THE EFFECTS OF OFF-HIGHWAY VEHICLES ON THE CULTURAL RESOURCES OF RED ROCK CANYON STATE PARK, CALIFORNIA

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An investigation of off-highway vehicle effects on archaeological sites and historical properties within Red Rock Canyon State Park was conducted in 2004-2006. Thirteen prehistoric occupation sites, 11 prehistoric lithic scatters, seven historic mining work camps, four prehistoric quarry sites, and one historic stage station are known to be traversed by roads and informal vehicle trails. Damage related to vehicle use consists of the following: deflation of cultural deposits, vehicle scars, loss of soils and vegetation, gullying, displacement and damage to artifacts and cultural features, and others. Soil deflation along roads and the volume of soil loss were found to be significant at certain sites. Solutions to the vehicle-caused problems could include: installation of effective vehicle barriers, closure of certain routes or route segments, public education, increased patrol by park rangers, regular maintenance of routes of travel, application of erosion-control measures, restricted access, and others.

The current project was initiated (1) to investigate the state of knowledge on the effects of off-highway vehicles on public lands, (2) to investigate off-highway vehicle use and its effects upon cultural resources within Red Rock Canyon State Park (SP), and (3) to identify some practical measures to address problems associated with off-highway vehicle (OHV) use. The fieldwork results and management recommendations are summarized and should be potentially applicable elsewhere.

RESEARCH ON OFF-HIGHWAY VEHICLE EFFECTS

A large volume of published research exists concerning the effects of off-highway vehicle use upon public lands, including numerous studies in the California deserts (e.g., Belnap 1995, 2002; Brattstrom and Bondello 1983; Bury and Luckenbach 1983; Gilbertson 1983; Havlick 2002; Hinckley et al. 1983; Kassar 2005; Lathrop 1983; Lovich and Bainbridge 1999:315-322; Lyneis et al. 1980; Shore 2001; Sowl and Poetter 2004; Webb and Wilshire 1983; Wilshire 1977, 1983; and others). Scientific research on OHV effects initially grew out of a response by federal and state land-managing agencies to the exploding growth of vehicle recreation in the late 1960s and through the 1970s. According to this research, off-highway vehicles damage soils directly through (1) disruption of the surface soil and (2) compaction of the surface soil and subsoil (e.g., Belnap 1995, 2002; Dregne 1983:26; Webb et al. 1978:228-232). The most important long-term effect of OHV use on public lands is the accelerated erosion and the attendant inability to support natural revegetation (Webb et al. 1978:219). Wilshire (1977, 1983) noted that none of the natural soil stabilizers inherent to California deserts can hold up to the damaging effects of repeated vehicle passes. Tuttle Ridge, a landform found in Red Rock Canyon SP, is a prime example of soil and plant loss from OHV use (cf. Wilshire 1978:6-8). Soil and sediment loss in the areas disturbed by vehicles was determined to be 11 million kg of material (Wilshire and Nakata 1977). Ongoing erosion and vehicle scars on Tuttle Ridge 25 years after closure to vehicle use are manifestations of past unregulated OHV recreation.

Off-highway vehicle use produces a profound effect upon vegetation, and rehabilitation efforts often are marginally successful or unsuccessful (e.g., Havlick 2002:96-98; Kutiel et al. 1998:19-20; Lovich and Bainbridge 1999:316, 320-321; and others). Plant cover loss has been found to range from 23 percent at the location of a one-time OHV event to upwards of 91 and 96 percent in areas of concentrated vehicle use (Lathrop 1983:157-163). Various studies point out that even a single pass by a four-wheel drive vehicle will reduce plant density and outright destroy small-sized plants (Kockelman 1983:416-417; Lathrop and Rowlands 1983:144-146). Natural recovery of soils and vegetation, that is, without active, sustained restoration efforts in OHV-affected areas, is ineffective (Lovich and Bainbridge 1999; Prose and Wilshire 2000:18-19; Webb et al. 1983:297-300). Disturbance from vehicular activities in arid lands will take long periods of time to naturally recover, even decades or centuries (Elvidge and Iverson 1983; Lovich and Bainbridge 1999; Webb et al. 1983:297).

Adverse effects upon wildlife include the loss of cover, loss of potential food, potential damage to burrows, excessive noise, driving across migration and forging routes, frightening animals enough to abandon their habitats, and death (Brattstrom and Bondello 1983; Bury and Luckenbach 2002; California Department of Parks and Recreation 1978:26; Havlick 2002:36-58, 96-99; Jennings 1997; Kassar 2005:15-37; Nicolai and Lovich 2000; Shore 2001:Table 3.15; Sowl and Poetter 2004:9-11). The removal

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of vehicles from an area regularly used by OHVs can result in measurable improvements in vegetation growth and greatly increased wildlife numbers.

Off-highway vehicle damage was identified as a significant source of damage to archaeological sites and other historic properties, second only to development, in a 1979 BLM study (Lyneis et al. 1980). The study found that OHVs enabled artifact collectors and pothunters to drive out to vast areas of public land, some of which was formerly difficult to access. Vehicles can also facilitate the inadvertent or purposeful destruction of significant cultural features. One recommended site protection strategy was moving roads away from archaeological sites to make them more inaccessible (Lyneis et al. 1980:146-147).

Other studies have found that archaeological sites can potentially be subjected to vehicular impacts similar to those discussed above (e.g., Schneider 2005). A study of recreation effects to archaeological sites in Colorado found OHV activity to be a significant source of damage to many sites (Hartley and Vawser 2004:3-5). Studies in Utah and Arizona and in Alaska found that OHV use causes inadvertent damage to sites on public lands, while also making remote sites more accessible to site vandals (Schiffman 2005; Sowl and Poetter 2004:11-12).

