Chapter 12

Recreational Values and Campsites in the Colorado River Ecosystem

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Introduction

Grand Canyon National Park is one of the best-known wildland preserves in the world. Its designation as a national park in 1919 sought to protect it for the benefit of human visitors as well as to safeguard the physical, biological, and cultural resources contained within its borders. Interest in recreation on the Colorado River has risen dramatically since the mid-1960s, and a 226-mi (364 km) journey through Grand Canyon by boat is now regarded as one of the world's premier wild-river experiences. Recreational use of the Colorado River corridor through Grand Canyon is closely regulated by the National Park Service (NPS), and demand for the corridor, particularly for river trips, greatly exceeds availability.

Beginning with the initial explorations of John Wesley Powell in 1869, river runners and hikers have used sandbars along the Colorado River below present-day Glen Canyon Dam as campsites. These camps, and their associated activities, make up an important element of the modern-day recreational experience within Glen and Grand Canyons. Because of their crucial role, the relative size, distribution, and quality of campsites along the Colorado River are of particular concern to river managers (Bureau of Reclamation, 1995; Stewart and others, 2000; Glen Canyon Dam Adaptive Management Program, 2001; National Park Service, 2004).

This chapter presents an assessment of the current state of knowledge concerning the impacts of Glen Canyon Dam operations on the changing condition of campsite areas and sandbars and the implications of physical changes of the Grand Canyon ecosystem for visitor capacity and quality of experience. After defining the study area and some key concepts, the chapter briefly reviews the relationships between the condition and extent of Colorado River sandbars and the quality of the visitor recreation experience. An overview of historical status and trends of the number and size of campsites along the Colorado River is followed by a summary of recent findings. Discussion focuses on the effects of the modified low fluctuating flow (MLFF) alternative and high-volume experimental flows on campsite area. The chapter concludes with an evaluation of these results relative to the stated recreation goals and management objectives of the Glen Canyon Dam Adaptive Management Program (GCDAMP).

Background

The Colorado River flows approximately 293 RM from Glen Canyon Dam to the Grand Wash Cliffs, the physical feature that marks the western boundary of Grand Canyon National Park. The focus in this chapter is on the portion of the river from Lees Ferry to Diamond Creek (RM 0–226), even though recreational use of the river corridor extends another 50 mi (80 km) downstream to Lake Mead. Lees Ferry is the launching point for river trips through Grand Canyon, and Diamond Creek, on the Hualapai Indian Reservation, is the typical takeout point.

Geomorphic Characteristics of Campsites

Debris fans are sloping deposits of boulders, gravel, and sand that form at the mouth of a tributary as the result of flash flood events that constrict the main channel and increase the local bed elevation of the river (Schmidt and Graf, 1990). At most constrictions, recirculation zones or eddies (currents of water moving against the main current in a circular pattern) are formed in the river, and because of lower flow velocities, sand is deposited within eddies. Flow patterns within an eddy define the configuration of sand that is deposited (Schmidt and Graf, 1990). Typically, eddies contain a primary recirculating zone and often have secondary zones of separated flow where the current rotates in the opposite direction of the primary zone or is virtually stagnant. Sand deposits are classified based upon where they are deposited in relation to the primary and secondary recirculating patterns. Two types of deposits are the highest in elevation and are most typically associated with campsites: separation deposits and reattachment deposits. Separation deposits mantle the downstream part of the debris fan near the point where the main current separates to form the eddy. Reattachment deposits are located at the downstream end of the primary recirculating zone where the main-channel current reattaches to the bank.

Channel-margin deposits are not associated with tributary debris fans and occur along the channel banks. These deposits form within small eddies associated with bank irregularities caused by talus and rock outcropping. A small number of these channel margin deposits are used as campsites. Within some reaches of the corridor, flat-lying units of rock crop out along the river, and the ledges are also used as campsites.

Visitor Capacity and Wilderness Experience

In the context of recreation, carrying capacity is now referred to as “visitor capacity,” defined recently as “. . . a prescribed number and type of people that an area will accommodate, given the desired natural/cultural resource conditions, visitor experiences, and management program” (Haas, 2001). Ecological aspects of visitor capacity usually relate to cumulative ecological impacts, but in places such as Colorado River campsites, actual physical space available, impacted or not, is also a critical factor. These categories have been referred to as “ecological” capacity (e.g., plant, animal, and soil impacts) and “physical” capacity (e.g., people per unit area of flat sleeping area; camping parties per beach) (Shelby and Heberlein, 1986). This distinction is useful for understanding visitor capacity for the Colorado River, where both physical space available and resource impacts are important management considerations.

In addition to resource protection, primary objectives for recreation management include minimizing impacts on, enhancing, and preserving the quality of recreation experiences. Experience quality is complex and affected by an array of factors, some of which are social rather than ecological or physical, so visitor capacity also has a “social” component. Social variables that affect experience quality include the number of people visible at one time in a given area and the number of encounters of one group with other parties or with groups of a particular type or size (Shelby and Heberlein, 1986). Resource protection will always be a primary concern in highly sensitive areas, such as desert riparian zones, where even moderate human activity may cause significant ecological impacts, and in settings where heavy use produces damage. Thus, in ecologically sensitive areas, visitor capacity is limited by the need to protect resources. For a broad range of less sensitive areas, however, social variables that affect recreation experience quality may limit visitor capacity at levels below those at which unacceptable resource impacts occur.

