

COLORADO RIVER CAMPSITE INVENTORY

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ABSTRACT.--Shoreline beaches along the Colorado River in the Grand Canyon are regularly used by river-running parties as overnight campsites. The availability of campsites in river sections where they are scarce, small, or both, limits the number and size of river-running parties that can be permitted without risking unacceptable environmental degradation. Because this upper limit depends on the number, size, and distribution along the river of campsites, a comprehensive inventory of usable campsites was needed. We made such an inventory of campsite locations and capacities and found 345 campsites usable for overnight camping by river-running parties.

With the influx of river-running recreationists into undeveloped sections of rivers, the wilderness aspects of these environments may be endangered by overuse. The greatest impact of river-running is in the use of shoreline beaches for overnight camping. Beaches on many sections of western rivers are not continuous, as on a seashore, but are discrete entities and limited in number. Visitor carrying capacity of a river section for river-running is a function of the number of beaches for campsite use, their locations, and their individual capacities. Therefore, the first phase of a project to assess the overall carrying capacity of the Grand Canyon river-running system was the campsite inventory described here.

The carrying capacity of any single beach is a function of the physical characteristics of the beach, the number of campers, group size, and the frequency and manner of use. By definition, the carrying capacity is the maximum number of camper days per year, or season, for which a beach can be used and not suffer unacceptable degradation under the management and maintenance procedures that are employed. The carrying capacity of a beach may be changed by changing the management or maintenance

practices or by other factors, such as erosion, encroachment by vegetation, or irreversible degradation by overuse.

Campsite capacity, in contrast to carrying capacity, is the number of campers that can occupy a campsite overnight. The campsite capacity for undeveloped sites, although not an absolute number, limits the mean daily carrying capacity and, therefore, is one of the factors determining the carrying capacity of the system.

River-running on the Colorado River in the Grand Canyon region is managed by the Grand Canyon National Park mainly on a concessionaire basis. Use of the River has reached a plateau of about 120,000 passenger-days per year with the limit on passenger-days per concessionaire set by the National Park Service. Nonconcessionaire trips are accommodated but are a minor portion of total use. The river-running parties use the beaches along the river for overnight camping. There has been no campsite development, so all support for camping must be carried by each party. Selection of campsites has been primarily left to the discretion of the trip boatmen. Prior to

this inventory, neither the number of campsites and potential campsites nor their capacities were known; estimates of the number of sites ranged from less than 100 to more than 200.

OBJECTIVES

The primary objective of the project was to determine the carrying capacity for river-running parties on 240 miles of the Colorado River from Lees Ferry, Arizona, to Separation Canyon, by locating campsites and estimating their capacities.

A secondary objective was to collect data on factors that affect the carrying capacity of the river system for river-running parties: (1) the suitability of campsites for camping and related activities, such as bathing, campfires, sanitation disposal, and boat mooring; (2) the status of vegetation on campsites, particularly its potential for encroachment into the campsite; (3) the present and potential influence of wind and water erosion on beaches; and (4) the effects of camping activities on the campsites.

A tertiary objective was to construct a baseline data bank, including aerial photography augmented by ground truth data.

METHODS

Preinventory Preparation

Photointerpretation was begun using U-2 high-altitude photography, furnished by the National Park Service, to gain an initial assessment of the magnitude of the low-level photography photointerpretation task. Low-altitude aerial photography of the river, the shorelines, and beaches was obtained by the Remote Sensing Branch of the USGS (United States Geological Survey) at Prescott, Arizona.

For each mile, beginning at Lees Ferry, a mile mark was made on the appropriate photograph, and the photograph was labeled for easy reference in the field. All potential campsites that could be identified by photointerpretation were annotated on the photographs.

Inventory Field Procedures

General Procedures

Three types of field evaluation were made for each visited site: campsite characteristics; vegetation ecology; and shoreline, beach, and water characteristics. Campsite evaluation included camper capacity estimation, type and stability of the footing, status of the firewood supply, shelter, use, open fire sites, and hazards. Evaluation of the vegetation was limited to that growing in and near the site and emphasized the identification of species, vegetation communities, and the assessment of selected species that can invade campsites. The shoreline and water were evaluated for landing and mooring of river craft and bathing. The beaches were evaluated for slope, erosion, and nature and bearing of the beach material. In addition to the evaluation, notation was made of specific features concerning the campsite. One to four panoramic ground photographs were taken of each campsite.

Progress was tracked continuously using the aerial photographs to make sure sites were not missed. During transit or after a cursory visit, a determination was made whether the site should be evaluated or eliminated from the inventory because of inaccessibility or inadequate camping area. In addition, for those sites to be evaluated by photointerpretation instead of by a visit, landing and mooring characteristics were annotated on the aerial photographs during transit.