Project Setting

Red Rock Canyon SP, a park unit renowned for its striking scenic qualities, is located in the Mojave Desert portion of Kern County and lies approximately 25 mi north of Mojave (Figure 1). The park occupies the western end of the El Paso Mountains. The focus of the current investigations is a 20,500-acre parcel in the northern end of the park that includes a portion of the Last Chance Canyon Archaeological District and a Birds of Prey Closure zone.

Red Rock Canyon SP, located in the western Mojave Desert, is characterized by a diversity of desert floral communities and landform features and contains six natural wildlife habitat types, including a biologically critical riparian zone in Last Chance Canyon (California State Parks 2003:2.2-2.26). Large areas of the park along major routes of travel hold stabilized Holocene-age dunes consisting of loosely compacted aeolian sands. Desert pavement surfaces occur on terraces at certain locations in the park. The complex geology of the park has provided rocks and minerals of economic value to humans throughout the millennia, such as tool-quality cherts and chalcedonies, placer gold, pumice, and clays (Dibblee and Gay 1952:30-34; Faull 1990, 2000; Flenniken 2000; Sampson 2003; Troxel and Morton 1962:77, 261-265). Fossil deposits with diverse floral and faunal remains occur throughout the park (California State Parks 2003:2.10-2.11).

Red Rock Canyon SP is located within the traditional range of the *Nïwï* or Kawaiisu people (Miller 1986:98-99; Zigmond 1986:398, Fig. 1, Fig. 6). Elders and leaders of the local Indian communities met with State Parks staff, including the present writer, in April 2003 and March 2005 to voice their opinions about vehicular recreation and other important management issues in Red Rock Canyon SP. Mr. Harold Williams, Chairman of the Kern Valley Indian Community, and Mr. Luther Girado, a Kawaiisu Elder, were consulted specifically for this project and shown selected archaeological sites and vehicle trails.

Red Rock Canyon became an important travel route for shipments of provisions for regional mining districts by 1862, and later for passengers (Faull 2000:261, 2003). Placer gold mining occurred in Red Rock Canyon and Last Chance Canyon in the 1890s and again in the 1930s (California State Parks 2003:72-73; Faull 1990; Sampson and Faull 1994). Industrial mining took place within the park during the twentieth century (Troxel and Morton 1962:261-265).

Previous Archaeological Research

Red Rock Canyon SP contains a total of 147 recorded archaeological sites and 52 isolated finds, primarily prehistoric. At least a third of this site total can be associated with the prehistoric procurement and knapping of flaked stone artifacts (Flenniken 2000; Sampson 2003). The park has prehistoric and historic-period occupation locations and aboriginal rock art (Gardner 1998; Harvey and Gardner 2003; McGuire et al. 1982; Sampson 1990, 2003). Historic sites primarily date to the late 1890s and early decades of the twentieth century (Dibblee and Gay 1952; Faull 1990; Sampson and Faull 1994; Troxel and Morton 1962:261-265).

Methods

Fieldwork for the current project was accomplished primarily by the author during field trips in 2004 through spring 2006. At times, Larrynn Carver, Mark Faull, Phil Hines, and Kyle Knabb assisted with fieldwork. Bruce Lund and Phil Hines, State Parks Off-Highway Motor Vehicle Recreation Division, discussed issues related to OHV use with the author and met in the field on June 22, 2006 to examine selected vehicular trails and discuss potential erosion-control measures (cf. California Department of Parks and Recreation 1991). The author toured Hungry Valley State Vehicular Recreation Area on April 28, 2005 to view visitor management techniques used at an OHV recreation park. Pete Yarbrough and Kim Matthews from Hungry Valley District and Dr. Howard Wilshire, retired U.S. Geological Survey geologist and vehicle effects expert, toured the project area with the present writer on October 12, 2005.

