ANAGEMENT
IA

Impacts:

Damage to Cultural Resources in the California Desert

by

Margaret M. Lyneis
David L. Weide
Elizabeth vonTill Warren

cultural resources publications

archaeology—history

Cover design represents a vandalized petroglyph from Corn Springs, Riverside County, California.

IMPACTS:

DAMAGE TO CULTURAL RESOURCES IN THE CALIFORNIA DESERT

Margaret M. Lyneis
Department of Anthropology
University of Nevada, Las Vegas

David L. Weide
Department of Geoscience
University of Nevada, Las Vegas

Elizabeth von Till Warren
Institute for American Research
Goleta, California

Contract No. CA-960-CT9-109
Bureau of Land Management
Desert Planning Staff
3610 Central Avenue, Suite 402
Riverside, CA 92506

Eric W. Ritter
General Editor
Riverside, California
1980

FOREWORD

For a number of years now, archaeologists and historians have been acutely aware of the damage and destruction of cultural resources in the southern California deserts. However, prior to this study such destruction had never been quantified or even subjectively discussed in detail. The acquisition of rigorously derived baseline data is only just beginning as this work goes to press.

The southern California deserts over the last decade of the 1970's have been the subject of a comprehensive planning effort. A portion of that effort has been directed toward the management and research of cultural resources, prehistoric and historic remains, and their associated environments, past and present. As part of the planning effort, it has been necessary to complete an Environmental Impact Statement regarding plan implementation. This impact document published here has been of great aid in that effort. Furthermore, this report goes beyond plan implementation to provide managers and the public with a publication detailing past impact trends and recommendations for better management of consumptive activities in parts of the California Desert.

Studies such as this can be no better than the data available to the authors through site records and inquiry response. Nevertheless, the authors are to be highly commended for their admirable job in bringing together the available data with very limited funding and so little time.

It needs to be pointed out that one aspect of cultural resource management must await fuller study, that is, the evaluation of human and natural impact on Native American and other ethnic values. While there would certainly be some commonalities with this study, this important project remains at least partially undone.

The reader will find this report to be clearly written, highly informative, and, unfortunately in terms of resource condition and trend, highly alarming. Hopefully, completion of this study is a highly positive step in the direction of increased protection, preservation and the proper study of our national heritage.

Eric W. Ritter
General Eidtor

ACKNOWLEDGMENTS

Many people shared their knowledge regarding, and concern for, the archaeological record of the California Desert. We are particularly appreciative of all those who completed and returned the Inquiry Form that we distributed, and to those who permitted us to quote their responses.

Brian Brown, Dennis G. Casebier, James Hinds, Deke Lowe, Art Rader and Jan Tarbell were especially helpful with respect to historic resources in the desert. Albert Endo, Desert Planning Staff, and Howard G. Wilshire, U. S. Geological Survey, contributed useful comments regarding natural processes which affect sites in the desert. Eric Ritter and the members of the Cultural Resources section of the Desert Planning Staff were consistently helpful, patient and responsive during the development of the study. Their comments and observations contributed substantially to this report. Gary Coombs of the Institute for American Research, Goleta, shared his observations on aspects of the quantitative data with us.

Joyce Peters, secretary of the Department of Anthropology, handled the accounting for the project, typed the report, and helped in many other ways. Evan Acker patiently read drafts and aided in the editing. James Heid worked as a graduate assistant, organizing and analyzing information from the Inquiry.

Our thanks to all of you.

ABSTRACT

Of the nearly 3000 prehistoric and historic sites recorded in the California Desert inventory, 36% have already been damaged so extensively that their condition is reduced to fair or poor. Vandalism is regarded as the major threat to archaeological sites in the desert, and both vandalism and ORV damage are increasing. Historic sites and prehistoric villages have suffered the worst. Less than 40% of them are in good condition. The damage that has been inflicted on archaeological sites in the desert demonstrates the effects of years of unmanaged use of the desert, and uncontrolled vandalism.

Patrolling of accessible sites, monitoring "inaccessible" sites, development of active interpretive programs, removal of trash and signs of vandalism, signing, and apprehension and prosecution of vandals are all common-sense techniques that may slow the destruction of particular archaeological resources. Table 34 (p.153) summarizes management approaches appropriate for a variety of archaeological sites. The relative effectiveness of the several techniques remains unknown, although the costs of each can be estimated for a particular site. We recommend that management strategies for archaeological sites in the desert be implemented in the framework of an experiment to obtain quantitative information regarding the effectiveness of alternate strategies and combinations of techniques in a variety of problem areas. We also recommend the development of archaeological destinations in the desert to channel the interests of desert residents of desert communities and visitors into non-damaging activities. Among such destinations are sites with interpretive programs and archaeological excavations underway with provisions for observation of and/or participation in the work.

A BLM-sponsored program of archaeological data recovery is a necessary component of the protection of resources in the desert. Management techniques may slow the rate of attrition of sites, and can protect selected sites. Sites in "open" areas and other unprotected locations will be lost, however, and with them a great portion of the prehistoric and historic record of the desert. These unprotected areas need to be the focus of scientific investigations.

Natural destruction of archaeological sites is primarily the result of erosion and deposition caused by desertwide winter cyclonic storms. Erosion is greatly accelerated on surfaces which have been disturbed by human activity. Wind deflation is a lesser hazard to cultural resources except where sites occur in unstable substrates such as sand dunes. As is the case with precipitation, wind deflation is more destructive where the natural surface has been broken by human activity.

Damage from natural causes is more frequent at sites in the northeast sector of the California Desert than elsewhere, the result of the interaction of desert topography with storm tracks moving northeast from the Pacific Ocean. Areas underlain by Tertiary terrestrial sediments are vigorously attacked by erosion in all areas of the desert, and sites situated on them are

especially vulnerable. Except in rare instances it is not feasible to protect sites against natural processes. Information regarding the rate of destruction caused by erosion and deflation is needed so that a site's prospects for the future can be estimated and considered in planning. Such information can only be gained from a program of controlled experiments and monitored, protected plots designed for long-term observation.

CONTENTS

Acknowledgments i

Abstract iii

Figures vi

Tables vi

INTRODUCTION 1

CULTURAL AND SOCIETAL FACTORS 4
- Development 4
- Animal Damage 7
- Vandalism 8
- ORVs 14
- Summary 18

THREATS AND CAUSES OF DAMAGE TO ARCHAEOLOGICAL SITES IN THE CALIFORNIA DESERT DURING THE 20th CENTURY 19
- Pre-DPS Sheets 19
- Desert Impacts Inquiry 31

CALIFORNIA DESERT INVENTORY: CONDITION OF SITES AND AGENTS OF DISTURBANCE 41
- Condition 47

NATURAL EROSION OF ARCHAEOLOGICAL SITES IN THE CALIFORNIA DESERT - David L. Weide 63
- Climate and the Present Status of Erosional Regimes 66
- Associations between Archaeological Sites, Landforms, and Erosion 80
- An Experimental Approach to Naturally Occurring and Enhanced Erosion 112
- Summary 114

CASE STUDIES OF SELECTED HISTORICAL SITES - Elizabeth von Till Warren 116
- Military Sites 116
- Health Resorts 120
- Mining Camps 121
- Railroad Sites 126
- Trails, Wagon Roads, and Related Structures 128
- Management Recommendations 131

OTHER APPROACHES TO IMPACTS STUDIES 135
- Vandalism in the Rocky Mountain West 136
- Collecting in the Lower Colorado Planning Unit 141
- Livestock and Lithics 142

MANAGEMENT GOALS, STRATEGIES AND TECHNIQUES 143
Protecting Groups of Related Sites 143
Reducing the Effects of ORV Damage 146
Protective Strategies for Petroglyph/Pictograph Sites 148
Control of Consumptive Educational Activities 149
Information Recovery Program 150

RECOMMENDED MONITORING PROGRAMS 152
Patrolling and Monitoring "Inaccessible" Sites 152

LITERATURE CITED 156

APPENDIX 1. LIST OF PERSONS AND ORGANIZATIONS CONTACTED 165

APPENDIX 2. HISTORIC SITES PHOTOGRAPHS 167

FIGURES

1. University of California Archaeological Site Survey Record 21

2. California Desert Impacts Inquiry Form 32

3. Study Areas and Planning Units in the California Desert 43

4. Archaeological Site Record Used in the California Desert Inventory 45

5. Monthly Occurrence of Gaged Stream Runoff in the Mojave Desert 69

6. Comparison of Channel Network Geometry Following Natural and Enhanced Erosion 73

7a. Distribution of Deflation 103

7b. Distribution of Rilling 105

7c. Distribution of Gullying 107

7d. Distribution of Sheetwash 109

8. Landforms in the California Desert 110

TABLES

1. Frequency of Site Sheets in Sample by County and Period 24

2. Quantity of Information Regarding Impacts by County and Time Period 27

Tables

3. Causes of Damage to Archaeological Sites by Time Period 28

4. Kinds of Threats to Archaeological Sites by Time Period 29

5. Probability of Damage to Archaeological Sites by Time Period 33

6. Characteristics of Respondents to the Desert Impacts Inquiry 34

7. Causes of Damage to Prehistoric and Historic Sites in the California Desert 35

8. Kinds of Places Where Sites Are Being Damaged in the California Desert 36

9. Kinds of Sites Exhibiting Damage in the California Desert 37

10. Localities Exhibiting Damage, Ranked by Number of Times Mentioned on Inquiry 38

11. Relationship Between Condition of Sites and Number of Disturbance Units 48

12. Condition of Sites in the California Desert by Site Type 50

13. Condition of Roasting Pits in Anza-Borrego Compared to Other Study Areas 52

14. Condition of Sites in the California Desert by Study Area 53

15. Kinds of Disturbance at Sites in the California Desert by Site Types 55

16. Study Areas Ranked by Condition and Disturbance 56

17. Association of Condition with Kinds of Disturbance 59

18. Association of Kind of Disturbance with Site Condition 62

19. Variables Affecting Erosion and Deposition 65

20. Comparison of Runoff Between Normal Years and Cyclonic Storm Years 71

21. Desert Surface Material and Critical Wind Speeds 75

22. Desert Surface Material and Critical Friction Velocity 77

Tables

23. Alluvial Fan Gradients, Central and South-Central Mojave Desert 79

24. Climate, Vegetation and Landform Features Listed on DPS Archaeological Site Record 81

25. Erosional Process and Geological Variables for Total Sites Recorded 82

26. Erosional Process and Landforms in the California Desert 88

27. Most Common Association of Recorded Physical Factors Related to Types of Erosion 89

28a. Erosional Process vs. Vegetation 90

28b. Erosional Process vs. Landforms 91

28c. Erosional Process vs. Bedrock 92

28d. Erosional Process vs. Soil Texture 93

28e. Erosional Process vs. Soil Type 94

28f. Erosional Process vs. Slope Angle 95

28g. Erosional Process vs. Slope Aspect 96

29. Ranking of Erosional Process and Landforms 98

30. List of Geomorphic Parameters and Chi-square Values 100

31. Field Studies of Erosional Processes 114

32. Site Types with the Highest Proportion of Reported Vandalism, Rocky Mountain West 137

33. Vandalism Techniques used in Rocky Mountain West, Ranked by Frequency of Use and Perceived Effectiveness 140

34. Site Types and Recommended Management Techniques for California Desert Cultural Resources Protection and Monitoring Program 153

INTRODUCTION

Historic and prehistoric sites of many kinds are found in the California Desert. Some, like abandoned towns, mining camps and rock art sites are easily recognized and intrinsically interesting to habitues and visitors to the desert. It takes an experienced eye to discern other sites, one attuned to the subtleties of the desert's terrain and vegetation. Most prehistoric sites, and many historic locations take refuge in this desert camouflage. In the final accounting, however, no site of any kind has any inherent protection. Sites which are evident are being dismantled, sometimes to satisfy personal acquisitiveness, sometimes for monetary gain, and sometimes for the warmth of an evening's campfire. Less obvious sites are often damaged inadvertently by people who do not recognize them and who drive over them or choose to camp on them for the same reasons that earlier users of the desert also occupied them. Such sites derive little protection from their obscurity, however, for people who would collect prehistoric and historic objects rapidly become skilled in recognizing these sites and removing their contents.

An archaeological site is a location where there is material evidence of past human activity, behavior and history. Indications of history, behavior and activity are not always self-evident upon viewing a desert archaeological site, but often must be teased from the material remains by the skills and theories of archaeology. Because the California Desert was the setting for several of the great experiments in the adaptation of human society to arid environments, that behavior is of great scientific concern to archaeologists. When it is understood and interpreted appropriately it can enhance man's understanding not only of the past, but of the diverse adaptive capacity of mankind.

Archaeologists are among those most concerned for the future of the prehistoric and historic resources in the desert. For a long time, archaeologists regarded sites in the desert as less threatened than those along the California coast which were being rapidly devoured by urban and suburban expansion. Prior to 1974, archaeologists most frequently indicated that the probability of damage to a site in the desert was "slight" when they recorded it. Clement W. Meighan describes one example, a site in the Coachella Valley:

> ...a buried site recorded by me in 1948. I thought it was secure because it was buried under about three feet of alluvium, but on a visit in 1976 I discovered the whole area had been graded to a depth of six feet to create a vineyard. This probably occurred in 1975.... Of 9 sites I recorded in the area 30 years ago, only one is in existence today.*

---

*Unless otherwise cited, quotations in this report are from responses to the Desert Impacts Inquiry distributed by this project in spring 1979.

All who find values in prehistoric and historic sites are aware of the continuing processes that attack and degrade them. We accept some of this attrition as inevitable, as inherent in the formation of the archaeological record. Common sense and our observations tell us, however, that many of these destructive processes are accelerating in the California Desert, fueled by the increased number of users of the desert. They spread to almost every corner of the desert by the increased use of motorized recreation vehicles, particularly 4-wheel drive trucks, dune buggies and dirt bikes, and by the spreading network of roads that accompanies transmission lines and other developments within the desert. It is the purpose of this report to document the condition of sites in the desert at present, to identify the factors that affect the condition of these sites, and to point out those causes of attrition, damage and destruction that are accelerating in the desert. These sources are precisely those which are amenable to management, and whose effects can be slowed if the users and managers of the desert are sufficiently concerned about the desert's cultural resources to treat them with respect and to afford them protection.

Natural and Human Agents of Damage

We treat the effects of natural and human agents of damage separately in our discussion. Natural agents are those which would effect sites even if people had never ventured into the desert. Primary among them are wind and water erosion and weathering of rock surfaces. The chemistry of ground water and soil determines what materials survive in a site that is not above ground, and how rapidly vulnerable materials decay. Our society is accustomed to accept these effects on historic and prehistoric remains, and only in very special cases such as ruins in parks have we sought to slow or reverse these processes. Our inclination to accept this damage is replaced by alarm, however, when we realize that the damages from each of these causes is accelerating as the result of the interaction of natural processes and people's activities in the desert. Michael McIntyre, who was the project manager of a desert survey in 1979 reports that:

> Recent survey by Greenwood and Associates has shown that the Los Angeles Department of Water and Power's Transmission lines have caused erosion patterns that are gradually altering several cultural resources located along the transmission lines. The main patrol road allows access into the area causing further damage to the sites in the area by vandals.

Contemporary human activities which damage prehistoric and historic sites are as diverse as the terrain of the desert. In the DPS inventory they are merged into the categories of DEVELOPMENT, VANDALISM, ANIMAL ORV, and OTHER. These terms subsume a diversity of accidental, thoughtless, and/or purposive damage and destruction that results from people's use and exploration of the desert. From rockhounds who strip a source of jasper, unaware that it is a prehistoric workshop where Indians made stone tools, to the commercial collector who is flown to an isolated mining camp to carry off objects and even parts of buildings to be sold at a profit, both ignorance and knowledge contribute to man's destruction of the record of the past in the California Desert.

CULTURAL AND SOCIETAL FACTORS

Use of the desert by contemporary society affects the cultural resources in many ways, but it rarely enhances them, unless one takes the view that today's trash is tomorrow's archaeology (a depressing, but not untrue situation). Attrition, damage, acceleration of the attack of natural processes and destruction of archaeological and historic sites are the result of increasing usage of the desert. E. N. Anderson, Jr., Associate Professor of Anthropology at the University of California, Riverside, reflects the despair that many feel:

> Every area I know has been deteriorating. Several sites and ecologically interesting areas I remember around Palm Springs and Palm Desert are now under huge apartment complexes, shopping centers and so on. Highways have gone through others. Offroad vehicle tracks and other recreational damage are essentially everywhere, in the areas near here (and thus near Los Angeles and San Diego and so on) especially.

Another respondent said:

> Take your pick. Not to sound like a fanatic, but destruction of both a willful and unknowing nature is occurring just about everywhere in the California desert from the Yuha to Mono county. Conspicuous sites such as historic structures etc. seem to present the most obvious targets for collectors, while flake scatters and other small types of site seem to suffer more from inadvertent destruction such as that caused by ORV's.

Development, animal damage, vandalism and ORV damage are four major kinds of destructive forces. Each includes a variety of forms of damage.

DEVELOPMENT

Transmission lines, military reservations, roads, mining, quarrying, campgrounds and other recreational improvements all occur on public lands in the California Desert and have had adverse consequences for historic and archaeological sites. Private landholdings are more frequently developed, and both ranching and urban/suburban development have damaged and destroyed sites.

Military damage occurs primarily within the numerous reservations that occupy a substantial portion of the California Desert, but it is not limited to them. In the past, maneuvers have been held on public lands. Within the past several years, military reservations have been opened to scrutiny to ascertain the quantity, diversity and condition of archaeological remains that they include. Military use results in several kinds of damage. Grading of roads disturbs sites. Tanks and other heavy equipment disturb artifact scatters, crush tools and break through protective soil crusts, permitting accelerated erosion. Bombing and gunnery ranges devastate sites in target areas, and historic structures are often used as targets. Military personnel often collect artifacts as well. Archaeological surveys underway at Edwards Air Force Base and other installations will provide quantitative estimates regarding the impact of past unregulated military activity on historic and prehistoric sites.

The marks of Patton's maneuvers undertaken in preparation for the North African campaign and of the more recent "Operation Desert Strike" are widespread in the Colorado desert and eastern Mojave. The marks of Patton's maneuvers are almost 40 years old, and demonstrate the permanence of such damage to the desert. A specific example of recent damage is described by Michael W. Kuhn, an environmental planner:

> Petroglyph covered surface east of mouth of Granite Cove along eastern flank of Granite Mts: I first visited the site during the fall of 1962. Approximately 50% of surface at that time was covered with pictographs. Large fires had apparently been built against the rock surface during "Operation Desert Strike" (the site was still littered with communication and barbed wire, tent stakes, garbage, canvas, etc.), or some other military operation, and other campers. Over the next ten years damage progressed as a result of heat accelerated exfoliation of the granite to the point that only fragments of a few petroglyphs are now visible under favorable lighting conditions. Most of this destruction, if not all, was apparently not done intentionally. The petroglyphs were not of display quality.

While there is little doubt as to the destructive nature of military activities on cultural resources, the remains of Patton's maneuvers may be of historic interest in that they are associated with a figure of national importance and are related to one of the major campaigns of World War II. Roy J. Shlemon, consulting geologist in Quaternary geology and soil stratigraphy, points out another value of these remains:

> Patton's "Desert Strike" maneuvers (WW II), gun emplacements and bivouac area generally between Palm Springs and Blythe. Mostly still intact but unprotected by BLM or other agency. Most useful, with other historic "markers", to assess rates of soil erosion and/or renewal of desert pavement.

There are positive considerations to be balanced against the damage that military activities can cause to cultural resources. The closure of these areas to development and recreational use has prevented some kinds of disturbance. The best example is the preservation of Early Man artifacts on the Naval Weapons Center at

China Lake. Emma Lou Davis, whose book The Ancient Californians: Rancholabrean Hunters of the Mojave Lakes Region (1978) reports her investigations of early occupation at Lake China, gratefully acknowledges:

> Were it not for Naval protection of the scientific resources on the missile impact ranges, there would be no China Lake Program. The archaeological and paleontological records there would have long ago been stolen by pothunters, and this report could never have been written (Davis 1978:xv).

Farming and ranching may not seem to be dominant uses of the desert, but where they are undertaken they threaten sites. We have cited Meighan's report of destruction of sites in the Coachella Valley for the establishment of vineyards. Philip J. Wilke of the Department of Anthropology, University of California, Riverside, reports that:

> Jojoba planting has destroyed much of the village of Cabezon on the Cabezon Reservation, Coachella Valley. One aboriginal well and much of the site itself were bulldozed.

Expansion of communities in the desert has taken a heavy toll of prehistoric and historic sites, and continues to do so. Many of these communities were located to take advantage of available water and established routes of travel, factors that had also resulted in prehistoric and historic occupation of these places. A recent example is the Oro Grande site, also known as the "Mohave Foot Site" near Victorville (Rector et al. 1979). Excavation was necessary because a sewage reclamation pond was to be built. In addition to the prehistoric occupation which was the initial objective of the excavation, archaeologists from the University of California, Riverside, uncovered a series of about 50 footprints, more than 4000 years old, preserved along a wide path following the course of the Mojave River.

Mining and quarrying occur on public and private lands in the desert. Philip J. Wilke, Department of Anthropology, University of California, Riverside, reports that: "Rock quarrying south of Travertine Point is destroying fish weirs below the shore line of Lake Cahuilla." Russell L. Kaldenberg, BLM Riverside District Archaeologist, reports that:

> Squaw Spring has suffered from pothunting, collecting and prospecting. Calico Early Man site has been damaged by a miner doing his assessment work (this is particularily true of the surface component [Lake Manix]....

Alan P. Garfinkel, a graduate student in Anthropology at the University of California, Davis, notes that a site in the El Paso Mountains in Kern County, Ker-22, was partially destroyed when miners regraded a dirt road in 1975.

Development of recreational facilities also impacts cultural resources in the desert. Placement of facilities without regard to the potential for the occurrence of archaeological remains has been discouragingly common. BLM procedures now in effect should prevent future campgrounds from being located on archaeological sites. The concentration of activities that occurs in the vicinity of such facilities increases the danger to sites nearby, however, exposing them to intensified vandalism and ORV damage. Daniel F. McCarthy reported that Corn Spring in the Chuckwalla Mountains of Riverside County was one such instance. According to McCarthy, the

> site is a large occupation and rock art site surrounding a native palm oasis. The area was made into a BLM campground years ago. Much vandalism has occurred in recent years.