On the Colorado River in Grand Canyon, legal guidelines call for not only resource protection and a quality recreational experience but also an undeveloped, uncrowded, wilderness-type experience. It is clear that on the Colorado River, outstanding opportunities for wilderness experiences are indeed a key factor in the river’s popularity and something that the general public has come to expect when visiting Grand Canyon. This popularity was confirmed during the initial phase of river recreation research in the 1970s (Shelby, 1976) and in subsequent studies (Bishop and others, 1987; Hall and Shelby, 2000).

The National Park Service has explicitly expressed an intention to manage for wilderness-type experiences for Colorado River visitors within Grand Canyon National Park (National Park Service, 1995, p. 11). In addition to the opportunity to experience natural ecological conditions, one of the most important attributes of a wilderness experience is solitude (Hendee and others, 1990). Because the operation of Glen Canyon Dam has eroded sandbars used for camping and has reduced the sand available for maintaining them (see chapter 1, this report), the area available for camping in the river corridor has declined significantly since construction of Glen Canyon Dam in 1963 (Kearsley and others, 1994; Kaplinski and others, 2005). The decrease in campsite area can affect solitude by increasing the level of crowding along the corridor. Crowding reduces the ability of separate river trips to camp out of sight and hearing of one another and also reduces the ability of individuals or small groups within a particular trip to camp out of sight and hearing of one another.

Because tracking changes in recreation resources and experience quality means identifying quantifiable parameters, campsite area has emerged as the preferred parameter for measuring these attributes for recreational monitoring programs in Grand Canyon. Campsite area is not the only factor in Colorado River recreation that affects experience quality, but it is a readily measurable factor that has arguably changed more than any other facet of the river experience in the past 40 yr.

Status and Trends

Studies of campsite area have been conducted by Weeden and others (1975), Brian and Thomas (1984), Kearsley and Warren (1993), Kearsley and others (1994), Kearsley (1995), and Kearsley and Quartaroli (1997). These studies evolved from qualitative estimates of campsite carrying capacity to quantitative aerial photographic measurements. Weeden and others (1975) and Brian and Thomas (1984) focused on developing an inventory of the size and number of campsites throughout the river corridor. Both of these studies estimated the capacity of each site with dam releases above the 24,000–28,000 cubic feet per second (cfs) stage elevation, with capacity defined as the number of campers that could occupy a campsite for an overnight stay. Researchers have focused on high-elevation campsites because summer demand for energy produces medium to high releases. As a result, lower sandbar elevations are inundated during the height of the commercial rafting season (mid-May through mid-September) and therefore are not available for camping during the time of year when campsites are in highest demand. Kearsley and Warren (1993) repeated the inventory and improved the campsite area measurements by developing techniques to quantitatively measure camp area from aerial photography and videography. Subsequent studies by Kearsley and others (1994), Kearsley (1995), and Kearsley and Quartaroli (1997) improved upon the aerial photographic mapping by using geographic information system software.

Kearsley and Warren (1993) studied camps between Lees Ferry and Diamond Creek and divided them into critical and noncritical reaches. A critical reach was defined as any contiguous stretch of the river in which the number of available campsites is limited because of geologic characteristics, high demand, or other logistical factors. Noncritical reaches were defined as any stretch of the river in which campsites are plentiful and little competition for the majority of sites occurs. These reach definitions closely parallel the geomorphic reach definitions of Schmidt and Graf (1990).

Kearsley and Warren (1993) found that campsites had decreased dramatically in both number and size since Weeden's team completed its initial survey in 1973. Reaches designated as critical because of limited availability of suitable campsites by Kearsley and Warren (1993) (Marble Canyon, RM 11–40.8; upper Granite Gorge, RM 76.5–116; and Muav Gorge, RM 139–164) are nearly the same as the critical sections identified by Weeden and others (1975). Campable area decreased primarily because of erosion in critical reaches; in noncritical reaches, decrease in campsite area was primarily the result of vegetation encroachment (Kearsley and Warren, 1993). An overall trend of increased campsite size and number between 1973 and 1983 was attributed to the high releases in 1983 needed to keep Lake Powell from spilling over Glen Canyon Dam. The 1983 high releases forced sand from the river channel onto sandbars, but the change was temporary; sandbars significantly decreased in size and number less than 1 yr later. Moreover, campsites in the upper Marble Gorge and upper Granite Gorge decreased between 1973 and 1983 and between 1983 and 1991. The inventory documented 226 campsites above 25,000 cfs, which represented a 32% decrease in the number of campsites between 1973 and 1991. The inventory also found a 51% decrease in large camps, resulting in a 44% decrease in campsite area between 1973 and 1991. Campsite area decreased an average of 9% between 1991 and 1994, with disproportionately larger decreases at camps in critical reaches

(Kearsley, 1995). River-induced changes accounted for 80% of lost campsite area above the Little Colorado River and 32% of loss below the Little Colorado River confluence.

Kearsley and others (1994) concluded that loss of Colorado River campsites was an ongoing process that was initiated with the installation of Glen Canyon Dam more than 30 yr ago and that the rate of decline had slowed over time. The overall pattern of change was one of initial systemwide decrease in sites (1965–73), variable change during years of regulated high flows because of high levels of precipitation (1983–86), and a systemwide decrease in campsites between 1984 and the mid-1990s. They noted that not all sandbars in Grand Canyon respond in the same manner to high flows, fluctuating flows, or vegetation encroachment and that campsite availability in critical reaches had decreased the most.

