays (Cordell and others 2012). Although BCEF had been established originally to investigate subjects related to forestry, it was becoming evident that opportunities were also available for conducting social sciences research, which had been done in other experimental forests near urban areas (Charnley and Cerveny 2011, Ponce and Gary 1979). Although not essential for planning or management, information on variation in the volume of visitation could be useful to improve understanding of factors that influence


**LEFT:** Roadside camping not allowed in Bent Creek Experimental Forest; **RIGHT:** Interviewer with stopped vehicle.

people's decisions to visit BCEF, such as season of year. Such information would be useful for designing sampling protocols for future studies. Surprisingly, influencing factors are often utilized when designing sampling strata for recreation studies (Bowker and others 2007), but little attention has been given to evaluating the importance of their effects on visitation.

This report presents results from two studies conducted at the same site on outdoor dispersed recreation in BCEF. The first study began in 2005 with the overall purpose of gaining a better understanding of the number of people entering BCEF for the purpose of recreation, including determining their numbers, learning the purpose of their visits, and estimating their economic impact on the local economy. This visitor study was based on the design of several earlier studies with similar objectives (Bowker and English 2002, Bowker and others 2007).

Although vehicular traffic was recorded in this BCEF visitor study, those data were neither summarized nor analyzed for trends. About 15 years following the study (in 2020), in response to observations and questions about increasingly crowded parking areas at trailheads, a second study was conducted, using traffic data from the first study. Objectives of this traffic study were to determine the number of vehicles entering BCEF during the 2005–2007 survey and estimate the trend of traffic volume for the decade following the survey. Together, the two studies (visitor survey study and vehicle traffic study) provide an overview of recreational activities in the experimental forest and establish a baseline level of anthropogenic-related disturbances.

Also, we describe other data collected during these studies that were not used in either of them. All data were archived to provide opportunities for research on other questions not addressed in the two studies reported here (see app. I).

# DESIGN AND METHODS

## Study Site

Studies were performed at the BCEF located in the southern part of Buncombe County, North Carolina (fig. 1), for two 12-month sessions: June 2005 through May 2006 (session one) and July 2006 through June 2007 (session two). The BCEF (35.48225° N 82.34620° W) is on national forest land nearest to the county's urban areas, including the city limits of Asheville and other urban areas connected by the Blue Ridge Parkway (BRP), which is administered by the U.S. Department of the Interior. The experimental forest is attractive for outdoor recreation because of the forested environment, a dense network of trails that follow former logging access roads, and national forest developed facilities at Lake Powhatan Recreation Area (fig. 2). Two entrances provide access: a clearly identified low-elevation secondary road from State Highway NC-191 (the main entrance) and an unidentified high-elevation, remote road crossing the BRP. Observations suggest few vehicles enter BCEF from the remote entrance on the BRP (W.H. McNab and J.K. O'Shields, personal observations). The high-elevation access road is occasionally used by local visitors who enter from NC-191 and drive 5 miles through BCEF on an unpaved road to exit on the BRP. Except for several private residences and service deliveries to Lake Powhatan, traffic entering BCEF was presumed for recreation purposes. Occasional nonrecreation traffic is negligible and includes random situations such as pizza delivery to a trailhead or searching for a lost dog. The BCEF administrative offices are located adjacent to NC-191 (fig. 2); therefore, Forest Service employees were not part of visitor traffic.


**LEFT:** Recreational horseback riding (photo courtesy of AdobeStock); **CENTER**: Safety zone sign; **RIGHT:** Biker viewing a map of demonstration sites.

## Study Design

The study design followed protocols of the National Visitor Use Monitoring (NVUM) program, which was developed to provide estimates of recreation visitation on national forests (English and others 2002). As noted previously, there were two separate but related studies: the visitor survey study and the vehicle traffic study.

The visitor survey study was conducted in two phases: (1) onsite contact with visitors to estimate the number of people entering BCEF and determine their reason for visiting, such as hiking or biking; and (2) telephone interviews with visitors surveyed in phase one who were willing to provide supplemental information about details of their visit, such as costs, frequency of visits, and why BCEF was their destination. Results from both phases of the visitor survey study were summarized as an office report (Bowker and others 2011), but the justification and sampling methods used for that study have not been published.

The vehicle traffic study was conducted using vehicle counts and related data collected during the visitor survey study. This study consisted of three phases to: (1) evaluate influences affecting traffic volume; (2) characterize contents of vehicles in terms of people and animals; and (3) determine the trend of annual traffic volume. Data on the influences phase are often collected when conducting visitor surveys (Bowker and others 2007) but are rarely summarized and reported as information potentially useful for conducting future studies.

## Visitor Survey Study

The visitor survey utilized a double sampling design that was conducted in two coordinated phases: (1) brief initial onsite interviews; and (2) followup telephone interviews. Information from both phases allowed for a description of visitor demographics and a profile of their visitation frequency, economics associated with their visits to BCEF, and observations about BCEF as a place for recreation.

**Phase 1 methods**—The onsite interviews were conducted mostly by volunteer students and residents with an interest in the survey during daylight hours from 6 a.m. until 6 p.m. at a single location near the main entrance into BCEF from NC-191 (fig. 2, also see cover photos). Interviews were conducted during 2-hour intervals, termed blocks (Gregoire and Buhyoff 1999). The sample blocks of time occurring during the 24 months of the study were classified by seven strata thought to influence the decision at a moment in time to visit BCEF for a particular purpose:

- Session: either (i) first (June 1, 2005–May 31, 2006) or (ii) second (July 1, 2006–June 30, 2007). This stratum evaluates large-scale economic influences potentially affecting variation of vehicle volume on an annual basis, such as the price of vehicle fuel, level of local unemployment, or population trends not apparent at smaller measurement intervals.
- Meteorological season: (i) spring (March–May), (ii) summer (June–August), (iii) fall (September–November), or (iv) winter (December–February).
- Holiday: either (i) no holiday or (ii) holiday. Ten days were designated as Federal holidays when this study was conducted, half of which always occur on a Monday as specified by the Uniform Monday Holiday Act of 1968. When a fixed-day holiday, such as the Fourth of July, occurred on a weekend, the adjacent Friday or Monday was classified as a holiday according to the Federal Holiday calendar.
- Hunting: either (i) not permitted or (ii) permitted. We use hunting in reference to days when that activity was permitted by the North Carolina Wildlife Resources Commission for white-tailed deer. In North Carolina, deer hunting using a rifle was allowed on most national forest lands for approximately 18 days from late November until early December, including Thanksgiving. Because Thanksgiving could be classified as either holiday or hunting, it was excluded from sampling. Hunting refers to days when that type of activity was permitted; it does not indicate that the physical activity of hunting occurred.
- Day type: either (i) weekday (Monday–Friday) or (ii) weekend (Saturday or Sunday).


**LEFT:** Entrance to Lake Powhatan Recreation Site located in Bent Creek Experimental Forest; **RIGHT:** Recreational fishing (photo courtesy of AdobeStock).

- Weekend day: either (i) Saturday or (ii) Sunday.
- Day time: either (i) morning (6 a.m. until 11:59 a.m.) or (ii) afternoon (12 p.m. until 6 p.m.)

Blocks of time for field sampling were scheduled using computer software to randomly select calendar days and times that represented combinations of strata. For example, based on the six blocks of time present in each of the 20 days classified as holidays occurring during the two sessions, 120 samples of traffic could be obtained from different combinations of season, day type and time of day. The software selected 16 blocks for sampling that were distributed among strata of sessions, seasons, day types and times of day. Spring and summer seasons were sampled more heavily than fall and winter because of likely greater variability of traffic associated with increased visitation during warm months. Also, two or three blocks were sampled on some days. Gregoire and Buhyoff (1999) provide additional information on stratified sampling for recreation surveys.

A total of 350 blocks were designated for sampling during the 24 months of the visitor survey study, of which 262 were sampled (app. E). Designated blocks that were not sampled (for example, because a volunteer was not available for staffing the survey field site) were rescheduled from a list of randomly selected replacement dates and times. Teams of two people located at an information kiosk near the main entrance into BCEF (fig. 2) collected the onsite data for phase one. An information sign alerted vehicle drivers approaching the survey site (see cover photos). A flag person stopped vehicles (as well as bicyclists and hikers) and asked the driver if they would be willing to participate in the survey. Vehicles with a willing occupant were directed to a side lane in the kiosk parking area. For vehicles with multiple occupants, the interviewer asked the occupant with the most recent birthday (and over 16 years of age) a standard set of questions about their intended destination in BCEF, such as Lake Powhatan or a trailhead, and their planned activity (e.g., fishing, hiking, biking) (app. A). The interviewer also casually noted the number of occupants and pets in the vehicle along with several other items of relevant information and recorded these data on part B of the onsite interview form (app. B). When the interview lane was occupied, approaching vehicles were counted and allowed to pass. The flag person used a hand-operated mechanical device to count vehicles stopped and passing. The verbal onsite questions required about 2 minutes to answer.

**Phase 2 methods**—A telephone survey of a random subsample of willing visitors sampled in phase 1 was conducted within a week following their visit to obtain more detailed information that became available after their visit to BCEF was completed. Information was gathered to characterize the population of visitors, length of visit, impressions of conditions and educational and service facilities at BCEF, and visitation expenses. The complete list of telephone interview questions (app. C) required about 10 minutes to answer.

**Visitor survey study analysis**—Summary of the data followed standard methods according to NVUM protocols (Zarnoch and others 2002). Data was analyzed for the number of visitors, not the number of vehicles. Data summarization was complex and is not presented here. Statistical tests were not performed on the survey data because there were no stated hypotheses associated with treatments requiring evaluation of their effects on visitation. Questions about the effects of pets in parks have been examined elsewhere (Rayburn and others 2019, Rock and others 2016). For example, at BCEF, the effects of pet leashing regulations on visitation could have been tested if dogs had been allowed to run unleashed on weekdays but were required to be leashed on weekends.

## Vehicle Traffic Study

Vehicle counts and other data from the visitor survey study were used for the vehicle traffic study. The traffic study consisted of three phases associated with vehicles used by visitors entering BCEF: (1) influences, (2) occupants, and (3) trend.

**Phase 1 methods and analysis**—The influences phase of the vehicle traffic study evaluated factors hypothesized to

affect traffic volume during the survey. Sampling strata were analyzed to identify times of the year, week, or day that could have affected the number of vehicles entering BCEF during each 2-hour block of traffic samples. Sampling strata were not designated treatments, but the survey study design allowed for testing their effects separately on traffic volume. Experimental units for evaluating strata were the number of vehicles entering during each 2-hour block of sample time, which were expressed as vehicles per hour for analysis. Vehicle counts were evaluated for normality using Shapiro-Wilk tests and if necessary were transformed to obtain normality. Because sample sizes were small and unequal, Welch's unequal variance, two-tailed t-tests were used to test hypotheses that averages of traffic volume samples by pairs of strata criteria were different (McDonald 2014, Ruxton 2006). Examples of logical strata pairs included: warm seasons (spring versus summer), days of week (weekday versus weekend), and others.

**Phase 2 methods and analysis**—The vehicle occupants phase of the traffic study utilized data from each vehicle entering BCEF that was stopped for interviewing, which was obtained during phase 1 of the visitor survey. For this phase, data from each experimental unit (a stopped vehicle) included the number of people (or pets), which was summarized by 2-hour sample block of time and expressed as the number per vehicle for analysis. Welch's unequal variance, two-tailed t-tests were used for these analyses. The genders and age classes of vehicle occupants were recorded on part B of the onsite interview (app. B), but the format of the summarized data did not allow for analysis by those factors. The number of pets observed in vehicles was summarized and analyzed using similar methods as for the number of people.

**Phase 3 methods**—Four steps were followed for the trend phase of the vehicle traffic study:

- Obtain an alternate source of monthly recorded traffic volume that was correlated with BCEF monthly traffic, and which extended 10 years before and after the visitor survey study.
- Fit a model for predicting monthly BCEF traffic during the 24 months of the visitor survey study as a mathematical function of the alternate traffic data from step 1: *BCEFm* = f (monthly alternate data).
- Predict BCEF traffic for each of the 120 months before and after the visitor survey study using the *BCEFm* model from step 2 and the alternate source of traffic data in step 1; then combine the monthly predictions of BCEF traffic by year to produce a dataset of predicted annual traffic for a decade before and after the survey.
- Fit a model to the 20 years of predicted BCEF traffic data from step 3 to use in predicting the trend of BCEF annual traffic volume between 2 selected years for up to 10 years after the survey study: *BCEFa* = f (annual alternate data).

Potential alternate sources of traffic data included the North Carolina Department of Transportation (NCDOT) and the BRP. Traffic volume data collected by the NCDOT for the highway system in Buncombe County were not recorded for the access road from NC-191 into BCEF. Published data for the volume of vehicles entering the BRP from major intersecting highways were available monthly from 1988 to the present (U.S. Department of the Interior 2021). The BRP data are relevant because previous observations (W.H. McNab, personal observation) had confirmed that vehicles exiting BRP at NC-191 often travel a short distance on State and county highways to enter BCEF. Vehicles entering the BRP from major intersecting highways along its total length are continually counted using permanent pneumatic tubes or induction loops (U.S. Department of the Interior 2003). Vehicles entering the BRP at minor entrances, such as NC-191, are estimated from equations based on relationships for the major entrances and were unsuitable for analysis. For both the visitor survey and trend analysis, vehicles were disregarded that may have entered BCEF from the remote, high-elevation entrance on BRP, at Bent Creek Gap (fig. 2). The BRP vehicle data have been utilized occasionally for other studies (Mathews and others [N.d.], Moerschbaecher and Weber 2004) and were selected as a potential data source for the vehicle traffic trend model.

To match structure of the monthly BRP data, the BCEF vehicle counts measured during the 2-hour blocks were converted to monthly estimates using the similar strata method (app. D). The BRP monthly vehicle count data were for 24-hour intervals, but the BCEF data represented counts for 12-hour days. Because the survey study was not conducted during June 2006, a missing value was calculated for that month. We used the method of single imputation for data missing at random (Horton and Kleinman 2007) by replacing the missing value for June 2006 with the average of BCEF traffic counted for June 2005 and June 2007. Estimating a missing value for June 2006 resulted in a dataset of 25 monthly observations of traffic. Hereafter, mention of the 2-year study refers to 24 months of visitation sample data but 25 months of vehicle volumes.

**Phase 3 analysis**—Four steps were performed for trend analysis:

1. Correlation analysis was used to evaluate traffic entering four BRP entrances (fig. 1) in the vicinity of Asheville to determine which was best correlated with traffic entering BCEF. Distributions of the BRP monthly vehicle counts were evaluated for normality based on a Shapiro-Wilk test and transformed using natural logarithms to reduce a negative skew of data and improve homogeneity of variance. The analysis was performed using transformed data, but relationships shown in the figures are not transformed to allow meaningful interpretation.
2. Linear regression was used to fit a model expressing the relationship of monthly volume of BCEF traffic, formulated as a function of vehicles entering BRP at the

best-correlated entrance location for the 24 months of the visitor survey study:

$$BCEFm = f(BRPm) + e$$

where

*BCEFm* = the predicted monthly number of vehicles entering BCEF,

*BRPm* = the measured monthly number of vehicles entering the BRP at the selected location, and

*e* = the random error.

We used the Durbin-Watson test to evaluate autocorrelation of predicted vehicle counts (Savin and White 1977).

Assessment of autocorrelation in model (1) resulted in additional analysis of the vehicle traffic data as explained later in this report. A pattern of recurring cyclical effects of residuals for estimated traffic counts in November and December was addressed by introducing one or more categorical variables associated with seasonal sampling strata in the model formulated as:

$$BCEFm = f(BRPm, FAL, WIN) + e$$

where

*FAL* = categorical variable representing the fall meteorological season as defined for the visitor survey study,

*WIN* = categorical variable representing the winter meteorological season as defined for the visitor survey study, and

*e* = the random error.

Two categorical seasonal variables were tested for significant (see app. J for the definition) effects because November occurred in the fall season and December occurred in the winter season. For example, the fall season is represented in the model by either 1 (fall season) or 0 (not fall season). This model describes the relationship between monthly traffic at BCEF in relation to vehicles recorded entering BRP monthly at the selected entrance in step 1 and adjusts the estimate if the season is either fall or winter.

3. Model (2) was used to predict monthly BCEF traffic for 10 years before and after the midpoint of the analysis (2006) based on measured monthly BRP traffic at the selected entrance. Predicted annual BCEF counts were obtained by summing the monthly traffic count estimates.
4. Linear regression was used to model the trend of predicted annual BCEF traffic for the decade before and after the visitor survey study:

$$BCEFa = f(Year) + e$$

where

*BCEFa* = the estimated number of vehicles entering BCEF annually for a specified year,

*Year* = the summed predicted monthly number of vehicles entering BCEF from model (2), and

*e* = the random error.

The trend of vehicles entering BCEF annually is expressed by the coefficient (slope) of the Year variable in model (3). Version 3.5.1 of the R statistical software was used for analysis (R Core Team 2018). Tests of significance were evaluated at the probability (*P*) level of 0.05.

# RESULTS

## Visitor Survey Study

**Phase 1 (data collection)**—Onsite interviews and vehicle counts were conducted during the 262 staffed blocks of the total 350 scheduled for sampling during the 24-month study (app. E). A single block of interviews was conducted on 173 days; on 39 days, interviews were conducted during two or three blocks. A total of 4,170 onsite interviews were conducted during the two sessions of the visitor survey, between mid-2005 and mid-2007. Followup interviews by telephone to obtain demographics and economic information were attempted from 1,761 of the onsite interviewed visitors, of which 1,106 (62.8 percent) were completed.

Most visits during both sessions of the study included two or more of the three recreational areas in the experimental forest (fig 3). Greatest use was expressed by vehicle operators for BCEF and either Lake Powhatan or the North Carolina Arboretum, resulting in 143,610 (±21,146, 95-percent confidence interval, CI) visits during session one and 147,529 (±15,548) visits during session two. The overlapping CI for the two sessions suggests the samples were from the same group of users and may be combined for a more accurate estimate of visitors on an annual basis. (See app. K for an explanation of CI.) Among the three single-use areas, BCEF received the greatest average number of visits for the two sessions (110,601) followed by Lake Powhatan (38,594). Judging by the State that issued the license plates on vehicles stopped for operator interviews during the survey, about 84 percent of visitors lived in North Carolina (fig. 4).

**Visitor demographics**—Most BCEF visitors interviewed identified their race or ethnicity as white (97 percent), and 2 percent were Hispanic (fig. 5). Slightly over one-third of respondents (34 percent) were adult females, and 8 percent were children (fig. 6). The average household size of visitors was 2.45 people. Excluding children under 16 years of age, the average age of visitors was 40.5 years. Many visitors (46 percent) were between 26 and 40 years old, followed by 31 percent between 41 and 55 years old (fig. 7). Only 2 percent of respondents were over 70 years old. Most Bent Creek visitors were well educated: 70 percent reported

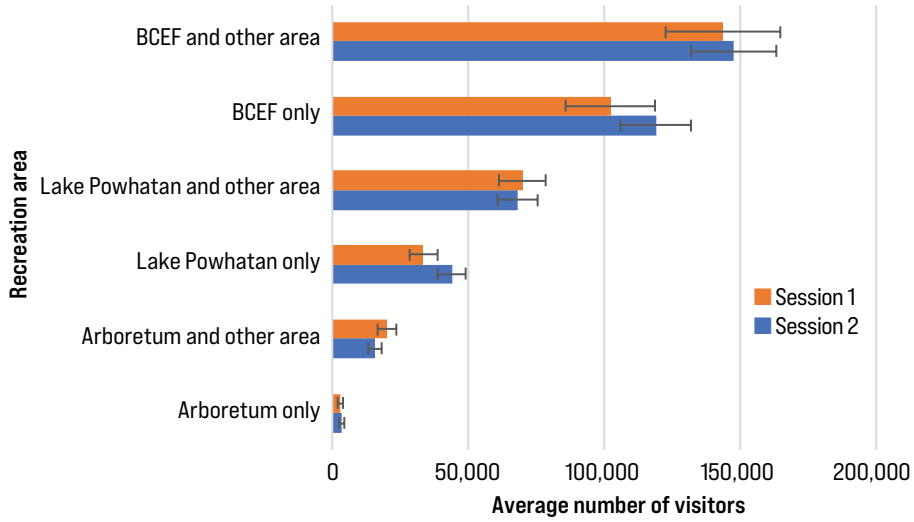



Figure 3—Average number of visitors using one or more recreation areas in Bent Creek Experimental Forest (BCEF) for two 12-month sampling sessions (June 1, 2005–June 30, 2007). Error bars are 95-percent confidence intervals of the visitor totals by session based on 4,170 samples.