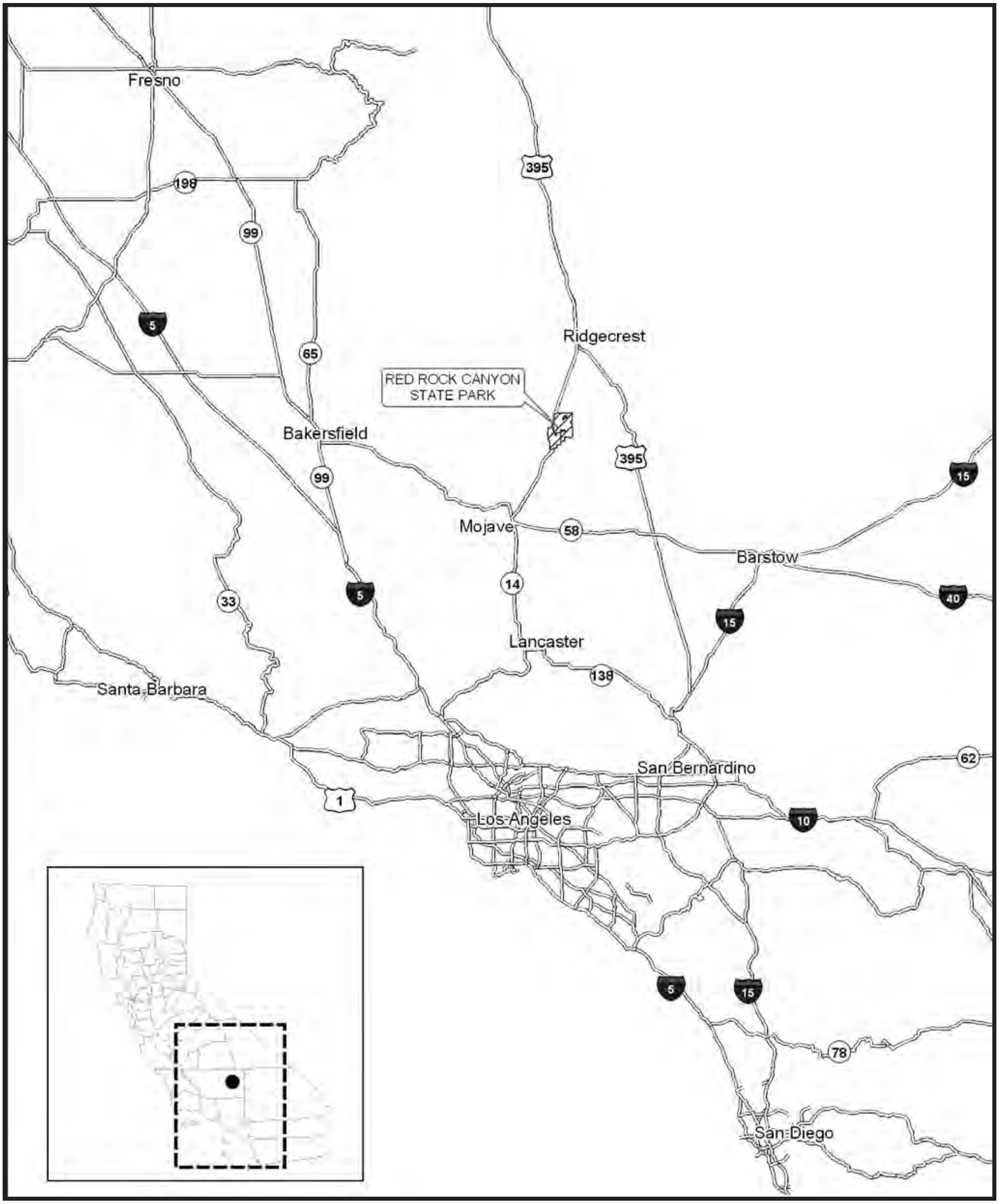

Figure 1. Red Rock Canyon location map.

The principal routes of travel in the latter areas were photographed during the fieldwork to document their current condition as baseline data for future evaluation work. Vehicle tracks driven off-trail, a use not permitted by park regulation, were documented by photographs and GPS point when observed in travels throughout the project area. Width and depth of cut measurements were taken along the routes of travel where they traversed archaeological sites, as well as observations of exposed artifacts or cultural features.

Measurements of road deflation (present road depth relative to the unaffected surface) and soil loss within roads were accomplished at selected archaeological sites in the project area. Measurement of road deflation within sites involved use of an automatic level instrument set up upon unaffected ground surface with multiple shots taken within a roadway and upon the ground outside the road. Thus, the difference in depth between the road surface and unaffected ground surfaces could be captured to provide a measure of the road-cut depth.

Soil loss within a road where it passes through an archaeological site was measured, as a means to document the amount of erosion caused by vehicle traffic. From an arbitrary starting point on-site, a series of spikes were laid out at 10-ft intervals on opposite sides of the roadway on unaffected ground (Figure 2). A long tape measure was extended between the two spikes, and depth measures were taken at 1-ft intervals within the roadway. A profile of the road surface is thus produced, and measurements of soil loss can be calculated using the recorded figures. This technique for measuring soil loss is outlined in an article by Dr. Howard Wilshire (2000). Erosional gullies of appreciable size found within roads at archaeological sites were photographed, measured, plotted with a GPS receiver, and placed on park maps.

Figure 2. Recordation method for soil loss transects (taken at KER-5118).

OHV Effects at Red Rock Canyon SP

A total of 36 archaeological sites within Red Rock Canyon SP are known to be traversed by park roads or informal OHV trails. Thirteen of these archaeological sites are defined as prehistoric occupation locations, each with substantial surface artifact distributions and subsurface cultural deposits. Another 11 sites are defined as prehistoric lithic scatters; they tend to be large in size. Seven of the 36 sites crossed by roads or OHV trails are historic-period mining-related work camps; two of the work camp sites also have mining features. Four prehistoric stone quarry sites within Red Rock Canyon SP have roads running through them. One historic stage station site is regularly crossed by OHV traffic.

Each of the 36 archaeological sites is experiencing at least some degree of degradation due to vehicle use and consequent erosion within the trail tread, and 17 of the 36 sites show pronounced damage. Damage related to vehicle use observed at archaeological sites in Red Rock Canyon SP include the following: deflation of the cultural deposits within the trail treads, degradation of cultural deposits (midden), vehicle scars resulting from off-trail riding, loss of soils and vegetation, gullying, displacement of artifacts, damage to artifacts and cultural features, road damage requiring extensive and potentially costly restoration efforts, alteration of natural hydrologic patterns, trash left on-site, unauthorized artifact collection, and possibly others. Off-trail riding, an activity not permitted within Red Rock Canyon SP, is a regularly occurring problem at 13 of the archaeological sites (36 percent) crossed by roads and OHV trails. Unregulated camping has been an indirect adverse effect of OHV use in the park but is now prohibited.

Site-specific findings and recommendations are now presented for a sample of the many archaeological sites evaluated in the project area. Those selected are a good representation of observed OHV effects and proposed treatments.

Site CA-KER-246, a site with midden deposits and abundant surface artifacts, is traversed on the south and east by Sierra View Road and lies just east of Old Dutch Cleanser Mine Road in the northern end of the park. This site, situated on a well-sorted, Holocene-age stabilized sand dune, is characterized by loose sandy sediments. Artifacts have been observed within and alongside Sierra View Road. An eroded fire hearth was exposed in the road cut of Sierra View Road at the extreme south end of the site. Sierra View Road measures 3.15 m or 10.3 ft in width and was found to be 1.70 ft lower in elevation than the portion of the site off the road. Nine inches (22 cm) of new down cutting were observed within the trail at KER-246 during the course of the current project.