Dennis Casebier (1979) has documented the damage to historical resources at Zzyzx Mineral Springs, also known as Soda Springs or Fort Soda. The BLM itself, and the California State Colleges which use the development as a field station through an agreement with the BLM, have modified buildings and removed trash without regard for their historical values. The historic developments at Soda Springs may have already destroyed much of the remains of prehistoric occupation there.

ANIMAL DAMAGE

Only recently have animals been widely recognized as a threat to archaeological sites. The damage they cause ranges from the displacement of earth in buried sites by burrowing rodents to disturbance of surficial layers of sites by the trampling of cattle, wild horses and burros. Recent increases in burro populations have made them a notable source of damage, particularly to sites situated at springs and other areas where the animals congregate.

Burrowing is a common adjustment for small mammals in the desert environment. Generally, about 72 percent of mammal species in deserts burrow to avoid the heat of the desert surface and to take advantage of increased humidity below ground. The burrows of kangaroo rats can reach depths of 50-65 cm. As animals burrow, they bring small artifacts and flakes to the surface along with large quantities of soil. Abandoned burrows collapse and fill with material from above, again rearranging artifacts. The loose soil brought to the surface is also vulnerable to wind and water erosion. Locally, however, burrowing may result in more porous soil so that erosion by water run-off may be lessened (Kendeigh 1961:164-165, 338).

Damage to sites by large animals is largely the result of contemporary human society. With the exception of the desert bighorn, limited deer populations and perhaps some antelope, large animals were rare in the California Desert after about 9000 B.C. until their recent reintroduction, and their effects were dispersed. Burros (Euler 1977), cattle and wild horses presently disturb and damage archaeological sites in the desert. John Roney (1977) has documented movement of, and damage to, artifacts by cattle in a controlled experiment in the northern Great Basin. In the responses to our inquiry, animal damage was the least frequently mentioned of the major destructive agents mentioned in the desert.

VANDALISM

Examples of both willful and ignorant destruction of cultural resources abound in the California Desert. Purposeful collecting of arrowheads and other artifacts have removed the chronological indicators from most surface sites in the desert, reducing archaeologists' capacity for placing these sites in their proper chronological period. The extensive assemblage of fluted points recorded and collected at China Lake by Davis (1978) is not duplicated in other scientific collections, although Rogers reported a few (1939:Pl.19) and Amsden described some from Lake Mohave (1937:86-87). For the most part, the diagnostic remains of this very early occupation are now scattered in private collections and desk drawers.

Pothunting is a closely related and even more destructive activity. These endeavors were named elsewhere, where whole ceramic vessels were the chief objective of uncontrolled digging for private gain. Pothunting in the more general sense of digging for Indian artifacts has disrupted many of the sites in the desert where there is any depth of deposit, particularly village sites, caves and rockshelters. Bottle diggers and coin collectors cause the same destruction at historic sites.

Ruth A. Musser, Cima Resource Area Archaeologist, BLM describes the devastation of one area:

> After interviewing a number of people, it became apparent that the archaeological record in the [Afton] canyon is in great jeopardy. Ruth D. Simpson of the San Bernardino County Museum related to me that thirty years ago the canyon was littered with prehistoric remains. These deposits have been mostly, if not entirely, destroyed by illicit collecting and off-road vehicles (the scars from the vehicles tires can be seen bearing over any hillside that is possible to climb with a four wheel drive or motorcycle). Robert Laidlaw of the Desert Plan Staff, Riverside BLM, told me that as a child, one of his Native American informants, a Chemehuevi, would visit Afton Canyon. He remembers a number of caves in the canyon which had deep deposits of midden. Recent visits to the canyon have revealed that the stratified deposits in the caves have been totally destroyed. Dropping a bomb on these caves would have not produced any greater harm than that which has resulted from the illicit collecting there.

Carole Robarchek summarized disturbance both from collecting and pothunting in the Eureka-Saline valleys beginning at least as early as the 1930s in this relatively inaccessible portion of the California Desert:

> The need for protection of the archaeological resources in these valleys cannot be stressed too strongly. All informants report a high rate of vandalism. W. Lewis Tadlock presents graphic evidence of the great extent of the vandalism in his preliminary report. Figure 2 illustrates that 50 percent of the site at Waucoba Springs was vandalized in 1965. His pits literally had to be squeezed into those areas which remained undisturbed. He also reports "pot-hunter" holes dug indiscriminately into sites all over the valley.
>
> The Baldwin Expedition of 1931 certainly collected the materials reported, but no one knows where these materials are deposited and his descriptions in his report are entirely inadequate for analysis purposes.
>
> Margie Kleiger, a student in archaeology at the University of California at Riverside, reports that tourists are collecting points, and that motorcycles and dune buggies have destroyed many sites in the area.
>
> All of the Davis site reports for the southern end of the valley report that site destruction was imminent in 1965!
>
> Both Dr. Simpson and the Enfields report the presence of pot hunters with shovels and screens searching for points in the dunes in the Eureka Valley in the late 1950's (Robarchek 1972:21).

The limited accessibility of sites in the desert and perhaps their reduced yield of spectacular artifacts compared to rich coastal sites with their burials and associations may have slowed the rate of attack on the desert sites in the early part of this century, but now it is exceedingly rare to encounter an undisturbed site anywhere in the desert.

Dr. William J. Wallace, Professor Emeritus of Anthropology, California State University, Long Beach, whose archaeological research in the California Desert has spanned thirty years, notes:

> The destruction and damaging of sites is pretty universal. I know of no area that has really escaped looters and the effects of ever-increasing public usage.

Looting of petroglyphs and pictographs is one of the greatest affronts to the cultural resources of the desert. Rock art sites are most intriguing to desert visitors. The high level of concern for these displays is indicated by the returns from our inquiry, in which 25% of the sites mentioned as examples of damage and destruction are rock art sites. Alan P. Garfinkel, graduate student in archaeology at the University of California, Davis, reports that "Petroglyphs have been removed at Sheep Springs during the last two years by crow bar". Philip J. Wilke, Department of Anthropology, University of California, Riverside, says that "at North Mule Mountains Tanks, quarrying of glyphs has seriously damaged the site." Russell L. Kaldenberg, BLM archaeologist for the Riverside District says that "Black Canyon, Deep Tank and Surprise Tank as well as Inscription Canyon have suffered from target shooters and looters who like to set petroglyphs on their mantels.... Steam Wells, too has suffered extensive damage to its petroglyph site, as the result of vandalism and quarrying."

Isaac C. Eastvold (1973) prepared a description of the known petroglyph sites in the California Desert for the Bureau of Land Management. He documents the kinds of vandalism and looting that these sites had suffered, including shooting, painting, building of fires at the base of petroglyph/pictographs panels, removal of glyph-bearing boulders and quarrying of bedrock outcrops on which there were glyphs.

None of these forms of vandalism are recent inventions, although their incidence has greatly increased. Malcolm Rogers of the San Diego Museum of Man, who recorded many sites in the California Desert between 1919 and 1945, noted instances of all of them. A review of his site records from the Mojave Desert revealed numerous instances of collecting and pothunting. Here are a few examples:

The cemetery at M-4 on East Cronese Lake: "Contents: 4 cremations in situ and several others washed out. Excavated in Oct. 1931. Relic hunters took out two more outlying ones in 1935."

M-29 in the Valley Wells region: "M-29 too stripped by relic hunters to be certain of history...."

M-36, Saratoga Springs: "The village which has the greatest concentration of chalcedony, felsite and jasper flakes seen in the Mohave is between the lake and the river. Relic hunters took all whole material previous to 1925."

M-51, near the Mohave delta: "Just east of this site on a rocky mesa was found a peculiar burial which had been dug out many years previous. The internment was made against the northeast side of a great boulder about 5 feet high and had about a 1000 pounds of boulders and some dirt stacked over it. Nothing was found with it although the destroyer of the burial might have obtained something. The skeleton was in bad condition, slightly mineralized with calcite replacement in the cancelous (sic) tissue and completely broken up in taking it out. No such burial has ever been found in the Mohave by us."

M-163, Nopah Dry Lake: "Site improperly examined by a museum party with the result that the geology, history, etc., cannot be restored, except for those cultures already recorded."

M-45, west end of Newberry Dry Lake: "PETROS" Several seen on a lava block on a bluff north of the site in 1921. Missing in 1926 (probably trucked off)."

M-71, Ivanpah Sink: "This site was thoroughly looted by T and TRR [Tonapah and Tidewater Railroad] crews who camped here when the railroad was being built. Whole material about nonexistant."

Historic sites are also the object of willful destruction. One respondent reports that "Crucero, the water stop on the old T&T Railroad, is a prime example of historical damage. It has almost disappeared over the years." Art Rader, the Director of the Southern Nevada Chapter of the National Railway Historical Society, has documented the destruction of the adjacent railroad station at Rasor, which is between Baker and Crucero. According to Rader:

> Site was intact when first visited in 1968. In each trip following, another building was destroyed until nothing survives today. In 1968, still standing were: T&T RR depot; station agent home; water tower; section gang house; wooden bldg. covering cistern; pump over well....

Vandalism includes both willful and ignorant destruction and both of these occur together on historic sites. Howard Neal reported that "the building on Rand Mountain that once housed the Yellow Aster Stamp Mill was destroyed by vandals in 1970 (Neal 1974:12). Helen McInnis documents the steps in the disappearance of the Searles Lake monorail, which had been constructed in 1923:

> The camp called Epson City and the unique little train were quick to disappear, but sections of the monorail remained visible for many years. From the old road going through Panamint Valley it could be seen in the distance, and close by the road through Wingate Pass the sturdy little A-shaped trestle trudged sturdily along for several miles, holding the solitary rail off the rocky ground.
>
> The trestles were eventually used for firewood by campers in the area, and sometime during the late 1930s scrap dealers salvaged the steel track. Today nothing remains of the elevated monorail, the only railroad track built into the western side of Death Valley (McInnis 1969:35).

Dennis Casebier has described the condition and essential vulnerability of historic sites in the east Mojave Desert region. He says:

> Off the highway, 25 miles north of the little town of Essex on U.S. 66 nestle one of the Mojave Desert's most secluded ghost towns - Providence. Complete with homes, garages, stores, offices and a ten-stamp dry crushing mill, Providence Town offers a mecca for

exploring ghost town fans, a paradise for the camera enthusiast and a bonanza for the mineralogist or amateur prospector. Built around the once fabulously rich Bonanza King silver mine, the town of Providence is generally accorded to be the best preserved ghost town in the West.

The above quotation was written in 1941 - only thirty-five years ago. What would we give to be able to turn the clock back just that short time and have Providence restored to what it was then? But it is too late. Providence is destroyed to the point that it would take a fortune to restore it - and, unfortunately, it is probably in better shape than any of the other early towns of the East Mojave Planning Unit. Ivanpah (the first) and Vanderbilt (the last of the major pre-railroad towns) are in even worse condition.

Providence is in the best condition of the early towns because a soft local stone was used in constructing many of the buildings. Much of that stone is still there. Restoration is possible but probably not practicable.

Of the three important pre-railroad towns - Ivanpah, Providence, and Vanderbilt - it would be difficult to choose the one most worthy of protection or restoration. Ivanpah was first - probably the crudest in terms of construction and improvements - but it was the first civilian community entitled to the name "town" in the East Mojave. Providence was probably the richest, and with the unique building material used for construction of its buildings it is perhaps the most interesting. Vanderbilt was probably the most extensive - although it did not become so large until it became a railroad town. Any one of the three could well qualify as the most typical and most worthy of protection and restoration. All three merit any protection that can be afforded them.

Hart is another ghost town not on a railroad - although it was born well into the railroad period. The camp was short-lived and less extensive than Ivanpah, Providence, and Vanderbilt. Little remains of Hart today.

Lanfair was a railroad town of importance. It owed its significance as being a center of the extensive homestead movement in Lanfair Valley. The site at Lanfair is a worthy spot to commemorate the homestead period in the East Mojave Planning Unit.

There is no old ghost town left "intact" from the old days. But there are examples of buildingsand structures from the different periods scattered here and there at

> the railroad towns (where vandalism has been less extensive) and in secluded corners of the desert. With respect to these, we stand in the shoes of the man who viewed Providence in 1941. Two visitors to the eastern Mojave Desert told me not long ago of finding an old homestead nestled away in a hidden corner of the desert. They told of the cottonwood trees behind the house, and old bed springs hung between the trees as a hammock. They described an old barn and a storage basement detached from the house with a dirt covered roof and Joshua trees growing on the top. There were old magazines lying around. "It looked just like someone walked out of it yesterday and left everything there," they said. I know the homestead they described. I have known it to be in the condition they described for more than ten years. How much longer will it last? Will we take any more effective action than the people of 1941 took to protect Providence? Will we shrink before the challenge to protect this vintage relic? This is only one example. There are other examples of ruins from other periods that have somehow so far escaped complete destruction. The forces that are in motion on the East Mojave right now will destroy essentially all these priceless relics of another age within the next several years. The old abandoned homestead tucked away in a little-known corner of the desert and sheltered by those cottonwoods planted years ago by a hopeful owner will be destroyed by the very people who would gain the most from it if it was properly protected and interpreted (Casebier 1976:331-333).

Much of the vandalism occurs as the result of thoughtlessness and ignorance. The Hemet Jeep Club included in its Newsletter a picture of members cheerily warming themselves around a fire of T&T railroad ties in 1964. They weren't expressing malicious disregard for history, but rather illustrating a form of good fellowship on a desert adventure.

Rockhounds have often destroyed quarry sites that had served as workshops for prehistoric manufacture of stone tools. They are attracted to the same cherts and jaspers that attracted the Indian populations of the desert, but may not recognize the signs of prehistoric workmanship. A respondent to our inquiry described one such occurrence:

> An extreme example of archaeological damage is in the vehicle open area, south of Barstow. The Mojave River Valley Museum ran a survey for BLM when the area was opened....I found a red jasper quarry in Afton Canyon that was beautiful. I took an archaeologist back to see it a few years later, and it was mostly gone. I believe rockhounds found it and stripped it.

Eric Ritter archaeologist, Desert Planning Staff, BLM, adds that other sources of crypto-crystalline rock such as chert and obsidian which were aboriginal quarries have been destroyed by rockhounding activities in the East Mojave, Mule Mountains, Coso Range and the Chocolate Mountains.

ORVs

Use of a variety of off-the-road vehicles has been a key factor in the increased recreational use of the California Desert during the past 10 years. People who would have perceived the desert as a barren, uninteresting and uncomfortable piece of terrain, something to be driven across on the way to Las Vegas or the Colorado River, recognized in it open hillsides, washes and dunes to challenge their vehicles and their skills as drivers. Truck mounted campers provided them with comfort and protection, and together, campers and ORVs brought large numbers of recreationists into the desert. Many of them were not sensitive to the other values and pleasures that the desert affords. Damage to cultural resources by ORV recreationists has been highly visible. It has angered other users of the desert who perceive ORV recreationists as thoughtless and insensitive, and who judge their form of recreation to be unnecessary. Respondents to our inquiry listed ORV damage second only to development as a cause of damage to archaeological and historic sites.

During the years when ORV usage was uncontrolled and unmanaged in the desert several forms of damage resulted from ORV use. Like vandalism, much of it was the result of ignorance, but some was purposeful. Direct damage occurred to many surface sites which were driven over by ORV's. Much of this happened without the recreationist being aware of the damage. Some areas, like Dove Springs, saw very intensive use (Sheridan 1978), for many ORV enthusiasts enjoy the camaraderie of a group of like-minded people. Others, however, sought to explore new terrain and areas, and ORV tracks began to show up on archaeological sites in all corners of the desert. Organized ORV events like the Barstow-Las Vegas race caused a swath of damage across the desert. The Bureau of Land Management attempted to control the course of these events and to route them around prehistoric and historic sites and other sensitive areas, with only partial success (Bureau of Land Management 1975a). In addition to these effects from recreational use of ORVs, the widespread availability of them as transportation has enabled collectors and pothunters to reach areas of the desert that had previously been of limited access. Two of many examples of ORV damage were described by respondents to our inquiry.

Mrs. Jane Gothold of the Pacific Coast Archaeological Society has guided the PCAS's archaeological work at China Ranch for a number of years, and has observed the effects of ORV usage:

> China Ranch/Amargosa Gorge area has seen an increase in the number of off road vehicles coming into the

> area. Dumont Dunes is most often the point of origin; since closure of the area except to "existing roads", there are many more coming up the old Tidewater-Tonopah railroad bed. They consider this an "existing road," as they have used it as such for years. The trestle bridge at China Creek (or Willow Creek) burned down 3 years ago (they used to cross it, missing planks and all); so they have made a "road" right through the creek (poor pupfish) near the 1903 house ruins. "Sleeping circles" at Acme Siding are all destroyed as of Easter '79. Indian trails behind the 1903 house are now jeep and motorcycle ruts, ETC.

Michael W. Kuhn, an environmental planner, has watched the attrition of archaeological remains as ORV usage, in this case, dune buggies, increased. He reports:

> Southeast foredunes of the Kelso dunes contain abundant archaeological sites. Having hiked in the dunes for many years, I have become very well acquainted with many of the sites. Before "dune buggies" became popular there were many, many dozens of complete metates, along with other artifacts. On any walk through the dune margins many large potsherd segments could be seen. By late 1973 and early 1974 (February) at which time dune buggies were still as numerous there as before closure of the dunes to vehicles, perhaps 2/3 of the complete metates had been, apparently, carried off for display on the hearths of some of the dune buggie (sic) enthusiasts. The metates had survived years of visitors, I would speculate, because they usually weigh over 40 lbs. each. Most were simply too heavy for someone to carry off on a normally a half mile or longer hike through the soft sand. With dune buggies all that was required was the ability for one or two persons to be able to load a metate into the vehicle. Large potsherds are now extremely rare and I have often found broken potsherds still juxtaposed that could be put back together. The breaking of the potsherds has probably been more an impact of grazing cattle in the dune margins as (sic) due to dune buggies. Many potsherds have probably been collected.

Although most of the damge by ORV's has been done unknowingly, there have been blatant examples of purposeful destruction. The destruction of the Yuha ground figures in Yuha Wash is one of the most disturbing. The ground figures were recorded and described by Emma Lou Davis and Sylvia Winslow (1965). In 1974, Dr. Davis reported that several had been destroyed by ORV traffic. The one remaining had been fenced by the BLM, affording it some protection (Weide and Barker 1974:88). The protection of the central figure by the fence was shortlived, however. Sometime in May 1975, motorcyclists removed the top rails of the fence, lifted their bikes over the fence and used the fenced areas as a motor-cycle rink, racing around and turning doughnuts on the surface. The BLM estimated that the figure was 70-75% destroyed (Bureau of Land Management 1975b; Eastvold 1979:53).

Damage resulting from ORV racing has been documented on numerous occasions. An example which illustrates the difficulty of controlling these events was described by the Mojave River Valley Museum Association for the hearings of the House Public Lands Subcommittee in Riverside January 11-12, 1973. The testimony was prepared by Beth Pinnell of the Association.

> One example of how police power would have enabled a BLM representative to save an important historical site from severe damage involves the Las Vegas cross country motorcyle race of 1970 and Alvord Summit where a section of famous old trails was remarkably well preserved and scenic.
>
> Alvord Summit was first crossed by New Mexican traders and their mule trains during the 1830-40s and was part of the Old Spanish Trail. Later the section of this trail between Utah and California became known as the Mormon Trail, and even later as the Salt Lake-Los Angeles Wagonroad. These three trails followed much the same route, and became one of the major routes from the East into California. That portion between Las Vegas and the Mojave River east of Yermo presented the worst hardships to the early travelers, and is described in many of the early journals of those travelers .
>
> The site at Alvord Summit is called "Impassible Pass" by Dr. Leroy Haffen in his classic volume "Journal of the Forty-Niners", and it was a difficult ascent from the south. The thousands of wagons and animals that climbed the steep embankment there over the decades cut the road wagon-high into the earth, and the wagon ruts down the long slope northward to Bitter Springs were clearly visable a hundred years after the road was last used.
>
> In an attempt to preserve this remarkable remnant of one of the most important trails in our West's history, Boy Scout Troop #64 from Lenwood, California spent three days in the Spring of 1970 building a monument at the summit, marking it as an historical site. They hauled in boulders and built a barricade across the bottom of the trail to the south and to the north past the summit to prevent vehicles from damaging the well cut trail over the summit.
>
> On the Friday following Thanksgiving, 1970, my brother Bob Depue and I were out flying, and discovered that the route for the second annual Las Vegas cross country motorcycle race was being marked. The long streaks of

lime were quite visable from the air, and much to our concern, the route was marked right up and over Impassible Pass.

Upon our return home, I immediately contacted Paul Sweeney, president of the Mojave River Valley Museum, and he and I met with the local BLM representative. I was for immediately contacting the motorcycle group, even though by that time it was late in the evening, but the BLM officer talked with the office in Riverside, and they instructed him to wait until morning.

The following morning Paul Sweeney, another museum member, Henry James, and myself met with Mario Lopez of the BLM office in Riverside at a cafe at Minneola Road near where the motorcycle race was to start.

Mr. Lopez explained to us that while the BLM had given permission for the race to be run over the same route as the one held the previous year, they had not approved the change through Spanish Canyon and over Alvord Summit, and that there was really nothing they could do in the way of controlling the situation or race. All we could do was ask the race officials to change the route to avoid Impassible Pass--there was no way we could force them to do so.

A deputy sheriff drove us to the camp site of the race officials--members of the San Gabriel Motorcycle Club. The site was an incredible scene of dust, roaring motorcycles and thousands of cars, trucks and campers massed in one small area near the start of the race. We did find the race officials, explained to them that their course was right over an important historical site, and asked that it be rerouted--even a few hundred yards either way in order to save Impassible Pass.

The race officials were curtious (sic) and listened. When Mr. Lopez questioned about the change in race routing, they stated they did not know the course deviated from the one authorized by the BLM, although a quick look at the map showed it to be miles north and making a deliberate change in direction in order to go up Spanish Canyon and over the Alvord Summit. When asked if they had not seen the historical marker at the Pass, one of the men remarked, "Oh, was that what those rocks were?" They stated that it was impossible to change the race course then, since the race was to start soon, but they would send someone to Impassible Pass to wave the cyclists to either side of the old wagon road at that point.