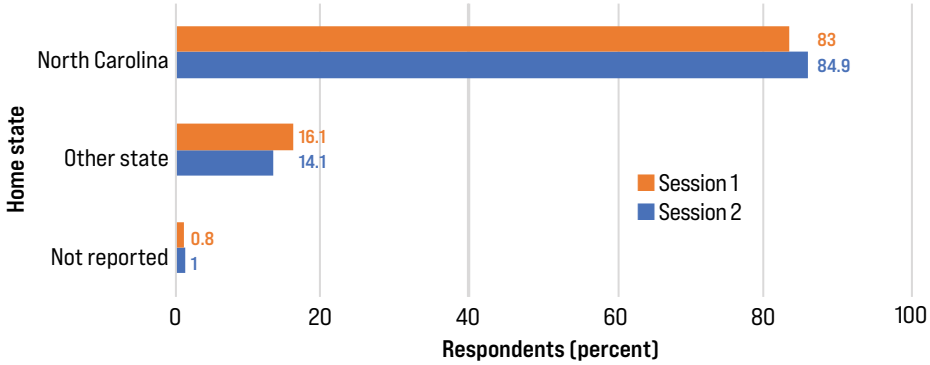



Figure 4—Percentage frequency distribution of people visiting Bent Creek Experimental Forest by home State and sample session.

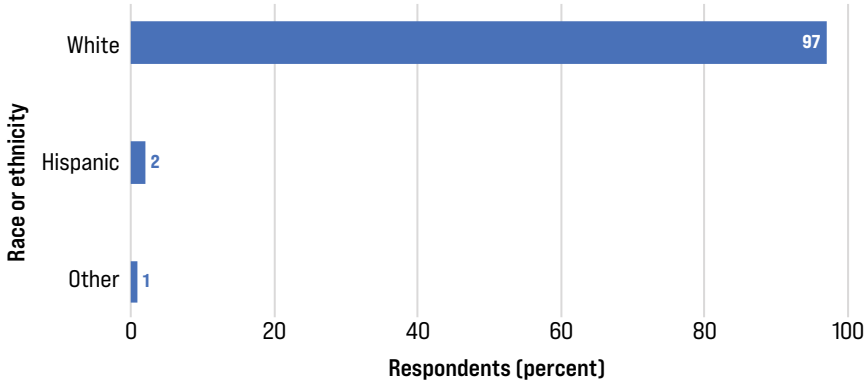



Figure 5—Percentage frequency distribution of people visiting Bent Creek Experimental Forest by race and ethnicity.

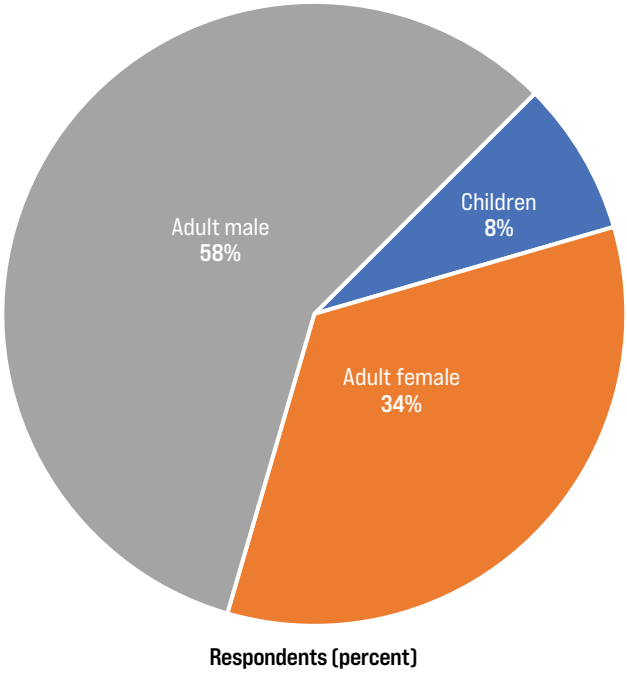



Figure 6—Gender and maturity of people visiting Bent Creek Experimental Forest.

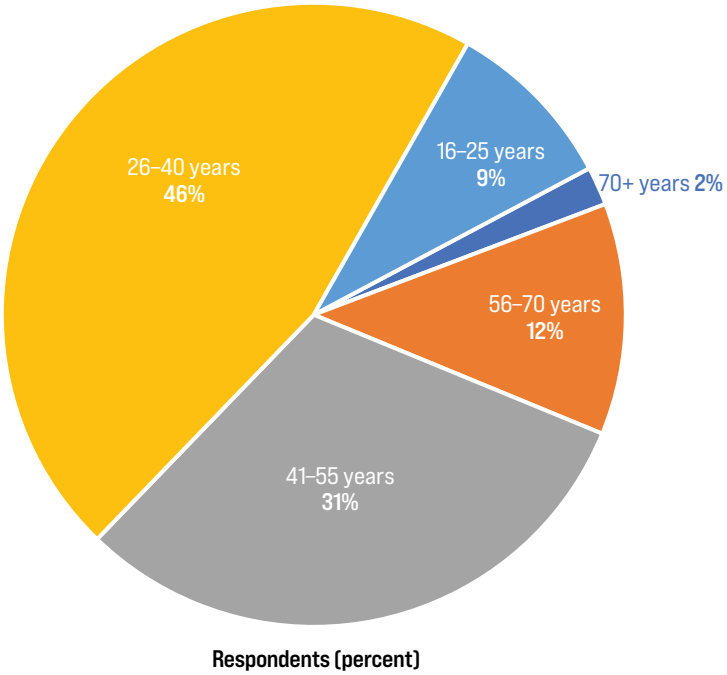



Figure 7—Age of people visiting Bent Creek Experimental Forest.

having a bachelor's degree or higher (fig. 8). Only 9 percent reported having only a high school diploma or less. Average annual household income of visitors in 2006 was $70,800 (the inflation-adjusted value for 2023 was $106,814). Slightly more than half (53 percent) of visitors reported an annual income between $25,000 and $75,000 (fig. 9). Eighteen percent of visitors reported an income greater than $100,000; only 7 percent earned less than $25,000 annually.

**Recreation profile**—An important component of the study was characterizing trips made by recreationists to BCEF. The number of annual visits to BCEF for recreation ranged from 1 to >100 (fig. 10). Slightly more than a third of recreationists (36 percent) made between 6 and 25 trips per year. Only 8 percent visited more than 100 times annually. Most visitors (62 percent) lived locally and usually travelled less than 10 miles (one-way) to BCEF (fig. 11); only 5 percent travelled more than 25 miles. About a quarter of respondents (27 percent) could be considered as new visitors to BCEF, having visited for one year or less (fig. 12). Almost half of respondents (49 percent) reported they had been visiting for 2 to 10 years. Nearly a quarter of respondents (24 percent) were long-term visitors of 11 or more years. In summary, travel and visitation to BCEF varied widely.

A broad range of developed and dispersed recreational activities were pursued at BCEF. Activities expressed by visitors as the purpose for their visit (app. F) were grouped into nine primary categories (app. A). Trail-related activities, including hiking and biking, accounted for the majority (70 percent) of purposes (fig. 13); all other activities collectively accounted for the remaining 30 percent. Among the 70 percent of trail-related activities, biking accounted for nearly 53 percent, followed by hiking (47 percent). Only 0.1 percent of visitors using trails said equestrian (i.e., horseback riding) was their primary activity. More than 80 percent of respondents ranked either conservation, health, or nature as very important reasons for making BCEF their destination for recreation (fig. 14). Slightly less than 60 percent said family activities were very important. Nearly 40 percent reported that their pet was a very important reason for visiting.

The social and physical environment of BCEF were also an important part of the visitor study. Sixty nine percent of visitors were aware that BCEF is part of the Forest Service experimental forest system, but 60 percent were not aware of a current research project there. Respondents were asked to rate the importance of five characteristics of BCEF related to safety and quality of experience (table 1). The top ranked statement was "forest research is important", to which 95 percent of respondents either agreed or strongly agreed. About equal in ranking were "safe for women, elderly, and children" (88 percent agreed or strongly agreed), and "rules and regulations are clearly identified" (85 percent agreed or strongly agreed). Visitors were also asked to rank importance of seven physical features of BCEF (fig. 15). The top five features differed in rank by only 0.1 point each, suggesting no clear preference among respondents. Ranked highest

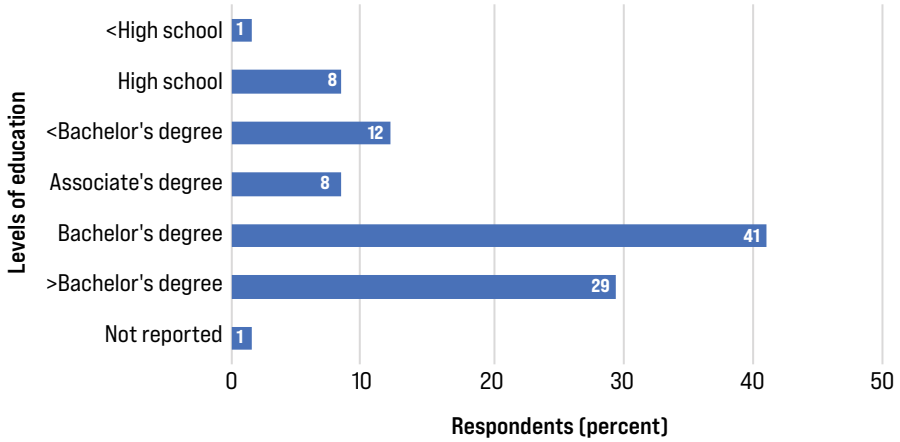



Figure 8—Percentage frequency distribution of people visiting Bent Creek Experimental Forest by attained level of education.

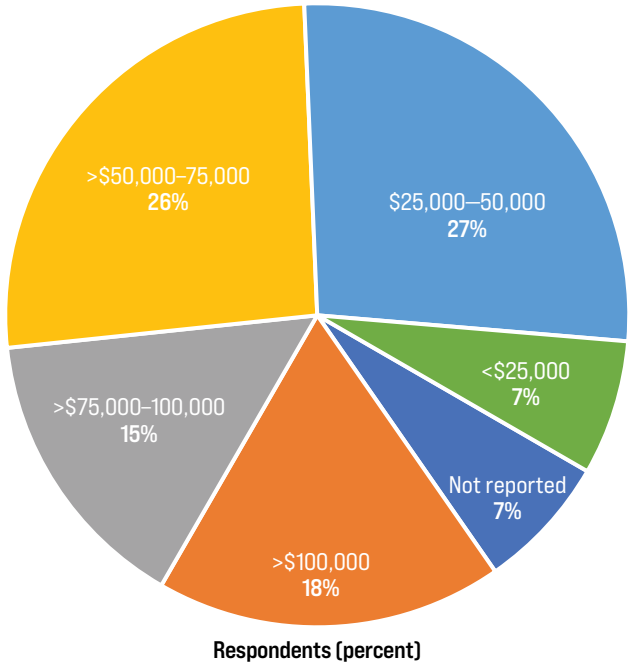



Figure 9—Annual household income (in 2006 dollars) of people visiting Bent Creek Experimental Forest.

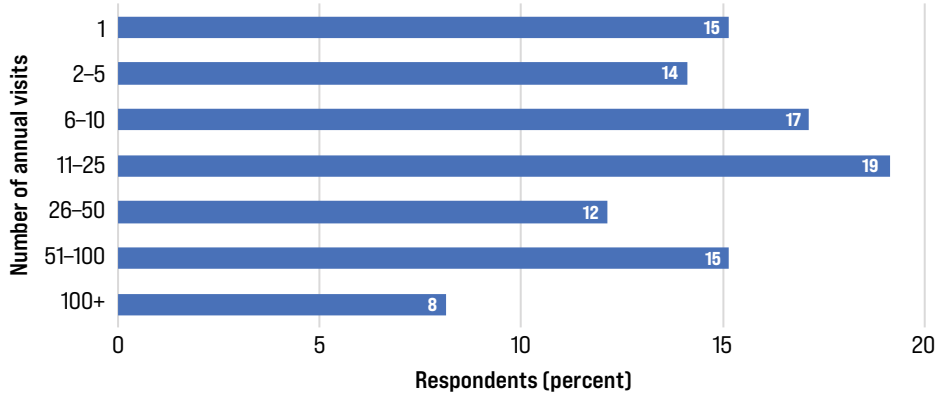



Figure 10—Percentage frequency distribution of people visiting Bent Creek Experimental Forest by number of annual visits.

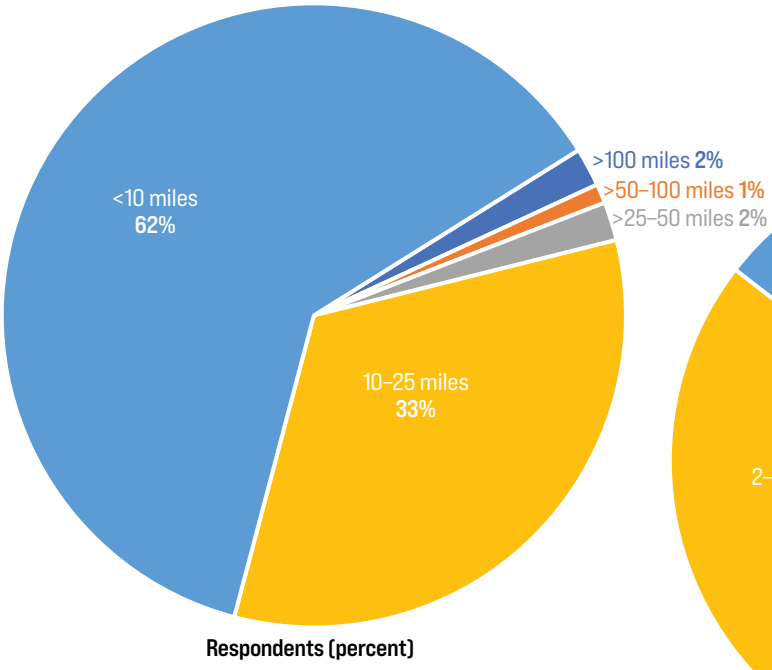



Figure 11—One-way travel distance for people visiting Bent Creek Experimental Forest.

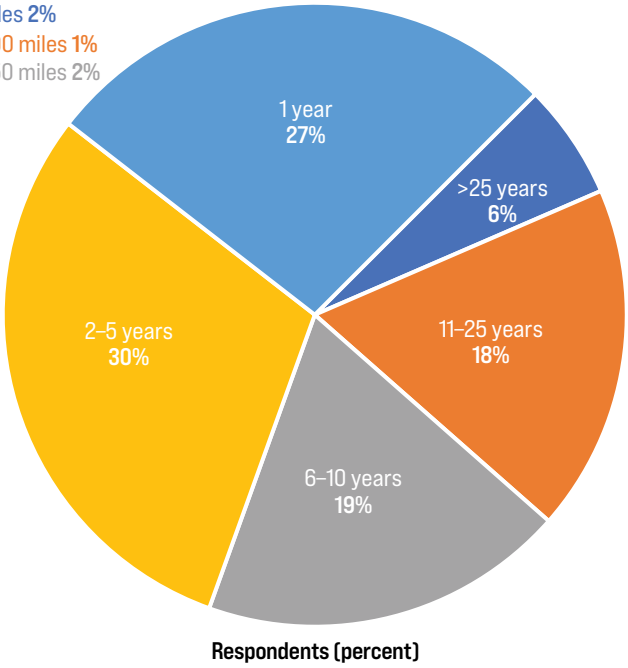



Figure 12—Number of years people had been visiting Bent Creek Experimental Forest.

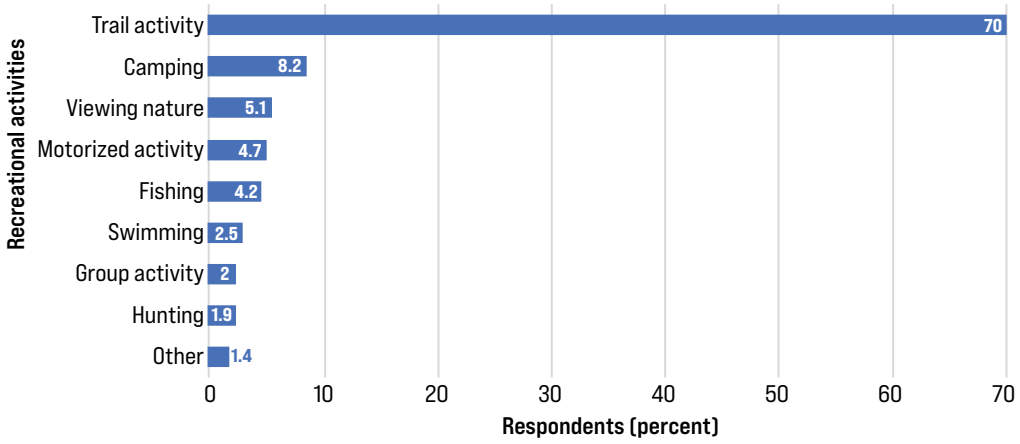



Figure 13—Percentage frequency distribution of predominant recreational activities favored by people visiting Bent Creek Experimental Forest (based on data in app. F).

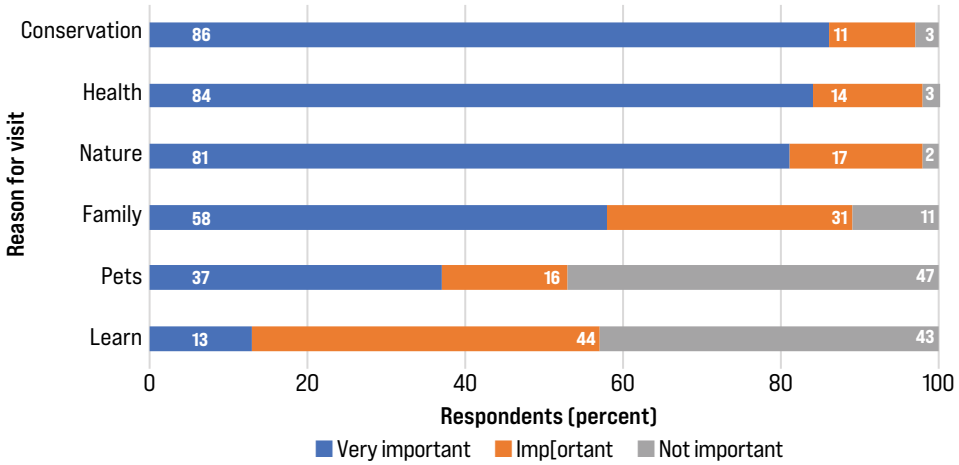



Figure 14—Reasons expressed by people for visiting Bent Creek Experimental Forest and their rankings by level of importance.