Sampling of Beaches

The pretrip photointerpretation yielded more than 400 identifiable potential camping beaches. Because it was not possible to visit all of them, it was decided that beaches in the section from mile 8 to a point to be determined in transit would be visited. The point where this complete sampling would end would be determined by the ability to gain the desired data by a *posteriori* photointerpretation, the rate of progress of the fieldwork, the concentration of beaches, and the degree of proficiency the research team gained in transit.

Complete sampling was done through mile 40. Beaches in the section from mile 40 through 73 were relegated to a *posteriori*

photointerpretation primarily because they were numerous, large, and well exposed on the aerial photographs. About four beaches were visited for a sample in this section.

All potentially acceptable beaches were visited from mile 74 to mile 166. In this section beaches are scarce and small. Thus, they are likely to seriously restrict river-running carrying capacity if you consider only the number of campsites as a factor.

In the section from mile 167 through mile 240, numerous large beaches exist. About 15 beaches were visited in this section and the remainder were analyzed by photointerpretation.

Postinventory Analysis

Reconciliation of Data

All data were cross-checked and compared with the displayed ground photographs, aerial photographs, maps, and other related literature such as river runners' guides. By doing this for each campsite, it was possible to resolve most anomalies, fill in occasional missing data, appropriately name campsites, and record the verified data on a single data form. Subsequently, these encoded data were entered into a computer-accessible disk file and a computer program was prepared to print out the description of each campsite.

RESEARCH PRODUCTS

Four major types of data resulted from the inventory: (1) computer-printed written descriptions in tabular form of each campsite (fig. 1), (2) ground photography, (3) annotated aerial photography, and (4) strip maps.

The Campsite Inventory

The inventory does not include the beaches that were determined to be unsuitable for camping by river-running parties. In order to qualify as a campsite, the camper capacity above the 24,000 ft³/s water level countour had to be 8 or more. That water level was considered to be the minimum safe high-water mark and it was reasonably well-defined by shoreline vegetation and erosion scars. The landing and mooring location had to be within 50 yards of the camping area,

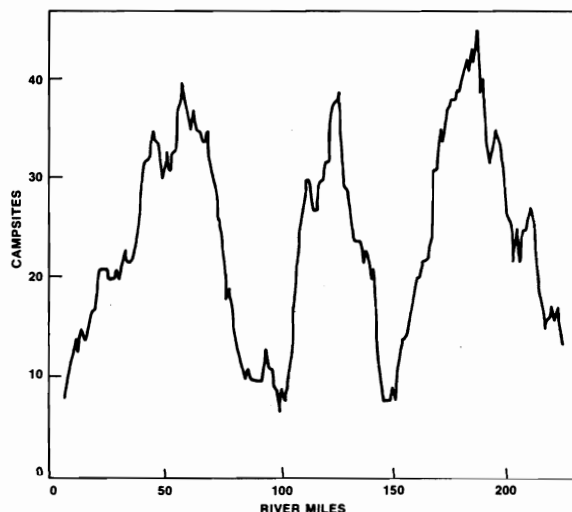


Figure 1.--Campsites with a capacity of 20 or more in 20-mile sections of the Grand Canyon River.

and landing and mooring had to be possible for all types of river-running craft presently in use. Sites that had been overgrown by vegetation or for which the campable area was blocked by a broad, dense band of shoreline vegetation were excluded. Sites that occurred in wash channels from tributary canyons were also excluded.

Campsite Characteristics

Location and name.--Each campsite location is given in miles and tenths from Lees Ferry according to the 1923 USGS. The tenth of a mile means the campsite occurs within that tenth. The L or R symbol indicates the shoreline, left or right, respectively, on which the campsite is located looking downriver.

Campsites that were visited in the survey were named predominantly for significant local features. If no such feature existed, it was named by the mile number rounded off to the nearest half mile.

Type.--Three types of campsites are defined: sand, ledge, and sand-ledge.

Capacity.--The campsite capacity is given as the approximate maximum number of people the campsite can accommodate for an overnight stay. The numbers are reported as 8, 10, 12, 15, 20, 25, 30, 35, and 40, where 40 means 40 or more.

Method of evaluation.--Evaluation was made by either a visit or by interpreting the aerial photographs. Only the capacity could be estimated by photointerpretation and is not as reliable as that obtained by a visit.

Use.--Evaluation of the degree of use was based primarily on evidence of long-term human impacts such as the condition and number of fire sites and the magnitude of vegetation disturbance. The following categories were used: no apparent use of the site for camping, light use, moderate use, and heavy use.