An aerial inspection the day following the race proved that the flagman had not been able to prevent irriparable (sic) damage to Impassable Pass. The estimated three thousand plus motorcycles in the race

> converged in this area in order to go over the summit, and the slopes on both sides of the wagon road were marked by thousands of tracks. The banks of the road were cut down by cyclists who rode around the barricades and into the road itself. Vegetation on both sides of the road was ground into dust, and the road and surrounding hillsides marred forever.
>
> Those who contend that the desert quickly repairs itself and that the damage done by the motorcycles will soon disappear should consider the fact that the ruts cut by the wagons of the pioneers were still quite visable a hundred years after the last one had passed that way. There is little reason to believe that damage done by the thousands of motorcycle tracks will disappear any sooner.

A respondent to our inquiry reported that by 1979, the motorcycle tracks on each side of the wagon road had become gullies which threaten to destroy the impression itself.

SUMMARY

A diversity of impacts that are the result of development and use of the California Desert threaten the prehistoric and historic sites of the area. Many of them have already suffered much damage, particularly in recent years. Before succumbing to the discouraging picture that emerges in this section, however, let us anticipate a later section of our report. In the inventory taken by the Desert Planning staff in 1976-1978, 64% of the sites located and recorded were described as being in GOOD condition. We shall see that some kinds of sites have suffered more severe damage than others, but it is clear that important prehistoric and historic resources do remain in the desert, and they are badly in need of protection.

THREATS AND CAUSES OF DAMAGE TO ARCHAEOLOGICAL SITES IN THE CALIFORNIA DESERT DURING THE 20th CENTURY

Three sources provide quantifiable information regarding threats and causes of damage to archaeological sites in the California Desert. The first of these, archaeological site sheets filed in central repositories through the years, is the only source with time depth. These records, with few exceptions, date from after World War II. The second, responses to the inquiry sheet distributed in the course of this project, report the causes that people who use the desert are most aware of currently. The archaeological site records completed in the course of the Desert Planning Staff's inventory are the third source. They specify forms of damage archaeologists observed on sites encountered in completing probabilistic archaeological surveys, and are the most representative of current conditions at a representative cross-section of sites on public lands in the California Desert. Each of these sources is affected by unique biases, and each will be discussed in turn.

PRE-DPS SITE SHEETS

The best single source of information regarding the condition, forms of damage and threats to archaeological sites in the California Desert prior to the DPS inventory is archaeological site survey record forms. To identify trends in changing site conditions and threatening circumstances, these site records were analyzed to produce information equivalent to that recorded on DPS site records.

The tradition of filing site sheets began in California archaeology at the University of California Archaeological Survey founded at Berkeley in 1948. Numbers were issued to sites by the order in which they were recorded within counties, in the tradition developed by the River Basin Surveys system of the Smithsonian Institution (Heizer 1965:6). The Archaeological Survey established files for each county as workers from Berkeley extended their areas of interest. When the UCLA Archaeological Survey was established in 1958, responsibility for the site records for the ten southern counties was transferred to UCLA (Meighan 1959:ii). The ten southern counties included all of the California Desert except Inyo: Imperial, Kern, Riverside, and San Bernardino were managed at UCLA after 1958.

In the 1960s with the development of archaeological programs at more institutions and the increased pace of fieldwork, the two archaeological surveys were unable to keep up with the rate of site records being submitted, and the requests for use of the records. The Berkeley survey changed its name and mission in 1961. California archaeologists tried to establish a state-wide survey with adequate staffing to manage site records, but did not succeed (King 1967). Since then, separate institutions assumed responsibility for some county site records, and it is from these disparate sources that the files of pre-DPS site sheets have been assembled in the course of the cultural resource inventories.

The pre-DPS site sheets were not particularly designed for the use made of them in this study. Several characteristics of the forms and the people who contributed them to the site survey files over the years must be kept in mind in evaluating the data extracted from them.

Sources of Site Sheets

Filing site sheets was a traditional, but voluntary aspect of archaeological field work. A statement in the 1967 *Annual Report of the UCLA Archaeological Survey* illustrates the nature of the archaeological site record:

> This file is added to each year by students carrying out research projects, by carrying out the survey of proposed highway right-of-ways, reconnaissance of proposed reservoirs and by various amateurs and professionals in southern California who rely upon the Archaeological Survey for coordination of assignment of permanent site designations for permanent record of site locations and descriptions (Hill and Toney 1967:iv).

The geographic distribution of the site records is uneven, reflecting the shifting interests and concerns of archaeologists. The records are also late in a historical sense, with systematic recording only beginning in 1948 at Berkeley and in 1958 at UCLA. Almost no historic sites were entered into the survey files, for those who contributed to the survey files were prehistoric archaeologists.

Quality of Recording

In the course of site recording in the California Desert a variety of site survey forms and records have been used. The types of information available today have been determined by the blanks on the forms, and by the thoroughness with which the forms were completed.

Most of the site record forms have evolved from the site record developed at the University of California, Berkeley, Archaeological Survey. A version of this form is reproduced here in Fig. 1. Items 21 through 24 provide information regarding the condition of the site when recorded, and item 25, *Possibility of destruction*, encouraged archaeologists to record the kind and extent of threats to sites. Information on condition of the site also occurs occasionally in 13, *Description of Site*, and under *Remarks*. These categories persisted as site forms proliferated in California. The UCLA Archaeological Survey continued to use the UC form unmodified. Forms with the same general organization and these

ARCHAEOLOGICAL SITE SURVEY RECORD

1. Site No.________ 2. Map________ 3. County________

4. Twp.______ Range______ 1/4 of_____ 1/4 of Sec.______

5. Location____________________

__________ 6. On contour elevation________

7. Previous designations for site__________

8. Owner__________ 9. Address__________

10. Previous owners, dates__________

11. Present tenant__________

12. Attitude toward excavation__________

13. Description of site__________

____

14. Area______ 15. Depth of deposit______ 16. Height______

17. Vegetation________ 18. Nearest water________

19. Soil of site________ 20. Surrounding soil type______

21. Previous excavation__________

22. Cultivation________ 23. Erosion________

24. Buildings, roads, etc.__________

25. Possibility of destruction__________

26. House pits__________

27. Other features__________

28. Burials__________

29. Artifacts__________

____

____

30. Remarks__________

____

31. Published references__________

32. Museum Accession No.______ Sketch map________

34. Date______ 35. Recorded by______ 36. Photos______

Figure 1. University of California Archaeological Site Survey Record. After A Guide to Field Methods in Archaeology (Heizer and Graham 1967:22).

blanks show up in survey records under the headings of San Bernardino County Museum (1968); Joshua Tree National Monument (1975); Maturango Museum/Mojave-Sierra Archaeological Society (MOSARC) (1970); Bakersfield College (1967); University of Southern California (1953); California State College, Long Beach (1963); Pacific Coast Archaeological Society, Inc. (1974); Imperial Valley College Museum (1974). A deviation from this form that resulted in the omission of some of these blanks appears in the San Bernardino County Museum site survey form which came into use in 1974. This form retains only a blank Details Concerning Possible Destruction. In addition, a form used in 1968 appears in the Riverside County files, headed SITE SURVEY RECORD FORM FOR THE DEEP CANYON AREA (marginally legible - the reading may not be completely correct) that does not request any information on condition or threats of damage.

If there is a surprising continuity in the persistence of these blanks as site sheets evolved in the California Desert, there are significant inconsistencies in how frequently they were filled in and the kinds of information they elicited. Some researchers rarely bothered with these blanks, choosing to complete only blanks that reflected their research interests, while others were inconsistently thorough. The blank Erosion sometimes was used to indicate amount of erosion, and contains information like "slight", "great", "moderate". Less frequently, others used it to indicate kind of erosion affecting the site; "wind" or "aeolian", or "water" were entered. The blank Possibility of destruction extracted two kinds of information. Some used it to indicate probability of destruction, and entered prognostications such as "slight", "unlikely", "great", or "good". Others indicated the forms of destruction which threatened a site: these might include factors such as continuing erosion, collecting or pothunting that had already affected the site or threatening factors such as ORV damage. Occasionally both probability of destruction and threatening causes were recorded for sites.

Learned traditions of site recording affect the quality of records from the California Desert, and are responsible for much of the variation between counties. For instance, the Inyo County records that fall within the California Desert are largely the result of the work of William Wallace, Edith Taylor and people trained by and working with the Wallaces. Their records are consistently complete and are excellent sources of information. They are, however, the result of surveys of selected portions of Death Valley National Monument, where development is of little threat. Much of the area they surveyed was in sand dunes, where erosion is the most evident cause of damage and threat of destruction. In contrast, the bulk of the Imperial County records are the result of the extensive efforts of the Imperial Valley College Museum both through field schools and trained amateurs. Jay von Werlhof has created a sensitivity to the potential damage by ORV's in people trained under him and they consistently include ORV's as a source of possible destruction. Because much of the area they have surveyed is characterized by unconsolidated sediments, sites are frequently affected by erosion, and are so reported. The San Bernardino County records have their own characteristics. They tend to have been filed by avocational archaeologists with diverse training and experience, and the frequency of consistent, useful information is less in these records than in other counties.

In summary, then, the quality of information on the pre-DPS site records is variable, affected by the site form used, the tradition, training and goals of the site recorder, and the characteristics and distribution of the areas that were surveyed.

Data Set for the Study of Pre-DPS Site Records

Pre-DPS site records that had been assembled in DPS headquarters in April 1979 were examined in the course of this study. All sites within the outer boundaries of the CDCA were included, regardless of ownership. Of the records from this area, three sets were excluded from this analysis: Alice Hunt's extensive series in the Inyo County set from Death Valley National Monument, because she systematically did not fill in blanks relating to condition and possibility of destruction; Robert Reynold's Mid-Hills survey, done through the San Bernardino County Museum, where again there is little or no information regarding condition and possibility of destruction; and the set of sites that have San Bernardino County Museum numbers because some undetermined portion of them are duplicated in the San Bernardino County file, but these two files were not yet fully coordinated at the time of this study.

Method of Analysis

A pilot study was undertaken first on a systematic sample comprising 5% of the existing sheets. The digits 06 were selected randomly, and then every twentieth site sheet by site number thereafter was examined (Imp-6, Imp-26, etc.). The pilot study indicated that substantial information existed on the site sheets to indicate forms of damage to sites at the time they were recorded, and potential threats to their continued existence. A second systematic sample was then drawn, a 10% systematic sample, with the starting digits 08. The two samples were combined to provide a 15% sample for each county except Imperial County. Imperial County records are so numerous that they would overwhelm information from other desert counties if their number was not reduced to the 10% sample used herein. More importantly for our purpose, most of them are very recent. About 90% of the sites were recorded in 1975 or later (Table 1).

The site records were coded for the following information:

1. year site recorded

2. categories of damage observed

Table 1. Frequency of Site Sheets in Sample by County and Period.

	Prior to 1950	1950-1954	1955-1959	1960-1964	1965-1969	1970-1974	1975-EOF	Total
Kern	0	8	3	4	5	10	16	46
Inyo	5	66	16	22	4	5	3	121
Riverside	3	9	5	8	8	30	46	109
San Bernardino	22	8	6	14	14	18	22	104
Imperial	1	6	0	4	3	14	180*	205
TOTAL	31	97	30	54	34	77	267	590

*Sample is 10% only for this group of sheets. All other periods sampled at 15%.

D = development, including mining, roads

A = animal, including wild burros and horses, range cattle

V = vandalism, including pothunting, collecting, purposeful damage to petroglyphs, pictographs

ORV = damage by jeeps, 4-wheel drive vehicles, dirt bikes

ES = erosion, slight (minimal, moderate, etc.; kinds not differentiated in tally)

EG = erosion, great (extensive, considerable etc.; kinds not differentiated in tally)

X = excavated (professionally)

3. kinds of threats of destruction. Same categories used as in categories of damage, above.

4. probability of destruction

N = none

S = slight, unlikely

M - moderate, yes

G - great, likely, good

Site sheets in the sample for each county were then put in order by date when they were recorded, and the information on them tallied. The study was designed primarily to identify trends in changing site conditions and threatening circumstances through time. All forms of damage were tallied. A record might list no damage, but sometimes one or several kinds of damage or threats of destruction are reported, so there is no one-to-one relationship between number of sheets coded and number of entries on the tally sheets. In order to summarize the information which pertains to kinds of damage and threats from the site records, the basic statistic used in this analysis is a ratio, the number of times a category of damage or threat is mentioned in the set of site sheets, divided by the number of sheets in the set. These ratios vary through time, by county, and by investigator, and form the basis for comparison, and identification of trends. The reader must keep in mind that when we say that kinds of damage were reported 21 times on the 31 sheets prior to 1950, this is different from saying 21/31 or 67% of the sites were reported as damaged. One site record may list two or three kinds of damage. Each of these kinds is counted toward the total of kinds of damage reported on a group of site sheets.

Characteristics of the Site Records Population

The site records reflect bursts of site recording activity, and are not evenly distributed among counties. Two activity spurts are particularly important in understanding the data derived from the pre-DPS site sheets. Inyo County accounts for more than 50% of all sheets in the years 1950-54 and 1955-59. Imperial County accounts for about 67% of the site sheets in our sample for 1975-EOF (end of file) even though it was sampled at a reduced frequency, 10%, compared to the other counties (Table 1). All desertwide trends derived from the sample of pre-DPS sheets are heavily influence by these two groups of sheets. The Inyo burst is the result of Wallace's Death Valley work; the Imperial burst is the activity of Imperial Valley College Museum.

No overall increase in the quality of recording damage, destruction, or threats of destruction occurred in the desert during the period under study. Judging from the ratio of items of information to number of sheets, there is no increase. The highs, with ratios of 2.0 per sheet and 1.8 per sheet are accounted for by the Wallace's sheets in Inyo County 1950-1959 and the IVCM sheets in Imperial County 1975-EOF (Table 2). If the Inyo County records are removed from 1950-54 and 1955-59, the ratios drop to 1.5 and 1.6 respectively. Similarly, if Imperial County records are removed from the period 1975-EOF, the ratio drops from 1.8 per sheet to 1.4.

Results of Pre-DPS Site Sheet Analysis

Desertwide trends in kinds of damage reported to sites, kinds of threats to sites and probability of destruction were identified by grouping data from all counties. During the period the site sheets cover, the number of threats to sites increased, the kind of threats changed, and there is a shift in the kinds of damage reported at sites (Tables 3 and 4).

Trends in damage to sites. Damage to archaeological sites by ORVs shows the most distinctive trend among the kinds of damage reported. The first report is in 1969 in Imperial County. The incidence of damage increases in the following years until in 1975-EOF it is the second most common form of damage reported, exceeded only by erosion. Erosion is consistently the most frequently reported cause of damage to sites. Damage by animals is noted only in the last two periods, and remains at a low frequency. Other forms of damage such as development, excavation and vandalism do not show any consistent changes, nor is there a consistent change in the total reports of damage to sites.

Trends in threats to sites. Since 1969, the threats to archaeological sites have increased steeply. Prior to 1970, if Inyo County sheets are omitted for 1950-54 and 1955-59, the ratio of reported erosion ranged from 0.1 to 0.4. After 1969, the incidence of threatened damage doubles. It is 0.7 in 1970-74, and rises to 0.8 in 1975-EOF. This is a desertwide trend, for even if

Table 2. Quantity of Information Regarding Impacts by County and Time Periods.

	Kinds of Damage	Kinds of Threats	Probability of Destruction	Total No. Sheets	Ratio
prior to 1950	21	3	16	40/31	1.3
1950-1954	94	59	43	196/97	2.0
1955-1959	25	18	18	61/30	2.0
1960-1964	38	20	22	80/54	1.5
1965-1969	26	12	12	50/34	1.5
1970-1974	38	51	20	109/77	1.4
1975-EOF	212	205	72	489/267	1.8
TOTAL	454	368	203	1025/590	1.7

Table 3. Causes of Damage to Archaeological Sites by Time Period.

	Development		Animal	ORV	Erosion		Excavation	Vandalized		Total	
	No.	Ratio	No.	No.		Ratio	No.	No.	Ratio	Damage/Sheets	Ratio
prior to 1950	4	0.13			14	0.5	3			21/31	0.7
1950-1954	9	0.09			72	0.7	1	12	0.12	94/97	1.0
1955-1959	2	0.07			19	0.6	1	3	0.10	25/30	0.8
1960-1964	10	0.19			25	0.5		3	0.05	38/54	0.7
1965-1969	6	0.18		1	14	0.4	1	4	0.11	26/34	0.8
1970-1974	5	0.07	1	4	18	0.2	3	7	0.09	38/77	0.5
1975-EOF	25	0.09	1	28	150	0.5	2	6	0.02	212/267	0.8
TOTAL	61		2	33	312		11	35		454	

Table 4. Kinds of Threats to Archaeological Sites by Time Period.

	Development		Animal	ORV	Erosion		Vandalism		TOTAL	
	No.	Ratio	No.	No.	No.	Ratio	No.	Ratio	Threats/sheets	Ratio
prior to 1950	3	0.06			0	0	1	0.03	3/31	0.1
1950-1954	3	0.03	1		47	0.5	8	0.08	59/97	0.6
1955-1959	2	0.02			15	0.5	1	0.03	18/30	0.6
1960-1964	3	0.05		1	8	0.1	8	0.15	20/54	0.4
1965-1969	6	0.17		2	2	0.05	2	0.06	12/34	0.4
1970-1974	14	0.22	6	16	1	0.01	14	0.18	51/77	0.7
1975-EOF	33	0.12	6	98	26	0.1	42	0.15	205/267	0.8
TOTAL	63		13	117	99		76		368/590	0.6

the Imperial County data are removed from 1975-EOF, the ratio remains at 0.7 (Table 4).

The increased threat to archaeological sites looms in three forms: ORV's, development, and vandalism. ORV's are first reported as threatening a site in San Bernardino County in 1961. By 1970-1974, ORV damage is the most frequent threat, exceeding vandalism and development. In the final period, 98 of 205 threats to sites are from ORV's, exceeding vandalism and development combined. Vandalism's threat increases consistently if not sharply during the time periods. If the data from the vandalism column on Table 4 is grouped, prior to 1960 the ratio of vandalism as a threat is 0.06, but in 1960-69 it almost doubles, increasing to 0.11. From 1970 to the end of the files, it increases markedly again, to 0.16. The threat of development was reported as low prior to 1965, ranging from 0.02 to 0.06. In the final three periods it is twice to three times as high, ranging from 0.12 to 0.22.

Erosion as a threat is reported in surprisingly low frequency, ranging from 0.01 to 0.04, except by Wallace's sheets, particularly 1950-54 and 1955-59. When those figures are contrasted with the figures from Table 3 which show ratios for <u>damage</u> by erosion ranging from 0.2 to 0.7 by time period, with an overall ratio of 0.5, we have a clear indication of how archaeologists' conceptual sets have affected the kinds of information entered on site sheets. When most archaeologists think of <u>Possibility of Destruction</u> they think of threats by society, not of natural causes such as erosion, which are not reversible and which are self-evident if you have already reported that the site <u>is</u> eroding.

Animal damage is not reported as a threat until 1970-1974. Prior to 1970, archaeologists did not perceive it as a large-scale threat to archaeological sites. They were inclined to accept damage by rodents and other small animals as one of the natural factors that are inherent in the condition of sites. More recently the cumulative effects of soil displacement by rodents and the resulting rearrangement of artifacts and features within archaeological sites has been documented.

<u>Trends in probability of destruction</u>. The primary trend in this area is the decreasing frequency with which archaeologists responded to the blank <u>Possibility of Destruction</u> by describing a probability such as "slight", "moderate", etc. Since they are increasingly inclined to specify the kinds of damage threatening sites, that information occupies the blank.

When archaeologists did indicate probability of destruction, it was most frequently "slight" until 1974. With the exception of 1950-1954, more than half the site sheets which had this kind of information listed the probability as "none" or "slight". The 1950-1954 data is largely the product of the Wallace's work in Inyo County. Thirteen of the 14 sites marked moderately endangered are in Inyo County, as are all 10 of those reported in great danger. In the final period, 1975-EOF, more than half of the sites so reported are moderately or greatly endangered. This trend appears to be desertwide, for even when Imperial County is removed from the 1975-EOF sheets, 25 of these responses remain, and of them 14 or 56% are "moderate" or "great" (Table 5).

DESERT IMPACTS INQUIRY

In late spring of 1979, we distributed about 120 formated inquiries to persons interested in and knowledgeable about prehistoric and historic sites in the California Desert. Seventy-one were returned, a rate of more than 50%. The inquiry form also had some secondary distribution, and we received and welcomed responses from a few individuals who had not been included in the original mailing. The form is illustrated as Fig. 2. The respondents were primarily archaeologists, with the remainder about equally divided among geologists, historians and interested citizens. Table 6 provides a breakdown of the respondents by profession and nature of affiliation. The inquiry form was open-ended, to encourage respondents to share information. The tabulations from those forms, Tables 7 through 10, are the result of classification of answers from those forms.

Causes of Damage

Vandalism in its many forms comprises the most frequently identified source of damage (Table 7). Collecting and pothunting are the most commonly cited forms of vandalism, with rock-hounding, petroglyph quarrying and shooting at petroglyphs also frequently mentioned. ORVs and development are the next most frequently identified. Most respondents blamed ORVs generally, but some specified that 2-wheel vehicles, specifically dirt bikes and motorcycles, were particularly to blame. Many also expressed their belief that much of this damage was inadvertent rather than purposeful, that ORV enthusiasts often did not recognize the sites they were driving through. With respect to development, many different forms were mentioned, but the category mining, mineral exploration and quarrying was cited most frequently.

Damage by animals and erosion was mentioned with much lesser frequency than forms of vandalism, ORV damage or development. There is a high level of awareness of the damage that results from large animals, primarily cattle and horses, however. Burrowing by small animals is rarely mentioned, and many people accept burrowing as part of the natural course of things. The various forms of erosion and weathering are infrequently mentioned. Here, too, people are inclined to accept the damage or be unaware of it unless they have witnessed the effects of such an event as a flash flood.

Archaeologists are mentioned as sources of damage by 6 respondents. They specify several archaeological activities: the conduct of survey and excavation for training purposes, with no report resulting; thoughtless surface collecting without internal controls and a research design; and "testing" of sites.