**Table 1—Agreement with statements about Bent Creek Experimental Forest expressed by visitors June 1, 2005–June 30, 2007, based on 1,106 telephone interviews**

| Rating[1] | Crowding reduces quality of visit | Safe for women, elderly, and children | Forest experiments reduce quality of visit | Rules and regulations are clearly identified | Rules and regulations are enforced | Forest research is important |
|---|---|---|---|---|---|---|
| | *percent*[2] | | | | | |
| 2 | 24 | 27 | 17 | 26 | 17 | 53 |
| 1 | 41 | 61 | 27 | 59 | 56 | 42 |
| 0 | 2 | 4 | 4 | 3 | 14 | 1 |
| -1 | 31 | 7 | 43 | 10 | 11 | 2 |
| -2 | 3 | 2 | 9 | 1 | 3 | 1 |

[1]Rating: 2 = strongly agree, 1 = agree, 0 = indifferent, -1= disagree, -2 = strongly disagree.
[2]Percentages may not add to 100 because of rounding.

was natural scenery, with a rating of 1.9; least important was pathways to the arboretum (rating of 1.0).

Finally, data were collected for an analysis of the economic effects of recreation at BCEF in Buncombe County. A variety of economic impacts and benefits of recreation visits to BCEF are provided in table 2. The estimated value of nonlocal spending per visit was $34.75 (in 2006 dollars). The estimated economic value in 2023, after the COVID-19 pandemic (Guan and others 2020), was $43.87 (see app. L for an explanation of the economic analysis). The total annual access value (Brown and Mendelsohn 1984) of recreation at BCEF resulting from approximately 145,570 user visits was estimated to be between $2.54 and $4.65 million (in 2006 dollars) or $3.21 and $5.87 million (in 2023 dollars). Bowker and others (2007) provide additional information on economic valuation of dispersed recreation in the southern Appalachian Mountains.

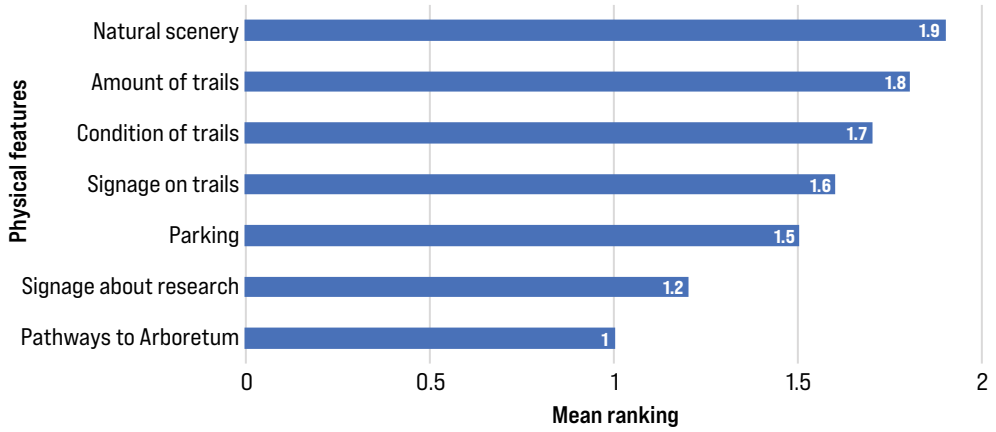



Figure 15—Ranking of the importance (0 = least, 2 = most) of physical features when visiting Bent Creek Experimental Forest.

**Table 2—Economic impacts and benefits of recreational visits to Bent Creek Experimental Forest June 1, 2005–June 30, 2007**

| Economic attribute | Mean | Source of information |
|---|---|---|
| Nonlocal spending per visit (USD) | $34.75[a] ($51,96[b]) | Telephone survey |
| Number of nonlocal visits per year | 5,031 | Onsite survey |
| Nonlocal expenditures (USD) | $174,845[a] ($261,417[b]) | Buncombe IMPLAN[c] |
| Total economic output (USD) | $226,828[a] ($339,139[b]) | Buncombe IMPLAN |
| Total value added (USD) | $75,807[a] ($113,342[b]) | Buncombe IMPLAN |
| Number of jobs supported | 2 | Buncombe IMPLAN |
| Total user visits per year | 141,000 | Onsite survey |
| Access value per visit (USD)[d] | $18.00–$33.00[a] ($26.91–$49.34[b]) | Telephone survey/TCM[e] |
| Total access value (USD) | $2.54–$4.65[a] ($3.80–$6.95[b]) million | Calculated[f] |

[a] Metrics in 2006 dollars.
[b] April 2023 dollar value based on change of the consumer price index since mid-2006 using the Consumer Price Index inflation calculator (U.S. Department of Labor, Bureau of Labor Statistics. 2021).
[c] IMPLAN = modeling software that performs economic impact analysis for planning purposes (see Crompton 2020).
[d] Access value (see app. L).
[e] TCM (travel cost method, see app. L).
[f] Calculated = Total user visits per year * Access value per visit.

## Vehicle Traffic Study

**Phase 1 (influences)**—Data for the traffic study consisted of 108 samples of the number of vehicles entering BCEF during session one and 154 samples during session two, for a total of 262 observations for analysis (app. E). Vehicle frequencies ranged from 1.50 to 111.50 per hour for session one and 1.50 to 94.50 per hour for session two. Vehicle frequencies by block of sample time revealed similar distributions for both sessions (fig. 16), which were deemed non-normal by Shapiro-Wilk tests. However, we found the distributions could be normalized with a square root transformation. Welch's two-tailed t-tests of the non-normal and normalized distributions produced nearly identical results of traffic data analysis for sessions one and two. We used the nontransformed data for subsequent descriptions and tests of vehicle volume differences by sampling strata to facilitate interpretation of results and calculation of 95-percent CI of the averages. Two-tailed t-tests are robust for evaluating the difference between averages of two similarly skewed data sets, even for small sample sizes (Zar 1996).

An average of 26.54 (±3.53, 95-percent CI) vehicles per hour entered BCEF during session one of the traffic study compared to 29.20 (±2.90, 95-percent CI) vehicles per hour during session two. The difference between the averages for sessions one and two (2.66 vehicles per hour) was not significant ($P > 0.05$), which means the difference likely occurred by chance. Average hourly traffic varied widely for the same months between the two sessions but differed significantly ($P < 0.05$) only for June (fig. 17), with a difference of 16.21 vehicles per hour. Although

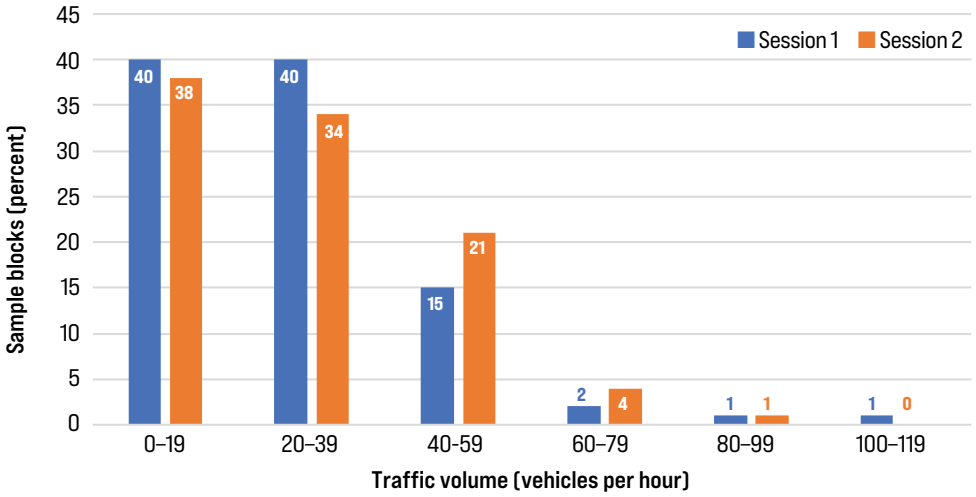



Figure 16—Frequency distribution of the volume of vehicles entering Bent Creek Experimental Forest during 2-hour blocks of sample time by study session. Session percentages do not total 100 because of rounding.

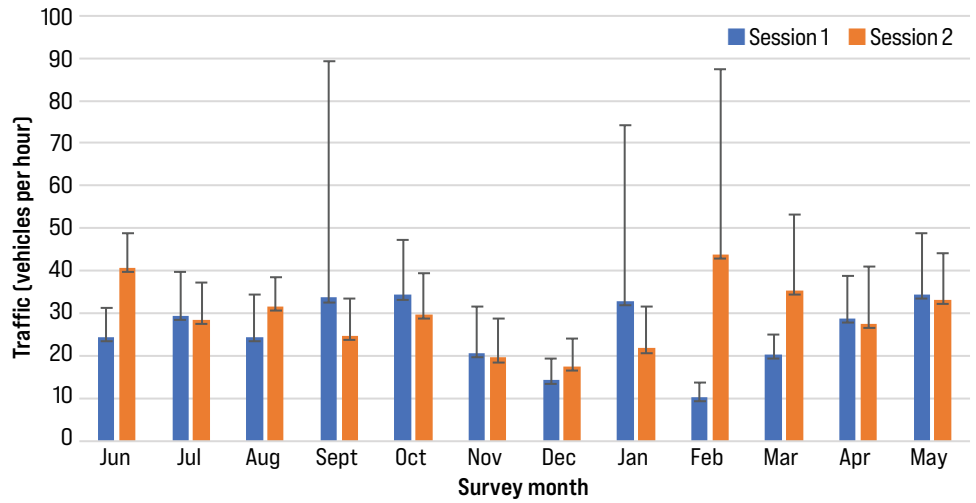



Figure 17—Average number of vehicles entering Bent Creek Experimental Forest during the two sessions of the recreation study. Error bars are upper 95-percent confidence intervals. *indicates the difference between traffic volume of the two sessions is significant at the $P$ <0.01 level of significance, determined by unequal variance, two-tailed t-tests. Months were tested separately.

the difference in average hourly traffic between the two sessions was greatest for February (33.55 vehicles per hour), it was not significant ($P$ = 0.09), primarily because of high variation in the field data, as shown by the wide 95-percent CI for the second session (±43.54 vehicles per hour). The CI were also relatively wide for January and September of session one, which contributed to the lack of significance for those months. Because of these and other variations, traffic by month for session one was poorly correlated with traffic for session two (r = 0.125), which means that inaccurate results would be obtained from using traffic for a specific month in session one to predict traffic for that same month in session two.

For pairs of similar meteorological seasons, significant differences were not present between spring and summer ($P$ >0.05) or fall and winter ($P$ >0.05). Spring and summer seasons were therefore pooled to form the warm macro season; fall and winter seasons were pooled to form the cool macro season. Traffic was greater ($P$ <0.05) for the warm macro season (30.37 vehicles per hour) compared to the cool macro season (24.54 vehicles per hour) (fig. 18). Among other pairs of logical strata comparisons, average hourly traffic was greater on weekends (32.95 vehicles per hour) compared to weekdays (24.12 vehicles per hour) ($P$ <0.01), and afternoons (31.88 vehicles per hour) compared to mornings (19.80 vehicles per hour) ($P$ <0.01). Average nonholiday traffic (27.96 vehicles per hour) did not differ significantly from holiday traffic (31.75 vehicles per hour) ($P$ >0.05). However, traffic on nonhunting days (29.46 vehicles per hour) was greater than on days designated for deer hunting (12.48 vehicles per hour) ($P$ <0.01).

**Phase 2 (occupants)**—Vehicles entering BCEF were occupied by an average of 1.57 people and 0.24 pets, almost entirely dogs. Average human occupancy of vehicles did not differ between the two sessions of the study ($P > 0.05$), but was significantly greater ($P < 0.01$) during the warm season (1.64 people per vehicle) compared to the cool season (1.46 people per vehicle) (fig. 19). Average vehicle occupancy was also greater on weekends (1.69 people per vehicle) compared to weekdays (1.47 people per vehicle) ($P < 0.01$), and afternoons (1.65 people per vehicle) compared to mornings (1.39 people per vehicle) ($P < 0.01$), but did not differ significantly between Saturday and Sunday ($P > 0.05$). Average vehicle occupancy was lowest during hunting season (1.35 people per vehicle). Compared with vehicle counts, CI were smaller for vehicle occupants because maximum variation was limited by vehicle capacity.

Average pet occupancy of vehicles was greater ($P < 0.01$) during the cool macro season (0.29 pets per vehicle) compared to the warm season (0.22 pets per vehicle) (table 3). The number of pets per vehicle was not significantly different ($P > 0.05$) for the other sampling strata. Dogs accounted for 969 of the 972 pets recorded during the onsite interviews; the other 3 pets observed were 2 birds (species not recorded) and 1 gray squirrel (*Sciurus carolinensis*) being released.

**Phase 3 (trend)**—Traffic entering BCEF during each month of the study was calculated from the 262 sample blocks (app. D). A missing value was calculated for June 2006, which had not been sampled. Estimated monthly traffic averaged 9,325 vehicles, and annual traffic averaged 111,902 vehicles. Traffic was greatest for October (11,858 vehicles) and least for November (6,199 vehicles). Monthly counts of vehicles entering the BRP were selected for four highway intersections in the vicinity of Asheville (fig. 1). The natural logarithm transformed counts of vehicles entering BCEF was significantly correlated ($P < 0.01$) with the transformed count of vehicles entering the BRP at the three milepost (mp) intersections nearest to BCEF: mp 384.7 ($r = 0.55$), mp 388.7 ($r = 0.59$), and mp 388.9 ($r = 0.55$). The correlation of BCEF with BRP vehicle counts was greatest for mp 388.7, which was used for the traffic trend model. A prediction model [equation (1)], based on the monthly number of vehicles entering the BRP at mp 388.7, accounted for about 25 percent ($R^2 = 0.25$, $P < 0.05$) of the variation of vehicles entering BCEF (fig. 20).

The autocorrelation test for the BCEF prediction model [equation (1)], based on BRP mp 388.7 traffic data revealed a nearly significant Durbin-Watson statistic (dw) value of 1.51 (critical value = 1.45), indicating a likely cyclical pattern of nonrandom monthly residuals. Comparison of the regression residuals for the 25 monthly samples revealed a generally random pattern of positive or negative values between successive months except for November and December of both sessions. For those 2 months, estimated vehicle counts were higher than observed for both sessions, resulting in consecutive negative residuals. In comparison, residuals for February–April were large but did not show a cyclical trend because they were negative for session one and positive for session two. Inclusion of a categorical seasonal variable, which included either November or December, in regression models with the BRP mp 388.7 traffic data resulted in nonsignificant relationships for both fall ($P > 0.05$) and winter ($P > 0.05$). However, an ad hoc categorial variable representing the subseason of November and December was significant ($P < 0.01$) when included in the model with BRP traffic at mp 388.7 (fig. 21). The fitted regression model was:

BCEF traffic (vehicles per month) = –255.742 + 0.132 * BRP mp 388.7 traffic (vehicles per month) – 3,562.03 * ad hoc variable

where the ad hoc variable = 0 if month was January–October, or 1 if month was November or December. The overall regression was significant ($R^2 = 0.51$, $P < 0.01$). We found that both independent variables were similar in level of significance ($P = 0.01$) in the model. Also, effects of autocorrelation were reduced to near zero (dw = 1.97; 2.0 is zero) and prediction residuals were randomly distributed across all months. It was unclear, however, what effect or influence the months of November and December represented as a logical subseason variable when included in the prediction model for BCEF traffic. That question is addressed later in this section.

For the trend analysis, monthly BCEF traffic was estimated from the relationship with BRP traffic (fig. 21) and summed across months to obtain 21 annual totals between 1996 and 2016. A linear regression [model (3)] was fitted to the 21 sequential years of estimated vehicle totals:

BCEF traffic (vehicles per year) = –871,736 + 481.6 * year

where year was 1996 through 2016 (fig. 22). The modelled relationship was not significant ($P > 0.05$), however, resulting in relatively wide 95-percent CI of estimated BCEF traffic ranging from a potential decrease of 274 vehicles to a possible increase of 1,237 vehicles annually (CI not shown in fig. 22).

**Ad hoc subseason variables**—Discovery that an ad hoc subseason variable accounted for a large portion of the variation of the consistently low BCEF traffic during November and December (figs. 17, 21) resulted in several unanticipated analyses to explore possible explanations. We hypothesized that reduced visitation to BCEF, as manifested by vehicle counts, could have been related to three influences. These influences could be tested with data available from the visitor survey study for: (1) holidays (Cools and others 2007), (2) weather (Eisenberg and Okeke 2009), and (3) hunting safety (Chavez 2001). November and December traffic data for the ad hoc subseason analysis consisted of three sampling strata: (1) holiday, (2) hunting, and (3) neither holiday nor hunting (i.e., nonstratified).

Three holidays occur during November and December: Veteran's Day, Thanksgiving, and Christmas. Survey data

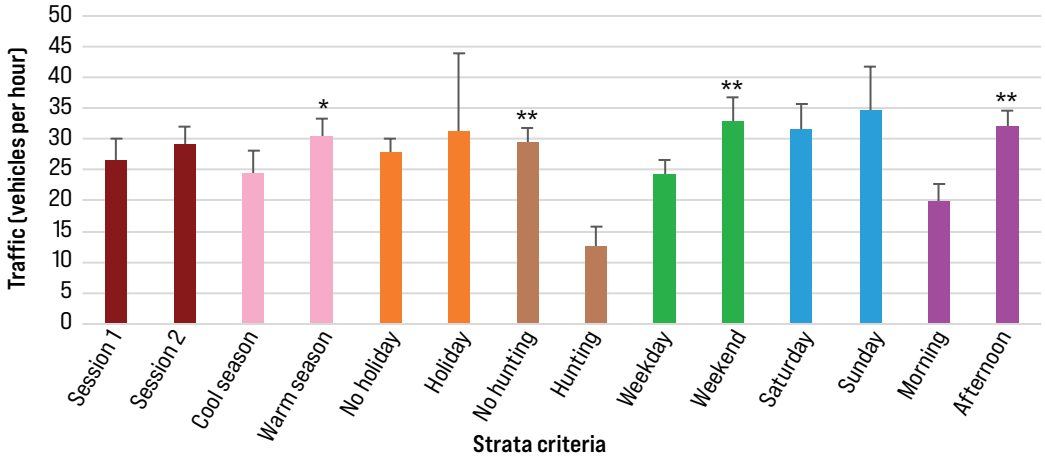



Figure 18—Average number of vehicles entering Bent Creek Experimental Forest during the recreation study by sampling strata. Error bars are upper 95-percent confidence intervals. *indicates a difference in vehicle traffic at the $P<0.05$ (*) or $P<0.01$ (**) levels of significance, determined by unequal variance, two-tailed t-tests. Effects were tested separately.

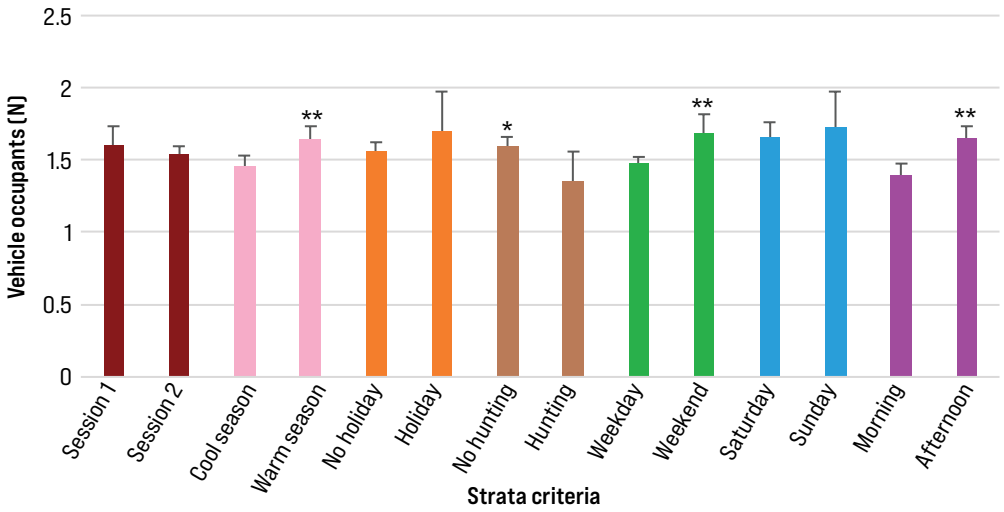



Figure 19—Average number of occupants in vehicles entering Bent Creek Experimental Forest by sampling strata. Error bars are upper 95-percent confidence intervals. *indicates a difference in vehicle traffic at the $P<0.05$ (*) or $P<0.01$ (**) level of significance, determined by unequal variance, two-tailed t-tests. Effects were tested separately.