An abandoned, eroding old trail segment at KER-246 can be more effectively closed with peeler log barriers or large boulders, and then revegetation can be attempted. Revegetation must incorporate locally collected seeds. To make restoration successful here, State Parks may also have to import soils and repair the existing soil system within the abandoned trail segment, inoculate the soils with mycorrhizal fungi prior to restoration, and consider transplanting seedlings rather direct seeding (cf. Lathrop and Rowlands 1983:138-146; Lovich 1992:35-42).

Steep Trail crosses KER-377, a large lithic scatter site, for approximately 500 ft or 152 m, and there are numerous chert and chalcedony artifacts visible within its surface. The down cutting effect of continued vehicular use upon the terrain with loose, sandy soils is considerable and readily apparent (Figure 3). At the junction of the latter two roads, Steep Trail has two paths that converge just less than 55 ft or 16.7 m below Old Dutch Cleanser Mine Road. One vehicle route measured 14 ft or 4.3 m in width; the other measures 19.5 ft or 4.7 m in width. A measure of deflation here showed Steep Trail measured 2.76 ft or 85 cm lower than unaffected terrain. This vehicle-caused deflation creates a significant loss of cultural deposits from KER-377.

An informal, unauthorized, lightly used motorcycle trail leads off from Steep Trail and cuts through site KER-377 for a distance about 1,275 ft (Figure 3). The informal trail lies 0.91 ft or 28 cm below the unaffected terrain on KER-377. The informal OHV trail measures 8.5 ft or 2.6 m in width.

A permanent barrier, such as a few large boulders, and a small sign are needed to block the unauthorized trail. The installation of water management features on the closed unauthorized trail is also recommended. The portions of the unauthorized trail lacking plant cover probably should be scarified using a hand crew to help promote seed growth.

Severe erosion has occurred at the upper end of Steep Trail, at a spot about 590 ft north of Old Dutch Cleanser Mine Road. Steep Trail is sloped here, so these conditions can produce too much water and too much water velocity, and combine to be problems for soil and trail stability. Boulders should be placed within the erosional gully located just to the southeast of Steep Trail, as well as along the edge of Steep Trail. Nearby, an erosion-control device should be placed on Steep Trail.

Site KER-6236 (the "Last Chance Canyon Quarry"), a large-sized prehistoric chert quarry, covers most of a prominent hill located east of KER-246, adjacent to KER-376 and to Steep Trail, and overlooking Last Chance Canyon. The boundary line between this site and KER-376 is not distinct, and largely is based upon a change in landform. The entire site area contains natural exposures of siliceous rock material and flaked stone artifacts of chert and chalcedony, including flakes, tested pieces of raw material, bifacial blanks, and hammerstones of quartzite and granite. In several places on the site, one can encounter dense concentrations of flaking debris. Site KER-6236 lies within the Last Chance Canyon Archaeological District, a National Register property.

Informal OHV trails lead onto this hill from the west; from the south, two informal trails converge on the south-facing slope of the site and continue upslope; and another informal trail is found on the east edge. These latter OHV trails average 8.5 ft or 2.6 m in width. The parallel OHV trails at the quarry site should be eliminated and restored. Any vehicular route kept open should be well delineated to help eliminate off-trail riding. Erosion within the OHV trails is most pronounced at the base of the hill, e.g., at site KER-376. Presently, the Last Chance Canyon Quarry site needs

Figure 3. (a, left) KER-377, Old Dutch Cleanser Mine Road cutting through site, 4/7/05, (b, right) KER-377 at top of Steep Trail. Note unauthorized OHV trail at left, photograph taken April 7, 2005.

signs stating the State Parks rules and a means to block the poorly designed, informal OHV trails.

Site KER-376, traversed by the now-closed segment of Steep Trail, a single-track OHV trail measuring 12.5 ft or 3.8 m, is situated upon a sloping ridgeline characterized by a stabilized sand dune with dense vegetation; the ridge is just above upper Last Chance Canyon. The site shows a dense artifact distribution over its surface, which includes a considerable amount of flaking debris, chert bifacial blanks, hammerstones, battered implements, and metates. Site KER-376 lies within the Last Chance Canyon National Register District.

Steep Trail has extraordinary erosional damage in which large gullies or channels were deeply cut into the trail tread (Figure 4). Measurements of new erosional channels cut into site KER-376 along Steep Trail taken at selected places were as high as 36 in (90 cm) wide and 20 in (51 cm) in depth. The depth of Steep Trail below the undisturbed ground surface where no gullying occurred is .82 ft (25 cm). Depth measurements taken with the automatic level at two locations within newly formed erosion gullies were 4.64 ft (142 cm) and 2.37 ft (73 cm). These indicate a significant loss of sediments from the site. Artifacts and cultural features were exposed in the areas of erosion.

The lower end of Steep Trail, including where site KER-5118 is located, shows severe erosional damage. Deep gullies are cut into the trail tread, in many places down to bedrock or to point where large boulders appear out of the trail tread. Gullies on or next to site KER-5118 showed measurements as large as 48 in or 120 cm deep and 43 in or 110 cm wide.

Soil loss was calculated in April 2006 for a 120-ft-long segment of Steep Trail as its passes through site KER-5118. The volume of soil loss in this segment of the OHV trail measured 2,674 ft^3 of soil, a significant amount. Therefore, the total volume of soil lost to erosion along Steep Trail from site KER-376 down to the bottom of Last Chance Canyon may be at least 64,845 ft^3. The latter figure is reached by extrapolating the volume of soil lost within KER-5118 to the known length of severe erosion on the section of Steep Trail from site KER-376 to down the bottom of Last Chance Canyon (2,910 ft).