DESERT IMPACTS INQUIRY
Department of Anthropology
University of Nevada
Las Vegas, NV 89154
(702) 739-3590

Respondent's Name ______________ ______________

Address ______________________________

______________ ______________

Phone No. ______________________________

1. How long have you been acquainted with the California desert?

2. What kinds of use do you do you make of desert lands?

3. In your experience in the California desert, what are the current causes of damage and destruction to archaeological sites?

4. In what kinds of places, and in what areas of the desert are historic and archaeological sites currently being destroyed or damaged?

5. Is there a particular archaeological or historic location that you have visited over the years which has been deteriorating? Can you provide us with a capsule summary of the damage to it, the causes, and approximately when it occurred?

6. Do you have photographs or other records that illustrate the condition of archaeological or historic sites at some time in the past that can be contrasted with their present condition?

7. Can you suggest a locality on public lands that displays a variety of historic and/or archaeological sites which have been damaged, and which might make a good case study for the Impacts project?

Figure 2. California Desert Impacts Inquiry form.

Table 5. Probability of Damage to Archaeological Sites by Time Period.

	None	Slight	Moderate	Great	Total
prior to 1950	2	13	1		16
1950-1954	1	18	14	10	43
1955-1959	4	8	2	4	18
1960-1964	3	11	4	4	22
1965-1969	1	6	2	3	12
1970-1974	2	14	2	2	20
1975-EOF	8	25	14	25	72
TOTAL	21	95	39	48	203

Table 6. Characteristics of Respondents to the Desert Cultural Resources Impacts Inquiry.

Archaeologists		
college and university faculty	5	
graduate students	5	
government employees		
BLM	10	
USFS	2	
State of California	3	
other federal	2	
museum employees	6	
privately employed	6	
avocationals	9	
Total archaeologists		46
Geologists		
college and university faculty	2	
USGS	3	
privately employed	1	
Total geologists		6
Historians		
privately employed	1	
graduate student	1	
avocational	1	
historical society spokespersons	3	
affiliation unknown	1	
Total historians		7
Others		
concerned citizens	4	
planners	2	
anthropologists	3	
ranchers	1	
natural resource specialist	1	
unknown	1	
Total other		12
TOTAL RESPONDENTS		71

Table 7. Causes of Damage to Prehistoric and Historic Sites in the California Desert, Responses to Inquiry

1.	Development (non-specific)	7	
	construction	6	
	housing	4	
	land reclamation	1	
	military	5	
	mining and mineral exploration, quarrying	14	
	road building, highways	8	
	utilities	7	
	Total DEVELOPMENT		66
2.	Animal		
	burrowing	2	
	large animals, grazing, trampling, etc.	11	
	Total ANIMAL		13
3.	Vandalism (non-specific)	22	
	petroglyph quarrying	9	
	pothunting	23	
	rockhounding	8	
	collecting	24	
	shooting at petroglyphs, pictographs	7	
	Total VANDALISM		93
4.	ORV (non-specific)	45	
	motorcycles, 2-wheel, dirt bikes	17	
	4-wheel	6	
	dune buggies	1	
	Total ORV		69
5.	Natural (non-specific)	1	
	erosion	10	
	flooding	3	
	wind	3	
	weathering	2	
	Total NATURAL		19
6.	Recreationists (non-ORV)		4
7.	Archaeologists		6
	TOTAL		257

Table 8. Kinds of Places Where Sites Are Being Damaged in the California Desert, Responses to Inquiry.

Everywhere (almost, practically, etc.)	21	
Close to roads, campgrounds, accessible	23	
Close to population centers	10	
In population centers	1	
Military bases and associated maneuver areas	4	
ORV open areas	2	
Kinds of places in the sense of terrain		
desert pavements	3	
playa and dry lake margins	4	
sand dunes	1	
rock walls and boulders	1	
alluvial fan surfaces	1	
old stream terraces	1	
springs	2	
TOTAL		74

Table 9. Kinds of Sites Exhibiting Damage in the California Desert, Responses to Inquiry.

Historic sites (unspecified)		4	
mining towns and camps		2	
roads and trails		1	
railroads		1	
historic towns, ghost towns		4	
	Total Historic		12
Prehistoric sites (unspecified)		2	
petroglyphs		3	
rock shelters		1	
flake scatters		1	
	Total Prehistoric		7

Table 10. Localities Exhibiting Damage, Ranked by Number of Times Mentioned on Inquiry.

		No.
1.	Fort Paiute (Pahute), Paiute Creek, Piute Pass	7
2.	Inscription Canyon, Black Canyon	7
3.	Deep and Surprise Tanks in Rodman Mountains. Barstow area	7
4.	Yuha intaglio	6
5.	Coachella fish traps	3
6.	Afton Canyon	3
7.	Granite Mountains	3
8.	Blythe intaglios	3
9.	Mohave Road, Old Government Road	3
10.	Zzyzx, Soda Springs, Ft. Soda	2
11.	Travertine Point, Salton Basin petroglyphs	2
12.	Palo Verde petroglyphs	2
13.	Providence ghost town	2
14.	Black Mountain archaeological zone in El Paso Mtns.	2
15.	Little Lake, Fossil Falls	2
16.	Crucero on the Tonopah & Tidewater Railroad	2
17.	La Quinta	2
18.	Red Rock Canyon State Park	2
19.	Dove Springs	2
20.	Coyote Hole State Park	2
21.	Halloran Springs	2
22.	Goldstone	2
23.	Mule Mountain Archaeological District	2
24.	Pilot Knob Mesa intaglios	2
25.	Old Ivanpah	1
26.	Rabbit Hole Spring	1
27.	Bull Spring	1
28.	Salt Springs	1
29.	Chicago Valley	1
30.	Mesquite Springs petroglyph site, Mojave R. area	1
31.	North Mule Mountains tanks petroglyph	1
32.	Willis Wells in Ord Mountains	1
33.	Ryan Ranch in Joshua Tree National Monument	1
34.	Squaw Spring, Red Mountain area	1
35.	Bobo Springs, Yucca Valley area	1
36.	Indian Wells Valley, Kern Co.	1
37.	Pleistocene Lake Mohave	1
38.	Colorado River terraces	1
39.	Black Canyon-Havasu Landing area	1
40.	Alvord Mine east of Calico	1
41.	Chubbuck	1
42.	Tumco, town of	1
43.	Crater townsite, Inyo Co.	1
44.	Panamint City	1
45.	Rose Valley and adjoining canyons	1
46.	China Ranch/Amargosa Gorge	1
47.	Tahquitz and Palm canyons	1
48.	Santa Rosa Flat	1
49.	Kearsarge Station	1
50.	Coca-Maricopa trail	1

(continued)

Table 10. Localities Exhibiting Damage, continued.

51.	Fox Trot rock art site, 29 Palms Marine Base	1
52.	Eureka and Saline valleys	1
53.	Sweeney Pass village, San Diego Co.	1
54.	Modoc Mine in Panamint valley	1
55.	Rasor on Tonopah and Tidewater Railroad	1
56.	Steam Wells just east of Randsburg	1
57.	Alvord Summit (Impassable Pass)	1
58.	Ocotillo Wells State Vehicle Recreation Area	1
59.	Anza Borrego State Park (Carrizo Canyon and Dos Cabezas	1
60.	Borrego Valley	1
61.	Granite Mountains (Granite Cove near Kelso) petroglyphs	1
62.	Emigrant Trail	1
63.	Valley Wells complex	1
64.	Argus Range	1
65.	Slate Range	1
66.	Cronese Basin	1
67.	The Maze, west side of the Colorado	1
68.	Lanfair Valley	1
69.	Ker-311 ("close" to the desert-the Tubatulabal site)	1
70.	Camp Rock spring, San Bernardino Co.	1
71.	Toll House, Inyo Co.	1
72.	Hayfield Petroglyph site, Riverside Co.	1
73.	Hedges, Imperial Co.	1

Kinds of Places

Question 4 elicited a variety of responses. Many people expressed the feeling that there was nowhere in the desert that damage had not occurred, but many of those respondents and others felt that it was more concentrated in accessible areas close to roads and campgrounds or near to towns and cities (Table 8). Others indicated the kinds of sites that were being damaged. Table 9 summarized those responses and shows that historic sites are mentioned more frequently than prehistoric sites.

Many people listed particular localities which exhibit damage in the course of answering questions 4 through 7. These are listed and tabulated on Table 10. Two characteristics of this list are particularily interesting. One is the large number of different places mentioned, 73 localities on 71 responses. Table 10 ranks them by the number of times each locality is mentioned. The damage to Fort Piute (Pah-Ute), Black or Inscription Canyon, Deep and Surprise Tanks, and the Yuha Intaglio are widely known. After those, individual localities are rarely mentioned by more than one or two respondents. Most respondents know of a different case of damage, an indicator of how widespread damage to prehistoric and historic sites damage is in the California Desert. The second interesting characteristic is the geographic dispersion of the damaged sites. They fall in all regions of the desert.

The list of particular localities which exhibit damage reflect the high awareness of damage to rock art sites and historic sites by respondents. At least 17 are petroglyph or intaglio sites, and another 19 are historic sites. These two categories make up half of the localities listed. Some of the other localities also include petroglyphs and/or historic sites among the variety of features present.

CALIFORNIA DESERT INVENTORY: CONDITION OF SITES AND AGENTS OF DISTURBANCE

In the course of preparing the California Desert Plan, the Bureau of Land Management's Desert Planning Staff conducted an inventory of prehistoric and historic sites in the desert. For inventory purposes, the California Desert is divided into a series of planning units which may be combined into larger parcels called study areas (Fig. 3). The major portion of the inventory consisted of on-the-ground archaeological reconnaissance survey of a sample of the desert lands. The survey was conducted as a series of probability samples from which predictions might be made regarding the number, kinds, locations and condition of sites in the desert. The sampling fraction was low in these surveys, and generally less than 1% of the land was examined. In a very few areas, more intensive survey was possible, and up to 10% of these selected lands were surveyed. In addition, sites outside of sample units were occasionally recorded by BLM personnel and others. These sites, too, are included in the inventory.

The data base for the impacts study analyzed the site record information for all sites in the Desert Planning Staff's computer file as of June 1980. We have not attempted to project the results of our analysis to numbers that might characterize the complete population of sites in the California Desert. The field surveys allocated their samples among environmental differently in addition to varying in their sampling frequency. On the whole, we have restricted ourselves to describing the kinds of damage that have occurred to the recorded sites and the condition of those sites. On the whole, the sites in the inventory are generally representative of those in the desert. They cannot be regarded as a predictive sample however, without considerations that were beyond the scope of this study.

The site record form used in the California Desert Inventory is reproduced as Figure 4. Two categories of its information are particularly important to this study: [18] DISTURB (kind of disturbance); and [19] CNDT (condition). For each site, the recorder would check one state of CONDITION: good, fair, or poor. Any number of kinds of disturbance might be recorded. The state "other" under DISTURBANCE served a two-fold purpose. It was to be checked if erosion had disturbed the site. In this case, the kinds of erosion would be recorded under category [41] EROSION. If still some other form of disturbance was observed at the site, the recorder was to check "other" and to describe it in the [20] COMMENTS box. Comments were not transcribed into the data storage, and were not available to our analysis. We did have photocopies of a sample of the site records themselves, and were able to scan these for some observation regarding the information in the comments box.

The two variables central to impacts analysis are quite different in their nature. DISTURBANCE, for which any number of categories can be checked, is limited in the kinds of analysis to which it can be subjected. Coombs has pointed out that a variable

Figure 3. Study areas and planning units in the California Desert Conservation Area.

Study area	Planning units included
1	Yuha, Imperial
2	Big Maria, Whipple Mountains, Picacho
3	Santa Rosa, Orocopia
4	Bristol/Cadiz, Turtle Mountains, Palen
5	Anza-Borrego
6	East Mojave, Mid-Hills, Devil's Playground
7	Mojave Basin, Owlshead/Amargosa
8	Bitterwater, Kingston
9	Calico, Antelope Valley, Kramer, Stoddard, Johnson/Morongo, Twentynine Palms
10	El Paso, Red Mountain
11	Panamint Valley, Darwin, Saline Valley, Eureka Valley

(Hatched areas excluded from BLM studies)

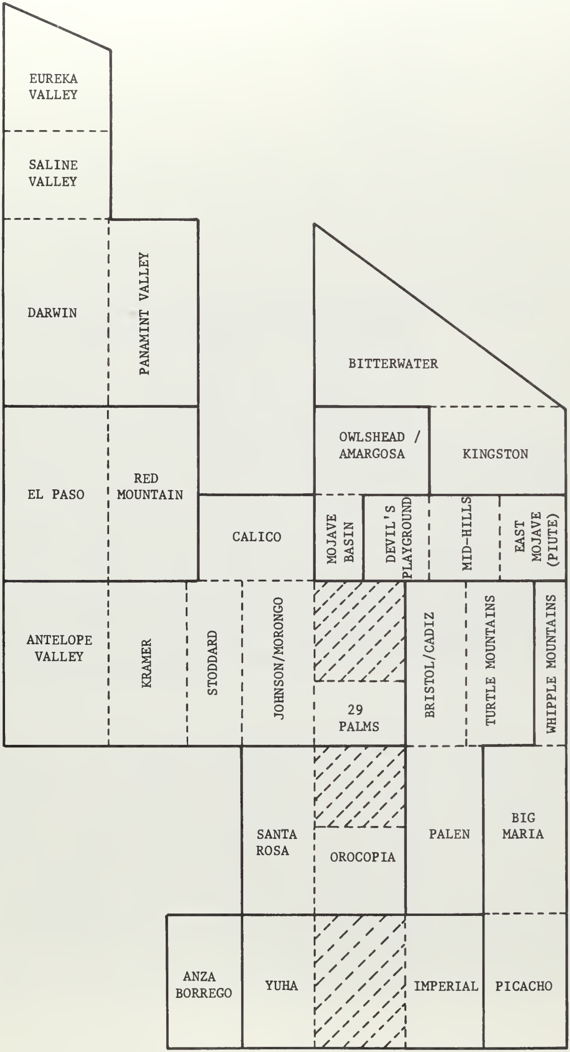

EUREKA VALLEY
SALINE VALLEY
DARWIN
PANAMINT VALLEY
BITTERWATER
OWLSHEAD / AMARGOSA
KINGSTON
EL PASO
RED MOUNTAIN
CALICO
MOJAVE BASIN
DEVIL'S PLAYGROUND
MID-HILLS
EAST MOJAVE (PIUTE)
ANTELOPE VALLEY
KRAMER
STODDARD
JOHNSON/MORONGO
29 PALMS
BRISTOL/CADIZ
TURTLE MOUNTAINS
WHIPPLE MOUNTAINS
SANTA ROSA
OROCOPIA
PALEN
BIG MARIA
ANZA BORREGO
YUHA
IMPERIAL
PICACHO

Figure 4. Archaeological site record used in the California Desert Inventory, Desert Planning Staff, Bureau of Land Management.

[1] County	
[2] District	
[3] Planning Unit	
[4] Sample Unit	
[5] Photos	
[6] Date	
[7] Recorder	

ARCHAEOLOGICAL SITE SURVEY RECORD

[8] Site # ________ [9] Other # ________

[10] Site Name ______________________

[11] Cadastral Location: Twn ____ Rng ____ ____of____ of Sec ____

[12] Quadrangle ______________________ [13] Elevation ________

[14] UTM Grid Loc. Zone ________ Northing ________ Easting ________

[15] Reference Points: ______________________

[16] OWNER				
BLM	OTHER FED.	STATE	PRIVATE	UNKNOWN

[17] NAT'L REGISTER							
(A) STATUS					(B) TYPE		
LISTED	CANDIDATE	POTENTIAL	NOT ELG.	NO DET.	DISTRICT	SITE	OTHER

[18] DISTURB				
DEVELOPMENT	ANIMAL	VANDALISM	ORV	OTHER

[19] CNDT		
GOOD	FAIR	POOR

[20] COMMENTS

[21] SITE TYPES																			
VILLAGE	TEMPORARY CAMP	SHELTER/CAVE	MILLING STA.	LITHIC SCATTER	QUARRY SITE	POTTERY LOCUS	CEMETERY	CREMATION LOCUS	INTAGLIO	ROCK ALIGNMENT	PETROGLYPH	PICTOGRAPH	TRAIL	ROASTING PIT	ISOLATED FIND	CAIRN	HISTORIC	OTHER

[22] AREA					
0-10 Sq. M.	11-50	51-250	251-1000	1001-5000	over 5000

[23] DEPTH				
SURFACE	1-20 Cm.	21-100	over 100	UNKNOWN

[24] General Site Description:

[25] FEATURES										
STRUCTURAL DEP.	ROCK RING	ROCK STRUCTURE	CAIRN /SHRINE	ROASTING PIT/FAR	HEARTH	PETROGLYPHS	PICTOGRAPHS	BEDROCK MORTAR	GRINDING SLICK	OTHER

[26] ARTIFACTS										
PROJECTILE POINT	FLAKED STONE TOOL	CORE-DETRITUS	MILLING TOOL	OTHER GROUND STONE	CERAMIC	BONE	PERISHABLE	ORNAMENT	Historic	OTHER

[27] ECO.			
FIRE AFFECTED ROCK	FAUNA	FLORA	OTHER

[28] MAT.			
CRYPTOCRYSTALLINE	OBSIDIAN	FELSITE	OTHER

[29] Describe:

[30] VEGETATION																	
BARREN	SALTBUSH	CREOSOTE	JOSHUA/CREOSOTE	JOSHUA/YUCCA	YUCCA/CACTUS	BLACKBRUSH	SAGEBRUSH	PINYON/JUNIPER	CONIFER	SHADSCALE	CHAPARRAL	OAK WOODLAND	MESQUITE	RIPARIAN	WASH	GRASSLAND	OTHER

[31] COVERAGE					
CONTINUOUS (over 75%)	INTERRUPTED (50-75%)	PARK-LIKE (25-50%)	RARE (6-25%)	BARELY PRESENT (1-5%)	ABSENT (0-1%)

[32] WATER				
INTERMITTENT STREAM	PERMANENT STREAM	SPRING	PLAYA	OTHER

[33] Describe

[34] LANDFORM											
MOUNTAIN	HILL	TERRACE	RIDGE	ALLUVIAL FAN	CANYON	ARROYO	SAND DUNE	DESERT PAVEMENT	BADLANDS	PLAYA	OTHER

[35] BEDROCK					
EXTRUSIVE IG.	INTRUSIVE IG.	METAMORPHIC	SEDIMENTARY	QUATERNARY ALLUV.	OTHER

[36] TEXTURE				
SAND	LOAM	SILT	CLAY	OTHER

[37] SOILS					
HIDDEN	ALLUVIAL	COLLUVIAL	EOLIAN	BEDROCK	OTHER

[38] Describe

[39] SLOPE								
POINT OF INFLEX	LOWER 1/3	MID 1/3	UPPER 1/3	0-5°	6-15°	16-30°	31-60°	over 60°

[40] ASPECT							
NORTH	NORTH/EAST	EAST	SOUTH/EAST	SOUTH	SOUTH/WEST	WEST	NORTH/WEST

[41] EROSION						
DEFLATION	RILLING	GULLYING	SHEET/WASH	ROCK/DEBRIS	SLUMPING	OTHER

[42] DRAIN.			
CONVERGING	DIVERGING	BRAIDED	OTHER

[43] Remarks

of this kind may be desirable for descriptive objectives but is unsuited for statistical analysis (1979b). CONDITION does not suffer this same problem, but it must be recognized as a somewhat subjective variable, in which considerable personal judgment was involved in characterizing a site as good, fair or poor.

A further problem exists in using these two variables as indicators of impacts on archaeological sites. There is no direct information regarding the intensity of the effect of a particular form of disturbance. "Other" comprises 63% of the disturbance units, and there are very few sites for which only one form of disturbance, either development, animal, vandalism or ORV damage, is indicated. We have taken this set of sites and have cross-tabulated their form of disturbance with their condition below (Table 18). They are a small and skewed sample of the sites recorded in the inventory process, however. The other way of looking at the question of intensity is indirect, but permits use of all site records which are coded for both DISTURBANCE and CONDITION (Table 17). This seeks an association between the record of a particular kind of damage at a site and the condition of that site. On as broad a base as Study Areas or the whole California Desert some associations emerge, even though at any one site, fair or poor condition may have been the result of another kind of disturbance, also recorded for that site.

The nature of the data then dictates that our use of it is primarily descriptive. In order to handle the variable DISTURBANCE quantitatively, we use a disturbance unit as the element to be counted. A particular site may exhibit 0 to 5 disturbance units. While there is a general association between the number of kinds of disturbance recorded at a site and the extent of its deterioration, there are instances where as many as three forms of disturbance were observed at a site, and yet it was judged to be in good condition. The association between numbers of kinds of disturbance recorded at a site and its resultant condition can be expressed by the ratio of disturbance units to sites for each CONDITION. Table 11 illustrates the relationship between condition and number of disturbance units per site for the grouped data from four selected site types: villages, temporary camps, shelters and caves, and historic sites.

The data from the California Desert Inventory will be used to characterize the condition of sites in the California Desert, and to analyze the factors that disturb these sites and that result in the reduction of their value as public and scientific resources. We will then look at the evidence regarding the relative impact of the several forms of disturbance on the archaeological sites of the desert.

CONDITION

More than half (64%) of the 2569 sites for which we have information from the California Desert Inventory were described as being in good condition, 30% in fair condition, and 7% in poor

Table 11. Relationship between Condition of Sites and Number of Disturbance Units. *

Condition	Number of disturbance units	Number of sites	Ratio
Good	434	387	1.12/1
Fair	448	334	1.34/1
Poor	167	99	1.69/1

*four selected site types summed: villages, temporary camps, shelters and caves, and historic sites.

condition (Table 12). These are evaluations by field archaeologists and generally reflect their value in yielding archaeological information appropriate to the particular kind of site. There is considerable variability in the condition of sites, both in terms of geographic location in the desert and depending on what kind of site it is. Information regarding condition of sites in Study Area 10, the El Paso and Red Mountain Planning Units, was not coded on the data type we received, and so Study Area 10 is not included in this discussion.