**Table 3—Average (± CI) number of pets per vehicle entering Bent Creek Experimental Forest by sampling strata June 1, 2005–June 30, 2007**

| Category A | Number of samples | Average (±CI) | Category B | Number of samples | Average (±CI) | Difference | | Probability |
|---|---|---|---|---|---|---|---|---|
| | | | | | | absolute[1] | percent[2] | |
| Session one | 108 | 0.242 (0.034) | Session two | 154 | 0.249 (0.031) | 0.007 | 2.89 | 0.759 |
| Cool season[3] | 102 | 0.288 (0.042) | Warm season[3] | 160 | 0.220 (0.025) | 0.068 | 23.61 | 0.006 |
| No holiday | 252 | 0.243 (0.004) | Holiday | 10 | 0.328 (0.052) | 0.085 | 35.98 | 0.353 |
| No hunting | 241 | 0.243 (0.023) | Hunting | 21 | 0.288 (0.115) | 0.045 | 18.52 | 0.433 |
| Weekday | 144 | 0.233 (0.029) | Weekend | 118 | 0.263 (0.036) | 0.030 | 12.88 | 0.211 |
| Saturday | 66 | 0.246 (0.044) | Sunday | 52 | 0.283 (0.062) | 0.037 | 15.04 | 0.334 |
| Morning | 81 | 0.276 (0.045) | Afternoon | 181 | 0.233 (0.026) | 0.043 | 15.58 | 0.108 |

Unequal variance, two-tailed t-tests were used to determine if the difference between category A and category B of each sampling strata was significant at the $P<0.05$ level of probability.

CI = 95-percent confidence interval of the mean using Student's t distribution.

[1]Absolute difference = category B – category A.

[2]Percent difference = [(category B – category A) / category A] * 100.

[3]Cool season = September–February; warm season= March–August.

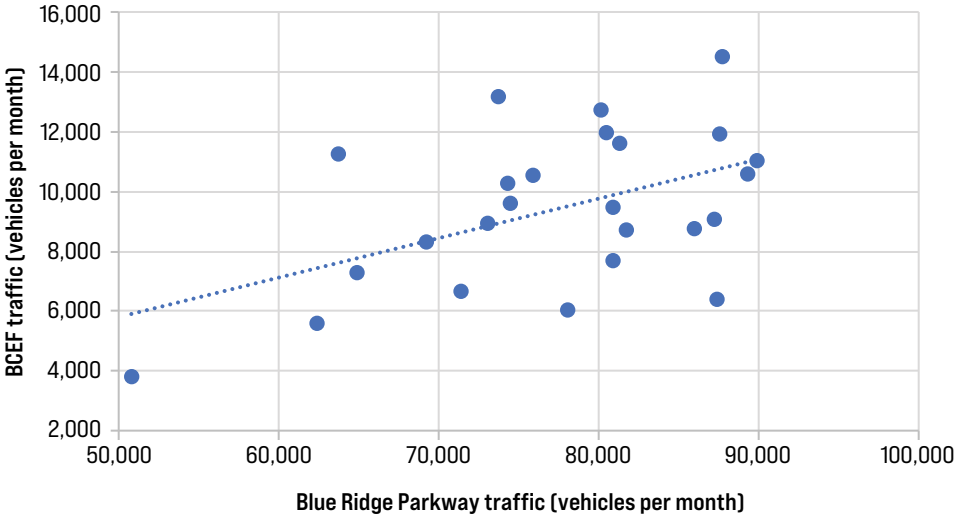



Figure 20—Linear relationship between vehicles entering Bent Creek Experimental Forest (BCEF) and the Blue Ridge Parkway (BRP) at milepost 388.7.

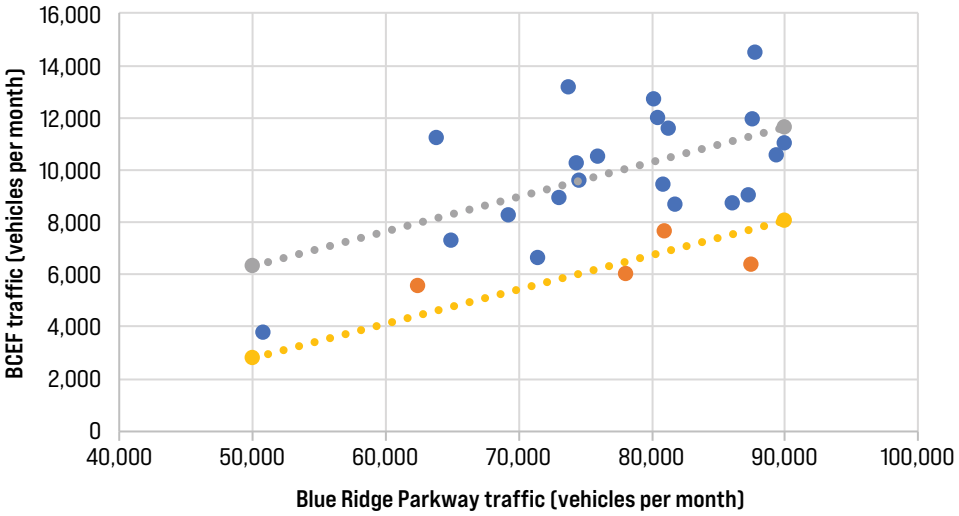



Figure 21—Multiple linear relationships between monthly traffic entering Bent Creek Experimental Forest (BCEF) in relation to monthly traffic entering the Blue Ridge Parkway (BRP) at milepost 388.7 (see fig. 1) and a categorical ad hoc subseason variable. Predictions from the model are represented by two trend lines. The blue line shows the relationship of BCEF traffic with BRP traffic from January through October (blue circles); the orange line shows the relationship with traffic during November and December (orange circles).

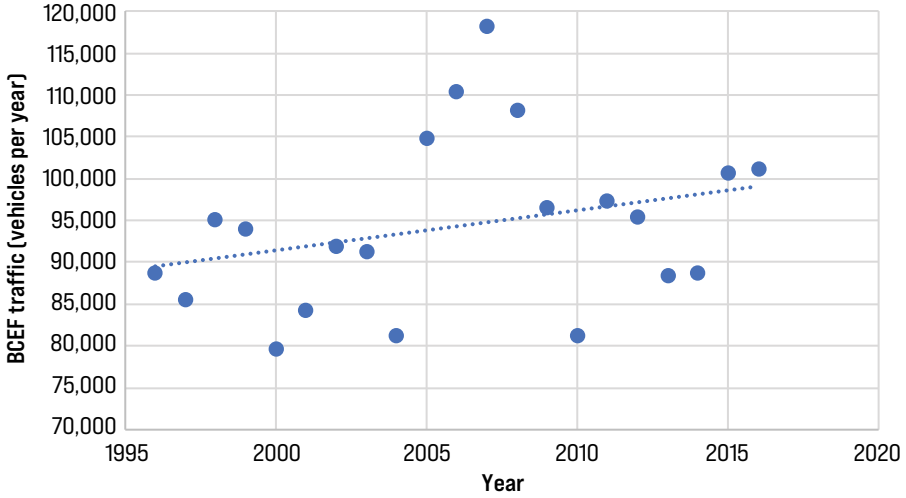



Figure 22—Projected traffic at Bent Creek Experimental Forest (BCEF) during daylight hours (6:00 a.m.–6:00 p.m.) by year as predicted by the traffic trend model (fig. 21). The trend line was not significant ($P > 0.05$).

were scheduled for sampling on five holiday blocks of time during those 2 months of the two sessions but were conducted on only four blocks (app. E). In comparison, 15 nonholiday blocks were sampled (table 4). Although hunting-permitted days were also nonholidays, they were excluded from the analysis to reduce variation in traffic associated with that influence. The difference between holiday and nonholiday traffic volume was 1.9 vehicles per hour, which was not significant ($P$ >0.05) (table 4). These results for the 2-month ad hoc subseason analysis agree with the larger number of samples from the two-session results (n = 10 blocks), which was that traffic entering BCEF on holidays was not different from traffic on nonholidays (fig. 18). In addition to the small number of holiday samples, the blocks were not well distributed: data for three of the four blocks were recorded at different times on the same weekend day. The few holiday samples did not allow more detailed testing for interaction effects from other strata, such as day of week. We found no published results on the effects of holiday travel on recreation in the United States for comparison with our BCEF study. In Belgium, however, Cools and others (2007) reported lower overall highway holiday traffic compared to nonholidays, which agrees with our findings for this part of the ad hoc subseason analysis. In summary, we were unable to determine if holidays affected BCEF traffic during November and December.

Weather as a reason for decreased vehicle traffic during the ad hoc subseason was investigated by comparing temperature and precipitation for the 10 years prior to the study and for the 25 months during the study. Monthly average air temperature and total precipitation were obtained for November and December from records at the Asheville regional airport for 1995 through 2004 and during the study (State Climate Office of North Carolina 2021). The airport is located about 3.1 miles south of BCEF at the same elevation. Average monthly values before the study were compared with averages during the study with t-tests. Average November and December air temperature before the survey (42.40 °F) and during the survey (42.12 °F) were not statistically different ($P$ >0.05) (table 4). Monthly precipitation for 10 years before the study averaged 3.27 inches compared with 4.11 inches during the study; the difference (0.84 inches) was not significant ($P$ = 0.06) (table 4). Although not significant, the higher-than-average precipitation during November and December of the two survey sessions could have been perceived as undesirable for recreation at BCEF and resulted in lower traffic during those months. However, DeFreitas (1990) concluded that average monthly or seasonal values of temperature and precipitation individually are poor predictors in comparison to specific daily events. Except for winter activities associated with snow, precipitation and wind can have a depressing effect on other types of outdoor recreation (Brookes 2007, Smith 1993). Recreation activities in mountainous areas are better associated with an index based on combinations of air temperature and wind velocity (George 1993). Bowker and others (2007) found precipitation caused reduced trail use in low-elevation mountains of Virginia. In Australia, DeFreitas (1990) reported that solar radiation as an integrating variable of precipitation, cloudiness, and season was not an important factor affecting recreation. We conclude that weather was not a contributing factor associated with reduced BCEF traffic during November and December.

Safety ranked high as a characteristic of BCEF that was viewed favorably by visitors (table 1). Hunting, however, could have been an issue of concern for visitor safety during November and December because of the perceived danger from high-powered rifles typically used for white-tailed deer (Chavez 2001, Crane 1998d). The effect of hunting-permitted days compared to not permitted days on traffic was evaluated using a t-test. Results of that test, based on 21 hunting days (which included 5 Saturdays) and 19 nonhunting days (which included four samples on 2 holidays: Veteran's Day and Christmas), revealed that traffic was significantly ($P$ <0.01) lower on days when hunting was permitted (12.48 vehicles per hour) compared to days when hunting was not permitted (26.00 vehicles per hour, table 4). However, traffic stratified by hunting could also be affected by an interaction with day type, as suggested by the full two-session analysis, which showed greater volume on weekends compared to weekdays (fig. 18). The full analysis also revealed no difference in traffic on Saturday compared to Sunday (fig. 18); however, those results might not be applicable for weekends when hunting was permitted, because of the interaction.

A two-way analysis of variance (ANOVA) was conducted to examine the simultaneous effects of hunting strata (permitted or not permitted) and day type (weekday or weekend) on traffic for the 40 blocks of data (see text in above paragraph referring to 21 hunting days and 19 nonhunting days and table 4). A Shapiro-Wilk normality test revealed non-normality of the data set (W = 0.864, $P$ = 0.01), which was square-root transformed to achieve normality (W = 0.965, $P$ >0.05). Although the field data for these two strata were marginally unbalanced in number of samples, we used a Type II ANOVA to test for main and interaction effects of the two levels each of hunting and day type (Langsrud 2003). The ANOVA revealed a significant interaction effect of hunting and day type ($P$ <0.05). From the ANOVA results we concluded that BCEF traffic in November and December was affected by an interaction between hunting strata and day type. The interaction indicates day type may have affected the volume of traffic differently when hunting was permitted compared with when it was not permitted.

Evaluation of the interaction (association) between hunting and day type, without the confounding effects of traffic sampled on holidays and Sundays, was conducted with a two-way contingency test of independence. Fisher's exact test using 34 samples revealed that traffic in relation to hunting (i.e., permitted or not permitted) was dependent on

day type (i.e., weekday or weekend) ($P$ <0.01). Traffic volume on weekdays was similar when hunting was either permitted (12.90 vehicles per hour) or not permitted (18.40 vehicles per hour). When hunting was permitted on weekends (Saturday only), traffic volume was less than half the amount (11.10 vehicles per hour) compared with Saturdays when hunting was not permitted (27.75 vehicles per hour). Plotted averages of the two values of each classification strata show the effects of the interaction on traffic volume (fig. 23), which is indicated by the two nonparallel trend lines. In summary, the interaction and contingency analyses indicate that knowledge of both the status of hunting and day type are required to obtain the best estimates of traffic during November and December.

**Table 4—Average (± CI) amount of traffic entering Bent Creek Experimental Forest in relation to selected sampling strata and climatic environment during the hypothesized ad hoc subseason of November through December**

| Category A | Number of samples | Average (±CI) | Category B | Number of samples | Average (±CI) | Difference | | Probability |
|---|---|---|---|---|---|---|---|---|
| | | | | | | absolute [1] | percent [2] | |
| No holiday (vehicles per hour) | 15 | 26.40 (9.40) | Holiday (vehicles per hour)[3] | 4 | 24.50 (26.22) | 1.90 | 7.20 | 0.847 |
| Temperature during survey (°F)[4] | 4 | 42.12 (8.80) | Temperature before survey (°F)[5] | 20 | 42.40 (2.60) | 0.28 | 0.66 | 0.933 |
| Rain during survey (inches)[6] | 4 | 4.11 (0.89) | Rain before survey (inches)[7] | 20 | 3.27 (0.60) | 0.84 | 20.44 | 0.062 |
| No hunting (vehicles per hour) | 19[8] | 26.00 (7.92) | Hunting (vehicles per hour) | 21 | 12.48 (3.23) | 13.52 | 52.00 | 0.003 |

Unequal variance, two-tailed t-tests were used to determine if the difference between pairs of similar influences (i.e., category A vs. category B) was significant at the $P$ <0.05 level of probability.

CI = 95-percent confidence interval of the mean using Student's t distribution.

[1] Absolute difference = category B – category A.

[2] Percent difference = [(category B – category A) / category A] * 100.

[3] Thanksgiving Day was not sampled for traffic because it could be classified as either holiday or a hunting-permitted day.

[4] Average November and December air temperature during the survey (2005–2006).

[5] Average November and December air temperature for the decade before the survey (1995–2004).

[6] Average November and December precipitation during the survey (2005–2006).

[7] Average November and December precipitation for the decade before the survey (1995–2004).

[8] Includes the four samples classified as holiday.

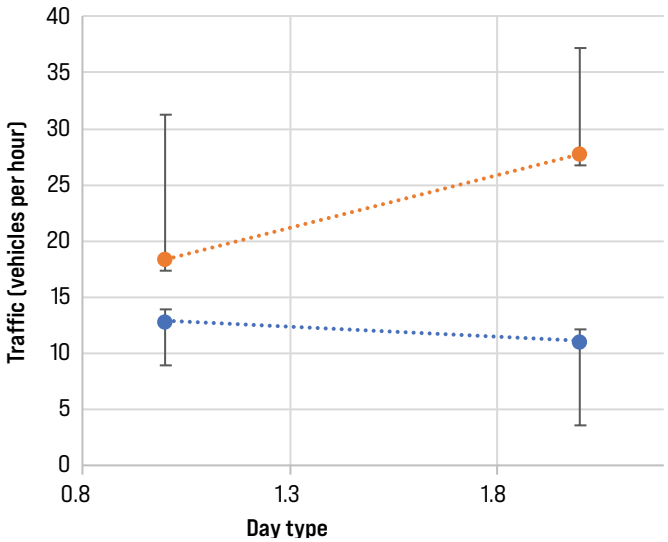



Figure 23—Interaction between the average volume of traffic entering Bent Creek Experimental Forest in November and December on weekdays (= 1) and weekends (= 2) when hunting was either permitted (blue) or not permitted (orange). Error bars are upper (hunting not permitted) or lower (hunting permitted) 95-percent confidence intervals.


**ABOVE:** Bent Creek Experimental Forest demonstration signs evolved from wooden construction (1991) to metal (2005).

# DISCUSSION

Results from this study indicate that BCEF is heavily visited and used for many types of recreational activities. BCEF is like other experimental forests near urban areas where effects of recreation have been identified as an appropriate subject of study (Adams and others 2004, Yung and others 2012). In 1998, for example, the district ranger responsible for managing dispersed recreation in BCEF expressed the need for soils research as a basis for trail location (Crane 1998b). Charnley and Cerveny (2011) suggest experimental forests have been underutilized for addressing subjects related to social science issues. This study originated primarily in response to differing views between researchers and some recreationists about the proposed renovation of several abandoned logging roads for mountain bike trails (USDA Forest Service 2003). We believe it is the first designed study among experimental forests that provides a quantitative description of public users and their activities. Our observations can serve as a basis for evaluating changes in levels of participation by segments of society in different types of outdoor activities in the southern Appalachians. Cordell (2012), for example, reported that between 2000 and 2009 national levels of hunting remained steady for juvenile boys, but increased for juvenile girls.

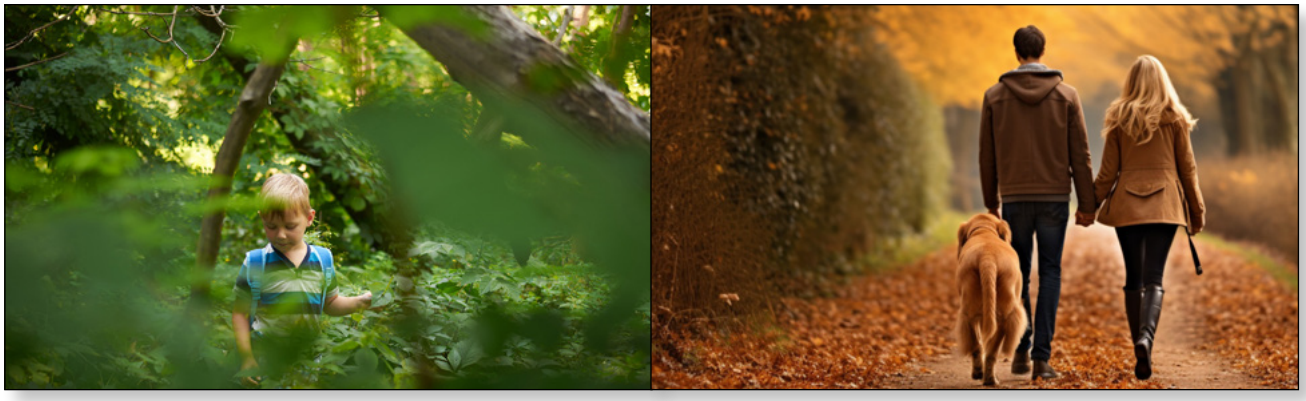
## Visitor Survey Study

Although information from other experimental forests is not available for comparison, reasons for public visitation to BCEF are like those for other areas in the southern Appalachian Mountains (Bowker and others 2007), and northern United States (Cordell and others 2012), where walking and bicycling are popular. Bicycling ranked most common in planned activities at BCEF (app. F, 34.83 percent), which likely includes mountain biking because nearly all roads and trails are unpaved and not suitable for touring and road bikes. Mountain biking popularity nationally is less but has remained steady during recent years (Outdoor Foundation 2021). Additional studies could evaluate the trend direction of mountain biking at BCEF. Continued high use could affect resource management decisions associated with trail maintenance, such as sediment catchment basins on sloping terrain and hardening surfaces in wet areas and stream crossings (Chavez and others 1993, Evju and others 2021). In a study of vegetation disturbance by trampling, Cole (1995) reported changes in foliage cover were related to the type of shoe worn by recreationists. Evju and others (2021) and Thurston and Reader (2001) found only small differences in soil erosion on trails and vegetation disturbance resulting from biking compared to hiking. Kuss and Hall (1991) reported that the initial use of a new trail had a greater effect on vegetation disturbance rather than continued use of the existing trail.