To monitor changes in campsite availability resulting from the 1996 beach/habitat-building flow, 53 camping sandbars were randomly selected from the 218 remaining from the 1991 inventory by Kearsley and Warren (1993). The sites were physically measured 2 weeks before, 2 weeks after, and 6 mo after the 7-d, 45,000-cfs experimental flow (Kearsley and Quartaroli, 1997). Float-by assessments were made of 200 sandbars, including the 53 that were also measured. Results showed a systemwide increase in campsite area. Half (100/200) of the sites assessed were at least 10% larger, 39% (77/200) were the same, and 12% (23/200) were smaller than before the experimental flow. For 53 sites directly measured, 62% (33/53) increased in size, 17% (9/53) were the same, and 21% (11/53) decreased in area. Float-by assessments were less sensitive to measuring change but not biased toward increase or decrease. At many sites, sand was deposited directly on top of existing campable areas and did not increase campsite area. At some sites, new sand was deposited as a mound over previously usable space, and the increase in slope angle resulted in decreased camping area.

Eighty-two new sites were created, in the sense that these sites were not usable just before the 1996 beach/habitat-building flow. Although 33 of these "new" sites were included in previous campsite inventories, all had degraded to being unusable by the time of the experiment. Many new sites consisted of deposition on low-elevation sandbars with little sun or wind protection. These sandbars were theoretically usable but not highly valued as camps and were subject to rapid erosion. Forty of the new sites were between RM 40 and RM 65. More than twice as many sites were created in noncritical reaches than in critical reaches. Six months after the beach/habitat-building flow, only 55% (45/82) of the new sites were still considered usable. The high flow obliterated three previously inventoried campsites. Overall, the 1996 beach/habitat-building flow increased the number, size, capacity, and aesthetic qualities of campsites. These benefits were substantial, but degradation occurred quickly: within 6 mo, nearly half of the new campsites were unusable, remaining new sites were half their initial size, and most of the increased area on measured established sites had eroded. Relatively high-flow releases immediately following the 1996 beach/habitat-building flow in late 1996 and 1997 probably exacerbated erosion.

Recent Monitoring

Following the Record of Decision in 1996 (U.S. Department of the Interior, 1996) and the establishment of the Glen Canyon Dam Adaptive Management Program, a new campsite monitoring program was initiated by the U.S. Geological Survey's Grand Canyon Monitoring and Research Center. The following discussion focuses on the results of 6 yr of campsite area monitoring beginning in 1998 and ending in 2003 (Kaplinski and others, 2005).

Monitoring Objectives and Methods

The 1998–2003 campsite area monitoring program focused on describing changes in the size of camping areas in the Colorado River corridor. Monitoring included annually measuring campsite area at a series of long-term monitoring sites and evaluating the changes in campsite area among years and as the result of different dam releases.

Annual surveys were conducted every October from 1998 through 2003 by crews from Northern Arizona University's Department of Geology to quantify campsite area change. Surveys at the selected study sites were conducted by using standard total station survey techniques (U.S. Army Corps of Engineers, 1994). The surveyors adopted the criteria of Kearsley (1995) and Kearsley and Quartaroli (1997) to identify campable area. Campable area was defined as a smooth substrate, preferably sand, with no more than 8° of slope and with little or no vegetation. Not all campable areas were mapped at every site. Instead, representative camp spots were selected across a range of stage elevations. Camping areas not represented in the mapping were typically far (>328 ft (>100 m)) from the main mooring/cooking areas.