Stability.--Erosion by foot traffic and subsequent wind erosion of such disturbed material occurs in campsites that are located on unstable sand deposits. Such erosion may not degrade the area as a campsite, but it will change its character and cause it to lose its natural appearance and characteristics.

Campsite stability was rated by the following: (1) stable campsite with a flat or gently sloping surface and with a firm bearing, (2) moderately stable campsite with moderate slopes within the general use area and based on loose sand, and (3) unstable campsite with steep slopes within the general use area and based on very loose sand.

Fire sites.--The evaluation of fire sites employed the following categories: no fire sites evident; a single, neat fire site evident; more than one neat fire site evident; and one or more dirty, messy fire sites spread over a wide area.

Firewood.--The evaluation of firewood employed the following classes: none present, a little present, some present, and plentiful.

Shelter.--Shelter was classified as follows: None, some campers could shelter, most campers could shelter, all campers could shelter, and most campers could sleep under shelter.

Hazards.--All of the campsites have hazards that are typical of the wilderness environment of the Colorado River. For those campsites in which unusual hazards were present, but not so dangerous as to disqualify the site for camping, the hazards were identified.

Shoreline, Beach, and Water Characteristics

Landing and mooring.--Landing and mooring evaluations, which apply to rowing as well as motorized craft, were classified as follows: (1) good approach with no off-shore rocks or shallows exposed at low water; (2) adequate approach but requires careful planning and maneuvering for rowing craft due to currents, or mooring requires care because of sharp rocks, off-shore rocks, or shallows; and (3) poor landing approach for any craft, or dangers exist for people or crafts while moored, such as swift shoreline currents or many sharp rocks on and near shore. Potential campsites were disqualified if the landing approach was exceptionally difficult.

Water stage.--Water stage pertains to the hours from 9 p.m. to 6 a.m., the time during which a boatman must tend the moored craft to avoid grounding, etc. Water stage was classified as follows: increasing flow at night, decreasing flow at night, increasing flow to high flow followed by decreasing flow during the night, decreasing flow to low flow followed by increasing flow during the night, and variable flow pattern depending on day of the week and released volume.

Bathing.--Bathing classifications were as follows: safe for bathing with a firm, gently sloping beach, shallow water, and weak currents; adequate for bathing with a steep or soft beach face, rapid off-shore drop, or rocky beach but with only weak currents; and dangerous for bathing due to rapid off-shore drop and swift shoreline currents.

Beach.--Beach characteristics apply to the area between the campsite and low water level. Although beaches are commonly considered to be sandy deposits forming shorelines, rocky shorelines have also been included. These characteristics were composed of three parts as follows: (1) material--coarse to medium sand; fine sands or silts; and rocks composed of exposed bedrock, angular bedrock debris, or rounded river cobbles or boulders; (2) slope--gentle (less than 10°), moderate (10° to 20°), and steep (greater than 20°); and (3) bearing--firm footing and soft footing (feet sink more than 3 inches into deposit).

Erosion.--Erosional conditions were classified as rapid, indeterminate, or none.

Vegetation Characteristics

A number of species are serious invading plants because they encroach into campable areas or beaches and exclude the beach for camping. These were the only ones inventoried and are given with their inventory names: tamarisk (*Tamarix pentandra*), arrowweed (*Pluchea sericea*), camelthorn (*Alhagi camelorum*), coyote willow (*Salix exigua*), Russian thistle (*Salsola Kali* var. *tenuifolia*), and foxtail brome (*Bromus rubens*).

Invading species present.--For each of the species tabulated above that was present in or near the campsite, the corresponding name is given.

Predominant invading species.--If one or more species predominate in ground coverage over all others present, the corresponding names are given.

Invasion assessment.--The invasion assessment categories were defined as follows: the beach has been completely invaded by the species in otherwise campable areas or access to campable areas has been blocked entirely by encroaching vegetation; the species are well established on the beach and are vigorous with regeneration strongly evident, but campable areas have not yet been invaded to exclude camping, although encroachment into camping areas appears imminent; the species are well established on the beach, but exclusion of camping because of vegetation encroachment has not occurred, and the potential for this occurrence cannot be determined; the species are well established on the beach in or around the camping area and camping activity appears to control further encroachment; the species are present on the beach but are not well established and the potential for encroachment into camping areas cannot be determined; and invading species are not present or, if present, are not encroaching into campable areas and do not present any evidence for potential encroachment.

Comments

Local features of interest and river-running considerations, such as the proximity of major rapids and accessibility by hikers, are given.

Cross-Reference Data

Ground photography.--One to four ground photographs were taken of each campsite visited. A caption was made stating pertinent information.