Villages and historic sites are more frequently in poor condition than other site types in the California Desert, with only 36% of village sites and 38% of historic sites regarded as being in good condition. Shelters and caves are also substantially diminished in their values, with 48% in good condition. These kinds of sites are thought to be most frequently the object of vandalism, and the kinds of disturbance recorded at them is examined below. The poor condition of villages, shelters and caves in the desert is of particular concern to prehistoric archaeologists. These two kinds of sites retain deposition sequences that can provide the chronological control which is of great importance in the California Desert. They also preserve faunal remains, evidence of people's activities and their arrangements for shelter and community organization.

Petroglyph and pictograph sites encountered in the inventory were few in number, totaling only 45 for which condition was reported. Surprisingly, a high percent of them, 71%, were recorded in good condition, and only 7% in poor condition. Petroglyphs and pictographs are thought to be frequent targets of vandalism, and the high percentage in good condition is not consistent with the perceptions of people who use the desert. There are two possible explanations for the reported condition of petroglyphs and pictographs. Damage to them in the form of graffiti, shooting and other thoughtless acts occurs where they are most accessible to the public, and so the damage is highly visible and impressive. Alternately, or perhaps in addition, removal by collectors or commercial procurers of primitive art may be so complete that archaeologists will not recognize that they have been taken unless there is a prior record of their existence.

Milling stations are generally in the best condition of sites in the desert, with 83% of them reported in good condition. Lithic scatters and isolated finds are also generally in better condition: along with petroglyph and pictograph sites, 70% or more of them are in good condition. Milling stations and lithic scatters are both surficial kinds of sites, usually lacking in deposition and thus not dug through by vandals. They are subject to collectors, however, and the traces of collection are subtle and probably underestimated by the Desert Planning Staff Inventory. To document that a site had been collected requires comparison of the present assemblage composition with some model or standard of what kinds of tools and artifacts should have been, or were, there. In the inventory, not only are such models lacking, but also, controlled collections for such comparisons were not made by field teams. In a very different

Table 12. Condition of Sites in the California Desert by Site Type.

	Counts				Percent			
	Good	Fair	Poor	Total	Good	Fair	Poor	Total
Villages	10	13	5	28	36	46	18	100
Temporary Camps	196	128	24	348	57	37	7	101
Shelters/caves	63	55	12	130	48	42	9	99
Milling stations	162	26	7	195	83	13	4	100
Lithic scatters	484	147	22	653	74	23	3	100
Roasting pits	219	110	14	343	64	32	4	100
Historic sites	119	138	58	315	38	44	18	100
Quarries	12	6	0	18	67	33	0	100
Pottery loci	39	22	6	67	58	33	9	100
Cemetery/cremations	0	0	0	0	0	0	0	0
Intaglio/cairn rock alignment/trail	51	20	3	74	69	27	4	100
Petroglyph/pictograph	32	10	3	45	71	22	7	100
Isolated find	212	69	20	301	70	23	7	100
Other	35	16	1	52	67	31	2	100
Total	1634	760	175	2569	64	30	7	101

situation, dealing with sites in the Little Colorado Planning Unit of the USDA Forest Service in Arizona, Lightfoot and Francis (1978) have shown that ceramic frequencies and lithic densities are modified significantly by casual collecting of sites, particularly when sites are within 150 m of unimproved roads. Although it has yet to be demonstrated in the California Desert, lithic scatters and quarry sites are probably not in as good condition as scientific resources as the California Desert Inventory reported them to be.

Isolated finds, 70% of which are reported to be in good condition, illustrate both the unobservable portion of the record of diminishing resources in the desert, and the check-a-box behavior that is normal response to a form like the Desert Planning Staff's site record form. This category was used to record occurrences of single artifacts when they were not in a context or association that could be construed as a site. We have no record or way of estimating how many isolated projectile points have been collected from the desert, but archaeologists might consider 50% a conservative estimate. That would mean that if the absent isolated finds could have been observed and were recorded appropriately as sites in poor condition, fully 53% of isolated finds would be in poor condition.

Other site types in the desert are in about the same condition as desert sites generally, in that they do not show much variation from desert-wide percentages. These site types are: temporary camps, roasting pits, quarry sites, pottery loci, intaglios, rock alignments, trails, cairns, and other sites. Roasting pits are not evenly distributed among the Study Areas, however. Like milling stations, the numbers of them recorded in Study Area 5, Anza-Borrego, overwhelm the frequencies from other Study Areas. Eighty-two percent (280 of 343) of the roasting pits are from Anza-Borrego. Roasting pits in Anza-Borrego are reported to be in poorer condition than those elsewhere in the desert. In Anza-Borrego, only 62% of the roasting pits are in good condition, in comparison to other Study Areas in the desert where 73% are in good condition (Table 13).

Turning to the condition of sites by Study Areas (Table 14), there is an apparent geographic pattern to the condition of sites. Figure 3 illustrates the location of Planning Units and Study Areas in the desert. In comparison with desert-wide percentages, the fringe of Study Areas along the Mexican border, the Colorado River and the Nevada border east of Death Valley National Monument (Study Areas 1, 2, 5 and 8) show higher percentages of sites in good condition than other Study Areas. The core of the desert, including those Study Areas which border the San Gabriel and San Bernardino Mountains, have excessive percentages of sites in poor condition. Study Area 4, which is made up of Palen, Bristol-Cadiz and Turtle Mountains Planning Units, is the worst. In this Study Area, only 50% of the sites are reported in good condition, and 17% are in poor condition. Study Area 7, including Mojave Basin and Owlshead/Amargosa Planning Units, also has a low proportion of sites in good condition, 72 of 147, but the excess number are in fair condition, and relatively few are judged to be in poor condition in that Study Area.

Table 13. Condition of Roasting Pits in Anza-Borrego Compared to Other Study Areas.

	Anza-Borrego (SA5)		Other study areas	
Condition	Number	Percent	Number	Percent
Good	173	62%	46	73%
Fair	95	34%	15	24%
Poor	12	4%	2	3%

Table 14. Condition of Sites in the California Desert by Study Area.

	Counts				Percent			
	Good	Fair	Poor	Total	Good	Fair	Poor	Total
Study Area 1*	118	44	3	165	72%	27%	2%	101%
Study Area 2	174	67	11	256	69%	27%	4%	100%
Study Area 3	42	13	8	63	67%	21%	13%	101%
Study Area 4	69	46	23	138	50%	33%	17%	100%
Study Area 5	336	134	18	488	69%	27%	4%	100%
Study Area 6	232	99	43	347	62%	26%	11%	99%
Study Area 7	72	68	7	147	49%	46%	5%	100%
Study Area 8	113	49	2	164	69%	30%	1%	100%
Study Area 9	91	66	22	179	51%	37%	12%	100%
Study Area 10	NO DATA							
Study Area 11	387	174	38	599	65%	29%	6%	100%
Total	1634	760	175	2569	64%	30%	7%	101%

*See Figure 3 for locations of Study Areas.

DISTURBANCE

Information regarding four kinds of disturbance, in addition to "other", was collected at sites located during the inventory. They are development, animal, vandalism and ORV. Each of these is a broad category, but these kinds of disturbance vary in the desert both according to site type and Study Area. A particular site may have no disturbance recorded for it, or it may have as many as all 5 kinds of disturbance. In our analysis a disturbance unit is the record of 1 kind of disturbance at one site. In general, as we showed above (Table 11), there is an association between greater number of disturbance units and poorer condition reported for sites. Desert-wide, there are 3165 disturbance units recorded at 2899 sites, for a mean desert-wide ratio of 1.09 disturbance units per site. In this analysis a higher ratio of disturbance units to sites than 1.09/1 is regarded as excessive.

Kinds of disturbance and ratio of disturbance units to site numbers each vary by site type and Study Area in the desert (Tables 15 and 16). Disregarding "other" disturbance which is predominantly erosion according to the Desert Planning Staff archaeologists, animal disturbance is most frequently reported at sites, followed by ORV, vandalism and finally, development. Numerically, "other" dominates the data, reported at 69% of the sites. In comparison, the next most common form, animal, is reported at only 16% of the sites. If "other" does generally mean erosion, that is the most common form of disturbance affecting sites in the desert.

Villages, which we reported above are most frequently found in poor condition, also have the highest ratio of disturbance units per site, 1.66/1 (Table 15). They are primary targets of vandalism, as predicted in the section regarding condition. More than half of them (18 of 32, 56%) have been vandalized. Villages are the only site type in which another form of disturbance than "other" is the most common form of disturbance.

Historic sites also are frequently in poor condition, and they, too, show an excessive ratio of disturbance units to the number of historic sites, 1.24/1. "Other" damage is most common, occurring at 234 of the 346 historic sites, 68%. Vandalism is next most common, recorded at 25% (86/346) of them. Animal damage occurs at 12% of them, followed closely by ORV and Development, at 10% each.

Two site types with excessive ratios of disturbance units to sites, roasting pits and other, were not characterized by high numbers of sites in poor or fair condition. "Other" sites show a high frequency of occurrence of "other" disturbance, and there is little that can be done with data of such vagueness. When we turn to roasting pits, the excessive disturbance units result not only from "other" disturbance, recorded at 90% (313 of 346) of the sites, but also from animal disturbance, recorded at 57% of the sites. Apparently, animal disturbance and erosion do not affect

Table 15. Kinds of Disturbance at Sites in the California Desert by Site Types.

	Development	Animal	Vandalism	ORV	Other	Total Disturbance Units	Total Number of sites	Ratio D.U./No.
Villages	7	8	18	3	17	53	32	1.66/1
Temporary camps	31	38	32	77	266	444	439	1.09/1
Shelter/cave	3	49	46	5	88	191	169	1.13/1
Milling stations	5	24	5	12	208	254	261	0.97/1
Lithic scatter	25	54	20	103	468	670	694	0.97/1
Roasting pits	0	197	4	3	313	517	346	1.49/1
Historic sites	33	41	86	34	234	428	346	1.24/1
Quarries	0	1	2	1	21	25	32	0.78/1
Pottery loci	3	5	0	10	50	68	67	1.01/1
Cemetery/cremations	0	1	1	0	1	3	2	N is too small
Intaglios/cairns rock alignments/trails	5	13	5	30	40	93	79	1.18/1
Petroglyph/pictograph	3	3	16	3	37	62	63	0.98/1
Isolated find	11	16	5	40	210	282	312	0.90/1
Other	0	12	6	12	45	75	57	1.32/1
TOTAL	126	462	246	333	1998	3165	2899	1.09/1

Table 16. Study Areas Ranked by Condition and Disturbance.

Ranked by Condition (Poor to Good Condition)		Ranked by Ratio Disturbance Units/sites	
Study Area 4*	1.66	Study Area 3	1.57/1
Study Area 9	1.61	Study Area 2	1.39/1
Study Area 7	1.56	Study Area 5	1.34/1
Study Area 6	1.49	Study Area 4	1.33/1
Study Area 3	1.46	Study Area 6	1.09/1
Study Area 11	1.42	Study Area 1	1.08/1
Study Area 2	1.35	Study Area 11	1.01/1
Study Area 5	1.35	Study Area 7	0.96/1
Study Area 8	1.32	Study Area 9	0.94/1
Study Area 1	1.30	Study Area 8	0.51/1
Kendall's Tau = 2.22222 E-2			

*See Figure 3 for locations of Study Areas.

the condition of roasting pits, and perhaps some other site types, as severely as does vandalism.

Shelters and caves, which are often in less than good condition, were also predicted to be targets of vandalism in the earlier section. Twenty-seven percent (46 of 169) caves reported showed signs of vandalism, demonstrating that they are as frequently targets for destructive activities as are historic sites. Animal disturbance was slightly more common at caves and shelters than vandalism, reported at 29% (49 of 169) of them. Caves and shelters show only a slight excess of disturbance units to sites 1.13/1 and like villages and historic sites, they suggest that vandalism is the most disturbing form of damage.

We have grouped the data from intaglios, rock alignments, trails and cairns because of the low frequency of occurrences of each site type, and because they are similiar in that each is a form of surficial rock feature. They were about in the same condition as sites are in the desert generally, but they show an excess of disturbance units per site, 1.18/1. ORVs are not only a particular threat to these kinds of sites, but 30 out of 79 of them, 38%, already exhibit damage from ORV activities, a disturbingly high number when we recall the relatively recent beginnings of extensive use of ORVs in the desert. After "other" disturbance, ORV damage is the most frequent form of disturbance at temporary sites, 18% of which show ORV disturbance; lithic scatters, 15%; pottery loci, 15%; isolated finds, 14%; and "other" sites, 21%.

We have already mentioned that animal damage is frequently reported at caves, rock shelters and roasting pits. It is also the most frequent disturbance at milling stations, but is only reported at 9% of them, for milling stations tend to be in good condition and have a low disturbance unit to site ratio, 0.97/1.

Development is not the predominant form of damage at any site type, but it is disproportionately distributed among site types. Although desert-wide only 4% of the sites (126 of 2899) exhibit disturbance by development, fully 22% (7 of 32) of all villages and 10% (33 of 346) of all historic sites have been damaged by development. This is probably the result of the coincidence of choice of location for recent developments with those of the historic period and the location of prehistoric villages in the desert, and is not unexpected. It should be recognized in addition, however, that the inventory will underestimate the numbers of sites of all types damaged by development because the Bureau of Land Management omitted most lands which were privately owned and/or largely developed from their inventory.

Pictographs and petroglyphs do not show an excess of disturbance units, perhaps because their normal location on vertical rock faces protects them from animal and ORV damage. As might be expected, they are very frequently damaged by vandalism, however. Twenty-five percent (16 of 63) are so recorded. These rock art sites are as frequently the target of vandalism as are village sites, historic sites, caves and rock shelters, and this amount of damage is in addition to the unnumbered cases of loss through removal by collectors and total destruction by development.

Desert-wide, 63% of the disturbance units recorded are "other", followed in descending order by animal (15%), ORV (11%), vandalism (8%) and least common, development (4%). "Other" forms of damage predominate in each of the Study Areas, but there is considerable variability in the relative frequency of disturbance by development, animals, ORVs and vandalism. ORV damage is the most frequently recorded of these forms of disturbance in Study Areas 1, 2, 7, 8 and 9 which include the Imperial Valley, Colorado River periphery and the Los Angeles to Las Vegas corridor. Vandalism is the most common form of disturbance in Study Area 2 and Study Area 11. Animal damage is most prevalent in only 3 Study Areas: Study Areas 3, 5 and 10. In Study Area 6, damage from animals and vandals are about equally common.

While there is a general tendency for sites in the desert which have more disturbance units to be in poorer condition, the Study Areas which have the highest ratio of disturbance units per site are not necessarily the Study Areas which have sites generally in the poorest condition. Condition of sites can be scaled for each Study Area by taking the number of sites recorded in each condition, multiplying them by the numerical equivalent of their condition and dividing by the total number of sites in the Study Area. Study Area 1, for example:

		N
Condition 1	(Good)	118 x 1 = 118
Condition 2	(Fair)	44 x 2 = 88
Condition 3	(Poor)	3 x 3 = 9
		215/165 - 1.30

Ranked in this fashion, sites in Study Area 1 are in better condition than sites in other Study Areas (Table 16).

In order to understand which kinds of disturbance have the greatest affect on the condition of sites, the association between kinds of disturbance and condition was analysed for 4 site types: villages, temporary camps, shelters and caves, and historic sites (Table 17).

Vandalism is clearly the most damaging of the 4 kinds of disturbance, omitting "other", at these sites. We have already pointed out that at village sites, vandalism is the most frequently reported form of damage and accounts in large part for the generally diminished condition of these important sites. Examination of contingency tables for shelters and caves, and historic sites, reveals the association between fair to poor condition and vandalism on these kinds of sites. Temporary camps are less frequently the object of forms of vandalism which leave traces, but here also, vandalism contributes a greater proportion of the disturbance units recorded at sites in only fair to poor condition than at sites in good condition.

Table 17. Association of Condition with Kinds of Disturbance at Villages, Temporary Camps, Caves and Shelters, and Historic Sites.

VILLAGES

	Development	Animal	Vandalism	ORV	Other	Total
Good	2	2	6	1	6	17
Fair	3	3	5	1	9	21
Poor	2	1	4	0	0	7
Total	7	6	15	2	15	45

TEMPORARY CAMPS

	Development	Animal	Vandalism	ORV	Other	Total
Good	4	25	14	22	159	224
Fair	14	19	19	36	84	172
Poor	8	5	9	12	7	41
Total	26	49	42	70	250	437

CAVES/SHELTERS

	Development	Animal	Vandalism	ORV	Other	Total
Good	1	18	7	0	43	69
Fair	1	14	19	4	36	74
Poor	0	2	9	1	9	21
Total	2	34	35	5	88	164

HISTORIC SITES

	Development	Animal	Vandalism	ORV	Other	Total
Good	9	8	11	6	90	124
Fair	12	19	40	19	91	181
Poor	7	14	29	8	40	98
Total	28	41	80	33	221	403

(continued)

Table 17. (continued)

FOUR SELECTED SITE TYPES GROUPED

	Development	Animal	Vandalism	ORV	Other	Total
Good	16	53	38	29	298	434
Fair	30	55	83	60	220	448
Poor	17	22	51	21	56	167
Total	63	130	172	110	574	1049

To obtain another measure of the effects of different kinds of damage on the condition of sites, we can look at sites for which only one form of disturbance is recorded (Table 18). One hundred thirty-one sites in the site types of villages, shelters and caves, temporary camps and historic sites, have only one form of damage recorded that is not "other". This sub-sample of sites shows that animal damage has the least effect on the condition of the sites where it is observed, for almost 56% of the sites where animal damage is recorded remain in good condition. Sites affected by the other three forms of damage: development, vandalism or ORV, are recorded to be in good condition only about 23% of the time. Each of these three forms of damage appears to affect the condition of sites similarly when they are the sole form of disturbance, for between 25% and 28% of the sites affected by each form of damage are in poor condition (Table 18).

Table 18. Association of Kind of Disturbance with Site Condition, Sites Exhibiting One Form of Disturbance only. Four Selected Site-types.

DISTURBANCE	CONDITION Good	Fair	Poor	Total	Percent in Good condition	Percent in Poor condition
Development	4	12	6	22	18.2%	27.3%
Animal	19	15	0	34	55.9%	0%
Vandalism	11	26	14	51	21.5%	27.5%
ORV	7	11	6	24	29.2%	25.0%
Total	41	64	26	131		

Chi-square = 17.0078 d.f = 6 $P = > 0.005, < 0.010$

NATURAL EROSION OF ARCHAEOLOGICAL SITES IN THE CALIFORNIA DESERT

David L. Weide

Erosion of archaeological sites in the California Desert involves important concepts fundamental to separating and evaluating the differences between "natural" and "enhanced" erosion. The former is due entirely to natural processes of weather, tectonics, and gravity while the latter is both initiated and accelerated by man's activities. It is important to note that in any landscape there is an inherent tendency toward erosion and that the possibility of erosion at any given point may best be considered in terms of probability. For instance, even the most heavily armored alluvial fan slope of 3 to 5 degrees may be severely gullied if impacted by a storm that deposits two to three inches of rain in twenty minutes. The probability of such a storm, however, may be as low as one in one thousand (1/1,000) thus, during any given year, there is only a one in one thousand chance of such an event occurring. This very low probability is a combination of temporal probability; will the storm occur at all? and spatial probability; will the storm impact that specific alluvial fan?

The probabilistic approach to landscape evolution commonly leads to a dichotomy in the thinking of those who interpret the geomorphic record. On one hand the landscape is viewed as a result of an evolutionary process requiring some considerable length of time. On the other, the processes that shape the land are merely moments in time separated by long periods of relative inactivity. To observe and record a particular landform (for instance a terrace containing an archaeological site) during the period of inactivity may result in underestimating the potential for erosion and deposition that lies within the fluvial systems.

This critical geomorphic problem was recognized by Schumm (1973) who concluded that geomorphic systems can be strongly influenced by thresholds. That is, abrupt changes may occur during landscape evolution, as threshold values of stress are exceeded. In terms of California, Colorado, and Great Basin desert landforms, and their included archaeological sites, we can recognize two major sources of natural erosional stress; wind shear and sheetwash/gullying, and two major sources of enhanced erosional stress consisting of the cutting action produced by vehicle tracks and the trails produced by domestic, feral, and native animals. The basic question then is: Under what stress conditions will there be a dramatic change in the geomorphic system with a significant modification of the landscape? This, of course, depends on both the rate and amount of the external stress applied and on the strength of the materials to which the stress is applied. It is in this context that thresholds are generally considered to exist in that a gradual increase in external stress eventually produces a sudden, dramatic response in the system. These are termed extrinsic thresholds because they depend on an external influence. A good example would be rill-cutting on an alluvial fan with a desert pavement surface. The surface will remain impervious until the sheetwash develops a specific critical thickness of flow that, in turn, is governed by the rate of rainfall, the length and angle of slope, and the texture and composition of the fan surface. Once the critical thickness is attained, however, sheetwash quickly becomes rill wash and dissection of the fan is assured. It is quite common on California Desert fans for sheetwash to occur many times before a large event produces runoff that exceeds the critical water thickness. The portion of the fan surface that is armored by desert pavement thus appears to be protected, stable, and in equilibrium with local environmental conditions. This, however, may be an illusion; an artifact of one's position in the temporal framework of erosional events. It is obvious, however, that alluvial fan resistance to erosion (its threshold tolerance) may vary widely across any given fan. Surfaces not protected by pavement will have a much higher susceptibility to runoff and cutting initiated in these low-threshold, active areas may then extend headward and/or laterally into the protected, inactive portions of the fan.

The result of sporadic runoff across an alluvial fan is therefore a segregation of the fan surface into a series of active and inactive portions (Hooke 1967:440). In a down-fan direction, runoff repeatedly concentrates in "active" channels while raised portions of the surface become isolated and static. It is on these abandoned surfaces that desert pavement, archaeological sites, trails, and other cultural features persist for long periods of time.

A second form of threshold is inherent in desert landform processes, the <u>intrinsic threshold</u>. Here landform change results from a condition of incipient instability without a change in the external influence of stress. For example, a hill slope may store a surface covering of weathered material until the mass of regolith or colluvial debris exceeds the retention capability of the slope. Downslope movement (soil creep) may then begin and continue until a lower, more stable angle is attained.