Research could evaluate attitudes of the recreation community about user fees to support general trail maintenance and special areas in BCEF. User fees are charged at many campgrounds and other national forest recreation areas in western North Carolina. Modification of some remote, little-used trails could be financed with user fees to provide various levels of desirable technical skills for traversing (Zajc and Berzelak 2016). The Tsali Recreation Area in the adjacent Nantahala National Forest, for example, has user fees to support services and a regulated schedule of use for hiking, biking, and equestrian activities across its 40 miles of trails (Bowker and English 2002, Chavez 2017, Saterwhite 1995).

The combination of a large population of visitors and an experimental forest provides opportunities for social science-related research associated with outdoor recreation (Berns and Simpson 2009). Survey responses were favorable regarding the coexistence of recreation activities and research in BCEF (table 1, fig. 15). Educational signage related to forest management research at BCEF began with installation of operational-size demonstration plots along well-travelled roads (Morrison 1990) and has continued with different types of displays (Kirschman 2014). Recreationists evaluated the signage as important (fig. 15).

Presence of the relatively large third-order stream, Bent Creek, offers opportunities for study of human disturbance on water quality in BCEF. During times of low water flow in Bent Creek during late summer, Lake Powhatan has been



**LEFT:** A young boy enjoying the outdoors (photo courtesy of AdobeStock); **RIGHT:** A couple walking their dog (photo courtesy of AdobeStock).

closed for swimming because of high bacteria content (Ball 2004, Jones 2002). In the Manitou Experimental Forest in central Colorado, Ponce and Gary (1979) reported that runoff from residential roads and improperly designed sewage disposal systems lowered water quality for lake-based recreation. Unger and others (2020) found human recreation activity in streams in the Pisgah National Forest altered habitat for the eastern hellbender (*Cryptobranchus alleganiensis alleganiensis*), a large aquatic salamander.

Recreation with and for pets, primarily dogs, was very important or important for 53 percent of visitors (fig. 14). Because the presence of dogs can affect the natural behavior of native birds and mammals (Miller and others 2001), research on this topic may be appropriate for future study in BCEF. In their review of dogs in parks, Weston and others (2014) concluded more study is desirable on visitors' attitudes about the presence of pets and the potential for transmission of diseases. In another example of researching the urban-forest interface, the avoidance response of elk (*Cervus canadensis*) to different recreation activities was studied in the Starkey Experimental Forest in northwest Oregon (Wisdom and others 2018). Also, a study by Van der Zande and others (1984) revealed that density of some species of breeding birds was better correlated with the intensity of recreation use on weekdays compared to weekends. Breeding habitat of the Eurasian wood grouse (*Tetrao urogallus*) can be affected by the density of hiking trails (Coppes and others 2017). Trail cameras provide the opportunity for unattended data collection of conventional wildlife-human interactions in aquatic (Unger and others 2020) and terrestrial (Cusack and others 2015) habitats or new applications such as visitor time spent viewing different types of signage at research sites.

The economic value of parks for recreation and research has long been recognized (Comstock 1874) and widely reported (Western and Henry 1979). Although BCEF is not a park, the visitor study reported an annual economic value of $2 to 5 million (table 2). In comparison, Bowker and others (2007) reported similar total access value for a rail-to-trail recreation facility in the southern Appalachian Mountains of Virginia. However, Buckley and Brough (2017) suggest parks provide value beyond tangible monetary assessments. Because few regional results are available on the economic value of recreation in the southern Appalachian Mountains, additional study is desirable.

## Vehicle Traffic Study

Our analysis of visitation trends was strengthened by the well-designed parent study plan that allowed determination of onsite BCEF vehicle traffic relationships with similar data from the BRP. A weakness of this traffic trend analysis was lack of annual vehicle counts after the survey for comparison with predictions from our trend model. The wide confidence intervals of the trend model suggest it should not be used to estimate BCEF vehicle counts for a specific year or to predict changes in traffic over time. Because the BRP serves as a bypass connector route around the eastern and southern sides of Asheville (fig. 1), some entrances are heavily used by commuters in addition to recreation visitors, which reduces value of this data source for estimating BCEF recreation volume. It should be noted that our study was conducted before construction in 2023 of a new connector route between the BRP entrance on NC-191 and Interstate 26 (fig. 1), which will likely change the source of traffic accessing BCEF (Boyle 2022).

Sampling strata for recreation studies often include variables associated with intervals of time, such as season, which are surrogates for factors that are difficult to quantify, such as climate (Bowker and others 2007, Cordell and others 2012). We tested the importance of seven strata on traffic volume and found significant effects of season (i.e., warm or cool), type of day (i.e., weekday or weekend), and time of day (i.e., morning or afternoon) (fig. 18). Greater volume of traffic during the warm season (30.37 vehicles per hour) compared to the cool season (24.54 vehicles per hour) was likely associated with favorable temperatures and increased travel during traditional summer vacations. Less apparent, however, is an explanation for the significant difference between weekday traffic (24.12 vehicles per hour) and weekend traffic (32.95 vehicles per hour). Additional research is required to learn if the difference (8.83 vehicles per hour) was related to the employment work schedules of

**LEFT:** Site of a fire study conducted in coordination with recreation users (Greenberg and others 2018); **RIGHT:** Trail runners (photo courtesy of AdobeStock).

drivers of those vehicles or other factors, such as availability of more weekdays for recreation compared with fewer weekend days.

The holiday and hunting strata provided contrasting and unexpected results that may be partially explained by the differing patterns of their occurrence and intensity of sampling during the two sessions. We found no difference ($P = 0.54$) in traffic between holidays (31.75 vehicles per hour) and nonholidays (27.96 vehicles per hour). Weather could have been a reason that holiday traffic was not higher because 8 days (of 10 total) occurred during cool months (September–February) when traffic is normally lower than in warm months (fig. 18). Also, many of the holidays occurred on or adjacent to a weekend, which increased the difficulty in accounting for variation in traffic associated with each stratum. Although traffic was sampled on half of the 20 days designated as holidays occurring for the two sessions, the resulting number (n = 10) was relatively small compared to the number of days that were not a holiday. For hunting, 29 days were designated, and traffic was counted on 21 days. The volume of traffic on days when hunting was permitted was clearly less (fig. 18) than on days when it was not permitted ($P < 0.01$), partially because intensity of sampling was greater (72 percent) than for holidays (50 percent), resulting in less variation in the data. An important difference between the two strata was the consecutive sequence of hunting days in late November and early December, and fewer visitors interested in participating in that activity (fig. 13), both of which likely reduced variation in sample data. The effect of hunting-permitted days on visitation traffic was stronger than expected. Many studies have demonstrated the wariness of large game animals to the presence of humans during hunting season (Bender and others 1999, Lone and others 2015, Stankowich 2008), but we found none that examined the wariness of humans to the potential presence of hunters. Further study of traffic volume differences associated with these strata could elucidate this.

Our examination of the effects of ad hoc subseason variables on BCEF vehicle traffic in November and December was a fortuitous, unplanned analysis of data allowed by the investigation design and sampling strata. Those results suggest that, individually, days when hunting was permitted had a strong influence on traffic, weather was likely a weaker influence, and holidays were not important. However, as Finger and Lehmann (2012) reported for a study of developed recreation with similar variables (but without hunting) in Switzerland, there are many interactions among variables that can affect the results. Therefore, our results of possible influences on fall traffic are probably more complex than we report here because of the interacting effects among holidays, weather, and other variables. Our examination of one interaction revealed a significant effect of days when hunting was permitted on Saturday traffic during November and December (fig. 23). The small number of observations available from our study did not allow a more detailed analysis to examine other possible complex interactions. Although a statistical association was found between decreased BCEF traffic and hunting days in November and December, that result should not be interpreted to imply that reduced traffic was caused by deer hunting. A hypothesis that actual deer hunting (not days classified as hunting permitted) influenced BCEF traffic should be tested with a study designed for that objective. Because the effect of deer hunting season on national forest visitation has not been reported in other studies, additional research appears warranted to further explore and test our findings. The availability of a large population of BCEF visitors offers the opportunity for additional study of other influences that may affect recreation traffic during November and December.

Our analysis revealed that the number of vehicles entering BCEF monthly was strongly correlated with traffic entering the BRP at a remote entrance. The volume of vehicles entering the BRP from the entrance at mp 388.7 explained 51 percent of the variation of traffic entering BCEF (fig. 20). Although mp 388.7 and mp 388.9 are entrances from the same highway (US-25) (fig. 1), each serves somewhat different population groups, which could partly account for the variation in correlation. Milepost 388.9 provides direct access to BRP from the affluent Biltmore Forest section of suburban Asheville, which includes large, widely separated


**LEFT:** Bent Creek Experimental Forest "Bike Xing" sign; **RIGHT:** Kids at a training session (photo courtesy of AdobeStock).

houses in a wooded environment with recreational opportunities of a park, golf course, and a network of lightly travelled roads with sidewalks for walking and biking. The entrance at mp 388.7 provides access to a large, densely settled area of Buncombe County farther from Asheville, where fewer suitable places for recreation are available.

Vehicle counts at the mp 388.7 entrance to BRP were highly correlated with the BCEF vehicle counts during the study period, but that relationship will likely change in parallel with spatial distribution of the population of Buncombe County, which could be associated with suburban housing developments and state road improvements. The population of Buncombe County increased 13 percent between 2010 and 2020 (U.S. Department of Commerce, Census Bureau 2020). During this interval, population growth began to shift from the Asheville urban area to surrounding suburban areas (Boyle 2019, Economic Development Coalition 2017), which resulted in associated changes in the pattern and distribution of housing within the county (Lacey 2021). These population and housing changes suggest that future BCEF visitation relationships could be different from that reported in our vehicle traffic study.

## CONCLUSIONS

This recreation study was the first conducted at the BCEF; therefore, estimation of the change in visitation volume was not possible because there were no previous data. Recreation inventories are conducted on a 5-year repeating basis for the Pisgah Ranger District of the Pisgah National Forest as part of the NVUM surveys (USDA Forest Service [N.d.]). However, those results are summarized across many recreation sites and are not applicable specifically to BCEF. The NVUM survey reporting 2008 data, for example, estimated 3.6 million annual visitors for the general forest area of 1 million acres of the combined Nantahala-Pisgah National Forests or an average of about 3.4 people per acre. In comparison, BCEF visitation during this study was equivalent to an annual average of 23.4 people per acre. The NVUM reports estimated visitation in these two national forests decreased 14 percent from 2008 to 2013 and then increased by 59 percent for the next 5 years until 2018. Data are not available to determine if the levels of outdoor recreation recorded by the NVUM also occurred at BCEF. A recommended method for updating the staffed BCEF survey was not part of this study design but could be possible using prediction models and data from unstaffed registration stations (James and Schreuder 1971). For purposes other than forest management decisions, updated data could be important to determine if the level of visitation to BCEF is self-regulating; that is, whether the number of encounters with other recreationists will increase to a level that causes visitation to become unappealing, thereby capping the volume of traffic at certain times (Wagar 1974, Watson and others 2016).

In summary, the 2005–2007 recreation study provides a one-time estimate of the volume of dispersed outdoor recreation at BCEF. It provides baseline data to address a statement made by a former BCEF research manager: "We can only meet a certain level of the demand for recreation use at Bent Creek" (Asheville Citizen-Times 2002). Except for one instance associated with road improvements for a timber harvest, results from the survey study indicate that recreation and forest research can coexist with few conflicts at BCEF, at least with the estimated level of visitation. Results of the analysis of traffic data suggested that traffic volume is associated with climatic season, day of week, and other influences, but association should not be confused with causation. This study provides baseline data for recreation-related management decisions associated with vehicle parking areas, restroom facilities, and trail maintenance. Because forest research is the primary use of BCEF, the relatively large population of visitors provides opportunities for social science studies of issues common to both sustainable forest management and sustainable dispersed recreation. Also, the methods used and available archived data (McNab and others 2022) allow exploration of other questions related to visitation that were not addressed in this study.

## ACKNOWLEDGMENTS

The authors are grateful for the participation of many volunteers (app. G) who collected onsite survey data from visitors entering Bent Creek Experimental Forest, including: Myra Buckner, Brad Burris, Ollie Ehlinger, Tom Hayes, Lauren Hodges, Matthew Hutchins, J.J. Jenkins, Debbie Kuhn, Garrett Male, Rachel Martin, James McDonald, Robert Meehan, Claudia Nix, Bridget O'Hara, April Pallete, Russ Petersen, Jr., Tara Piper, Ann Pongrace, Jasmine Rafferty, Denise Rathbone, Bobbie Roberts, George Roberts, Irene Sadler, Karen Sanders, Mary Shultz, Matthew Smith, Aimee Tomcho, Ahliae Toulouse, and Della Williams. We apologize for omitting anyone who volunteered for the recreation study. Employees of the U.S. Department of Agriculture Forest Service included Jill Baker, Gary Bartlett, Kenny Frick, and Virginia McDaniel. University of Georgia (UGA) students included Carter Betz and Bonnie Murphy. Leesa Brandon and Caitland Worth provided information on traffic data for the Blue Ridge Parkway. Photographs of Deer Lake Lodge were provided by Jeffrey Owenby, Pisgah National Forest. Documents not available online were provided by Carin Clay, National Forest Service Library. Christine Coulter McNab, Old Buncombe County Genealogy Society, provided access to historical newspaper articles. This research was supported by Cooperative Agreement #2521RC282207 entitled "Assessment and Management of Natural Capital Benefits: Land and Water Resources" between the Forest Service-Southern Research Station and Outdoor Recreation and Wilderness Assessment group (H. Ken Cordell, Project Leader at the time of the study and Forest Service principal investigator) and the UGA Department of Agricultural and Applied Economics (John C. Bergstrom, Professor and UGA principal investigator). The authors declare no conflicts of interest. We thank David Casey, Erik Berg, Cathryn Dowd, John Bergstrom, and Frank Roesch for their constructive review comments on an earlier draft of this manuscript.



## REFERENCES

Abell, M.S. 1933. A glimpse of the Appalachian Forest Experiment Station. Ames Forester. 21: 13–16.

Adams, M.B.; Loughry, L.; Plaugher, L., comps. 2004. Revised March 2008. Experimental Forests and Ranges of the USDA Forest Service [CD-ROM]. Gen. Tech. Rep. NE-321. Newtown Square, PA: U.S. Department of Agriculture Forest Service, Northeastern Research Station. 183 p. https://doi.org/10.2737/NE-GTR-321.

Alexander, B. 2005. The first American forest. American Forests. 111(2): 7–10.

Alexander, P. 2000. Fire burns experimental forest. Asheville Citizen-Times. March 29; Sect. B: 1, 6.

Arthur, J.P. 1914. Western North Carolina: A history from 1730 to 1913. Johnson City, TN: The Over Mountain Press. 710 p.

Asheville Citizen. 1917. First fish permit given Earle Godby. March 23: 3.

Asheville Citizen. 1919. Forest reserve is beauty spot. November 10: 9.

Asheville Citizen. 1920. Alleged deer slayer, wearing disguise tried for trespassing. November 7: 20.

Asheville Citizen. 1921a. Pisgah Reserve road work being finished. March 27: 3.

Asheville Citizen. 1921b. Government gives permission to locate camp in national forest. April 9: 5.

Asheville Citizen. 1921c. Announce personnel for forest station. June 28: 10.

Asheville Citizen. 1922. Camp Powhatan to open on Monday with "full house." June 9: 11.

Asheville Citizen. 1925. Local scouts preparing outdoor home for Daniel Boone Council on Bent Creek in Pisgah Forest. March 1: 26.

Asheville Citizen. 1926. Scientists will study results. May 7: 28.

Asheville Citizen. 1929. 1,000-acre forest is being blocked out for study. March 2: 7.

Asheville Citizen. 1932. Hunters begin slaying deer in Pisgah Forest. December 6: 3.

Asheville Citizen. 1934. Twenty CCC men begin forest station work. March 20: 12.

Asheville Citizen. 1935a. Pisgah Forest smaller game in abundance. December 10: 14.

Asheville Citizen. 1935b. Repairs being made on Camp Powhatan dam. July 2: 8.

Asheville Citizen. 1937a. Flood waters threatening parts of city. January 7: 1.

Asheville Citizen. 1937b. Camp problem considered by "Y" committee. January 7: 14.

Asheville Citizen. 1937c. CCC camp will be transferred from Bent Creek. October 8: 7.

Asheville Citizen. 1940. Heavy damage is reported in Pisgah Forest. August 31: 6.

Asheville Citizen. 1941. WPA to construct $240,000 Pisgah recreational area. January 18; Sect. A: 1–2.

Asheville Citizen. 1942. Lake Powhatan project may be opened Oct. 1. August 16; Sect. A: 7.

Asheville Citizen. 1959a. Day camp established by group. April 23: 15.

Asheville Citizen. 1959b. Handicapped but happy, children splash, play. July 8; Sect. 2: 1.

Asheville Citizen. 1960. Camp Deer Lake awarded seal. March 27; Sect. C: 7.

Asheville Citizen. 1966a. Notice of dissolution of Deer Lake Enterprises, Inc. August 10: 20.

Asheville Citizen. 1966b. Real estate transfers. Deer Lake Enterprises Inc. to USA [Forest Service]. September 23: 8.

Asheville Citizen. 1975. Untitled brief article reporting naming of an environmental lecturer at Camp Deer Lake. November 21: 21.

Asheville Citizen. 1977. Deer Lake Environmental Center loses lake; future is at stake. November 15: 10.

Asheville Citizen-Times. 1931a. $2,100,000 to be expended in forestry program near here. March 8: 1, 2.

Asheville Citizen-Times. 1931b. Boy Scouts are building cabin. August 23; Sect. B: 2.

Asheville Citizen-Times. 1934. Fawn nursery in Pisgah Forest is new industry. July 22; Sect. C: 6.

Asheville Citizen-Times. 1938. Water sports enjoyed at Boy Scout Camp [Daniel Boone, near Old Fort]. July 24; Sect. D: 6.

Asheville Citizen-Times. 2002. Bent Creek must cope with popularity's price. April 2; Sect. A: 6.

Asheville Citizen-Times. 2005. Forest Service seeks volunteers for Bent Creek visitor use survey. June 10; Sect. C: 6.

Asheville Gazette News. 1914. U.S. purchases Pisgah Forest. May 22; Sect. A: 1.

Asheville Times. 1939. Plan new W.N.C. recreation area. January 16; Sect. A: 1–2.

Asheville Times. 1941. WPA workers to halt work until hunt is finished. November 26; Sect. A: 1.

Ball, J. 2002a. Forest Service seeks recreation, research balance for Bent Creek. Asheville Citizen-Times. March 31; Sect. A: 1, 4.

Ball, J. 2002b. Bent Creek changes include camping restrictions. Asheville Citizen-Times. August 7; Sect. B: 2.

Ball, J. 2004. What is causing a spike in bacteria in Powhatan? Asheville Citizen-Times. August 19; Sect. C: 1.

Bender, L.C.; Beyer, D.E., Jr.; Haufler, J.B. 1999. Effects of short-duration, high-intensity hunting on elk wariness in Michigan. Wildlife Society Bulletin. 27: 441–445. https://www.jstor.org/stable/3783912.

Berns, G.N.; Simpson, S. 2009. Outdoor recreation participation and environmental concern: a research summary. Journal of Experimental Education. 32(1): 79–91. https://doi.org/10.1177/105382590903200107.