Figure 4. Severe erosion on Steep Trail at KER-376.

Just south of KER-376, Steep Trail takes a steep drop down the slope toward KER-5118 and beyond to the bottom of Last Chance Canyon. The current ongoing pronounced erosion on this abandoned section of Steep Trail can be arrested with a control of water volume and velocity within the trail tread. The source of water at the top of the slope (the south edge of archaeological site KER-376) must be broken, and then work down the slope. Excavate breaks in the road shoulder berm on the east side of Steep Trail measuring about 3 to 4 ft in width at intervals of about every 100 to 150 ft. These breaks will serve as a useful interim erosion-control measure by pulling water off the abandoned and eroding trail tread. The sediment from the berm breaks should be pulled onto the tread of the abandoned trail. Check dams of local rock serving as sediment traps can be built within the deepest gullies on the trail.

Four archaeological sites, KER-6259, KER-6258, KER-6237, and KER-6235/H (Cudahy Camp), were found to be situated directly within the existing OHV route as it passes through the middle portion of Last Chance Canyon. This section of Last Chance Canyon (Figure 5) has a viable riparian zone with year-round surface water and a well-developed growth of riparian trees and understory plants.

Figure 5. OHV trail in middle Last Chance Canyon with KER-6258 at right, site KER-6237 in background, and KER-5951 ("Grubstake Hill") on hillside in background. Taken on 3/23/06.

A small prehistoric lithic scatter, designated site KER-6259, is located on an alluvial terrace north of Grubstake Hill and lies along the west bank of the canyon bottom. The existing vehicular trail adjoins the site on its west side. Gray chalcedony and dark orange chert flakes were observed here, as well as one rhyolitic core tool. A small historic-period camp location, identified as site KER-6258, was documented on the same alluvial terrace as KER-6259. This site, measuring 50 m north-south by 45 m east-west, represents the remains of a miners' camp with artifact scatter and a tent pad. The existing vehicular route cuts across the alluvial terrace and site KER-6258 in three parallel alignments. The eastern portion of the site is most profoundly affected by vehicular traffic. The vehicle route within this section of Last Chance Canyon cannot both avoid the sites and stay out of the riparian zone.

Two prehistoric short-term occupation sites (KER-6237 and KER-6260) are present at the base of the north slope of Grubstake Hill. The two sites likely represent short-term camps used by prehistoric people walking through Last Chance Canyon. The existing main vehicular trail through Last Chance Canyon traverses KER-6237. Site KER-6237, measuring ca. 75 by 36 m, is a lithic scatter with widely distributed chert and chalcedony flakes, as well as two chalcedony cores and some fire-affected rocks. One solder-top condensed milk can (ca. late 1800s in age) was also observed on-site. Use of the OHV trail through this section of Last Chance Canyon has also led to considerable off-trail activity upon KER-6237 and the parking of vehicles on-site.

Soil loss transects were established and measured along the existing OHV route that now traverses site KER-6237, and the loss of soils at this location was found to be significant. The OHV trail measured up to 35½ in. (90 cm) deeper than the undisturbed portion of the site (Figure 6). The volume of soil lost within the 55-ft-long transect within KER-6237 was determined to be 481 ft^3. The loss of soil extrapolated along the entire length of the OHV trail where it passes through the site (246 ft) calculates to 2,151.38 ft^3. That figure represents a significant amount of cultural deposits lost to vehicle use.

Site KER-6260, located just west of KER-6237, is bisected by an abandoned road that formerly provided access to the "Grubstake Hill" mines. This site is identified as a lithic production area containing debitage of chert, rhyolite, and welded tuff and a few cores. The existing, abandoned OHV trail cuts through the site north-south or upslope, so, it is susceptible to erosion. Erosion-control devices are needed on the abandoned vehicle trail at this location to save the existing soils and ultimately allow regrowth by local plants.

The site of "Cudahy Camp," designated KER-6235/H, is located upon low alluvial terraces at opposite sides of the middle portion of Last Chance Canyon. The canyon is relatively wide here, but becomes narrow and steep-sided downstream from Cudahy Camp. Existing vehicular trails traverse both the east bank and the west bank at this location. Cudahy Camp, measuring approximately 190 by 140 m in area, represents the remains of a historic work camp associated with the historically significant Old Dutch Cleanser Mine; the mine operated from 1923 to 1947 (Troxel and Morton 1962:264). The alluvial terrace on the east side of the canyon holds the remains of the main residential area and the company offices, as well as a large-sized and culturally significant prehistoric occupation location. Abundant chert debitage and a few chalcedony biface fragments were found on the east terrace. The prehistoric component still seems to be in relatively good condition. The potential for buried cultural deposits within KER-6235/H is good.

The site of Cudahy Camp has been impacted by modern-day camping and vehicle activity (Figure 7). Illegal target shooting occurs at this location and trash is left on-site by campers. The site has now been closed to camping. OHV users perform unauthorized hill climbs on the edge of the residential area that leave the bare slopes scarred and highly susceptible to erosion.

Figure 6. OHV Trail as it traverses KER-6237, view to south-southeast. Tape has been strung horizontally to depict the unaffected ground surface. Site KER-6258 lies in background. Photograph was taken on 5/10/06.

Figure 7. Cudahy Camp impacted by modern-day camping and vehicle activity.