Both intrinsic and extrinsic thresholds exist throughout the California Desert with the potential of operating on all landforms. Since archaeological sites are contained in and on geomorphic surfaces, the cultural component of any site is subject to the threshold concept. It should be noted, however, that because archaeological materials may differ in size from the matrix that contains them, they may respond to a different set of threshold values. For instance, a scatter of small flakes on a fan surface consisting primarily of a mosaic of cobble-size clasts may be disturbed by sheetwash that is incapable of cutting the fan surface. On the other hand, a feature comprised of large rocks, such as an agave roasting pit, may withstand erosion better than the surrounding matrix.

In any case, geomorphic surfaces and the threshold intensities that dictate whether or not erosion will occur involve the interaction of twelve basic variables that are to some extent interdependent. To further complicate any statistical interpretation, the twelve vary as to whether they function as dependent or independent variables. These variables, as defined by Schumm and Lichty (1965) are shown on Table 19.

Table 19. Variables Affecting Erosion and Deposition.

1. Time (long span and instantaneous)
2. Initial relief (determines stability and the effect of gravity)
3. Geology (lithology and structure)
4. Climate (includes paleoclimates and individual weather events)
5. Vegetation (type and density)
6. Relief (volume of a landform and/or drainage basin above base level)
7. Hydrology (runoff and sediment yield per unit area)
8. Drainage network morphology (quantity and pattern of tributary streams)
9. Hillslope morphology (slope length and angle, surface roughness)
10. Hydrology II (discharge of water and sediment)
11. Channel and valley morphology (open channel geometry)
12. Depositional system morphology and sediment characteristics

The degree of interaction between these twelve variables as they affect archaeological sites in the California Desert provides a basis on which to discuss the potential for erosional impact arising from both natural and enhanced geomorphic processes that have forced the crossing of an erosional or depositional threshold.

CLIMATE AND THE PRESENT STATUS OF EROSIONAL REGIMES IN THE CALIFORNIA DESERT

Cutting of Late Pleistocene and Holocene valley and channel fill is the dominant erosional process now operating in the greater part of the California Desert. This is in direct response to the present climatic pattern where precipitation is commonly distributed as either (1) rare, intense cyclonic storms that impact large areas and persist for at least three days or, (2) more frequent but relatively localized convective thunder storms. The sequence of geologically historical steps leading to this present cycle of erosion was recognized in the Whipple Mountains Planning Area by Bull (1974) and verified in the eastern Sinai of Israel under almost identical conditions of climate, topography, and bedrock lithology (Bull and Schick 1979). Basically the process involves three steps beginning some seven to eight thousand years B.P. (Van Devender and Spaulding 1979:709) when a climate marked by mild wet winters and cool summers began a trend toward less equable conditions of drought and infrequent, high-intensity precipitation. The onset of a warm, dry middle Holocene climate in the California Desert reduced the density of a well established vegetative cover both by up-slope retreat of conifers and by reduction in number and size of the mesic species that were capable of adapting to decreased soil moisture.

Dispersed vegetation exposed extensive areas that, during the preceeding 14,000 years of Late Wisconsin mesic conditions (Van Devender and Spaulding 1979:706) had developed a moderately thick cover of weathered material. This colluvial debris (variously grus on the broad domes of Cretaceous granitics coarse angular regolith on outcrops of Precambrian metamorphics, and clay-silt soils on Paleozoic sediments and Tertiary volcanics) was rapidly stripped from slopes and deposited as valley fill. As stripping progressed an increasing amount of slope surface lay exposed as bedrock capable of generating instantaneous runoff following as little as 2 to 3 mm of rain (Bull and Schick 1979:169). Widespread exposure of bare rock and a correspondingly effective catchment, containment, concentration and discharge of high intensity precipitation then set the stage for the current pervasive erosion of early to middle Holocene alluvial fill and relict remnants of Pleistocene fans throughout the California Desert. The net result of this 7,000 year sequence is a mosaic of geomorphic surfaces many of which are highly unstable with respect to the present climatic, vegetative, and pedogenetic environments.

Present Rainfall Regimes in the California Desert

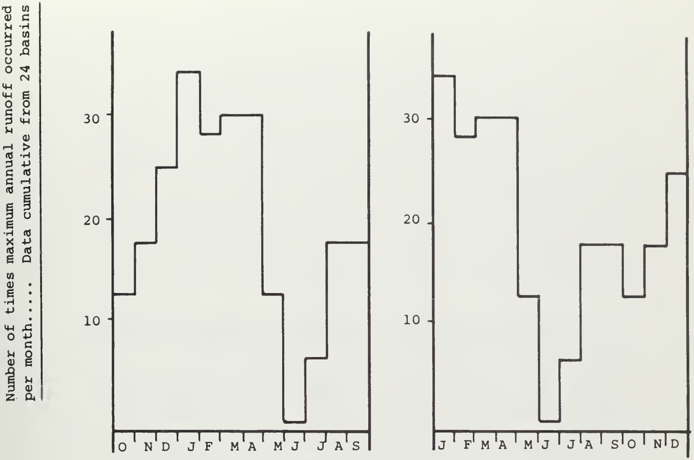
Rainfall throughout the California Desert responds to three major weather patterns, two winter cyclonic storm systems and a relatively small number of high intensity, localized summer convectional thunderstorms. In all cases, however, rainfall-induced runoff initiates the following sequence: (1) infiltration, (2) saturation, (3) surface ponding, (4) sheetwash, (5) rill formation, (6) rill cutting, (7) rill expansion to gullies, (8) headward retreat of the gully marked by a pronounced knick point, and (9) down-channel, in-channel and surficial deposition. It is important to note that this sequence may be discontinuous and slow or extremely rapid depending upon a large number of interrelated factors including the duration and intensity of the rainfall, the condition of the vegetative cover, and the texture and degree of consolidation of the material being excavated.

Widespread intensive erosion is commonly associated with winter cyclonic storms that originate off the Pacific coast of Baja California and move northeast across a wide front extending from Yuma to Santa Barbara and inland at least to Las Vegas. The second type of winter storm originates off the coast of California and moves east or southeast into the inland desert. In doing so it is forced to cross the mountain barriers of the Sierra Nevada, the San Gabriel, or the San Barnardino ranges. As it does so, the relatively high altitudes of these barriers extract much of the potential precipitation as orographic rainfall on the Pacific slope side. The strong seasonality of precipitation in the desert is shown in Figure 5 which compares the total of the largest monthly runoff events from 24 gaged basins during the period 1961 to 1970 with the monthly distribution of runoff for both the calendar year and the water year.

<u>Tropical cyclonic storms in the California Desert</u>. With few exceptions, tropical cyclones originating off the west coast of Mexico move north and turn westward out to sea. Others may dissipate offshore due to the loss of an energy source over the relatively cold ocean surface. On those rare occasions when cyclones do enter southern California they are diverted by the coastal mountains into the interior of the California Desert. Two such storms, tropical cyclones Kathleen (September 10-12, 1976) and Doreen (August, 1977) moved northeast across southern California causing extensive loss of life, millions of dollars of destruction to property and crops, and quite probably, vast amounts of erosional and depositional damage to archaeological sites. Based on data presented by Weaver (1962) this type of cyclone has a strong probability of occurring once in 15 years. Since the meteorological data base began about 1900, similar storms came ashore in 1918, 1932, 1939, 1976, and 1977. It is interesting to note that owing to the nature of the storm tracks followed by these cyclones, the Colorado Desert Planning Units bear the brunt of the erosion. Since the bulk of the archaeological sites in part of this planning area are developed on extremely soft lacustrine sediments that are not protected by pediment or armored fan surfaces (for instance, those of the Yuha Desert) they suffer severe rill and gully cutting. In addition, torrential channel flow undercuts banks thus destroying sites occupying the normally stable interfluve areas.

Fors, in his analysis of Tropical Cyclone Kathleen (1977), notes that one of the reasons that impact was so widespread was due to the speed (in excess of 30 miles per hour) with which the major zone of

Figure 5. Monthly occurrence of gaged stream runoff in the Mojave Desert, California.



Water Year (1)
1961 - 1970

Calendar Year (1)
1961 - 1970

---

(1) Surface Water Supply of the United States:
1961-65 (U.S.G.S. W.S.P. 1927, 1970)
1966-70 (U.S.G.S. W.S.P. 2127, 1974)

precipitation moved across the southern part of the California Desert. In addition, his 72 hour precipitation maps (Fors 1977:17) show that large areas of the interior received in excess of three inches of precipitation. The resulting sheetwash, rill, gully, and channel flow deserves serious consideration as a major form of "natural" impact on cultural resources.

Since long-term rainfall records for the central part of the California Desert are rare and unfortunately undependable, a measure of the destructive potential for a large cyclone may be gained from the records of stream runoff. In addition, runoff measurements reflect water that has moved across the desert surface or, in other words, the remainder after infiltration (which normally should not affect sites) has been removed. Table 20 illustrates the increase in runoff during 1969, a year when two minor cyclones moved into the desert during late January and early February. In the table 1969 is contrasted with 1968 and 1970, both "normal" water years. From the data shown in Table 20 it is apparent that the most critical values are those for "maximum" runoff. This reflects the peak of storm intensity and therefore the time of maximum damage. Note that peak intensities range from seven times normal to 270 times normal depending on the configuration of the catchment basin and perturbations in the behavior of the storm. A review of the U.S. Geological Survey data (1970, 1974) indicates that storm years comparable to 1969 recur with a probability of one in five.

Convectional storms in the California Desert. Convectional storms, commonly seen as summer thunderstorms, are more frequent and produce higher rainfall intensities than do cyclonic storms. Convectional storms, however, are much more limited in terms of the area they impact. The July 3, 1975, thunderstorm that caused extensive flooding in Las Vegas, Nevada, for instance, involved an area of 553 km^2 and a total volume of 2.3×10^7 m^3 of water during a period of four hours (Randerson 1976a:727). An even more violent storm is reported by Weaver (1962:196) at Campo, in the mountains of San Diego County, when a thunderstorm in 1891 dropped 11.5 inches of rain in 80 minutes over an area of several hundred km^2.

A measurement of the erosive power of a major convectional storm is provided by Glancy and Harmsen (1975) in their analysis of the Eldorado Canyon flood. The duration of that storm was 1.5 hours during which time approximately 1.9 inches of rain fell over an area of 59 km^2. The area and the precipitation, which are much lower than those of the July 3 Las Vegas storm, eroded and transported in excess of 53,520 m^3 of sediment. While a large portion of this material involved channel sediment in transit, significant scouring did occur on slopes adjacent to the main channels. Enough sheetwash and rill-cutting occurred to severely scour and cut any archaeological sites of a surface nature present in the drainage basin. Figure 6A illustrates the pattern of rill cutting in response to a storm event similar to the September 14 flood in Eldorado Canyon and compares it with a rill pattern that is totally the result of cultural activity (Figure 6B).

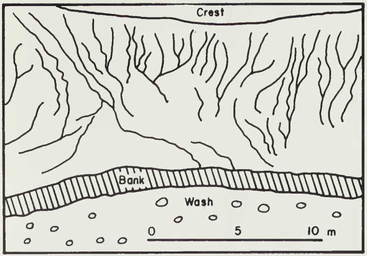
A comparison of the two patterns reveals strong similarities but also significant differences. Perhaps the most critical aspect of the

Table 20. Comparison of Runoff Between Normal Years and Cyclonic Storm Years

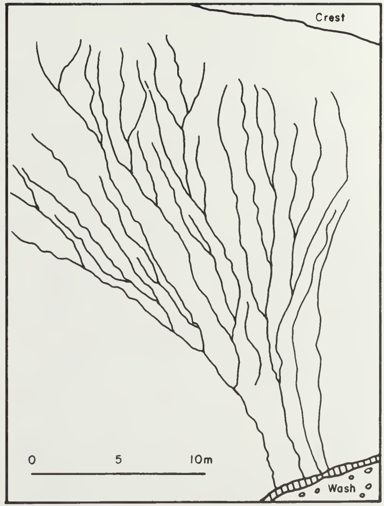
Region and Stream	Runoff in Cubic Feet per Second[1] for Water Year:			
	1968	1969	1970	
Antelope Valley				
(Little Rock Creek)	4231	20745	3454	Total
	12	57	9	Mean
	264	1730	175	Maximum
Victorville				
(Mojave River at	9476	146758	11655	Total
lower narrows)	26	402	32	Mean
	54	21000	102	Maximum
Hesperia	8600	109791	7080	Total
(Deep Creek)	24	301	19	Mean
	411	14700	343	Maximum
Palm Springs				
(Tahquitz Creek)	714	10266	913	Total
	2	28	2	Mean
	6	1080	22	Maximum

[1] Surface Water Supply of the United States 1966-1970 (USGS WSP 2127, 1974).

Figure 6. Comparison of channel network geometry following natural and enhanced erosion.



A. Rill erosion on a 15° slope in un-named tributary to lower Eldorado Canyon (after Glancy and Harmsen; 1975, Fig. 25). There is strong evidence that a single storm comparable to that of Sept. 14, 1974, would produce this intensity of rill cutting. Both A and B are drawn to the same scale.



B. Rill erosion at the Hollister,California ORV Facility after several seasons of use. Slope is approximately 25°. (After G.S.A. Report; 1977, Fig. 5).

enhanced erosion (Figure 6B) is that the main rills connect with the floor of the wash. This allows complete drainage of the slope and promotes faster headward cutting by the remainder of the rills. In the case of the natural erosive pattern, rills begin and end near mid-slope. Thus, even if the drainage density values are quite similar, more sediment is actually removed from the slope of enhanced erosion.

Analysis of storm-induced erosion. Two primary factors are involved in attempting to estimate the potential threat to archaeological sites from both cyclonic and convectional storms. These include a method of estimating the recurrence interval (how often a storm event of given magnitude will strike) and, second, the size of the area that will be affected. In terms of cyclonic storms, Weaver's (1962) estimate of a 1:15 probability factor is a reasonable approximation. Thus, since cyclonic storms tend to impact the entire area of the California Desert, some destruction, especially to surficial sites such as lithic scatters, intaglios, and rock circles should be expected. If the return interval is reasonably correct, there would have been approximately 70 such events during the past 1,000 years. Convectional storms are much more difficult to predict. Using data supplied by Randerson (1976b:3) storms comparable to the July 3, 1975 flood have occurred in the general vicinity of Las Vegas once since 1923 (the date of record) while storms comparable to the Eldorado Canyon flood have occurred 14 times during the same interval. This implies a return interval of 1:4 for storms of less than 3 inches precipitation and 1:60 for storms of greater than 3 inches of precipitation. In either case, destruction to archaeological resources would be considerable. The area of convectional storms must next be considered. To date only two major convectional events have been accurately measured with respect to the area of their impact; the July 3, 1975, Las Vegas event at 553 km^2 and the September 14, 1974, Eldorado Canyon event at 59 km^2. Randerson (1979, p.c.) considers the latter to be unusually small and assumes 400 km^2 to be more representative of the size of the average convectional storm. Since the area of the California Desert planning area is approximately 62,500 km^2 about 156 "typical" convectional events would be required to blanket the entire area. Following simple probability theory, if any storm area represents 1/156 of the total desert region and if destructive convectional storms have an annual probability of 1/4, then the probability of any site being damaged in any given year is (1/156) (1/4) or approximately 1:600. Contrasting this with the 1:15 probability of damage arising from a cyclonic storm it seems apparent that the widespread winter storm poses more of a problem to management of cultural resources.

Erosion by Wind

Erosion resulting from wind is the second most common form of natural and enhanced damage to archaeological sites. Geomorphic surfaces that contain archaeological material may be grouped into classes based on grain size and surface roughness that reflect their ability in an undisturbed state to withstand wind erosion. Examples of these materials and their critical pickup speed (threshold velocity) are shown in Table 21 (Cooke, R.W. 1980:p.c.).

Table 21. Desert Surface Material and Critical Wind Speeds.

Material	Mean Particle Diameter (mm)	Critical Pickup Speed (undisturbed)		Critical Pickup Speed (disturbed)	
Dune sand	0.2	10 mph	(16 kph)	9 mph	(14.5 kph)
Alluvial flat sand	0.1	20	(32)	17	(27)
Alluvial flat silt	0.04	25	(40)	21	(34)
Playa silt and clay	0.008	35	(56)	30	(48)
Alluvial fan gravel	3.36	35	(56)	30	(48)
Desert pavement	10.00	stable		21	(34)

The critical pickup speed or wind velocity is a geomorphic threshold. Below that velocity, the loose granular surface is stable and no erosion will occur. Disturbance of the surface by mechanical means lowers the critical pickup speed. Since lower velocity winds occur frequently, the result is an erosional foothold that tends to rapidly deflate the surface. An even more accurate measure of wind erosion is the Critical Friction Velocity. This measurement is commonly used by micrometeorologists because it allows for variability in surface roughness and turbulence within the wind layer in contact with the ground. The extreme change in Critical Friction Velocity caused by mechanically disturbing desert soils is shown by Gillette et al. (1979: Tables I and IV) who used a portable wind tunnel on in-situ parcels of desert soil that were then intentionally disturbed by driving a vehicle across them (Table 22).

In the California Desert one of the most visible signs of increasing wind erosion are vast plumes of dust in the lower atmosphere. Nakata et al. (1976:644) have shown that vehicle traffic causes this wind erosion. For example, in an extreme case of cutting or disruption, desert pavement transforms from an almost totally stable surface to material almost as easily eroded by wind as alluvial flats and playa margins composed of silt. This is because the gravel armor of a pavement is almost always underlain by up to 10 cm of well-sorted silt. The gravel armor protecting the underlying silt layer is cemented by flat-lying, oriented silt and clay particles into a crust ranging up to 3 cm in thickness that is almost impervious to water (Cooke and Warren 1973:125). It then functions two ways to retard erosion of the pavement. First, it extends and broadens the area of sheetwash thus inhibiting the formation of rills and gullies. Second it produces a very smooth surface that reduces wind turbulence and thus increases the wind velocity necessary to cause erosion. Once disturbed, pavements will return to their original configuration provided disturbance is not continuous. The rate of pavement restoration is highly variable since it is dependent on numerous contributing factors. The time required ranges from tens of thousands of years to intervals of less than a decade (Cooke and Warren 1973:129).

Erosion on Slopes

Coombs (1979b) has noted a marked correlation between slope angle and whether or not "damage" has resulted from natural or enhanced processes. From a sample of 900 (out of 2900) systematically discovered and recorded desert sites, Coombs noted that less than 6 percent of the sites damaged by human impact occur in areas with slopes greater than six degrees. Conversely, more than 20 percent of the sites suffering from natural erosion lie on surfaces with slopes greater than six degrees. This may, again, reflect a "threshold effect." On gentler slopes, undisturbed surfaces have developed sufficient armor to withstand normal runoff events. The surface protection may be in the form of vegetation, desert pavement, or surficial clay skins. Since slopes less than 10 degrees are more prone to heavy vehicle traffic, the protective surface may soon be destroyed triggering the transformation from sheetwash to rill and gully cutting.

Using Coombs' data (supported by additional data from the computerized site inventory supplied by the Bureau of Land Management) combined

Table 22. Desert Surface Material and Critical Friction Velocity.

Material	Critical Friction Velocity (undisturbed)	Critical Friction Velocity (disturbed)
Alluvial Stream deposits	278 cm per second	66 cm per second
Alluvial fan deposits (#1)	300 "	59 "
Alluvial fan deposits (#2)	215 "	42 "
Playa crusts (center #1)	285 "	182 "
Playa crusts (center #2)	339 "	158 "
Playa crusts (margin #1)	155 "	40 "
Playa crusts (margin #2)	175 "	20 "
Eolian deposits on fan (#1)	191 "	43 "
Eolian deposits on fan (#2)	147 "	33 "
Lower alluvial fan surface near playa	146 "	21 "

with a study of alluvial fan slopes (Anstey 1965), it is possible to approximate the fan area most susceptible to enhanced erosion.

From Anstey's initial population of 50 fifteen minute quadrangles covering most of the Mojave Desert region, sixteen were chosen that represented two blocks situated in the central Mojave (latitude 35°15'N) and in the south-central Mojave (latitude 24°15'N). These quadrangles and their representative fan data are shown in Table 23.

Together these 199 fans constitute approximately 65 percent of the aggregate alluvial fan and bajada surfaces throughout the sixteen representative quadrangles. Since all of the major fans have gradients of less than six degrees, it is apparent that vast areas are available to vehicular traffic. When combined with the extensive network of roads (all degrees of quality) throughout the California desert, the extensive challow-gradient fan surfaces contribute to the startling fact that 50 percent of the California Desert is within 1.0 mile of vehicular access while 95 percent of the total area is within 2.96 miles of vehicular access (Badaracco 1979).

An interesting measure of natural erosion on desert slopes is provided by Hunt and Mabey (1966:96). Since the field work leading to Hunt's report was done in 1960 and encompasses areas of Death Valley National Monument where access has been regulated since 1933, his data reflect a minimum of vehicle disturbance. In all Hunt measured 67,650 linear feet of trail across various fan surfaces bordering the Panamint and Funeral Mountains. Of that aggregate length, 25,715 feet of 38 percent had been destroyed, primarily by natural processes of sheetwash and gully cutting, during approximately 50 years beginning in 1910 when roads suitable for vehicles were constructed. A destruction rate of 38 percent in 50 years does not necessarily imply a rate of 1 percent in 16 months nor 100 percent destruction in 132 years for, as Hunt points out, areas where trails remain in pristine condition also contain geomorphic features such as low gravel ridges that have persisted for perhaps 12,000 years. Destruction, however, is assured where runoff, either as sheetwash to rill and gully cutting is concentrated on the fan surface. Additional studies relating both the number and density of archaeological sites on alluvial fans have been reported by Gallegos (1979:75-90) where statistical relationships between the locations of archaeological sites and desert surfaces and landforms beyond the scope of this study are thoroughly explored.