Bosworth, D. 2004. Four threats to the nation's forests and grasslands. Speech delivered to the Idaho Environmental Forum, Boise, ID, January 16, 2004.

Bowker, J.M.; English, D.B.K. 2002. Mountain biking at Tsali: an assessment of users, preferences, conflicts, and management alternatives. Gen. Tech. Rep. SRS-59. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 28 p. https://doi.org/10.2737/SRS-GTR-59.

Bowker, J.M.; Bergstrom, J.C.; Gill, J. 2007. Estimating the economic value and impacts of recreational trails: a case study of the Virginia Creeper rail trail. Tourism Economics. 13(2): 241–260. https://doi.org/10.5367/000000007780823203.

Bowker, J.M.; Zarnoch, S.; Bergstrom, J. [and others]. 2011. Bent Creek Experimental Forest recreation use survey highlights. Unpublished PowerPoint presentation; May 3. On file with: U.S. Department of Agriculture Forest Service, Southern Research Station, Bent Creek Experimental Forest, 1577 Brevard Road, Asheville, NC 28806.

Boyle, J. 2019. Asheville population growth slumping as surrounding areas pick up pace. Asheville Citizen-Times. September 15; Sect. A: 1, 4, 7.

Boyle, J. 2022. $32M option picked for I-26 interchange. Asheville Citizen-Times. February 21; Sect. A: 1, 13.

Brookes, A. 2007. Preventing death and serious injury from falling trees and branches. Australian Journal of Outdoor Education. 11(2): 50–59. https://doi.org/10.1007/BF03400857.

Brooks, J.J.; Champ, P.A. 2006. Understanding the wicked nature of "unmanaged recreation" in Colorado's Front Range. Environment Management. 38: 784–798. https://doi.org/10.1007/s00267-005-0372-2.

Brown, G., Jr.; Mendelsohn, R. 1984. The hedonic travel cost method. The Review of Economics and Statistics. 66(3): 427–433. https://doi.org/10.2307/1924998.

Buckley, R.C.; Brough, P. 2017. Economic value of parks via human mental health: an analytical framework. Frontiers in Ecology and Evolution. 5: 1–9. https://doi.org/10.3389/fevo.2017.00016.

Caird, R.W. 1935. Physiology of pines infested with bark beetles. Botanical Gazette. 96(4): 709–733. https://doi.org/10.1086/334518.

Cerveny, L.K.; Charnley, S. 2014. Public use and citizen outreach at experimental forests and ranges. In: Adams, M.B.; Loughry, L.H.; Plaugher, L.L. Experimental forests and ranges of the USDA Forest Service. Gen. Tech. Rep. NE-321. Newtown Square, PA: U.S. Department of Agriculture Forest Service, Northeastern Research Station: 609–629. Chapter 26. https://doi.org/10.1007/978-1-4614-1818-4_26.

Charnley, S.; Cerveny, L.K. 2011. U.S. Forest Service experimental forests and ranges: an untapped resource for social science. Journal of Forestry. 109: 313–320.

Chavez, D.J.; Winter, P.L.; Baas, J.M. 1993. Recreational mountain biking: a management perspective. Journal of Park and Recreation Administration. 11(3): 29–36.

Chavez, K. 2001. Woman crusades for awareness of hunting danger after dog shot. Asheville Citizen-Times, October 19; Sect. B: 1.

Chavez, K. 2017. Paying to play in Pisgah. Asheville Citizen-Times. December 17; Sect. A: 1, 4–6.

Clark, P. 2003. Forest Service may cut number of trail miles affected by research in Bent Creek. Asheville Citizen-Times. November 3; Sect. B: 1.

Cole, D.N. 1995. Recreational trampling experiments: effects of trampler weight and shoe type. Res. Note INT-425. Ogden, UT: U.S. Department of Agriculture Forest Service, Intermountain Research Station. 4 p. https://doi.org/10.2737/INT-RN-425.

Comstock, T.B. 1874. The Yellowstone National Park. The American Naturalist. 8(2): 65–79. https://doi.org/10.1086/271264.

Cools, M.; Moons, E.; Wets, G. 2007. Investigating effect of holidays on daily traffic counts: time series approach. Transportation Research Record. 2019(1): 22–31. https://doi.org/10.3141/2019-04.

Coppes, J.; Ehrlacher, J.; Thiel, D. [and others]. 2017. Outdoor recreation causes effective habitat reduction in capercaillie *Tetrao urogallus*: a major threat for geographically restricted populations. Journal of Avian Biology 48: 1583–1594. https://doi.org/10.1111/jav.01239.

Cordell, H.K. 2008. The latest on trends in nature-based outdoor recreation. Forest History Today. Spring: 4–10.

Cordell, H.K. 2012. Outdoor recreation trends and futures: a technical document supporting the Forest Service 2010 RPA Assessment. Gen. Tech. Rep. SRS-150. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 167 p. https://doi.org/10.2737/SRS-GTR-150.

Cordell, H.K.; Betz, C.; Bowker, J.M. [and others]. 1999. Outdoor recreation in American life: a national assessment of demand and supply trends. Champaign, IL: Sagamore Publishing. 449 p.

Cordell, H.K.; Betz, C.J.; Mou, S.H.; Gormanson, D.D. 2012. Outdoor recreation in the Northern United States. Gen. Tech. Rep. NRS-100. Newtown Square, PA: U.S. Department of Agriculture Forest Service, Northern Research Station. 74 p. https://doi.org/10.2737/NRS-GTR-100.

Crane, N. 1998a. Five points bike loop at Bent Creek offers a little bit of everything to cyclists. Asheville Citizen-Times. August 14; Sect. D: 3.

Crane, N. 1998b. Bent Creek swells – when will it burst? Asheville Citizen-Times. September 11; Sect. C: 3.

Crane, N. 1998c. Owl ridge run easy for beginners. Asheville Citizen-Times. September 11; Sect. C: 3.

Crane, N. 1998d. Accidents rare, but precautions still need to be taken in the fall. Asheville Citizen-Times. October 23; Sect. A: 1, 5.

Crittenden, L. 1997. Bending Creek? Bent Creek straining under weight of its own popularity. Asheville Citizen-Times. March 2; Sect. E: 6.

Crompton, J. 2020. Uses and abuses of IMPLAN in economic impact studies of tourism events and facilities in the United States: a perspective article. Tourism Review 75(1): 187–190. https://doi.org/10.1108/TR-05-2019-0159.

Cusack, J.J.; Dickman, A.J.; Rowcliffe, J.M. [and others]. 2015. Random versus game trail-based camera trap placement strategy for monitoring terrestrial mammal communities. PLOS ONE. 10(5): e0126373. https://doi.org/10.1371/journal.pone.0126373.

DeFreitas, C.R. 1990. Recreation climate assessment. International Journal of Climatology. 10: 89–103. https://doi.org/10.1002/joc.3370100110.

Economic Development Coalition. 2017. Regional population trends. Western Carolina University, Economic Development Coalition. https://www.wcu.edu/engage/regional-development/public-policy-institute/Regional-Outlook-Report/chapter1.aspx. [Date accessed: November 19, 2021].

Eisenberg, D.; Okeke, E. 2009. Too cold for a jog? Weather, exercise, and socioeconomic status. B.E. Journal of Economic Analysis & Policy. 9(1): 25. https://doi.org/10.2202/1935-1682.2104.

Ellsworth, D.L.; Honeycutt, R.L.; Silvy, N.J.; Smith, M.H. 1994. White-tailed deer restoration to the southeastern United States: Evaluating genetic variation. The Journal of Wildlife Management. 58(4): 686–697. https://doi.org/10.2307/3809683.

English, D.B.K.; Kocis, S.M.; Zarnoch, S.J.; Arnold, J.R. 2002. Forest Service National Visitor Use Monitoring process: research method documentation. Gen. Tech. Rep. SRS-57. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 14 p. https://doi.org/10.2737/SRS-GTR-57.

Erickson, A.B. 1940. Notes on a method for censusing white-tailed deer in the spring and summer. Journal of Wildlife Management 4(1): 15–18. https://doi.org/10.2307/3796261.

Evju, M.; Hagen, D.; Jokerud, M. [and others]. 2021. Effects of mountain biking versus hiking on trails under different environmental conditions. Journal of Environmental Management. 278: 111554. https://doi.org/10.1016/j.jenvman.2020.111554.

Finger, R.; Lehmann, N. 2012. Modeling the sensitivity of outdoor recreation activities to climate change. Climate Research. 51: 229–236. https://doi.org/10.3354/cr01079.

Frothingham, E.H. 1921. Forest experiment station for the south. American Forestry. 27(333): 598–599.

George, D.J. 1993. Weather and mountain activities. Weather. 48(12): 404–410. https://doi.org/10.1002/j.1477-8696.1993.tb05829.x.

Greenberg, C.H.; Seiboldt, T.; Keyser, T.L. [and others]. 2018. Reptile and amphibian response to season of burn in an upland hardwood forest. Forest Ecology and Management. 409: 808–816. https://doi.org/10.1016/j.foreco.2017.12.016.

Gregoire, T.G.; Buhyoff, G.J. 1999. Sampling estimating recreational use. Gen. Tech. Rep. PNW-456. Portland, OR: U.S. Department of Agriculture Forest Service, Pacific Northwest Research Station. 39 p. https://doi.org/10.2737/PNW-GTR-456.

Guan, W.; Ni, Z.; Hu, Y. [and others]. 2020. Clinical characteristics of coronavirus disease 2019 in China. New England Journal of Medicine. 382: 1708–1720. https://doi.org/10.1056/NEJMoa2002032.

Haasis, F.W. 1930. Forest plantations at Biltmore, North Carolina. Misc. Publ. 61. Washington, DC: U.S. Department of Agriculture. 30 p. https://doi.org/10.5962/bhl.title.65418.

Hall, W.L. 1919. Influences of the national forests in the southern Appalachians. Journal of Forestry. 17(4): 402–407.

Horton, N.J.; Kleinman, K.P. 2007. Much ado about nothing: a comparison of missing data methods and software to fit incomplete data regression models. The American Statistician. 61(1): 79–90. https://doi.org/10.1198/000313007X172556.

Hutchison, C. 1976. Pint-sized pioneers survive in chilly environment. Asheville Citizen. January 24; Sect. 2: 11.

James, G.A.; Schreuder, H.T. 1971. Estimating recreation use on the San Gorgonio Wilderness. Journal of Forestry. 69: 490–493.

Jolley, H.E. 2007. That Magnificent Army of Youth and Peace: The Civilian Conservation Corps in North Carolina, 1933-1942. Raleigh, NC: Office of Archives and History, North Carolina Department of Cultural Resources. 167 p.

Jones, A. 2002. Bacteria levels force closure of lake. Asheville Citizen-Times. July 24; Sect. B: 1.

Kimball, L.R.; Whyte, T.R.; Crites, G.D. 2010. The Biltmore mound and Hopewellian mound use in the southern Appalachians. Southeastern Archaeology 29(1): 44–58. https://doi.org/10.1179/sea.2010.29.1.004.

Kirschman, J.E. 2014. Technology transfer: taking science from the books to the ground at Bent Creek Experimental Forest. In: Waldrop, T.A., ed. Proceedings, wildland fire in the Appalachians: discussions among managers and scientists. Gen. Tech. Rep. SRS-199. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station: 201–204. https://doi.org/10.2737/SRS-GTR-199.

Kneipp, L.F. 1930. Recreational use of the national forests. Journal of Forestry 28(5): 618–625.

Kuss, F.R.; Hall, C.N. 1991. Ground flora trampling studies: five years after closure. Environmental Management. 15: 715–727. https://doi.org/10.1007/BF02589629.

Lacey, D. 2021. Permits for affordable housing OK'd: 230 new apartments, townhouses coming to Buncombe County. Asheville Citizen-Times. April 20; Sect. A: 3, 4.

Langsrud, O. 2003. ANOVA for unbalanced data: Use Type II instead of Type III sums of squares. Statistics and Computing. 13: 163–167. https://doi.org/10.1023/A:1023260610025.

Lewis, J. 2016. The gift of the Pisgah National Forest. Asheville Citizen-Times. October 16; Sect. E: 8.

Lone, K.; Loe, L.E.; Meisingset, E.L. [and others]. 2015. An adaptive behavioural response to hunting: surviving male red deer shift habitat at the onset of the hunting season. Animal Behaviour. 102: 127–138. https://doi.org/10.1016/j.anbehav.2015.01.012.

Mathews, L.G.; Kask, S.B.; Stewart, S. [N.d.]. Valuing the contribution of scenic quality to recreational experiences: a case study in the Southern Appalachian region. Final report prepared for the Blue Ridge Parkway Foundation under grant #CA5143990137. 33 p.

McCoy, G.W. 1934. Outstanding work being done by 16 CCC camps in Great Smokies. Asheville Citizen-Times. September 2; Sect. A: 8.

McDonald, J.H. 2014. Handbook of biological statistics. Baltimore, MD: Sparky House Publishing. 299 p.

McNab, W.H.; O'Shields, J.K.; Zarnoch, S.J. [and others]. 2022. Bent Creek Experimental Forest: Data from the 2005-2007 survey of visitor characteristics, perceptions, economics and traffic. Fort Collins, CO: Forest Service Research Data Archive. https://doi.org/10.2737/RDS-2022-0049.

Meyer, A. 1985. This bike can go anywhere. National Parks. 59(5/6): 12–13.

Miller, S.G.; Knight, R.L.; Miller, C.K. 2001. Wildlife responses to pedestrians and dogs. Wildlife Society Bulletin. 29(1): 124–132. https://www.jstor.org/stable/3783988.

Moerschbaecher, M.K.; Weber, L.M. 2004. A survey of roadkill along the Blue Ridge Parkway. Journal of the North Carolina Academy of Science. 120(3): 113–116.

Morrison, C. 1990. Foresters plan demonstration forest [Photo]. Asheville Citizen-Times. February 24; Sect. C: 6.

Morrison, C. 2004. Trail restrictions miff cyclists. Asheville Citizen-Times. April 11; Sect. D: 1–2.

Nash, L. 2006. Forest Service plans upgrades to Bent Creek. Asheville Citizen-Times. February 2; Sect. B: 1.

Naves, G.W. 1931. Asheville men and women will take to hills. Asheville Citizen-Times. February 8; Sect. A: 12.

Neary, D.G.; Swift, L.W., Jr.; Manning, D.M.; Burns, R.G. 1986. Debris avalanching in the Southern Appalachians: an influence on forest soil formation. Soil Science Society of America Journal. 50: 465–471. https://doi.org/10.2136/sssaj1986.03615995005000020043x.

Nesbitt, W.A. 1941. History of early settlement and land use on the Bent Creek Experimental Forest, Buncombe County, N.C. 78 p. Unpublished paper. On file with: U.S. Department of Agriculture Forest Service, Southern Research Station, Bent Creek Experimental Forest, 1577 Brevard Road, Asheville, NC 28806.

Neufeld, R. 2018. Pioneer Bent Creek memories reach back to the time of change. Asheville Citizen-Times. January 15; Sect. A: 3.

Nivens, D. 1989. Arboretum rising in Buncombe. Asheville Citizen. February 27; Sect. B: 1, CL: 1.

North Carolina Department of Conservation and Development. 1937. Wildlife management in North Carolina. [North Carolina] Department of Conservation and Development, Division of Game and Inland Fisheries. 8 p.

O'Neal, G. 1994. Styles' body believed found. Asheville Citizen-Times. November 26; Sect. A: 1, 6.

Osborne, C. 1986. Plans for arboretum take root in Bent Creek. Asheville Citizen. January 17; Sect. A: 1–2.

Osborne, C. 1989. WNC Arboretum nears completion; directors thrilled. Asheville Citizen. December 2; Sect. A: 12.

Outdoor Foundation. 2021. Outdoor participation trends report. 27 p. https://outdoorindustry.org/resource/2021-outdoor-participation-trends-report/. [Date accessed: March 2, 2022].

Padgitt, B.W. 1927. 5,000 deer in Pisgah Forest report states. Asheville Citizen. February 13; Sect. B: 3.

Ponce, S.L.; Gary, H.L. 1979. The effect of lake-based recreation and second home use on surface water quality in the Manitou Experimental Forest. Res. Pap. RM-211. Fort Collins, CO: U.S. Department of Agriculture Forest Service, Rocky Mountain Forest and Range Experiment Station. 10 p. https://doi.org/10.5962/bhl.title.98698.

Rayburn, A.P.; Murdock, S.; Lile, J. [and others]. 2019. Gone to the dogs: closure and restoration of the former Elk Meadow Park dog off-leash area. Natural Areas Journal 39(1): 122–127. https://doi.org/10.3375/043.039.0109.

R Core Team. 2018. R: a language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing. http://www.R-project.org/. [Date accessed: March 2, 2022].

Rock, M.J.; Graham, T.M.; Massolo, A.; McCormack, G.R. 2016. Dog-walking, dog-fouling and leashing policies in urban parks: insights from a natural experiment designed as a longitudinal multiple-case study. Landscape and Urban Planning 153: 40–50. https://doi.org/10.1016/j.landurbplan.2016.04.018.

Royall, D. 2003. A fifty-year record of historical sedimentation at Deer Lake, North Carolina. The Professional Geographer. 55(3): 356–371. https://doi.org/10.1111/0033-0124.5503012.

Ruxton, G.D. 2006. The unequal variance t-test is an underused alternative to Student's t-test and the Mann-Whitney U test. Behavioral Ecology. 17(4): 688–690. https://doi.org/10.1093/beheco/ark016.

Santa Maria, A. 2014. Managing dispersed recreation in the Allegheny National Forest. Kalamazoo, MI: Western Michigan University. 166 p. M.A. thesis.

SAS Institute Inc. 2004. Cary, NC: SAS Institute Inc.

Saterwhite, B. 1995. Tsali's growing popularity prompting changes. Asheville Citizen Times. August 13; Sect. D: 7.

Savin, N.E.; White, K.J. 1977. The Durbin-Watson test for serial correlation with extreme sample sizes or many regressors. Econometrica. 45(8): 1989–1996. https://doi.org/10.2307/1914122.

Savre, F.; Saint-Martin, J.; Terret, T. 2010. From Marin County's seventies clunker to the Durango World Championship 1990: a history of mountain biking in the USA. The International Journal of the History of Sport. 27(11): 1942–1967. https://doi.org/10.1080/09523367.2010.491624.

Slater, J. 1971. Area high schools to participate in ecological study. Asheville Citizen-Times. September 12: 1.

Smith, K. 1993. The influence of weather and climate on recreation and tourism. Weather. 48(12): 398–404. https://doi.org/10.1002/j.1477-8696.1993.tb05828.x.

Stankowich, T. 2008. Ungulate flight responses to human disturbance: a review and meta-analysis. Biological Conservation. 141: 2159–2173. https://doi.org/10.1016/j.biocon.2008.06.026.

State Climate Office of North Carolina. 2021. Cardinal [data retrieval interface]. Raleigh, NC: North Carolina State University. https://products.climate.ncsu.edu/cardinal/request. [Date accessed: September 16, 2021].

Tennessee Valley Authority. 1973. Floods on French Broad River in North Carolina. Special Report. Knoxville, TN. 11 p.

Thurston, E.; Reader, R.J. 2001. Impacts of experimentally applied mountain biking and hiking on vegetation and soil of a deciduous forest. Environmental Management. 27: 397–409. https://doi.org/10.1007/s002670010157.

Unger, S.D.; Williams, L.A.; Lawson, C.R.; Groves, J.D. 2020. Using trail cameras to assess recreation in hellbender streams of North Carolina national forests. Journal of the Southeastern Association of Fish and Wildlife Agencies. 7: 255–262.

U.S. Department of Agriculture (USDA) Forest Service. 1927. Establishment report for Bent Creek Experimental Forest. July 29, 1927. 5 p. Administrative report. On file with U.S. Department of Agriculture Forest Service, Southern Research Station, Bent Creek Experimental Forest, 1577 Brevard Road, Asheville, NC 28806.