The existing vehicular route cuts across the alluvial terrace and site KER-6258 in three parallel alignments. The eastern portion of the site is most profoundly affected by vehicular traffic; it does not directly affect the tent pad feature. One segment of the OHV trails situated upon this alluvial terrace crosses a portion of site KER-6259. The vehicle route within this section of Last Chance Canyon cannot both avoid the sites and stay out of the riparian zone (water is present within the creek here).

The site of Cudahy Camp (KER-6235/H) has been damaged by OHV travel on-site, camping, littering, target shooting, and other unregulated visitor activities. Vehicle barriers, erosion-control devices, and revegetation (where feasible) are needed on the unauthorized hill climbs on-site and the OHV trails heading onto the alluvial terrace where the site lies. Routine patrol by park rangers and other field staff is difficult but possible. (The park has prohibited camping here since this study was completed.)

Our knowledge of the archaeological resources within the middle portion of Last Chance Canyon, as well as the sensitive natural values and geologic features, point to vehicle closure as the best alternative for optimum site protection and preservation of the riparian zone. A closure of a relatively short section of middle Last Chance Canyon would still allow vehicle access to this part of the park. Park visitors in vehicles could drive south through the upper portion of Last Chance Canyon, access the canyon from the south off of Redrock-Randsburg Road, or, access the middle of the canyon via Pleasant Valley Road. Detailed biological surveys should be conducted within Last Chance Canyon.

Iron Canyon Road heads up canyon in a northerly direction beginning at Red Rock Wash and ends next to Scenic Cliffs. This single-track dirt road traverses significant historic-period gold mining sites dating to the 1890s and the early decades of the 1900s. They are Red Rock Camp (KER-5103H), Conglomerate Hills Mining Complex, Bonanza Gulch Mining Camp (KER-3056H), Santa Monica Gulch Mining Complex, Iron Canyon Placers (KER-5127H), and the Hill Cabin Site (KER-5108H). Iron Canyon Road, which measures up to 42 ft at one location on-site, cuts through Red Rock Camp for about 580 ft, and has potentially damaged building locations dating to the 1890s and displaced many artifacts from that same era.

The archaeological sites along Iron Canyon Road should be revisited regularly to update their condition and monitor vehicle-use patterns in the canyon. Red Rock Camp is showing the most pronounced soil loss and degradation of cultural remains due to erosion along the banks of Red Rock Wash and vehicle use on Iron Canyon Road. Some limited archaeological data-recovery work may be needed at Red Rock Camp to address the ongoing erosion problem. The fence placed across Iron Canyon Wash to prevent vehicle access into Red Rock Wash should be kept in good repair.

General Recommendations

OHV use should be permitted on the basis of a consideration of topography, soil characteristics, precipitation patterns, and the presence of sensitive resources such as archaeological sites, traditional cultural places, plants, wildlife habitat, fossil deposits, riparian zones, etc. Apply standard engineering practices in the construction and maintenance of vehicular trails. OHV trails should not be permitted within creeks or other riparian areas. Implement an active program of archaeological site monitoring in the park and include a provision to study vehicle effects. Vehicles should be restricted from dune systems, due to their loose soils and to best protect sensitive plants and animals that live in dune habitats (e.g., desert tortoise, etc.). Separate OHV use from other forms of recreation, such as camping, bird watching, observing wildlife, studying plants, seeking solitude, taking photographs, etc., where feasible.

When evidence of off-trail riding by OHV users has been observed, it must be raked out and blocked as soon as possible to prevent continued use. Park staff could regularly patrol travel routes after busy weekends and holidays to maintain areas and block unauthorized trails. The closure of vehicle routes does not equate to land restoration. Large boulders, fencing, and road obliteration will be the most effective barriers for closing roads and informal OHV trails and to protect sensitive habitat or archaeological sites. Conduct focused patrols of vehicular trails after traditionally busy weekends. Be prepared to perform ad hoc repairs of vehicle tracks driven off-trail and blockage of unauthorized trails.

Conclusions

Scientific research demonstrates the serious adverse effects of off-highway vehicles upon desert soils, wildlife, vegetation, archaeological sites, scenery, and other values. Arid lands simply cannot sustain vehicular recreation for an appreciable period of time, in particular when it is loosely regulated and not well maintained. OHVs provide access to previously remote locations where extant archaeological sites and natural resources cannot be regularly patrolled, studied, monitored, or maintained.

Vehicular recreation is recognized as a significant and challenging park management issue for Red Rock Canyon SP. Seventeen of the 36 archaeological sites (46 percent) traversed by roads manifest pronounced damage resulting from regular OHV use and erosion that follows from vehicular activity. The damage defined here as “pronounced” includes measurable degradation of cultural deposits, vehicle scars, loss of soils in measurable volumes, loss of vegetation, creation of deep gullies, displacement and damage to artifacts and cultural features, modern-day trash left on-site, and other problems. Off-trail riding by OHVs was found to be a recurring problem at 13 archaeological sites, but the problem can be easily treated using well-situated park signs and vehicle barriers, increased ranger patrol, issuance of more citations, limiting "green sticker" vehicle use to specific routes, and other measures.

One possible means to identify site protection needs would be to establish a statewide cultural inventory and monitoring program, and build it into existing programs employed in all park units. The current project at Red Rock Canyon SP might be viewed as an example of an evaluation and monitoring program for vehicular recreation that could be applied at more State Parks and other public lands. Effective, thoughtful resource management will always produce a more enjoyable and memorable recreational experience for the visiting public.

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References Cited

Belnap, Jayne
1995 Surface Disturbances: Their Role in Accelerating Desertification. *Environmental Monitoring and Assessment* 37:39-57.