Erosion Resulting from Animal Activities

Extensive damage to archaeological sites from the activities of animals may arise from (1) the concentrated efforts of burrowing rodents, (2) grazing of domestic animals, and (3) the impact of relatively large numbers of feral burros, descendents of pack animals introduced into the American southwest in the middle nineteenth century. Within the California Desert domestic stock impose a surprisingly heavy load on the available food and water resources. Current Bureau of Land Management estimates indicate more than 10,000 cattle and 60,000 sheep annually gain all or

Table 23. Alluvial Fan Gradients Central and South-Central Mojave Desert

	Central Mojave Block								South-Central Mojave Block								
Quadrangle Name	Goldstone Lake	Tiefort Mountains	Red Pass Lake	Baker	Lane Mountain	Alvord Mountain	Cave Mountain	Soda Lake	Lead Mountain	Bristol Lake	Cadiz Lake	Milligan	Valley Mountain	Dale Lake	Cadiz Valley	Iron Mountain	TOTAL
TOTAL No. FANS	60	92	73	48	70	48	77	52	81	41	29	34	46	44	27	33	855
Large fans (L = 3500'+)	5	12	21	17	20	14	12	12	11	8	9	10	16	14	8	10	199
GRADIENT (°)																	
0.50				1													1
0.50-0.99						2		1					2				5
1.00-1.49	1	2	5		1	4	5	4		2	3		4			2	33
1.50-1.99	1		3	2	7	4	2	1	4	2	4	4	2	3	1	4	44
2.00-2.49	1	1	5	4	8	3	2		2	2	1	5	4	6	7	3	55
2.50-2.99	1	3	3	4	1		1	1	4	2		1	1	4			26
3.00-3.49	1	2	2	3	2	1	1	1	1		1					1	16
3.50-3.99		1					1	2						1			5
4.00-4.49				2									1				3
4.50-4.99		1	2		1												4
5.00		2	1	1				2					2				8
	5	12	21	17	20	14	12	12	11	8	9	10	16	14	8	10	

part of their subsistence from 54 grazing areas totalling 4.5 million acres (Ritter p.c. 1980). Adding to this impact is that of perhaps as many as 10,000 feral burros and horses scattered throughout most major mountain areas (Ritter p.c. 1980). The impact of feral burros has been extensively studied in such immediate areas as Death Valley and the Panamint Mountains and, more remotely, in Grand Canyon National Park. The latter study (U.S. National Park Service 1979) lists effects of burros on cultural resources that are directly applicable to large areas within the California Desert. These include: trampling and cutting of trails especially in the vicinity of natural springs and seeps, dust wallowing, rubbing against structures and rock-art surfaces, depositing urine and feces, and modification of soil and introduction of new pollens in rock shelters. Euler (1977) working in the Tonto and Shinumo areas of the Grand Canyon National Park has estimated that over one-half of the archaeological sites surveyed have received burro damage and that in areas of heavy burro concentration, up to 50 percent of each archaeological site impacted by burros had been destroyed. An additional problem in the apparent high reproduction rate of feral burros estimated to be 15 percent per year (Ritter p.c. 1980).

In addition to direct impact on archaeological sites, burro activity includes widespread destruction of vegetation and extensive tracking. Both of these activities weaken the desert surface and so act to lower any critical threshold limit. It should also be noted that burro damage is concentrated in the vicinity of springs and natural water seeps. It is precisely these localities where archaeological remains also tend to be concentrated. In view of the ecological impact of large numbers of feral burros, currently both the State of California and the Federal Government are establishing policies aimed at managing burro populations and maintaining a balance with other resources.

ASSOCIATIONS BETWEEN ARCHAEOLOGICAL SITES, LANDFORMS, AND EROSION

The raw data for this portion of the Desert Impact Study were derived from approximately 3000 computer-coded site sheets. The specific site sheet entries used in this analysis are shown in Table 24. The entries on the site sheets were coded to allow multiple designations of any process of environmental factor. Any site, therefore, had the possibility of appearing more than once when grouped by erosional type. The physical features for all sites in the sample were then arrayed against EROSION as a geomorphic process as shown in Table 25 a-g.

Erosional Processes

In the first analysis five erosional processes: deflation, rilling, gullying, sheetwash, and rock debris were evaluated on an individual basis. In the subsequent analysis geomorphic processes were combined into three more general categories including (1) eolian deflation, erosion and deposition, (2) runoff including sheetwash, rilling, and gullying, and (3) gravity combining rock debris and slumping. Further reviews of the raw data, especially Category 34, LANDFORMS, suggested that

Table 24. Climatic, Vegetation, and Landform Features Listed on D.P.S. Archaeological Site Record.

(31) VEGETATION COVERAGE
- Continuous (over 75% cover)
- Interrupted (50 - 75%)
- Park-like (25 - 50%)
- Rare (6 - 25%)
- Barely Present (1 - 5%)
- Absent (less than 1%)

(35) ROCK TYPE
- Extrusive igneous
- Intrusive igneous
- Metamorphic
- Sedimentary
- Quaternary alluvium
- Other

(37) SOIL TYPE
- Midden
- Alluvial
- Colluvial
- Eolian
- Bedrock
- Other

(40) SLOPE ASPECT
- North
- Northeast
- East
- Southeast
- South
- Southwest
- West
- Northwest

(34) LANDFORMS
- Mountain
- Hill
- Terrace
- Ridge
- Alluvial fan
- Canyon
- Arroyo
- Sand dune
- Desert pavement
- Badlands
- Playa
- Other

(36) SOIL TEXTURE
- Sand
- Loam
- Silt
- Clay
- Other

(39) SLOPE ANGLE
- 0° - 5°
- 6° - 15°
- 16° - 30°
- 31° - 60°
- 60°+

(41) EROSION
- Deflation
- Rilling
- Gullying
- Sheetwash
- Rock Debris
- Slumping
- Other

Table 25. Erosional Process and Geologic Variable for Total Sites Recorded in D.P.S. Program. (Numerical values are "numbers of occurrences").

	Deflation	Rilling	Gullying	Sheetwash	Rock Debris	Slumping	TOTAL
(A) Vegetation cover							
Continuous	11	7	12	15	4	0	49
Interrupted	18	28	53	78	9	2	188
Park-like	34	103	171	458	39	2	807
Rare	195	261	358	710	99	12	1635
Barely present	185	218	215	522	105	12	1257
Absent	66	52	56	138	26	3	341
	509	669	865	1921	282	31	4277
(B) Bedrock							
Extrusive igneous	60	97	124	170	103	3	557
Intrusive igneous	47	115	216	684	118	14	1194
Metamorphic	7	18	62	120	21	4	232
Sedimentary	39	64	73	136	44	8	364
Alluvial	348	383	475	943	39	8	2196
Other	46	23	19	41	7	1	137
	547	700	969	2094	332	38	4680

(continued)

(Table 25 Contd.)

(C) Landform	Deflation	Rilling	Gullying	Sheetwash	Rock Debris	Slumping	TOTAL
Mountain	22	75	147	424	79	10	757
Hill	52	103	123	370	100	8	756
Terrace	88	107	141	239	14	13	602
Ridge	74	109	180	573	68	8	1012
Alluvial fan	220	316	394	748	38	7	1723
Canyon	15	56	75	138	66	7	357
Arroyo	25	46	94	146	14	6	331
Sand dune	101	41	22	68	4	1	237
Desert pavement	153	124	203	308	18	3	809
Badlands	2	12	14	31	5	1	65
Playa	45	23	17	54	1	1	141
Other	83	170	165	356	58	5	837
	880	1182	1575	3455	465	70	7627

(continued)

(Table 25 Contd.)

(D) Soil texture	Deflation	Rilling	Gullying	Sheetwash	Rock Debris	Slumping	TOTAL
Sand	260	325	397	723	89	16	1810
Loam	70	133	207	607	37	5	1059
Silt	58	69	68	169	26	7	397
Clay	22	28	30	58	2	1	141
Other	53	56	98	155	70	7	439
	463	611	800	1712	224	36	3846
(E) Soil type							
Midden	22	75	143	324	71	12	647
Alluvial	363	522	610	1221	65	19	2800
Colluvial	27	54	168	475	64	8	796
Eolian	121	46	27	85	12	3	294
Bedrock	31	65	64	157	102	13	432
Other	23	7	40	111	11	1	193
	587	769	1052	2373	325	56	5162

(continued)

(Table 25 Contd.)

(F) Slope angle	Deflation	Rilling	Gullying	Sheetwash	Rock Debris	Slumping	TOTAL
$0 - 5^{o}$	428	526	673	1593	146	21	3387
$6 - 15^{o}$	131	118	175	305	78	13	820
$16 - 30^{o}$	17	35	52	93	41	8	246
$31 - 60^{o}$	12	18	22	52	32	5	141
$60^{o}+$	5	6	7	10	13	5	46
	593	703	929	2053	310	52	4640

(continued)

(Table 25 Contd.)

(G) Slope aspect	Deflation	Rilling	Gullying	Sheetwash	Rock Debris	Slumping	TOTAL
N	71	103	101	241	46	10	572
NE	56	104	132	259	43	12	606
E	95	138	149	325	56	10	773
SE	64	93	116	275	32	9	589
S	84	90	139	312	50	9	684
SW	54	55	99	184	28	7	427
W	49	74	117	205	46	10	501
NW	50	56	68	230	34	7	445
	523	713	921	2031	335	74	4597

more generalized groupings would reduce the ambiguity engendered by some of the entries on the standard site recording form and disparate levels of experience in noting landforms that existed among the field crews.

Consequently the eleven landform entries were grouped into five categories including (1) landforms of high relief; mountains, hills, ridges, (2) landforms of fluvial origin; terrace, canyon, arroyo, badlands, (3) surfaces; alluvial fan and desert pavement, (4) eolian landforms; dunes, and (5) interior drainage closed-based surfaces; playas. The combined values for this arrangement of raw data are shown in Table 26.

In order to quantify associations between the erosional categories of wind, water, and gravity and the eight other physical parameters recorded on the site sheets, a series of Chi-square tests were run. This statistic was chosen because it is the most common and initially useful means of examining this form of data. It should be noted, however, that since multiple entries were common on the overall population of site sheets, the totals obtained will vary and commonly exceed the number of sites actually encountered in the field. Furthermore, the category "Other" which contained a considerable percentage of the information recorded, has been eliminated from the study.

The simplest association, the one showing the maximum number of recorded occurrences for any physical parameter as recorded in the field, is translated in Table 27. It shows, for instance, that throughout all of the California Desert planning area, most records of erosional damage, regardless of type of erosion, occur on slopes between 0^{o} and 5^{o}; and, with the exception of gravity-induced erosion, the predominant soil type effected by erosion is alluvium; and with the exception of gravity-induced erosion, most damage occurs under conditions of "Rare" vegetation (6 to 25 percent vegetation cover). Results of the Chi-square analysis (shown in Tables 28a to 28g) focus on the interaction between the three major erosional processes (wind, running water, and gravity) and the major physical factors of vegetation, soil, topography, and landforms.

Erosional process and vegetation cover. In part the relationships between erosion by wind and running water and the extent of vegetation cover shown in Table 28a may be governed by two factors. First, while it is important to note that when the archaeological field work was done only perennial vegetation was mapped, it is also significant that desert annuals retard both eolian and fluvial erosion. During the spring for instance (March through June) annuals such as tumbleweed (Salsola kali) might provide an "Interrupted" cover. By October, however, the tumbleweeds would have matured and been removed from the site leaving the surface open to attack by runoff arising from winter rainfall. The second source of error may result from consistent underestimation of the percent vegetation cover. Based on the survey data, most surfaces with archaeological sites carry a 1 to 5 percent perennial vegetation cover. Data on other undisturbed surfaces, however, indicate a somewhat higher density. Lathrop (1978) shows the following percentage perennial vegetation cover for: Jawbone Canyon/Dove Springs, 23; Barstow to Las Vegas raceway, 14; Afton Canyon, 8; Stoddard Valley, 7; and World War II training areas near Essex and Needles, 20.

Table 26. Erosional Process and Landforms in the California Desert.

Grouped Landforms Containing Sites TOTAL DESERT PLANNING AREA	Number of Recorded Instances of: DEFLATION	RILLING GULLYING SHEETWASH	ROCK DEBRIS SLUMPING	TOTAL
Mountains, Hills, Ridges	148	2014	284	2446
Terrace, Canyon, Arroyo, Badlands	143	1069	122	1334
Alluvial Fan, Desert Pavement	373	2233	67	2673
Sand Dunes	96	131	5	232
Playa	45	94	2	141
	805	5541	480	6826

Table 27. Most common association of recorded physical factors related to types of erosion on archaeological sites in the California Desert.

	Deflation	Rilling	Gullying	Sheetwash	Rock debris	Slump
Vegetation coverage	6 - 25%	6 - 25%	6 - 25%	6 - 25%	1 - 5%	1 - 5%
Landform	Allu. fan	Allu. fan	Allu. fan	Allu. fan	Hill	Terrace
Bedrock type	Qal.	Qal.	Qal.	Qal.	Int. ig.	Int. ig.
Soil type	Alluv.	Alluv.	Alluv.	Alluv.	Bedrock	Alluv.
Soil texture	Sand	Sand	Sand	Sand	Sand	Sand
Angle of slope	$0 - 5^{\circ}$	$0 - 5^{\circ}$	$0 - 5^{\circ}$	$0 - 5^{\circ}$	$0 - 5^{\circ}$	$0 - 5^{\circ}$
Aspect of slope	Any	ENE	Any	ENE	Any	Any

Table 28a. Erosional Process vs. Vegetation.

Vegetation coverage	Wind	Running water	Gravity
continuous (+ 75%)	11[a] (-5.17)[b]	34 (5.58)	4 (-0.41)
interrupted (50 - 75%)	18 (4.37)	159 (-7.13)	11 (2.76)
park-like (25 - 50%)	34 (62.04)	732 (-80.10)	41 (18.06)
rare (6 - 25%)	195 (-0.42)	1329 (-8.23)	111 (8.65)
barely present (1 - 5%)	185 (-35.41)	955 (60.42)	117 (-25.01)
absent (0 - 1%)	66 (-25.42)	246 (29.46)	29 (-4.04)
		TOTAL OBSERVATIONS	4277
		CHI-SQUARE	101.7
		d.f.	10[c]

[a] observed value

[b] expected - observed value

[c] For two-way classification (contingency) tables, degrees of freedom are computed as: (No. rows - 1) (No. columns -1)

Table 28b. Erosional Process vs. Landforms.

Landforms	Wind	Running water	Gravity
mountain + hill	74 (103.59)	1242 (-11.77)	197 (-91.82)
terrace	88 (-17.34)	487 (2.49)	27 (14.85)
ridge	74 (44.79)	862 (-39.14)	76 (-5.65)
alluvial fan	220 (-17.76)	1458 (-57.02)	45 (74.77)
canyon	15 (26.90)	269 (21.28)	73 (-48.18)
arroyo	25 (13.85)	286 (-16.86)	20 (3.01)
sand dune	101 (-73.18)	131 (61.71)	5 (11.47)
desert pavement	153 (-58.04)	635 (22.80)	21 (35.24)
bad lands	2 (5.63)	57 (-4.15)	6 (-1.48)
playa	45 (-28.45)	94 (20.65)	2 (7.80)
		TOTAL OBSERVATIONS	6790
		CHI-SQUARE	768.8
		d.f.	18

Table 28c. Erosional Processes vs. Bedrock.

Bedrock	Wind	Running water	Gravity
extrusive igneous	60 (-6.71)	279 (76.67)	106 (-69.96)
intrusive igneous	47 (95.98)	1015 (-60.69)	132 (-35.29)
metamorphic	7 (20.78)	200 (-14.57)	25 (-6.21)
sedimentary	39 (4.59)	273 (17.93)	52 (-22.52)
alluvial	348 (-85.04)	1801 (-45.83)	47 (130.87)
other	46 (-29.59)	83 (26.50)	8 (3.10)
		TOTAL OBSERVATIONS	4568
		CHI-SQUARE	456.49
		d.f.	10

Table 28d. Erosional Process vs. Soil Texture.

Soil texture	Wind	Running water	Gravity
sand	260 (-39.18)	1445 (20.17)	105 (19.00)
loam	70 (59.20)	947 (-89.75)	42 (30.55)
silt	58 (-9.56)	306 (15.37)	33 (-5.80)
clay	22 (-4.80)	116 (-1.86)	3 (6.66)
other	53 (-5.66)	258 (56.08)	77 (-50.42)
		TOTAL OBSERVATIONS	3795
		CHI-SQUARE	175.0
		d.f.	8

Table 28e. Erosional Process vs. Soil Type.

Soil type	Wind	Running water	Gravity
midden	22 (51.57)	542 (-16.33)	83 (-35.25)
alluvial	363 (-44.60)	2353 (-78.07)	84 (122.66)
colluvial	27 (63.52)	697 (-50.27)	72 (-13.25)
eolian	121 (-87.57)	158 (80.87)	15 (6.70)
bedrock	31 (18.12)	286 (64.99)	115 (-83.12)
other	23 (-1.05)	158 (-1.19)	12 (2.24)
		TOTAL OBSERVATIONS	5162
		CHI-SQUARE	690.0
		d.f.	10

Table 28f. Erosional Process vs. Slope Angle.

Slope angle	Wind	Running water	Gravity
$0 - 5^{o}$	428 (4.86)	2792 (-102.11)	167 (97.24)
$6 - 15^{o}$	131 (-26.20)	598 (53.23)	91 (-27.02)
$16 - 30^{o}$	17 (14.44)	180 (15.37)	49 (-29.81)
$31 - 60^{o}$	12 (6.02)	92 (19.98)	37 (-26.00)
$+60^{o}$	5 (0.88)	23 (13.53)	18 (-14.41)
		TOTAL OBSERVATIONS	4640
		CHI-SQUARE	246.1
		d.f.	8

Table 28g. Erosional Process vs. Slope Aspect.

Slope aspect	Wind	Running water	Gravity
north	71 (-1.69)	445 (3.48)	56 (-1.80)
northeast	56 (17.43)	495 (-19.86)	55 (2.43)
east	95 (-1.33)	612 (-5.92)	66 (7.25)
southeast	64 (7.37)	484 (-22.19)	41 (14.82)
south	84 (-35.17)	260 (55.98)	59 (-20.81)
southwest	54 (-2.26)	338 (-3.21)	35 (5.46)
west	49 (11.71)	396 (-3.19)	56 (-8.52)
northwest	50 (3.92)	354 (-5.09)	41 (1.17)
		TOTAL OBSERVATIONS	4316
		CHI-SQUARE	63.4
		d.f.	14

Erosion and landforms. A review of the relationship between erosional process and landform (Table 28b) makes it possible to rank the relative effectiveness of the three major erosional processes. Predictably, for instance, the action of wind was most frequently observed on sites related to sand dunes and least effective on localities situated in mountains and hills. On the other hand, the action of gravity was dominant on mountain/hill localities and least effective on alluvial fans. The cutting action of running water (rilling, gullying, and sheetwash) was most apparent on alluvial fans and least apparent on sand dunes. The net ranking of erosional effectiveness by landform is shown in Table 29.

The unusually large number of sites situated on desert pavement areas that appear to suffer from deflation deserve further comment. It is, for instance, commonly assumed that desert pavements result from removal of the fine material by wind, leaving a mosaic of lag gravel. It would seem logical, therefore, to assume that since sites are incorporated into and on areas of pavement, they would be the result of eolian deflation and vertical concentration. This, however, is not the case. Cook and Warren (1973:124-129) present persuasive evidence that most pavements develop, even in their incipient stages, through the mechanism of alternate wetting and drying of the subsurface soil combined with sheetwash. Eolian deflation, in fact, does not play a significant role in the development of desert pavement surfaces. Once a pavement is formed, however, and then broken by some exterior mechanical means, deflation acts swiftly on the sub-surface silt layer and, combined with concentration of sheetwash into rill cutting, serves to destroy the pavement surface. It should also be noted that desert pavement, per se, does not constitute a landform but rather a soil condition. Pavements, for instance, are common throughout the California Desert and are developed on alluvial fans, terrace deposits, and pediments formed on intrusive igneous and metamorphic rock. Furthermore, the presence or absence of desert pavement is not a function of the age of the deposit or the age of the rock unit as suggested by Gallegos (1979:79) but is almost entirely controlled by the lithology of the contributing rock, the slope angle, and the local microclimate.

On playa surfaces, however, deflation is an ever-present process. Bassett and Kupfer (1964:35) report that since World War II maneuvers, the surface of Cadiz Dry Lake has been lowered approximately nine inches (23 cm) leaving tire tracks once cut six inches (15 cm) into the playa crust now standing three inches (7 cm) in raised relief. A markedly slower rate of deflation, 36 inches (90 cm) in 6000 years, is noted by Parker (1963:21) for the Bristol Lake playa surface where it is overlain by basalt flows issuing from Amboy Crater.

Erosion and rock type. The relationship between erosional process and bedrock is directly related to topography. As might be expected wind erosion concentrated on sites supported by alluvial material whereas erosion resulting from running water and gravity tended to be more concentrated in areas underlain by igneous rocks. This may be due to the fact that significant areas of the California Desert are underlain by pediment surfaces. Commonly these stripped rock surfaces incorporate extensive areas of exposed bedrock. Rock debris, therefore, would constitute a prevalent form of gravity erosion. It must also be noted that the category "Rock Debris" was undoubtedly applied to archaeological sites occupying dry caves and rock shelters. The latter category of sites was not included in this erosion study.

Table 29. Ranking of Erosional Process and Landforms.

	Wind	Running water	Gravity
First	sand dunes	alluvial fan	mountain/hill
	desert pavement	ridge	canyon
	Playa	arroyo	ridge
	alluvial fan	mountain/hill	bad lands
	terrace	bad lands	arroyo
	bad lands	terrace	playa
	arroyo	playa	sand dunes
	canyon	canyon	terrace
	ridge	desert pavement	desert pavement
Last	mountain/hill	sand dunes	alluvial fan

Erosion and soil texture. Here again, the results of a Chi-square test, Table 28d, illustrate the basic pedogenetic relationship that sand is easily eroded by wind while the addition of organic matter, forming "Loam", drastically reduces the eolian impact. Conversely, the category "Loam" reflected the highest incidence of runoff erosion while rock debris (commonly categorized as "Other" constituted the dominant material effected by gravity.

Erosion and soil type. The relationships shown above are reinforced by analysis of EROSION vs. SOIL TYPE (Table 28e) eolian material being most subject to wind deflation and alluvial material least susceptible to gravity erosion.

Erosion and slope angle and aspect. These two parameters (Tables 28f, 28g) appear to exert very little control over the intensity of erosional processes. In part, these results are the result of the location of archaeological sites rather than the relative effectiveness of geomorphic process vs. topography.