Aerial photography and maps.--Aerial photographs taken just prior to the campsite survey have been annotated showing the location of inventoried campsites by the location conventions used in this inventory. The reference numbers of the aerial photographs on which the campsite is shown are given for each campsite. Strip maps of the river have been annotated showing the mile point down the river from Lees Ferry. The center point for every fifth aerial photograph has been annotated on the strip maps for cross-referencing aerial photographs to river locations and campsite inventory data.

Collection Date

The month and year of data collection are given for each campsite. For expediency, the inventory has already been updated by additional information gathered in conjunction with a followup investigation. In continued updating, the collection date that refers to the last update for a campsite becomes important.

RESULTS

The inventory was conducted to determine the user carrying capacity of the system. The total number of campsites was found to be 354, of which 26 percent had capacities of 8 to 15 campers, 35 percent had capacities of 20 to 35, and 39 percent had capacities of 40 or more campers. Overall, then, smallness of campsites is not a limiting factor for use. The average number of campsites per mile from Lees Ferry to Separation Canyon is 1.48. For campsites with capacities of 20 or more, the average is 1.09 per mile, or 21.9 per 20 miles. Rowing rafts can cover about 20 miles in a day. The average of 21.9 campsites per 20 miles suggests a deceptively large carrying capacity. It does not take into consideration the distribution of campsites, which is extremely nonuniform (fig. 2). The range is from less than 10 to greater than 40 per 20-mile section. The most important feature of the distribution is that three critical stretches exist which will limit the carrying capacity. If rafts cannot travel more than 20 miles per day, the number of campsites in the 20-mile section with the smallest number will set the use limit on the whole system. The three river stretches are all nearly the same in this regard. Besides the influence on carrying capacity, these three stretches will be the most critical for monitoring, maintenance, and scheduling.

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LOCATION -- R 7.9          NAME -- BADGER CREEK

          CAMPSITE CHARACTERISTICS

TYPE -- SANDY           CAPACITY -- 40
EVAL. METHOD -- VISITED  USE -- MODERATE
STABILITY -- STABLE     FIRE SITES -- MORE THAN ONE, NEAT
FIREWOOD -- PLENTIFUL  HAZARDS -- NONE
SHELTER -- NONE

          SHOPLINE, BEACH, AND WATER CHARACTERISTICS

LANDING & MOORING -- GOOD    WATER STAGE -- DECREASING
BATHING -- ADEQUATE         BEACH MATERIAL -- COARSE
BEACH SLOPE -- MODERATE     BEACH BEARING -- FIRM
EROSION -- RAPID

          VEGETATIVE CHARACTERISTICS

INVADING SPECIES PRESENT -- RUSSIAN THISTLE, COYOTE WILLOW,
                          ARROWWEED, TAMARISK
PREDOMINANT INVADING SPECIES -- RUSSIAN THISTLE, ARROWWEED, TAMARISK,
                          COYOTE WILLOW
INVASION ASSESSMENT -- ENCRoACHING

          COMMENTS

BELOW BADGER CREEK RAPIDS

          CROSS-REFERENCE DATA

AERIAL PHOTOGRAPHS -- 0020,0021,0022
GROUND PHOTOGRAPHS -- UPPER, LOWER
MAP NO. 1 OF 9

DATA COLLECTED -- 07/73

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Figure 2.--Extended computer-printed form for campsite at Badger Creek.

Of the visited sites, 9 percent had apparently not been used for camping, 75 percent had been used lightly to moderately, and 16 percent had been heavily used. Open fire sites were not evident on 18 percent of the campsites; 63 percent had only a single, neat fire site; and 19 percent had two or more fire sites or had messy, dispersed fire sites.

Campsites are typically exposed with 84 percent having little or no shelter. Shelter, where it existed, was usually under tamarisk and this was the most frequently encountered species; 84 percent of the campsites had it. Tamarisk was also the predominant invading species on 43 percent of the campsites. Considering all invading species, on 18 percent of the campsites, complete encroachment by vegetation appeared imminent; whereas on 10 percent of the campsites human impact appeared to be controlling the encroachment. On 41 percent of the campsites, there was no threat of encroachment by vegetation.

Uses for the Inventory

The inventory can serve as the basis for managing the use of campsites. Additionally, it can be the basis for use-monitoring and maintenance programs. The inventory must be considered to be dynamic, and must be kept current with respect to both management data and changes in the physical resource.

The inventory can be used for selecting campsites and associated areas for research sites. The inventory and its supporting ground and aerial photographs constitute a baseline for a number of features on which temporal comparisons may be based.

Educational use of the inventory can be made in acquainting new Park personnel with the inner canyon and river-running system and in the training and workshop sessions for river-runners, boatmen, etc. The ground and aerial photographs can be particularly valuable for this purpose.