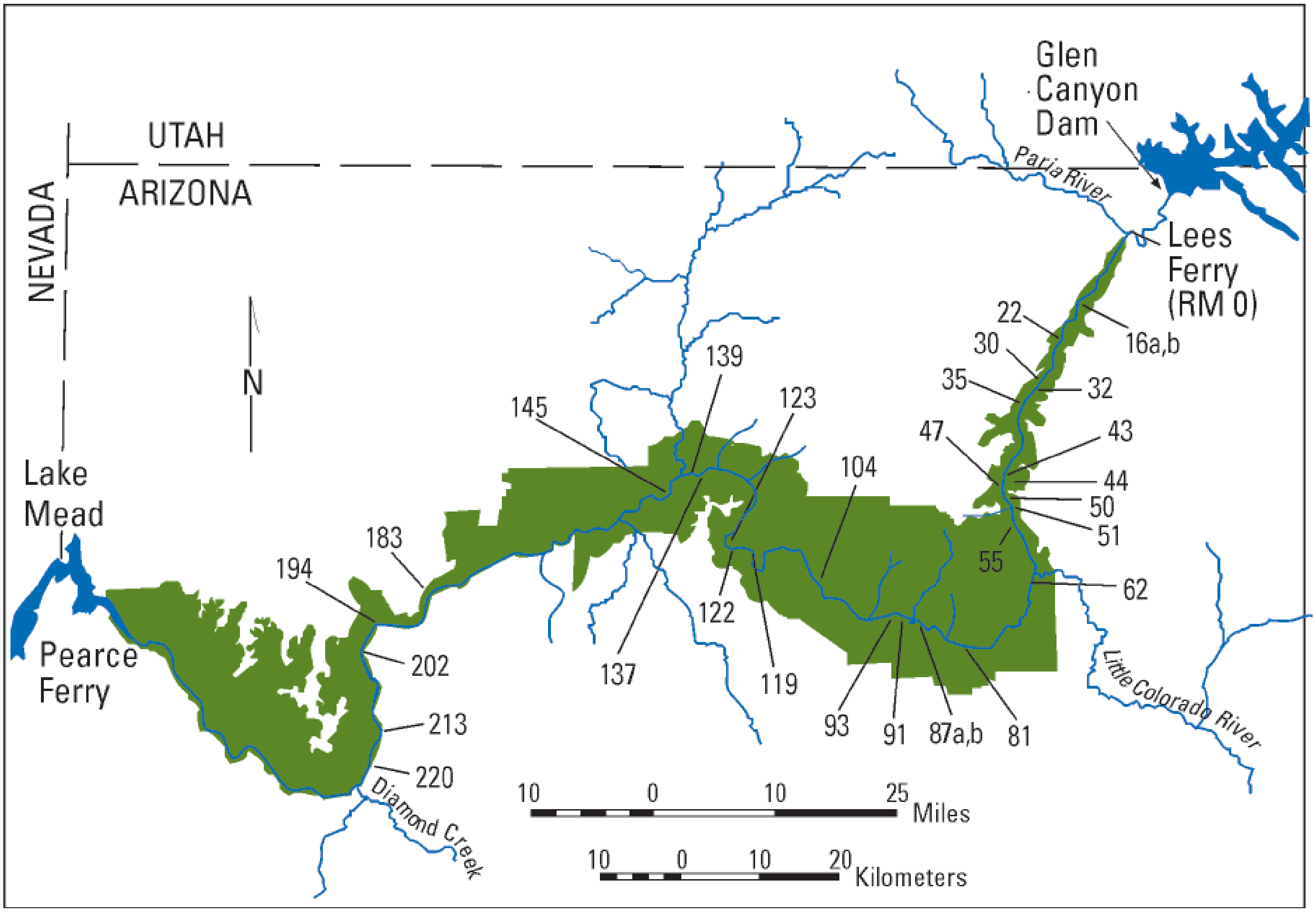


Figure 1. The Colorado River corridor below Glen Canyon Dam and locations of 31 study sites from the 1998–2003 campsite area monitoring program. The shaded area represents Grand Canyon National Park. Study site locations are noted by river mileage.

Study Sites

The study sites are located throughout the Colorado River corridor between Lees Ferry and Diamond Creek (fig. 1) and were selected to coincide with a subset of the long-term study sites used by the Northern Arizona University sandbar monitoring project, which monitors change in sandbar area and volume (Beus and others, 1992; Kaplinski and others, 1995, 1998; Hazel and others, 1999, 2001, 2002). These sites were originally selected on the basis of (1) distribution throughout the geomorphic reaches, (2) size sufficient to guarantee persistence through the period of study, (3) geomorphic diversity within and between sites, (4) availability of historical data, and (5) variation in recreational use intensity and vegetation cover (Beus and others, 1992). Given these criteria, only a subset of the sandbar monitoring sites could be used to monitor campsite areas. These sites, although not chosen randomly, have proven to be representative of systemwide changes in terms of changes in sand volume and area at campsites located above high normal flows (above 20,000 cfs) (Schmidt and others, 2004). Therefore, it is reasonable to assume that changes to campsite areas at these sites are also representative of changes to campsite area systemwide.

The study began with 31 study sites. In 2002, 6 sites were added, for a total of 37 sites. Only the original 31 sites, which have been measured since 1998, were used to summarize the campsite areas, while all sites were used to calculate average percent change between years. Sixteen of these sites are located in Marble Canyon between the Paria River and the Little Colorado River confluence, and 21 are located in Grand Canyon below the Little Colorado confluence. There are 18 sites within critical reaches as defined by Kearsley and Warren (1993), and 19 are in noncritical reaches.

Dam Releases Before and During the Study Period

Dam releases during the 1998–2003 study period included normal modified low fluctuating flow (MLFF) operations, plus a low summer steady flow (LSSF) experiment during 2000, the habitat maintenance flows (HMF) in May 2000 and September 2000, and fluctuating nonnative fish suppression flows from January to March in 2002 and 2003 (fig. 2). Normal MLFF dam releases fluctuate diurnally and seasonally, based on power demand and water-delivery schedules. Typically, flow releases are higher in winter and summer months and lower during spring and fall months. In 1998 and 1999, daily mean flow releases ranged from an average of approximately 19,400 cfs in high-volume months to approximately 12,400 cfs in low-volume months. The LSSF experiment in 2000 consisted of two high-flow releases in spring and fall and a period of low steady (no diurnal fluctuation) flow during summer. The low steady flow during summer was lowered to a constant 8,000 cfs. The high flows were short-duration (4 d) dam releases of 31,000 cfs. These were the only two flows large enough to reach above the 25,000-cfs stage elevation, or the upper limit for nonexperimental MLFF operation releases, during the study period.

River flow levels during the 1998 and 1999 survey trips fluctuated from 10,000 to 18,000 cfs. Therefore, surveyors were only able to measure camp areas consistently at every site above the 15,000-cfs stage elevation. Subsequent analysis of campsite area below 25,000-cfs stage elevation excluded the measurements made during 1998 and 1999. During the 2000 to 2003 surveys, low-volume releases allowed measurement of camp area above the 10,000-cfs stage elevations at some sites and above 15,000-cfs stage elevation at all sites. Fluctuating nonnative fish suppression flows were conducted from January through March in 2002 and 2003. During these experiments the flows fluctuated from 5,000 to 20,000 cfs. Comparison of camp area change between surveys was conducted by using area measured only above the 25,000-cfs stage elevation.