U.S. Department of Agriculture (USDA) Forest Service. 1935. Proposal of additions to the Bent Creek Experimental Forest supplementary to the order establishing the Bent Creek Experimental Forest, July 29, 1927. 2 p. Administrative report. On file with U.S. Department of Agriculture Forest Service, Southern Research Station, Bent Creek Experimental Forest, 1577 Brevard Road, Asheville, NC 28806.

U.S. Department of Agriculture (USDA) Forest Service. 1999. Art Rowe letter of no significant finding. On file with: Pisgah National Forest, Pisgah Ranger District, 1600 Pisgah Highway, Pisgah Forest, NC 28768.

U.S. Department of Agriculture (USDA) Forest Service. 2001. Decision memo, Deer Lake Lodge demolition. 3 p. On file with: Pisgah National Forest, Pisgah Ranger District, 1600 Pisgah Highway, Pisgah Forest, NC 28768.

U.S. Department of Agriculture (USDA) Forest Service. 2002. Environmental assessment for managing visitor use in Bent Creek. 31 p. On file with: National Forests in North Carolina, Supervisors Office, 160 Zillicoa Street, Asheville, NC 28801.

U.S. Department of Agriculture (USDA) Forest Service. 2003. Revised environmental assessment for the Bent Creek Complex. 65 p. On file with: National Forests in North Carolina, Supervisors Office, 160 Zillicoa Street, Asheville, NC 28801.

U.S. Department of Agriculture (USDA) Forest Service. [N.d.]. National Visitor Use Monitoring survey results national summary report. NVUM data collected FY 2016 through FY 2020. https://www.fs.usda.gov/sites/default/files/2020-National-Visitor-Use-Monitoring-Summary-Report.pdf.

U.S. Department of Commerce, Census Bureau. 2020. Population of Buncombe County, North Carolina. https://www.census.gov/quickfacts/fact/table/buncombecountynorthcarolina. [Date accessed: November 23, 2021].

U.S. Department of the Interior, National Park Service, Blue Ridge Parkway. 2003. Monthly public use report. https://irma.nps.gov/STATS/Reports/Park/BLRI. [Date accessed: March 11, 2021].

U.S. Department of the Interior, National Park Service, Blue Ridge Parkway. 2021. National park statistics; national park visits by location. https://irma.nps.gov/STATS/Reports/Park/BLRI. [Date accessed: September 9, 2021].

U.S. Department of Labor, Bureau of Labor Statistics. 2021. Consumer price index inflation calculator. https://www.bls.gov/data/inflation_calculator.htm. [Date accessed: April 8, 2021].

Van der Zande, A.N.; Berkhuizen, J.C.; van Latesteijn, H.C. [and others]. 1984. Impact of outdoor recreation on the density of a number of breeding bird species in woods adjacent to urban residential areas. Biological Conservation. 30: 1–39. https://doi.org/10.1016/0006-3207(84)90018-1.

Wagar, J.A. 1974. Recreational carrying capacity reconsidered. Journal of Forestry. 72(5): 274–278. https://doi.org/10.1093/jof/72.5.274.

Watson, A.E.; Cordell, H.K.; Manning, R.; Martin, S. 2016. The evolution of wilderness social science and future research to protect experiences, resources, and societal benefits. Journal of Forestry. 114(3): 329–338. https://doi.org/10.5849/jof.14-145.

Western, D.; Henry, W. 1979. Economics and conservation in third world national parks. BioScience. 29(7): 414–418. https://doi.org/10.2307/1307647.

Weston, M.A.; Fitzsimons, J.A.; Wescott, G. [and others]. 2014. Bark in the park: a review of domestic dogs in parks. Environmental Management. 54: 373–382. https://doi.org/10.1007/s00267-014-0311-1.

Wisdom, M.J.; Preisler, H.K.; Naylor, L.M. [and others]. 2018. Elk responses to trail-based recreation on public forests. Forest Ecology and Management. 411: 223–233. https://doi.org/10.1016/j.foreco.2018.01.032.

Yarnell, S.L. 1998. The Southern Appalachians: a history of the landscape. Gen. Tech. Rep. SRS-18. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 45 p. https://doi.org/10.2737/SRS-GTR-18.

Yung, L.; Bradbury, M.; Williams, D.R. 2012. Experimental forests and climate change: views of long-term employees on ecological change and the role of experimental forests and ranges in understanding and adapting to climate change. Res. Pap. RMRS-100. Fort Collins, CO: U.S. Department of Agriculture Forest Service, Rocky Mountain Research Station. 56 p. https://doi.org/10.2737/RMRS-RP-100.

Zajc, P.; Berzelak, N. 2016. Riding styles and characteristics of rides among Slovenian mountain bikers and management challenges. Journal of Outdoor Recreation and Tourism. 15: 10–19. https://doi.org/10.1016/j.jort.2016.04.009.

Zar, J.H. 1996. Biostatistical analysis. Upper Saddle River, NJ: Prentice-Hall, Inc. 662 p.

Zarnoch, S.J.; Kocis, S.M.; Cordell, H.K.; English, D.B.K. 2002. A pilot sampling design for estimating outdoor recreation site visits on the national forests. Res. Pap. SRS-29. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 20 p. https://doi.org/10.2737/SRS-RP-29.

# APPENDIX A
# Onsite Interview Questionnaire

This form (considered as part A of the onsite visitor interview) was used to collect individual responses from visitors when conducting the 2-hour blocks of onsite interviews from June 1, 2005 to June 30, 2007.

**Clicker Number of Interview** _____ **Time of Interview** _____

## BENT CREEK VISITOR USE SURVEY—Individual Interview Form

Initial interviewer instructions are in red on the survey form.
The words the interviewer actually says to the person being interviewed are in **BOLD** text.
Further instructions for the interviewer appear after the ☛.

---

After the visitor stops, introduce yourself and read the following statement to the visitor:

**The Forest Service and the University of Georgia are conducting a 2-minute survey to collect information from visitors for 1 year to help with forest management decisions. Your participation is completely voluntary and confidential.**

Then ask:

Q1. **What is the primary purpose of your visit to Bent Creek Experimental Forest?** Read the following answer choices and ✓ the appropriate box.

- ❑ Recreation/viewing scenery ☛ GO TO Q2.
- ❑ Working or commuting to work ☛ END INTERVIEW AND GO TO PART B.
- ❑ Some other reason ☛ Fill in reason on line below. If it matches one of the answer choices for Q6, AND GO TO Q2. Otherwise, END INTERVIEW AND GO TO PART B.

_____

Q2. **Would you be willing to participate in this interview?**

- ❑ **YES** (they agree to be interviewed) ☛ GO TO Q4.
- ❑ NO (they do not agree to be interviewed) ☛ GO TO Q3.

Q3 **May I ask why you do not want to be interviewed?**

- ❑ **Previously interviewed** ☛ END INTERVIEW AND GO TO PART B.
- ❑ No time ☛ END INTERVIEW AND GO TO PART B.
- ❑ Not interested ☛ END INTERVIEW AND GO TO PART B.
- ❑ Other ☛ Fill in reason on line below, then END INTERVIEW AND GO TO PART B.

_____

Q4. **I need to select just one of you to complete this interview. To make sure the survey is random, which of you had the most recent birthday and is 16 years of age or older?** You will direct ALL questions to ONLY this person.

Q5. **What is your home ZIP Code?** _____

☛ Fill in the 5-digit ZIP Code. If the visitor is from another country, fill in the name of the country. Go to Q6.

☛ Hand visitor flashcard for Q6 and Q7. Read them the activities for Q6 as they follow along. Choose all that apply. For Q7, have them pick only one primary activity from Q6.

[photo courtesy of AdobeStock]

APPENDIX A

Q6. **In which of the following activities will you participate during your visit today?**

✓ All activities that apply and GO TO Q7.

❑ Fishing - all types
❑ Hunting - all types
❑ Swimming or wading

VIEWING AND LEARNING NATURE

❑ Viewing wildlife, birds, fish, etc.
❑ Viewing natural features such as scenery, flowers, etc.
❑ Nature study (education/scientific)

TRAIL ACTIVITIES

❑ Hiking, walking, or running
❑ Horseback riding
❑ Bicycling, including mountain bikes

MOTORIZED ACTIVITIES

❑ Driving for pleasure

CAMPING OR OTHER OVERNIGHT

❑ Camping

GROUP ACTIVITIES

❑ Relaxing; hanging out; escaping heat, noise, etc.
❑ Picnicking and family day gatherings in developed sites (family or group)
❑ Games or sports
❑ OTHER (write in activity)

_____

Q7. If more than one activity is selected for Q6, ask: **Which of these, if any, is your primary activity?**

(Fill in primary activity from the flashcard) _____

❑ NO PRIMARY ACTIVITY

Q8. **Where will you be recreating?** (✓ all that apply):

❑ **Bent Creek Experimental Forest** (including trails around Lake Powhatan or using Bent Creek to access The North Carolina Arboretum) ☛ GO TO Q9.

❑ **Lake Powhatan Fee Area** (paid entrance fee to use this area) ☛ END INTERVIEW AND GO TO PART B IF BENT CREEK IS NOT ✓.

❑ **The North Carolina Arboretum** ☛ END INTERVIEW AND GO TO PART B IF BENT CREEK IS NOT ✓.

Q9. **Have you participated in this interview within the past 12 months?**

❑ **YES** ☛ END INTERVIEW and GO TO PART B.

❑ NO ☛ GO TO Q10.

Q10. **Would you be willing to answer some additional questions in a short followup telephone interview?**

❑ YES ☛ GO TO Q11.
❑ NO ☛ END INTERVIEW.

Q11. **May I have your first name and your phone number, please?**

Name: _____ Primary phone #: area code (  ) _____

Q12. **What is the best day and time of day to call you at this number?**

Day: _____

Time: _____

This ends the interview. Read the following to the visitor:

**You should expect a call within the next month. I don't have any more questions. Thank you very much for stopping. ENJOY YOUR VISIT.**

# APPENDIX B
# Onsite Interviewer-Observed Data

Data on this form (considered as part B of the onsite visitor interview), provides additional information useful for analysis of visitor trends, demographics, and vehicle occupants. After the visitor interview, the interviewer recorded information based on their casual observations.

Complete this section of the onsite questionnaire by observation at the end of the interview.

**Interviewer name:**

**Date:**

**Number of axles** (circle one)**:**

**2 3 4 5**

**State on license plate:**

_____

**If respondent did not enter in a motorized vehicle, ✓ one:**

❑ Bicycle ❑ Walking

**Gender of respondent (circle one):**

❑ Male ❑ Female

**Enter number of people in the group for each category (and sum total), including respondent:**

Adult (16+) males _____

Adult (16+) females _____

Youth (<16) males _____

Youth (<16) females _____

Total # in group: _____

❑ Uncertain ( ✓ here if you don't know # in group)

**Pets ( ✓ one):**

❑ Yes ❑ No ❑ Uncertain

APPENDIX C

# APPENDIX C
# Telephone Interview Questionnaire

This form was used to collect information from a subsample of visitors who agreed to a followup telephone interview after the onsite interview (see app. A) and recreation at Bent Creek Experimental Forest.

## Bent Creek Experimental Forest Telephone Questionnaire

Survey ID # _____2. Phone # (  ) _____

LEAD IN: **Thank you for agreeing to participate in this telephone interview about your visit to Bent Creek Experimental Forest on** <date>**. This information is CONFIDENTIAL and will be used only to assist in management decisions at Bent Creek.**

### Part A. VISITOR AND TRIP PROFILE (Asked of everyone)

A.Q1. **How many visits have you made to Bent Creek in the past year for recreation? _____visits**

A.Q2. **How many of those visits were for <main activity>, the primary activity you identified during the onsite interview? _____visits**

☛ Note: Main Activity is a variable in the onsite survey and should be programmed into A.Q2. If main activity is missing, A.Q2 is skipped. If asked, A.Q2 must be ≤A.Q1. If A.Q1 = 1, then enter A.Q2 = 1 and don't ask A.Q2. For MAIN ACTIVITY, See Q7 answer response on the onsite survey questionnaire]

A.Q3. **How many miles do you usually travel, one way, to reach Bent Creek? _____miles**

A.Q4. **In the past year, how many visits did you make to other forests or parks like Bent Creek? _____visits**

A.Q5. **Including this year, how many years have you been visiting Bent Creek for recreation? _____years**

A.Q6. **If Bent Creek were not available, is there another place you would have gone for similar recreation opportunities?** Please answer **Y** (yes) ☛ Go to A.Q7, **N** (No), DK (Don't know), or **R** (Refused) ☛ If N, DK, or R, go to B.Q1.

**Y  N  DK  R**

[Clarification for interviewers: It does not matter if the respondent actually went to the other place, just that there is another place they would have gone.]

A.Q7. **How many miles do you usually travel, one way, to this other place? _____miles**

## Part B. INFORMATION ABOUT BENT CREEK EXPERIMENTAL FOREST (Asked of everyone)

B.Q1. **Before participating in this survey were you aware that Bent Creek is one of the 77 experimental forests established and operated by the USDA Forest Service?**

**Y N DK R**

B.Q2. **The Forest Service primarily manages experimental forests for specific long-term research and education objectives. Are you aware of any current research projects on Bent Creek?**

**Y N DK R**

B.Q3. **How important are the following reasons in your decision to visit Bent Creek?**
Please tell me whether it is **V** (Very important), **S** (Somewhat important), or **NAT** (Not at all).
(*Randomize list*)

| | |
|---|---|
| a. Health and wellness | **V S NAT** |
| b. Opportunity to view nature | **V S NAT** |
| c. Opportunity to learn about forestry practices | **V S NAT** |
| d. A place to take my pets/animals | **V S NAT** |
| e. A place to be with family/friends | **V S NAT** |
| f. A convenient place for forest recreation | **V S NAT** |

B.Q4. **Next, please tell me how important each of the following items is to you.**
Would you say **V** (Very important), **S** (Somewhat important), or **NAT** (Not at all)?
**Then, please tell me how satisfied you are with these items at Bent Creek.**
Would you say **V** (Very satified), **S** (Somewhat satisfied), or **NAT** (Not at all)? (*Randomize list*)

| | **Importance** | **Satisfaction** |
|---|---|---|
| a. Parking | **V S NAT** | **V S NAT** |
| b. Natural scenery | **V S NAT** | **V S NAT** |
| c. Amount of trails | **V S NAT** | **V S NAT** |
| d. Condition of trails | **V S NAT** | **V S NAT** |
| e. Connecting paths to The North Carolina Arboretum | **V S NAT** | **V S NAT** |
| f. Signs identifying and explaining trail usage | **V S NAT** | **V S NAT** |
| g. Signs identifying and explaining forest experiments | **V S NAT** | **V S NAT** |

B.Q5. **Please tell me whether you SA** (Strongly agree), **A** (Agree), **D** (Disagree), **SD** (Strongly disagree), or are **U** (uncertain) **about the following statements:** (*Randomize list)*

a. **Crowding reduces** the quality of my visits to Bent Creek.
**SA A D SD U**

b. Bent Creek is a **safe place** for women, elderly, or children to recreate.
**SA A D SD U**

c. **Forest experiments**, like prescribed burns and harvests, reduce the quality of my visits to Bent Creek.
**SA A D SD U**

d. **Rules and regulations** are clearly identified at Bent Creek
**SA A D SD U**

e. **Rules and regulations** are well enforced at Bent Creek
**SA A D SD U**

f. **Research** designed to keep forests healthy is important to conduct at Bent Creek
**SA A D SD U**

APPENDIX C

## Part C. SPENDING INFORMATION
**(Asked only if question A.Q3 >20 miles. If <20 miles, skip to part D.)**

**Now, we would like to ask about your trip to Bent Creek during which you were interviewed.**

C.Q1. **Did you spend the night away from home on this trip?**

❑ Yes, ❑ No ☛ If No, skip to C.Q4.

**If YES:**

C.Q2. **How many nights total were you away from home on this trip? _____nights**

C.Q3. **How many nights did you spend within 20 miles of Bent Creek? _____nights**

☛ C.Q3 must be ≤C.Q2.

C.Q4. **Including yourself, how many people were in your spending party? _____people**

C.Q5. **Was Bent Creek your primary reason for visiting the Asheville area?**

❑ Yes, ❑ No <If no, skip to D.Q1.>, ❑ Don't know, ❑ Refused

**Next, we would like to ask you about your estimated expenses on your trip to Bent Creek. The information will be used to calculate the economic effects of recreation at Bent Creek on the local economy.**

**For the following expenditure categories, please round to the nearest dollar: first, the amount you spent during your entire trip, and then within 20 miles of Bent Creek.**

[Clarification: For each category, ask about expenditures for their entire trip, then ask about Bent Creek/ Asheville area expenditures before moving to the next category. If respondent spent $0 in a category on their whole trip, enter 0 for Bent Creek and do not ask.]

| | Whole trip | Bent Creek Asheville area |
|---|---|---|
| **Lodging** ☛ If C.Q1 is No, skip this question: (e.g., hotel/motel, campground) | $_____ | $_____ |
| **Food and beverage:** (e.g., groceries, $ spent at restaurants) | $_____ | $_____ |
| **Transportation**: (e.g., gasoline/oil, plane fare, etc.) | $_____ | $_____ |
| **Recreation equipment, rentals, fees:** (e.g., equipment rental or purchase, campground fee) | $_____ | $_____ |
| **Any other expenses:** (i.e., any expenses for this trip that do not fit in above categories) | $_____ | $_____ |

## Part D. DEMOGRAPHIC INFORMATION (Asked of everyone)

**For statistical purposes I need to ask you a few final questions about yourself. Please remember that all information is confidential.**

D.Q1. **What is your age? _____years**

D.Q2. **Are you Hispanic, Latino, or of Spanish origin?**

❑ Yes, ❑ No ☛ If no, skip to D.Q11, ❑ Don't know, ❑ Refused

D.Q3. **What race or races do you consider yourself to be?**
☛ Respondent may select more than one race.

1. White
2. Black or African American
3. American Indian or Alaska Native
4. Asian
5. Native Hawaiian or other Pacific Islander
6. Don't know
7. Refused

D.Q4. **What is the highest level of education you have completed?**

A. Less than high school
B. High school
C. Some college
D. Associate's degree or equivalent
E. Bachelor's degree or equivalent
F. Graduate degree (M.S., Ph.D., M.D., etc.)

D.Q5. **Including yourself, how many people are in your immediate household? _____people**

☛ If D.Q5 = 1, then enter D.Q6 = 1 and do not ask D.Q6.

D.Q6. **Including yourself, how many people in your household recreate at Bent Creek? _____people**

D.Q7. **Which of the following best represents your household's annual income?**

❑ A. Under $25,000 ❑ B. $25,000–49,999 ❑ C. $50,000–$74,999 ❑ D. $75,000–$99,999
❑ E. Above $100,000 ❑ F. Don't know ❑ G. Refused

**THANK YOU!**

APPENDIX D

# APPENDIX D
# Converting Sample Vehicle Counts to a Monthly Total

Vehicles entering Bent Creek Experimental Forest during the 12 daytime hours for each month of the study were used, along with the Blue Ridge Parkway traffic data, to develop a prediction model. The following example demonstrates the procedure for using sample data collected on known days of the week (i.e., weekdays and weekends) and at known times [i.e., 6 a.m. to 11:59 a.m. (mornings) and 12 p.m. to 6 p.m. (afternoons)] to estimate traffic on other days and times of that month when vehicles were not counted.