2002 Impacts of Off-Road Vehicles on Nitrogen Cycles in Biological Soil Crusts: Resistance in Different U.S. Deserts. *Journal of Arid Environments* 52:155-165

Brattstrom, Bayard H., and Michael C. Bondello
1983 Effects of Off-Road Vehicle Noise on Desert Vertebrates. In *Environmental Effects of Off-Road Vehicles, Impacts and Management in Arid Regions*, edited by Robert H. Webb and Howard G. Wilshire, pp. 167-206. Springer-Verlag, New York.

Bury, R. Bruce, and Roger A. Luckenbach
1983 Vehicular Recreation in Arid Land Dunes: Biotic Responses and Management Alternatives. In *Environmental Effects of Off-Road Vehicles, Impacts and Management in Arid Regions*, pp. 207-221, edited by Robert H. Webb and Howard G. Wilshire, pp. 207-221. Springer-Verlag, New York.

2002 Comparison of Desert Tortoise (Gopherus agassizii) Populations in an Unused and Off-Road Vehicle Area in the Mojave Desert. *Chelonian Conservation and Biology* 4: 457-463

California Department of Parks and Recreation
1978 *Off-Highway Vehicle Recreation in California*. California Department of Parks and Recreation, Sacramento.

1991 *Soil Conservation Guidelines/Standards for Off-Highway Vehicle Recreation Management*. California Department of Parks and Recreation, Off-Highway Motor Vehicle Recreation Division, Sacramento.

California State Parks
2003 *Red Rock Canyon State Park, Preliminary General Plan Amendment & EIR*. California State Parks, Southern Service Center, San Diego. Draft.

Dibblee, T. W., and T. E. Gay, Jr.
1952 *Mineral Deposits of the Saltdale Quadrangle, California*. California Division of Mines, Bulletin No. 160. San Francisco.

Dregne, Harold E.
1983 Soil and Soil Formation in Arid Regions. In *Environmental Effects of Off-Road Vehicles, Impacts and Management in Arid Regions*, edited by Robert H. Webb and Howard G. Wilshire, pp. 15-30. Springer-Verlag, New York.

Elvidge, Christopher D., and Richard M. Iverson
1983 Regeneration of Desert Pavement and Varnish. In *Environmental Effects of Off-Road Vehicles, Impacts and Management in Arid Regions*, edited by Robert H. Webb and Howard G. Wilshire, pp. 225-243. Springer-Verlag, New York.

Faull, Mark R.
1990 Cultural Resource Management at a Natural History Park: Red Rock Canyon State Park, Kern County, California. In *Death Valley to Deadwood; Kennecott to Cripple Creek: Proceedings of the 1989 Historic Mining Conference, Death Valley National Monument*, edited by Leo R. Barker and Ann E. Huston, pp. 129-136. National Park Service, San Francisco.

2000 Recognition of Cultural Significance at Red Rock Canyon, Kern County, California. *Proceedings of the Society for California Archaeology* 13:259-265.

2003 *A Historical Overview of Red Rock Canyon State Park: with Special Emphasis on the 1994 Last Chance Canyon Addition*. Report on file, California State Parks, San Diego.

Flenniken, J. Jeffrey
2000 *Infield, Onsite, Technological Analyses of Flaked Stone Artifacts on the Surface of Seven Sites, Red Rock Canyon State Park, Kern County, California*. Lithic Analysts Research Report No. 71. Report on file, California Department of Parks and Recreation, San Diego.

Gardner, Jill K.
1998 Testing a Regional Model of Changing Settlement and Subsistence Patterns in the Western Mojave Desert: Results From the Coffee Break Site. Unpublished Master's thesis, Department of Anthropology/ Sociology, California State University, Bakersfield.

Gilbertson, David
1983 The Impacts of Off-Road Vehicles in the Coorong Dune and Lake Complex of South Australia. In *Environmental Effects of Off-Road Vehicles, Impacts and Management in Arid Regions*, edited by Robert H. Webb and Howard G. Wilshire, pp. 365-372. Springer-Verlag, New York.

Hartley, Ralph J., and Anne M. Wolley Vawser
2004 *Assessing Contemporary Human Activity at Sites in the Anasazi Archaeological District, San Juan National Forest: A Quantitative Approach*. Report on file, Midwest Archaeological Center, National Parks Service.

Harvey, Victoria, and Jill K. Gardner
2003 *Archaeological Investigations at CA-KER-246, Red Rock Canyon State Park, Kern County, California*. Report on file, California Department of Parks and Recreation, San Diego and California State University, Bakersfield.

Havlick, David G.
2002 *No Place Distant: Roads and Motorized Recreation on America's Public Lands*. Island Press, Washington, D.C.

Hinckley, Bern S., Richard M. Iverson, and Bernard Hallett
1983 Accelerated Water Erosion in ORV-Use Areas. In *Environmental Effects of Off-Road Vehicles, Impacts and Management in Arid Regions*, edited by Robert H. Webb and Howard G. Wilshire, pp. 81-96. Springer-Verlag, New York.

Jennings, W. Brian
1997 Habitat Use and Food Preferences of the Desert Tortoise, Gopherus agassizii, in the Western Mojave Desert and Impacts of Off-Road Vehicles. In *Proceedings: Conservation, Restoration, and Management of Tortoises and Turtles - An International Conference*, edited by Jim Van Abbema, pp. 42-45. New York Turtle and Tortoise Society, New York.

Kassar, Chris
2005 *Motorized Recreation at a Crossroads: Lessons from the Past Converge with Management Practices of the Future*. Report on file, Friends of the Inyo, Bishop, California.

Kockelman, William J.
1983 Management Concepts. In *Environmental Effects of Off-Road Vehicles, Impacts and Management in Arid Regions*, edited by Robert H. Webb and Howard G. Wilshire, pp. 399-446. Springer-Verlag, New York.