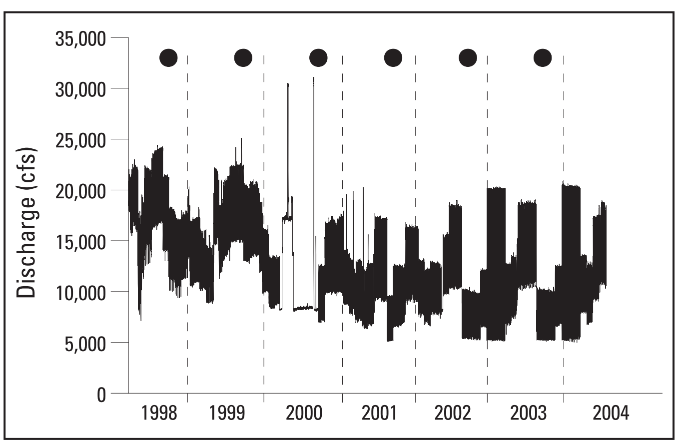


Figure 2. Daily mean discharge hydrograph from the USGS gaging station on the Colorado River near Lees Ferry during the period of study. Note the daily and seasonal fluctuations in flow volume during 1998 and 1999 and during the low summer steady flow experiment in 2000 that included two high-flow events.

Findings

Recent analysis of the 1998–2003 monitoring results by Kaplinski and others (2005) demonstrated that the total camp area above the 25,000-cfs stage elevation significantly decreased during the study period (fig. 3). Total campsite area changes were derived by summing all of the campsite area measurements in a particular reach. Between 1998 and 2003, the total campsite area decreased by 55%. The average decrease was 15% between each survey (fig. 3).

Longitudinal changes were examined by comparing the total campsite area above and below the Little Colorado River (LCR) confluence (fig. 4). In the following discussion, the term Marble Canyon refers to sites above the LCR, while the term Grand Canyon refers to sites below the LCR. Campsite areas in Marble Canyon and Grand Canyon decreased at a similar rate and showed an overall loss of 57% and 53%, respectively. There was a longitudinal difference in the response to the powerplant capacity flows conducted as part of the 2000 LSSF experiment. Camp area in Grand Canyon increased slightly (4%) following the high flows of the LSSF experiment, while campsites in Marble Canyon decreased by 24%. Area increases in Grand Canyon camps are possibly related to greater deposition downstream of the LCR where the sediment supply is presumably greater.

The pattern of campsite area change was different in critical and noncritical reaches (fig. 5). Total campsite area within critical reaches decreased by 37% during the study period for an average decrease of 8% per year. In noncritical reaches the change was greater, with a total decrease of 63% and an average decrease of 18% per year. Campsite area increased slightly in the critical reaches (7%) following the LSSF experiment, whereas sites in noncritical reaches decreased by 18%. Critical reaches are generally narrower than noncritical reaches, and the campsites tend to be smaller and less vegetated

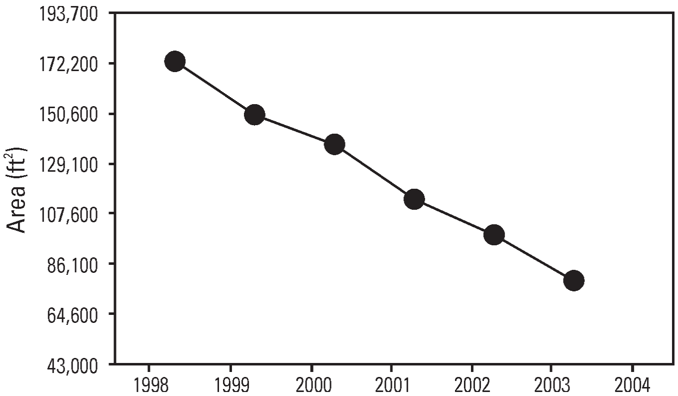


Figure 3. Total camp area above the 25,000-cfs stage elevation.

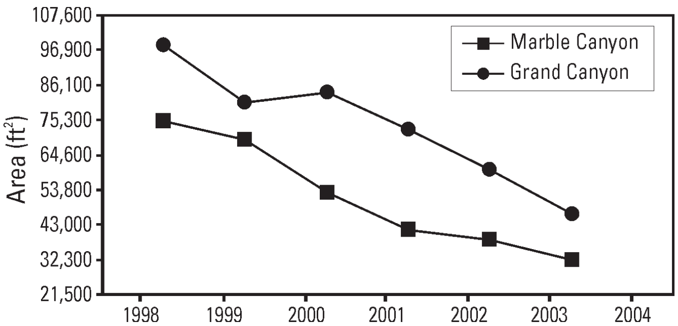


Figure 4. Total camp area above the 25,000-cfs stage elevation in Marble and Grand Canyons.

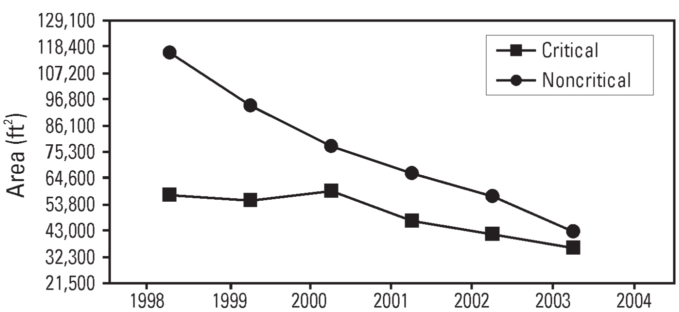


Figure 5. Total camp area above the 25,000-cfs stage elevation in critical and noncritical reaches.

because the steep bedrock channels provide little space for sediment deposition.

Campsite area exists across the entire range of normal Glen Canyon Dam releases (5,000 to 25,000 cfs), and the amount of camp area available is greatly dependent on flow levels. Some GCDAMP management objectives are specifically concerned with measuring sandbar area and volume between the 5,000-cfs and 25,000-cfs stage elevation, as well as above the 25,000-cfs stage elevation. In the most recent monitoring study, surveyors measured all campsite areas exposed at the time of the visit, allowing campsite area changes to be divided between discrete ranges of stage elevation (fig. 6).