## Similar Strata Method

Cordell and others (2012) reported that people spend more time recreating outdoors on weekends compared to weekdays; we found a similar difference (figs. 18 and 19). Therefore, expanding traffic volume from vehicles per hour to vehicles per month should be weighted by the number of hours available on weekdays versus weekends. We also found a difference in traffic between mornings and afternoons (fig. 18). Using vehicle volume sample data by time of day and day of week for each month, we calculated an average value of traffic for weekday mornings and afternoons and for weekend day mornings and afternoons. Morning and afternoon data were then combined for an estimate of traffic by weekday and weekend day for each month. Average monthly traffic was obtained by expanding daily traffic according to the number of weekday days and weekend days in each month as shown for June 2005:

**Weekday vehicle counts for June 2005**—Seven 2-hour blocks of sample time were scheduled but only six blocks were sampled (app. E):

- Average vehicles per hour for weekday mornings: missing/no data. (One sample time was scheduled, but it was not staffed, therefore vehicle count data for weekday mornings is considered missing.)
- Average vehicles per hour for weekday afternoons: 287 vehicles were counted during a total of 12 hours = 23.92 vehicles per hour. (Vehicles were counted during six 2-hour blocks of sample time during afternoons.)
- Average vehicles for a weekday: 23.92 vehicles per hour * 12 hours per day = 287.00 vehicles per day. (Because no estimates of morning traffic were obtained, the afternoon estimate of vehicles per hour is used for the entire 12-hour day.)
- Total weekday vehicles for June 2005 = 287 vehicles per weekday * 22 weekdays in June = 6,314 vehicles.

**Weekend day vehicle counts for June 2005**—Seven 2-hour blocks of sample time were scheduled but only five blocks were sampled (app. E):

- Average vehicles per hour for weekend mornings: 114 vehicles were counted during a total of 4 hours = 28.50 vehicles per hour. (Vehicles were counted during two 2-hour blocks of sample time during mornings.)
- Average vehicles per hour for weekend afternoons: 138 vehicles were counted during a total of 6 hours = 23.00 vehicles per hour. (Vehicles were counted during three 2-hour blocks of sample time during afternoons.)
- Average vehicles for a weekend day: (28.50 vehicles per hour morning + 23.00 vehicles per hour afternoon) / 2 samples = 25.75 vehicles per hour * 12 hours per day = 309.00 vehicles per day.
- Total weekend vehicles for June 2005 = 309 vehicles per weekend day * 8 weekend days in June = 2,472 vehicles.

**Total vehicles for June 2005 = 6,314 weekday vehicles + 2,472 weekend vehicles = 8,786 vehicles.**

# APPENDIX E
# Data Matrix of Block Samples

**Data matrix of the number of 2-hour blocks of time scheduled and sampled for vehicles entering Bent Creek Experimental Forest by session, month and year, season, holiday, whether hunting was permitted, day of week, and time of day.**

| Month and year by session | Weather season | Designated-day blocks sampled | | Tot. blk. sch.[3] | Weekday blocks[4] | | | Weekend blocks[5] | | | Total by month |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Hol.[1] | Hnt.[2] | | a.m[6] | p.m.[7] | Subtotal | a.m. | p.m. | Subtotal | |
| **SESSION 1** | | | | | | | | | | | |
| June 2005 | Warm | — | — | 14 | 0 | 6 | 6 | 2 | 3 | 5 | 11 |
| July 2005 | Warm | (2) | — | 22 | 4 | 5 | 9 | 2 | 5 | 7 | 16 |
| Aug. 2005 | Warm | — | — | 20 | 1 | 6 | 7 | 2 | 0 | 2 | 9 |
| Sep. 2005 | Cool | — | — | 17 | 0 | 1 | 1 | 0 | 2 | 2 | 3 |
| Oct. 2005 | Cool | — | — | 15 | 0 | 5 | 5 | 1 | 0 | 1 | 6 |
| Nov. 2005 | Cool | — | (6) | 18 | 2 | 5 | 7 | 1 | 6 | 7 | 14 |
| Dec. 2005 | Cool | — | (4) | 12 | 1 | 3 | 4 | 0 | 1 | 1 | 5 |
| Jan. 2006 | Cool | — | — | 9 | 1 | 2 | 3 | 2 | 1 | 3 | 6 |
| Feb. 2006 | Cool | — | — | 5 | 1 | 0 | 1 | 1 | 1 | 2 | 3 |
| Mar. 2006 | Warm | — | — | 10 | 2 | 1 | 3 | 2 | 2 | 4 | 7 |
| Apr. 2006 | Warm | — | — | 21 | 2 | 7 | 9 | 3 | 6 | 9 | 18 |
| May 2006 | Warm | — | — | 13 | 0 | 5 | 5 | 1 | 4 | 5 | 10 |
| **Subtotal** | **—** | **(2)** | **(10)** | **176** | **14** | **46** | **60** | **17** | **31** | **48** | **108** |
| **SESSION 2** | | | | | | | | | | | |
| July 2006 | Warm | (1) | — | 18 | 4 | 2 | 6 | 4 | 8 | 12 | 18 |
| Aug. 2006 | Warm | — | — | 18 | 2 | 8 | 10 | 2 | 5 | 7 | 17 |
| Sep. 2006 | Cool | — | — | 15 | 2 | 4 | 6 | 2 | 4 | 6 | 12 |
| Oct. 2006 | Cool | (1) | — | 19 | 0 | 9 | 9 | 4 | 3 | 7 | 16 |
| Nov. 2006 | Cool | (3) | (5) | 16 | 3 | 4 | 7 | 2 | 3 | 5 | 12 |
| Dec. 2006 | Cool | (1) | (6) | 11 | 0 | 4 | 4 | 3 | 2 | 5 | 9 |
| Jan. 2007 | Cool | (1) | | 12 | 0 | 4 | 4 | 4 | 4 | 8 | 12 |
| Feb. 2007 | Cool | — | — | 4 | 0 | 1 | 1 | 0 | 3 | 3 | 4 |
| Mar. 2007 | Warm | — | — | 9 | 2 | 2 | 4 | 1 | 2 | 3 | 7 |
| Apr. 2007 | Warm | — | — | 14 | 0 | 7 | 7 | 3 | 3 | 6 | 13 |
| May 2007 | Warm | (1) | — | 23 | 4 | 4 | 8 | 4 | 8 | 12 | 20 |
| June 2007 | Warm | — | — | 15 | 4 | 4 | 8 | 1 | 5 | 6 | 14 |
| Subtotal | — | (8) | (11) | 174 | 21 | 53 | 74 | 30 | 50 | 80 | 154 |
| **Total** | **—** | **(10)** | **(21)** | **350** | **35** | **99** | **134** | **47** | **81** | **128** | **262** |

Blocks designated as holiday or hunting (in parentheses) are not included in the weekday, weekend, or month totals.

[1]Hol. = blocks of time sampled on days designated as holiday (e.g., Labor Day, Independence Day).

[2]Hnt. = blocks of time sampled on days designated as deer hunting permitted.

[3]Tot. blk. sch. = total number of 2-hour blocks scheduled for sampling for each month. This total includes samples on days administratively designated as either holiday or hunting permitted.

[4]Weekday = blocks sampled Monday, Tuesday, Wednesday, Thursday, or Friday.

[5]Weekend = blocks sampled Saturday or Sunday.

[6]a.m. = blocks sampled during morning (6 a.m.–11:59 a.m.).

[7]p.m. = blocks sampled during afternoon (12 p.m.–6 p.m.).

APPENDIX F

# APPENDIX F
# Purpose of Visitation

**Primary recreation activities planned by visitors, grouped by major category and listed in order presented on visitor flashcard (app. A), based on data collected during onsite interviews, June 1, 2005–June 30, 2007.**

| Major category | Specific or related activity | Number of visitors | Percentage of visitors |
|---|---|---|---|
| **TRADITIONAL ACTIVITY** | | | |
| Fishing | Fishing | 139 | 4.15 |
| Fishing | Boating | 1 | 0.03 |
| Hunting | Hunting | 63 | 1.88 |
| Swimming | Swimming | 80 | 2.39 |
| Swimming | Kayaking | 2 | 0.06 |
| Swimming | Showering | 1 | 0.03 |
| Swimming | Swimming, hiking | 1 | 0.03 |
| **Subtotal** | | **287** | **8.56** |
| **VIEWING AND LEARNING NATURE** | | | |
| Viewing nature | Relaxing, etc. | 64 | 1.91 |
| Viewing nature | Viewing nature/scenery | 56 | 1.67 |
| Viewing nature | Viewing wildlife | 46 | 1.37 |
| Viewing nature | Sightseeing | 4 | 0.12 |
| Viewing nature | Viewing birds | 1 | 0.03 |
| Viewing nature | Viewing, biking | 1 | 0.03 |
| **Subtotal** | | **172** | **5.13** |
| **MOTORIZED ACTIVITIES** | | | |
| Motorized activity | Driving for pleasure | 154 | 4.60 |
| Motorized activity | Driving, walking | 2 | 0.06 |
| **Subtotal** | | **156** | **4.66** |
| **CAMPING OR OTHER OVERNIGHT** | | | |
| Camping | Camping | 272 | 8.12 |
| Camping | Driving, camping | 1 | 0.03 |
| Camping | Dump station | 1 | 0.03 |
| **Subtotal** | | **274** | **8.18** |
| **GROUP ACTIVITIES** | | | |
| Group activity | Picnicking | 43 | 1.28 |
| Group activity | Training dogs | 6 | 0.18 |
| Group activity | Geocaching | 4 | 0.12 |
| Group activity | Paintball | 4 | 0.12 |
| Group activity | Playing sports or games | 4 | 0.12 |
| Group activity | Family gathering | 3 | 0.09 |
| Group activity | Visiting friends | 3 | 0.09 |
| **Subtotal** | | **67** | **2.00** |

APPENDIX F

**Primary recreation activities planned by visitors, grouped by major category and listed in order presented on visitor flashcard (app. A), based on data collected during onsite interviews, June 1, 2005–June 30, 2007.**

| Major category | Specific or related activity | Number of visitors | Percentage of visitors |
|---|---|---|---|
| **TRAIL ACTIVITIES** | | | |
| Walking-Running | Hiking | 915 | 27.31 |
| Walking-Running | Running | 87 | 2.60 |
| Walking-Running | Walking | 71 | 2.12 |
| Walking-Running | Walking/hiking with dog(s) | 28 | 0.84 |
| Walking-Running | Hiking, camping | 3 | 0.09 |
| Walking-Running | Hiking, biking | 1 | 0.03 |
| Walking-Running | Hiking, running | 1 | 0.03 |
| Walking-Running | Hiking, walking, picnicking | 1 | 0.03 |
| Horseback riding | Horseback riding | 3 | 0.09 |
| Bicycling | Biking | 1,167 | 34.83 |
| Bicycling | Mountain biking | 70 | 2.09 |
| **Subtotal** | | **2,347** | **70.04** |
| **OTHER (WRITE IN ACTIVITY)** | | | |
| Other | Checking out campgrounds/picnic area | 5 | 0.15 |
| Other | Visiting area attractions | 5 | 0.15 |
| Other | Student or test driving | 2 | 0.06 |
| Other | Looking for Arboretum | 1 | 0.03 |
| Other | Biking, hiking, swimming | 1 | 0.03 |
| Other | Looking for lake | 1 | 0.03 |
| Other | Looking for graveyard/genealogy | 1 | 0.03 |
| Other | Looking for turkeys | 1 | 0.03 |
| Other | Lost | 1 | 0.03 |
| Other | Lunch break | 1 | 0.03 |
| Other | Managing | 1 | 0.03 |
| Other | Mucking | 1 | 0.03 |
| Other | Mushrooms | 1 | 0.03 |
| Other | Picking up children who are running | 1 | 0.03 |
| Other | Releasing a squirrel | 1 | 0.03 |
| Other | Resident | 1 | 0.03 |
| Other | Rock hounding | 1 | 0.03 |
| Other | Running, biking | 1 | 0.03 |
| Other | Teaching | 1 | 0.03 |
| Other | Trail work | 1 | 0.03 |
| Other | Working | 5 | 0.15 |
| Other | Filming race competition | 3 | 0.09 |
| Other | Scouting for hunting or fishing spot | 3 | 0.09 |
| Other | Looking for lost item | 2 | 0.06 |
| Other | Looking for property | 2 | 0.06 |
| Other | Photography | 2 | 0.06 |
| Other | Searching for a dog | 2 | 0.06 |
| **Subtotal** | | **48** | **1.43** |
| **TOTAL** | | **3,351** | **100** |

## APPENDIX G
## Visitor Interview Staffing

Visitor interviews were conducted mostly by volunteer students from the University of North Carolina-Asheville and residents of Buncombe County who responded to a newspaper article enlisting help with the study (Asheville Citizen-Times 2005). U.S. Department of Agriculture Forest Service employees located at Bent Creek Experimental Forest conducted interviews when volunteers were not available.

## APPENDIX H
## Camp Deer Lake history

Camp Deer Lake was established in 1959 as a day camp for children from 5 to 14 years of age, with an emphasis on organized camping (Asheville Citizen 1960) and a facility suitable for recreation by children with disabilities (Asheville Citizen 1959b). The Deer Lake Enterprises organization that had purchased the property in 1959 was dissolved in mid-1966 (Asheville Citizen 1966a). The property was then purchased by the U.S. Department of Agriculture Forest Service several months later (Asheville Citizen 1966b). In 1971, one of the first national programs for environmental education, the Cooperative Environmental Education Program (CEEP), jointly sponsored by the Forest Service, Western Carolina University, and a group of county public school systems, was established at Deer Lake (Slater 1971). The CEEP was notable in that it initially received a large grant from the North Carolina Department of Public Instruction [which funded an environmental lecturer and supervisor (Asheville Citizen 1975)] and obtained support later from the National Endowment for the Arts (Hutchison 1976). The CEEP was terminated in late 1977 when the Deer Lake earthen dam was breached by flooding from an intense storm in November (Asheville Citizen 1977, Neary and others 1986). Without maintenance, the unoccupied 2,300-square-foot Deer Lake Lodge deteriorated and presented a hazard to curious recreational visitors. After salvage of the American chestnut (*Castanea dentata*) siding and other materials, the lodge was deconstructed in 2001 (USDA Forest Service 2001).

## APPENDIX I
## Data Availability

Field and interview data from this recreation study are available for public access as multiple files stored in nonproprietary digital formats using American Standard Code for Information Interchange (ASCII) characters. File and variable descriptions are stored as TXT (text) formatted files; numerical and text field data are stored in a table-structured format as CSV (comma separated values) formatted files. Data are archived on the U.S. Department of Agriculture Forest Service, Southern Research Station website, and available for download at: https://doi.org/10.2737/RDS-2022-0049.

## APPENDIX J
## Statistical Significance

The terms significant and not significant describe the binary qualitative result of a quantitative statistical test used to evaluate the probability that the averages of samples from two or more groups are part of either the same or a different population. Consider, for example, the question: did the rate of vehicles entering Bent Creek Experimental Forest (BCEF) differ between sessions one and two? The two average values (26.54 and 29.20 vehicles per hour for sessions one and two, respectively) may not be a valid comparison using only averages because fewer samples were collected for session one (n = 108) compared to session two (n = 154). A t-test considers the number of samples and variation in values of the samples when comparing averages of two groups. Depending on the number and variation of individual sample

values for each group, results of the t-test are declared either statistically significant or not significant. A significant result does not imply the size of the difference between the two group averages is either large or perhaps considered as important. Rather, statistical significance provides a measure of probability that the difference between the two averages likely did not occur by chance or luck. Significance is usually evaluated at the 5 percent level of probability ($P = 0.05$), meaning that if the study was repeated 100 times, an incorrect conclusion could occur on five occasions. Significance can also be evaluated at the $P = 1$ percent level of probability ($P = 0.01$) to provide a higher level of confidence that the same results would occur if the study were repeated. For this study, tests were considered significant if $P < 0.05$. Answering the above question, unless a 1 in 20 chance situation has occurred, a calculated $P$-value of 0.25 suggests there is likely no difference in the rate of vehicles entering BCEF between sessions one and two. Alternatively, if the difference of 2.66 vehicles per hour had been declared significant (say $P = 0.02$) by the statistical test, a logical explanation could be proposed such as lower fuel costs (and increased travel) during session two, or perhaps weather conditions were considerably different between the two sessions.

# APPENDIX K
# Confidence Interval

The confidence interval (CI) of a sample average defines the range of values that should include the true average with a specified level of confidence. For example, during the first session of the study, the number of visits to Bent Creek Experimental Forest (BCEF) was estimated as 143,610 with a 95-percent CI of ±21,146 visits. Therefore, unless a one-in-twenty chance situation occurred during session one, perhaps associated with an unusual weather event, we presumed with 95-percent confidence that the true population average was between 122,464 visits and 164,756 visits. For session two, the average number of recreation visits was estimated as 147,529. Because this second estimate of the annual number of people visiting BCEF is within the confidence limits of the first estimate (122,464–164,756), it can be concluded with a moderate level of confidence that there is little evidence of a real difference between these two estimates of the true number of annual visitors to BCEF. Because estimation of CI depends on the number of samples taken, a better estimate of the true average could be obtained by combining the estimates for sessions one and two. Also, if greater certainty is desired about the true average of visits, the CI can be estimated based on the 99-percent level of confidence. Confidence intervals provide a quick method of comparing group averages to evaluate if the difference is likely significant. Usually (but not always) overlapping CI suggest no real difference is present between two groups.

# APPENDIX L
# Economic Analysis

The economic analysis of the visitor survey was based on the cost of consumer goods and services in June 2006, near the midpoint of the study. The 2006 costs were updated to April 2023 after the COVID-19 pandemic in the United States (Guan and others 2020), using the Consumer Price Index calculator (U.S. Department of Labor, Bureau of Labor Statistics 2021). The access value per trip (table 2) is defined as the sum of costs expended by a visitor to utilize a site. It provides a method of placing an economic value on a public facility, such as a recreation area (Brown and Mendelsohn 1984). The travel cost method (TCM, table 2) is a method used to model the average individual net economic value of accessing and utilizing a recreation site (Bowker and others 2007). The TCM depends on establishing a relationship between travel costs and the number of trips.

**McNab, W.H. ; O'Shields, J.K.; Bowker, J.M.; Zarnoch, S.J. 2023.** Estimating recreation use in Bent Creek Experimental Forest. Res. Pap. SRS-67. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 47 p. https://doi.org/10.2737/SRS-RP-67.

Dispersed recreation is an important use of national forests, including in experimental forests where long-term research is conducted to evaluate effects of environment and disturbances on ecosystems. Recreation has markedly increased in Bent Creek Experimental Forest since it was established in 1925. The objective of this investigation was to quantify visitors, their activities, and associated vehicular traffic to provide a baseline for evaluating the effects of recreation on the experimental forest environment and to identify potential research opportunities. In a core study conducted from 2005 to 2007, one person in each of 4,170 vehicles entering the experimental forest was interviewed to determine visitor numbers and intended recreational activities. A followup telephone subsample of 1,106 interviewed visitors was conducted to determine their demographics and travel expenses. Visitation averaged 145,570 people annually. The predominant recreation activities were hiking and bicycling. A typical visitor was a white male between 26 and 40 years of age with a bachelor's degree, who had travelled less than 10 miles oneway. Average cost per visit was between $18 and $36. Vehicle occupancy averaged 157 people and 24 pet dogs per 100 vehicles. Significant temporal influences affecting the rate of hourly traffic volume included season of year, day of week and time of day, but not whether the day was a holiday. Vehicle traffic was reduced in fall when deer hunting was permitted. Study results suggest that the large population of visitors using the experimental forest offers opportunities for social science research on ecosystem disturbances related to recreation. Data from this study were archived and are available for further use.

**Keywords:** Dispersed recreation, economic analysis, pet dogs, recreation survey, temporal sampling strata, traffic trends, vehicle counts.

**PHOTO CREDITS**

Unless otherwise noted, all photographs, maps, or other reproduced materials are from public domain materials produced by the U.S. Department of Agriculture Forest Service.

All **cover photos** courtesy of AdobeStock except fourth from left, top row and third from left, bottom row, which are coutesy of the U.S. Department of Agriculture Forest Service.

**PRODUCT DISCLAIMER**

The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

**September 2023**
https://doi.org/10.2737/SRS-RP-67

Forest Service
Research & Development
Southern Research Station
**Research Paper SRS-67**

Southern Research Station
200 W.T. Weaver Blvd.
Asheville, NC 28804
www.srs.fs.usda.gov