Kutiel, P., E. Ede,n and Y. Zhevelev
1998 Effect of Experimental Trampling and Off-Road Motorcycle Traffic on Soil and Vegetation of Stabilized Coastal Dunes, Israel. *Environmental Conservation* 27:14-23

Lathrop, Earl W.
1983 The Effect of Vehicle Use on Desert Vegetation. In *Environmental Effects of Off-Road Vehicles, Impact and Management in Arid Regions*, edited by Robert H. Webb and Howard G. Wilshire, pp. 153-166. Springer-Verlag, New York.

Lathrop, Earl W., and Peter G. Rowlands
1983 Plant Ecology in Deserts: An Overview. In *Environmental Effects of Off-Road Vehicles, Impact and Management in Arid Regions*, edited by Robert H. Webb and Howard G. Wilshire, pp. 113-152. Springer-Verlag, New York.

Lovich, Jeffrey E.
1992 *Restoration and Revegetation of Degraded Habitat as a Management Tool in Recovery of the Threatened Desert Tortoise*. Report on file, Bureau of Land Management, California Desert District Office, Riverside, California.

Lovich, Jeffrey E., and David Bainbridge
1999 Anthropogenic Degradation of the Southern California Desert Ecosystem and Prospects for Natural Recover and Restoration. *Environmental Management* 24:309-326

Lyneis, Margaret, David L. Weide, and Elizabeth von Till Warren
1980 *Impacts: Damage to Cultural Resources in the California Desert*. United States Bureau of Land Management, Riverside, California.

McGuire, Kelly R., Alan P. Garfinkel, and Mark E. Basgall
1982 *Archaeological Investigations in the El Paso Mountains of the Western Mojave Desert: The Bickel and Last Chance Sites (CA-KER-250 and -261)*. Report on file, Bureau of Land Management, Ridgecrest and California Department of Parks and Recreation, San Diego.

Miller, Wick R.
1986 Numic Languages. In *Great Basin*, edited by Warren L. d'Azevedo, pp. 98-106. Handbook of North American Indians, Vol. 11, William C. Sturtevant, general editor. Smithsonian Institution, Washington, D.C.

Nicolai, Nancy C., and Jeffrey E. Lovich
2000 Preliminary Observations of the Behavior of Male, Flat-Tailed Horned Lizards Before and After an Off-Highway Vehicle Race in California. *California Fish and Game* 86(3):208-212.

Prose, Douglas V., and Howard G. Wilshire
2000 The Lasting Effects of Tank Maneuvers on Desert Soils and Intershrub Flora. U. S. Geological Survey, Open-File Report OF 00-512.

Sampson, Michael P.
1990 Studies of Rock Art and Earthen Art in Red Rock Canyon State Park, Kern County, California. *Proceedings of the Society for California Archaeology* 3:207-216.

2003 *Archaeological Survey of the Last Chance Canyon Addition and Selected Adjoining Lands in Red Rock Canyon State Park, Kern County, California*. Report on file, California Department of Parks and Recreation, San Diego.

Sampson, Michael P., and Mark Faull
1994 Dry Placer Mining within Red Rock Canyon State Park in the Western Mojave Desert, California. Paper presented at the Third International Mining History Conference, Golden, Colorado.

Schneider, Joan S.
2005 *Desert Cahuilla Acquisition Project: Cultural Resources*. Manuscript on file, California State Parks, Borrego Springs.

Schiffman, Lisa
2005 Archaeology, Off-Road Vehicles, and the BLM. *Archaeology* (April 20). Electronic document, http://www.archaeology.org/online/features/southwest/.

Shore, Teri
2001 Off-Road to Ruin, How Motorized Recreation is Unraveling California's Landscape. California Wilderness Coalition, Davis.

Sowl, Kristine, and Rick Poetter
2004 *Impact Analysis of Off-Road Vehicle Use for Subsistence Purposes on Refuge Lands and Resources Adjacent to the King Cove Access Project*. Report on file, Izembeck National Wildlife Refuge, April 16. Electronic document, http://izembek.fws.gov/impanalysis.pdf.

Troxel, Bennie W., and Paul K. Morton
1962 *Mines and Mineral Resources of Kern County, California*. California Division of Mines and Geology, County Report No. 1. San Francisco.

Webb, Robert H., H. Craig Ragland, William H. Godwin, and Dennis Jenkins
1978 Environmental Effects of Soil Property Changes with Off-Road Vehicle Use. *Environmental Management* 2(3):219-233.

Webb, Robert H., and Howard G. Wilshire (editors)
1983 *Environmental Effects of Off-Road Vehicles, Impacts and Management in Arid Regions*. Springer-Verlag, New York.

Wilshire, Howard G.
1977-1978 *Study Results of 9 Sites Used by Off-Road Vehicles that Illustrate Land Modifications*. U.S. Geologic Survey Open-file Report No. 77-601. Desert Protective Council, Palm Springs, California.

1983 The Impact of Vehicles on Desert Soil Stabilizers. In *Environmental Effects of Off-Road Vehicles, Impacts and Management in Arid Regions,* edited by Robert H. Webb and Howard G. Wilshire, pp. 31-50. Springer-Verlag, New York.

2000 Cheap and Easy Methods for Collecting Data on Soil Loss, Erosion Rate, Compaction and Displacement. *The Road RIPorter* September/October:8-10.

Wilshire, Howard G., and J. K. Nakata
1976 Erosion Off the Road. *Geotimes* July/August.

Zigmond, Maurice
1986 Kawaiisu. In *Great Basin*, edited by Warren L. d'Azevedo, pp. 398-411. Handbook of North American Indians, Vol. 11, William C. Sturtevant, general editor. Smithsonian Institution, Washington, D.C.