High-elevation campsite area (above 25,000 cfs) has progressively decreased during the study period, with the exception of a short-lived increase within the 25,000-cfs to 30,000-cfs range following the LSSF experiment. Repeat surveys after 2000 showed that this slight increase in campsite area decreased to levels equivalent to those measured in 1998.

Camp area at lower elevations has increased because of the deposition from high-flow events associated with the LSSF experiment in 2000, the fluctuating nonnative fish suppression flows from January to March 2003, and medium- to high-volume (10,000 to 25,000 cfs) summer dam operations. In fact, the amount of campsite area available at lower elevations is now greater than that available at higher elevations (fig. 7). Since the lower elevation areas are within the zone of flow fluctuation, these increases may not persist because lower elevation sandbars are more susceptible to bank erosion than sand at higher elevations (Hazel and others, 1999).

Campsite area and sandbar volume both decreased during the study period; however, campsite area decreased at a greater rate than did sandbar volume (fig. 8), which indicates that other factors contributed to the

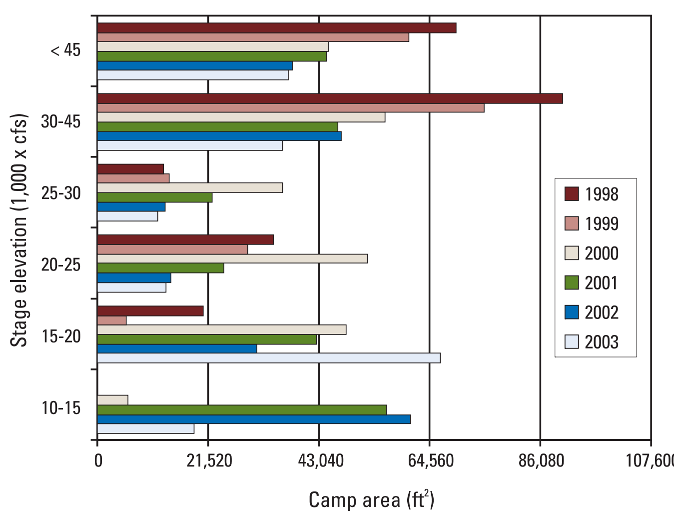


Figure 6. Distribution of total campsite area above the 25,000-cfs stage elevation in three different stage ranges.

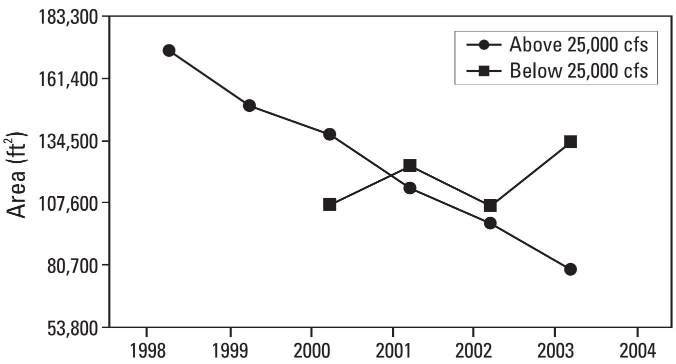


Figure 7. Total campsite area above and below the 25,000-cfs stage elevation.

loss of high-elevation campsite area. These factors presumably include vegetation growth, surface water runoff, aeolian processes (wind-caused sediment movement), and human impact.

Although not quantitatively addressed in this study, visual observations and photographic documentation compiled by the Grand Canyon River Guides, Inc., Adopt-a-Beach Program during the same period (1998–2003) indicate that, excluding sandbar erosion, vegetation growth contributes most significantly to the loss of high-elevation campsite area (Thompson and others, 1997; O'Brien and others, 1999, 2000; Thompson, 2001, 2002). Unfortunately, a direct comparison of campsite area change and vegetation colonization during the 1998–2003 study period was not possible because of the incompatibility of vegetation monitoring protocols (M. Kearsley, Northern Arizona University, oral commun., 2004). Kaplinski and others (2005) recommended that, in the future, vegetation coverage changes at campsites should be tracked by using remotely sensed aerial imagery to provide a quantified assessment of the role of vegetation in reducing total campsite area.

Surface runoff events that significantly decreased campsite area were observed at only three sites during the 6 yr of monitoring. Human impacts were generally minimal, except at locations where vegetation pruning and removal had increased or maintained campsite areas. Aeolian reworking of sandbars did not appear to be a significant factor in affecting campsite area because of the amount of vegetation established along higher elevation sandbar areas.

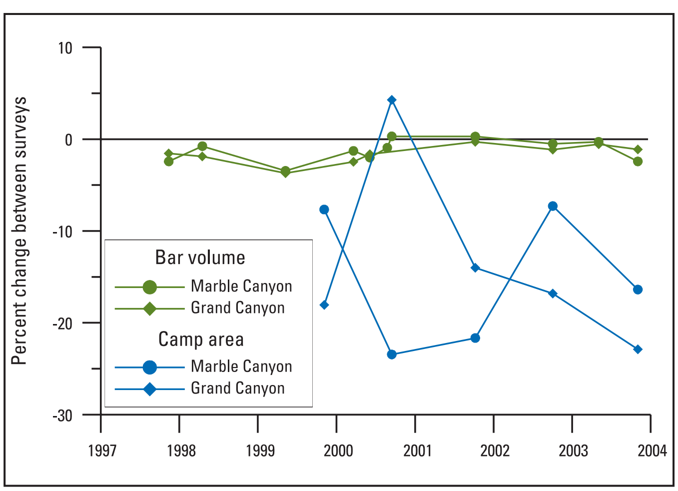


Figure 8. Percent change between surveys of sandbar volume and campsite area in Marble and Grand Canyons.

Discussion and Conclusions

Campsites within the Colorado River ecosystem exist primarily on sandbars. The size and capacity of camping area are directly related to the areal extent of sandbars and the amount of vegetation colonizing the sandbars (Kearsley and others, 1994). Previous studies by Kearsley and Warren (1993) and Kearsley and others (1994) established that substantial losses in open areas used for camping had occurred because of sandbar erosion and colonization by vegetation. Although both erosion and vegetation reduce campsite area, the processes and their effects are not identical.

Erosion of sandbars is caused primarily by operations of Glen Canyon Dam. The magnitude of daily fluctuations, the ramping rates, and the increased ability of clearwater releases to transport sediment have all been identified as contributing factors (Beus and others, 1992; Rubin and others, 2002).

Vegetation encroachment is leading to higher rates of campsite area decrease than can be attributed to erosion alone. Encroachment by nonnative species such as tamarisk (*Tamarix ramosissima*) and camel thorn (*Alhagi maurorum*), as well as by native species such as arrowweed (*Pluchea sericea*) and coyote willow (*Salix exigua*), has led to colonization on previously open sections of sandbars, thus further decreasing campsite area. In some larger and less frequently visited sites, dense patches of vegetation now make the sites essentially unusable for camping activities. Although this process has substantially reduced available space at many campsites, the effects of these changes on visitor capacity are somewhat less clear than when area is lost to erosion. For example, in some frequently used camps, individual sleeping sites are cleared of and kept free of vegetation by constant use. These individual sites are also often separated by vegetation "screens" that may actually serve to reduce the distance that recreationists feel they need to be separated from one another in order to achieve privacy. Additionally, clumps of mature tamarisk trees along steep riverbanks may serve to reduce sandbar erosion by anchoring sediment in place.

Rainfall-induced flash flooding also reduces campsite area. Flash flood impacts were transient before completion of the dam because the effects of tributary erosion were erased every year or two as flood flows from high spring runoff deposited sediment and reworked sandbars. Today, the effects of tributary flash floods are cumulative and tend to be long lasting because periodic high-flow events that are capable of transferring tributary-derived sediment to higher elevations are infrequent.

The monitoring results of Kaplinski and others (2005) showed that between 1998 and 2003 more than half of the available campsite area at the study sites was lost. Camping area above the 25,000-cfs stage elevation decreased by 55% during this 6-yr period, and the average rate of change was 15% per year. The decrease in high elevation campsite area occurred both in Marble Canyon and in Grand Canyon (above and below the LCR) as well as within critical and noncritical reaches. Notably, lower elevation campsite areas increased after 2000, and the total campsite area below the 25,000-cfs stage elevation now exceeds the area available at higher elevations. The rate of decrease in high-elevation campsite area greatly exceeds the decrease in sandbar volume. This difference indicates that other factors—probably vegetation encroachment—have contributed to the recent loss of high-elevation campsite area. Unfortunately, Kaplinski and others (2005) could not undertake a quantitative comparison of campsite area change and vegetation colonization from 1998 to 2003 because the vegetation study is designed to detect systemwide, rather than site-specific, changes in vegetation cover (Mike Kearsley, Northern Arizona University, oral commun., 2004).

In order to construct a longer term view of changes to campsites in Grand Canyon, Kaplinski and others (2005) compiled the percent change between surveys from the campsite inventories conducted by Brian and Thomas (1984), Kearsley and others (1994), and Kearsley and Quartaroli (1997) and combined them with the results from the 1998–2003 campsite monitoring program. Between 1973 and 2003, the only observable periods of increases in either the number of camps or the size of camps occurred after the high flows of 1983–84, which were needed to keep Lake Powell from overtopping Glen Canyon Dam, and the 1996 beach/habitat-building flow, when flows were greater than powerplant capacity. During years between flood events, both before and after the implementation of the 1996 Record of Decision (U.S. Department of the Interior, 1996), sandbars declined in area, volume, and total number.

The campsite monitoring results showed that current operations of Glen Canyon Dam are not meeting the goals of the GCDAMP with respect to the recreational resources of the Colorado River corridor. Specifically, the GCDAMP seeks to "maintain or improve the quality of recreational experiences for users of the Colorado River Ecosystem, within the framework of the GCDAMP ecosystem goals" (Glen Canyon Dam Adaptive Management Program, 2001). With this goal in mind, the Adaptive Management Work Group developed the following management objectives to maintain or improve recreational resources:

1. Maintain or improve the quality and range of recreational opportunities in Glen and Grand Canyons within the capacity of the Colorado River ecosystem to absorb visitor impacts in ways consistent with NPS and tribal river corridor management plans (objective 9.1) (Glen Canyon Dam Adaptive Management Program, 2001).

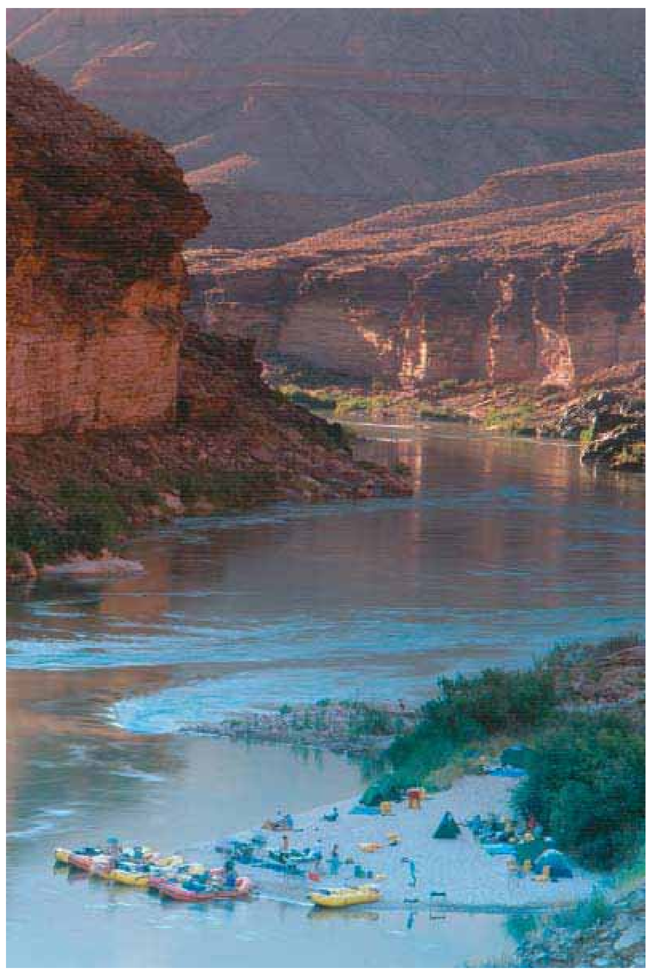
2. Increase the size, quality, and distribution of camping beaches in critical and noncritical reaches in the mainstem within the capacity of the Colorado River ecosystem to absorb visitor impacts in ways consistent with NPS and tribal river corridor management plans (objective 9.3) (Glen Canyon Dam Adaptive Management Program, 2001).

3. Maintain or enhance the wilderness experience in the Colorado River ecosystem in consideration of existing management plans (objective 9.4) (Glen Canyon Dam Adaptive Management Program, 2001).

The significant decrease in campsite area during the study period indicates that the second management objective above (objective 9.3) is not being met. While this study does not explicitly link changes in campsite area to the recreational/wilderness experience in Grand Canyon, the significant decrease in campsite area indicates that other management objectives are possibly not being met. For example, a significant decrease in campsite area may indicate a decrease in the range and quantity of recreational opportunities. Also, because existing campsites are smaller and thus more crowded, the quality of campsites is not being maintained or improved. The decrease in campsite area leads to more crowding and less choice for camps, which can negatively affect the wilderness experience (Hendee and others, 1990). On the other hand, conclusions about the inherently sociological aspects of the river experience based solely on changes to campsite area at a limited number of sites are tenuous. Future research and monitoring should be expanded to include sociological aspects of the recreational experience. In addition, future research should investigate the linkages between the sociological aspects of the recreational experience and physical parameters, such as campsite area, in order to evaluate whether GCDAMP goals are being achieved.

The continued existence of sandbars suitable for camping in the Colorado River ecosystem will depend on periodic high flows to redeposit sediment lost through incremental erosion, scour, and vegetation encroachment; therefore, the continuing availability of campsite area is necessarily linked with the frequency and magnitude of flood events from Glen Canyon Dam. Unless vegetation is physically removed, and provided that enough sediment is available for deposition, high-flow events are the only mechanism by which sandbars used as campsites above the 25,000-cfs stage elevation can be built and maintained.

In order to properly address the management objectives of the GCDAMP, the recreational monitoring program should be expanded to include monitoring and research of both physical and psychological parameters of the river experience. Currently, the program consists only of campsite area measurements at a limited number of sites. This limited amount of information makes a complete assessment of the stated goals and objectives of the program currently impossible. One of the largest gaps in the current knowledge base is a complete, systemwide inventory of campsites in the Colorado River ecosystem in Grand Canyon. Since the last inventory in 1991, significant changes have occurred, and a new measurement of the number and size of camps is essential to evaluate the current state of the resource. O'Brien and Roberts (1999) and Roberts and Bieri (2001) used a modified version of the 1991 campsite inventory to develop a numerical river trip simulator model to predict visitor-use dynamics on the Colorado River. This model has been subsequently used by the NPS to assist in developing a management plan of the river corridor (National Park Service, 2004). Unfortunately, an up-to-date measurement of campsite carrying capacity was not available for the planning efforts. O'Brien and Roberts (1999) and Roberts and Bieri (2001) recommended that a method be developed to convert campsite area measurements to carrying capacity of a site; they suggested addressing this key information need by developing a standardized method of estimating carrying capacity for a beach so that onsite estimates are performed consistently. They also recommended that an interdisciplinary team comprising a statistician, a sociologist, a geologist, and surveyors should be included in order to develop an empirically verifiable and repeatable method of measuring and interpreting the campsite area, location, and abundance in relation to other variables such as trip length, attraction sites, number of people, and social aspects of visitor use. Campsite area measurements clearly indicate that campsite area has declined. How does this measured decline relate to carrying capacity of the river corridor? Does the decline in campsite area relate directly to a decline in the quality of the recreational and wilderness experience? Are these parameters linked and, if so, how? Future research aimed at addressing both the physical parameters and the psychological aspects of recreation along the Colorado River would help answer these types of questions and more clearly assess whether or not the goals and management objectives of the GCDAMP are being achieved.



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