Variability of erosional processes. Based on Chi-square values it is possible to list the seven controlling geomorphic factors in terms of the amount of influence they may exert on the three grouped erosional processes (Table 30). The approximation is based on the average of the "observed-minus-expected" values for the Chi-square tables (28a-28g). Such a list should not be considered a "ranking" per se but simply an indication of which parameters exert more or less control over the amount of erosional activity. It is apparent, for instance, that bedrock and soil type exhibit more variability than do vegetation or slope aspect; thus the former possibly exert more influence over the type and intensity of erosion than do the latter. Landforms, soil texture, and slope angle are approximately equal in their values and appear to fall somewhere between the extremes in terms of their influence over erosion.

Geographic Distribution of Erosional and Depositional Processes

Throughout the California Desert the spatial distribution of the intensity of geomorphic process results from the complex interaction of at least four regional variables. First, the spatial organization of topography changes from a general northeast-southwest alignment in the northern desert, north of the Garlock Fault, to an east-west or circular arrangement in the southern half of the desert. Combined with this change in parallel linearity is the second factor, a marked regional change in lithology. The desert north of the Garlock Fault is dominated by Paleozoic sediments while south of that major left-lateral rift, Mesozoic granitic and metamorphic rocks combine with Tertiary sediments to form much of the geologic terrain. This regional division is reflected by the pediments that dominate southern landscapes and the complex associations of alluvial fan systems that commonly border the northern ranges. Topography and lithology combine with regional climate patterns to complete the basis for regional erosional and depositional patterns.

Table 30. List of Geomorphic Parameters and Chi-Square Values.

Parameter	Average of "Observed-minus-expected" Chi-square Values
Bedrock Type	173.1
Soil Type	171.9
Landform	153.9
Soil Texture	108.4
Slope Angle	107.7
Vegetation Density	93.7
Slope Aspect	55.5

The major cyclonic storms that periodically sweep the California Desert may enter either from the southwest corner, Baja California - San Diego, in which case their general track is north-northeast; or they may enter at a point farther north, Los Angeles - Santa Barbara, in which case their track is east to slightly southeast. In either case the topography of the coast and transverse ranges, the San Bernardino, San Gabriel, and Tehachapi mountains, exerts a marked effect. Storms entering from the north are forced over a high topographic barrier. This tends to produce a rain shadow effect across the western California Desert that is not present further east. The net result of the interaction between topography, lithology, and climate is to produce a series of regional patterns of erosional and depositional efficiency that may be shown on a series of isoplethic maps.

Development of erosional and depositional efficiency maps. As part of the overall planning program for the California Desert, this vast area, in excess of 25 million acres, was subdivided into 30 planning units that subsequently were incorporated into 11 regional study areas. Since the data bank of archaeological site records could be organized on the basis of study area, it was possible to examine the relative effectiveness of geomorphic process through the technique of isoplethic mapping.

Following standard cartographic procedures (Monkhouse and Wilkenson 1971:40-43) the 30 planning units were simplified to rectangular shapes while retaining their general spatial relationships and relative sizes. The resultant map, the base map for Figures 7a-7d, consists of the 30 planning units, dashed outlines and numbers, and the 11 regional study areas. The number of sites reporting a specific form of erosion were then counted and listed as a percent value for each study area. These values were then averaged for the entire California Desert. When values for a specific study area were compared with average values, departure toward either more-than or less-than average could be shown. The amount of departure was then assigned a whole number value. These values were then contoured using an arbitrary but equal increment of intensity. Data points were placed in the geometric center of each study unit since the initial sample of sites was assumed to be representative of the study unit as a whole.

Distribution of deflation. Archaeological sites suffering from deflation are concentrated in the north-central California Desert (Study Areas 6 and 7, Figure 7a) and are markedly absent in the northwest, northeast, and southeast corners of the region. When the isopleth map of deflation (Figure 7a) is compared with the California Desert landforms map (Figure 8) there is a strong relationship between archaeological deflation and the eastward splay of sand deflated from the channel of the Mojave River by a strong prevailing easterly wind. It is probable that wind activity in this portion of the desert results from a shearing effect along the line of contact between northeast-moving and east-moving air masses. It is interesting to note that the isopleths of high deflation activity trend southeast into Study Area 2. This coincides with the deposits of eolian origin shown northeast of the Salton Sea in Figure 8. Areas where deflation is a minimal process might be explained by the wind-shadow effect of the San Bernardino, San Gabriel, and Tehachapi ranges.

Figure 7a. Distribution of deflation in the California Desert, as recorded at archaeological sites. See Figure 3 for names of study areas and planning units.

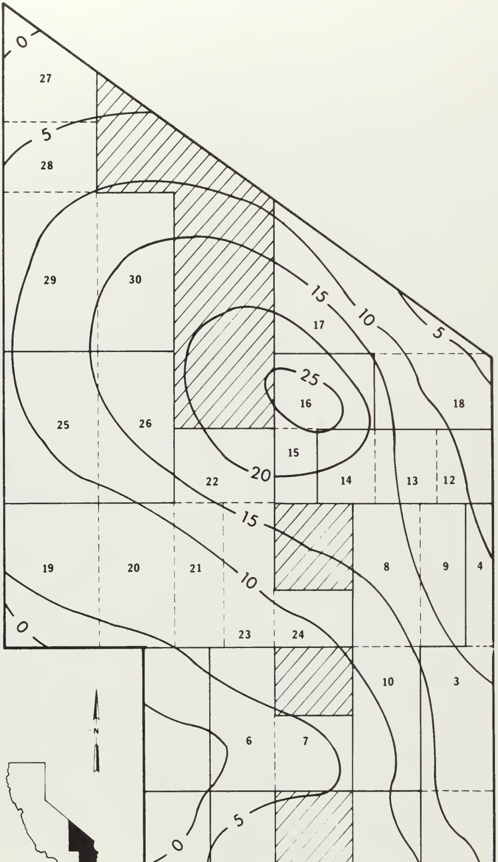

0
27
5
28
29
30
15
10
5
17
25
16
18
25
26
15
20
22
14
13
12
15
19
20
21
10
8
9
4
0
23
24
10
3
N
6
7
5
0
11
1
2
5

Figure 7b. Distribution of rilling in the California Desert as recorded at archaeological sites. See Figure 3 for names of study areas and planning units.

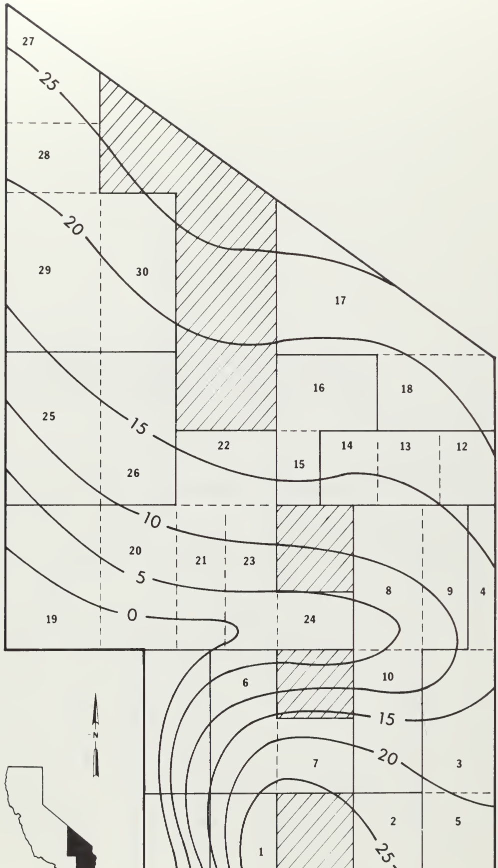
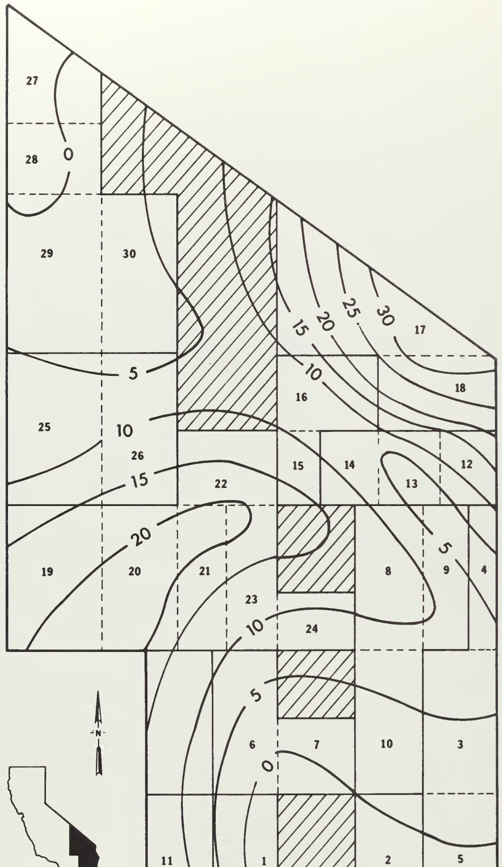
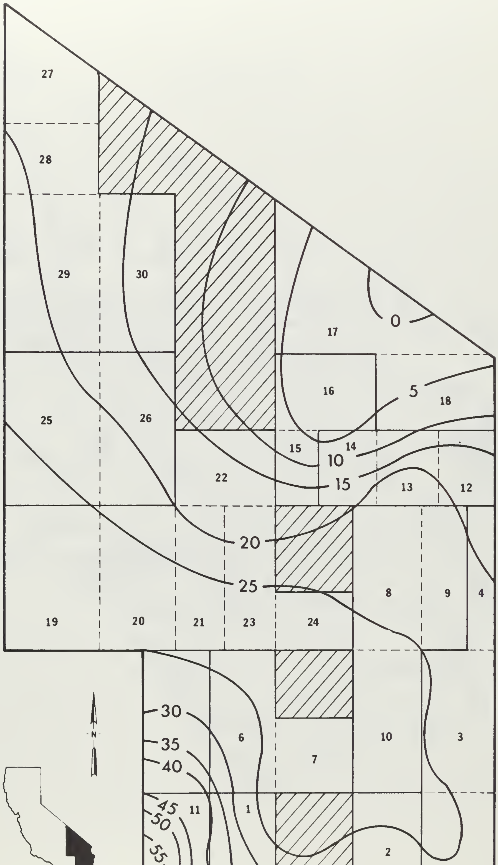

27
25
28
20
29
30
17
16
18
25
15
22
14
13
12
15
26
10
20
21
23
5
8
9
4
19
0
24
10
6
15
N
20
7
3
2
5
25
1
11

Figure 7c. Distribution of gullying in the California Desert as recorded at archaeological sites. See Figure 3 for names of study areas and planning units.



27
28
0
29
30
15
20
25
30
17
5
18
16
10
25
10
26
15
14
12
13
22
15
20
5
19
20
21
8
9
4
23
10
24
5
6
7
10
3
0
11
1
2
5
N

Figure 7d. Distribution of sheetwash in the California Desert as recorded at archaeological sites. See Figure 3 for names of study areas and planning units.



27
28
29
30
17
0
16
5
18
25
26
15
14
10
22
15
13
12
20
25
8
9
4
19
20
21
23
24
30
35
40
6
7
10
3
45
50
55
11
1
2
5
N

Figure 8. Landforms in the California Desert form a complex mosaic of surfaces that respond to an equally complex array of erosional and depositional processes. The archaeological remains on these surfaces constitute one of the most important resources in the California Desert Conservation Area.


Landforms of the California Desert
Based on enhanced ERTS imagery furnished by J P L
118°
117°
37°
116°
36°
115°
35°
34°
33°
SIERRA NEVADA
TEHACHAPI MTS
SAN GABRIEL MTS
SAN BERNARDINO MTS.
SANTA ROSA MTS.
SALTON SEA
EXPLANATION
Bedrock outcrop (Precambrian through Tertiary igneous, metamorphic and sedimentary rocks)
Fan and pediment surfaces
Eolian deposits (noting major active dune fields)
Playa and other lacustrine surfaces
Agricultural land
0 50 km
0 50 mi
DLW 79

Distribution of rilling. (Figure 7b). The process of rilling exhibits both a southern and northern maxima separated by a broad east-west band of low intensity cutting through the southcentral portion of the California Desert. This pattern may be an artifact of lithology rather than a singular distribution of rainfall. Late Tertiary to Pleistocene sediments comprise much of the surficial geology in the southern portions of the desert while widespread alluvial fans mark much of the northern surface. In both cases the surficial material would be highly susceptible to rilling. The central portion of the desert, dominated by broad granitic pediments, would be less susceptible to this form of erosion.

Distribution of gullying. (Figure 7c). This form of erosion is concentrated in the northeastern and west-central areas of the California Desert. The western concentration may result from rare but extremely powerful storms that survive intact as they cross the crest of the San Barnardino Range. Areas to the northeast, comprising Study Area 8, tend to be dominated by south-facing ranges. These would possibly intercept the bulk of north to northeast moving precipitation thus marking an area of higher-than-average runoff from winter cyclonic storms.

Distribution of sheetwash. (Figure 7d). Sheetwash damage appears to be concentrated in the southwest corner of the desert. Again, this may well be an artifact of softer Tertiary lacustrine and marine deposits that support broad gently dipping terrace and beach margin features bordering the Salton Basin. Such topographic features, combined with periodic storms moving north-northeast from Baja California could account for this concentration.

A review of the distribution of the four major forms of natural erosion damage to archaeological sites in the California Desert reveals that the four processes are not equally distributed. By concentrating efforts directed toward examination and protection of sites based on this form of process distribution it may be possible to retard at least a portion of natural erosional damage.

AN EXPERIMENTAL APPROACH TO NATURALLY OCCURRING AND ENHANCED EROSION

Although several erosional processes act singly or in concert to bring about the destruction of archaeological sites, two mechanisms deserve immediate attention in terms of establishing on-going experimental programs. These are (1) runoff erosion including sheetwash and gullying and (2) eolian erosion or deflation in areas where existing vegetation cover has been destroyed. Both runoff and eolian experiments should be designed to contrast undisturbed surfaces with surfaces that have undergone various intensities of natural and enhanced disturbance.

At present an extensive body of geologic, engineering, and soils literature deals directly with quantifying the erosive impact of rainfall and runoff on small drainage basins. Studies by Wischmeier (1975), Bryan (1968), and Schumm (1956) and review papers such as those by Toy (1977) and Schumm (1977) provide numerous examples of specific experimental techniques, collection of data, and analysis of results. What is required, however, is to apply these types of experimental studies to both disturbed and undisturbed archaeological sites. In point of fact of course, it is neither desirable nor logistically feasible to subject an actual site to this form of erosion experiment. Excellent results could be obtained, however, from simulated and/or constructed sites.

Specific runoff erosion experiments should measure the amount of water applied to a unit area in a unit time and should be designed to measure the amount of time required to initiate particle movement. This should be done using several configurations of desert surface materials. Using a pump-sprinkler system as described by Lusby (1977) significant information could be gained as to the armoring effects of desert pavements in various stages of cementation both before and after a controlled number of disturbance events.

On the assumption that the most severe disturbance conditions occur on armored surfaces such as desert pavements, stabilized dunes and playa crusts, the runoff experiments suggested above could be applied to all three types of surface materials. The same areas could then be tested for resistance to wind erosion. Quantitative data on wind erosion could be gained from a series of portable wind tunnel experiments as described by Gillette et al. (1979) or a series of soil compaction studies as described by Wilshire and Nakata (1976) and Iverson and Hinckley (1979). Types of materials included in deflation experiments would include eolian, playa, and fan deposits. The erosional and deflation experimental program is summed up in Table 31 where each pair of environments and erosive processes would be tested in both the undisturbed and disturbed state.

Duration of Experiments

Since contemporary geomorphic experiments aim at understanding the rate at which a given process operates, it is unfortunate that studies of erosion and deposition in an arid climate must, in fact, be carried out under the conditions of that climate. Processes in arid environments, while they may act with extreme power, occur at very rare intervals. In fact, years may elapse between events of such magnitude as to cause appreciable change. One is left with the dilemma that "real-time" experimental programs require decades if not centuries, but any operational or financially feasible program should be completed in months. In the case of the California Desert, a number of specified areas that replicate or are analogous to different types of archaeological sites must be set aside in a series of protected localities for long term experiments. At present there are a number of Federal installations in the California Desert that could provide a wide range of secure test areas. Initially an experimental program should be designed around a ten year interval with biennial measurements made in April, to take advantage of stored winter soil moisture, and in October, to maximize the impact of summer drought.

Table 31. Field Studies of Erosion Processes.

Experimental Program	Geomorphic Environment: Armored Slope Surface	Stabilized Dune Surface	Playa Crust
Rainfall simulation	measures erosion and sediment yield	measures erosion and sediment yield	
Measured wind velocity		measures erosion and dust yield	measures deflation and dust yield

SUMMARY

Natural destruction of cultural resources in the California Desert is widespread but is not predictible in terms of time and place. Infrequent but prolonged desert-wide winter cyclonic storms which strike about one year in 15 account for the bulk of the damage arising from a combination of erosion and deposition. Summer convectional storms, which occur with extreme erosional and depositional intensity, are less important because they impact very small areas. Both types of precipitation, however, cause a disproportionate amount of damage on surfaces that have been modified by human activity. A second form of natural erosion, wind deflation and deposition, does not pose a particular hazard to cultural resources except, as is the case with precipitation, where human activity has destroyed the natural surface.

An analysis of data collected during an archaeological inventory of 30 planning units in the California Desert indicates that destruction by both surface runoff and eolian deflation is concentrated in the northeast sector of the California Desert Conservation Area; a phenomenon caused by the interaction of the desert topography and the normal southern California storm tracks moving northeast from the Pacific Ocean. Areas underlain by Tertiary terrestrial sediments, however, are vigorously attacked regardless of their location. While there is no economically feasible method of protecting most cultural resources against the actions of natural processes, a program of continuous and long-term experimentation should be implemented as soon as possible. Such a program should consist of controlled field experiments as well as the establishment of protected plots designed for extended observation.

CASE STUDIES OF SELECTED HISTORICAL SITES

Elizabeth von Till Warren

To provide a sample of actual case histories of discernible impacts on historical sites, a brief field investigation was conducted in late December 1979. Sites selected for this investigation typified different categories of historical uses, and for which there are some comparative data available. At each site selected, both natural and man-caused destruction was examined. Photographs taken during the field investigation are listed in Appendix 2. A set of these photographs is on file with the Desert District, California Bureau of Land Management.

In the northeastern Mojave, major historic sites older than 50 years include: mining camps, ranches, military camps, health spas, railroad facilities, trails, wagon roads and early automobile highways. Specific sites visited and photographed during the three-day investigation included examples of most of these types of sites: military (Fort Pah-Ute), mining (Ivanpah, Salt Creek), ranches (China Ranch, Irwin Ranch, Ivanpah), railroad (Tonopah & Tidewater in Amargosa Canyon), trails (Mohave: Spanish Trail, north branch), wagon road (Old Government Road), automobile road (Arrowhead Trail). Data have also been included for Fort Soda/Zzyzx Resort and for Rasor Ranch on the Tonopah & Tidewater, although neither was personally visited during the field excursion. Information on the conditions of these sites was supplied by Dennis G. Casebier and Art Rader, respectively.

MILITARY SITES

Fort Pah-Ute

Constructed in 1867-68 by a detachment of men from Camp Mojave, Arizona Territory, remnants of this rock fort are still found on the eastern slopes of the Pah-Ute Mountains of eastern San Bernardino County, California. Below the military fort on the eastern slopes of Pah-Ute Mountains, are also the remains of a small desert ranch. Dennis G. Casebier has documented the story of the fort and ranch in his "Tales of the Mojave Road" series, Number Four (1974c). Many fine photographs are included in this publication, some dating from as early as 1919, others from later times and as recently as 1974. These photographs partially document the deterioration of the fort complex. Casebier has additional photographs taken at several times during the past twenty years, and new pictures were taken on December 30, 1979 expressly for this project. From these sources, Casebier's accounts and personal observations, and my own recent research, it is possible to identify several sources of the destructive forces at the fort and ranch. Natural processes have resulted in the collapse of walls unprotected by roof; widening of the wash between the stone corral to the south and the living quarters to the north; washing out of adobe mortar and threatened collapse of creek bank below Bishop's Wall. Man-caused damage has accelerated destruction of fort walls. Fort rocks have been realigned to delineate features that were not part of original design such as walkways and fire pits. The Mohave trail and wagon road is obliterated by indiscriminate use of vehicles. Ranch structures have burned, petroglyphs have been vandalized or removed; limbs have been sawed off mesquite trees. Signs are inappropriate and detract from the site's values.

Natural causes. Positive description of the roof materials of the Fort is lacking in the historic record unearthed to date. It is known that no roofing materials were ever shipped to Fort Pah-Ute (Casebier 1980a:p.c.). Either materials were constructed from "whatever the country provided" such as the willows, mesquite and cottonwoods of the stream channel, or the building were never roofed permanently. A practice quite common in temporary military posts of the period was to use a canvas roof (Casebier 1980a:p.c.; Hinds 1980:p.c.). If a roof had been placed on the structures, it vanished shortly after the post was abandoned on May 3, 1868. Three and one-half years later, on September 11, 1871, the post was visited by the Lt. George M. Wheeler party of that year. Mr. Gilbert of the Wheeler expedition provided a brief description of the Fort in his report. He noted that the Fort was constructed of stone and adobe (mortar?) and had no roof (Wheeler 1889).

In the 112 years intervening since the Fort's construction, the adobe has completely weathered away, giving the appearance of dry laid rock walls. In the severe storms of 1938, a flash flood washed away portions of the corral walls that had been extended across the wash to a second corral (Casebier 1974c), and substantially widened the wash itself. A 1919 photograph reproduced by Casebier (1974c:48) depicts the fort walls standing to full height, with a gabled wall evident on the west side. 1929 and late 1930s photographs (Casebier 1974c:45,51) also show the south wall still nearly intact, but by 1974, the wall was only about one-half its original height. The walls apparently withstood the ravages of time and weather for 70 years, and little if any vandalism was done by the local inhabitants of nearby desert communities such as Needles or Searchlight who frequented the spot for recreation in the early 20th century (Casebier 1974c:59).

Man-caused deterioration. The dramatic change in the Fort's appearance occurred between 1946 and 1966, when Dennis Casebier first visited the site and photographed it. In 1946, George Irwin left his small ranch located below the Fort on the east slopes of the Pah-Ute Mountains. After his departure, fort walls were demolished and many stones with petroglyphs on them were carried off. Since 1966, additional wall deterioration has occurred (Casebier 1974:44,45,48,49,51) and comparison photographs (Appendix 2, Warren 1-11; Wilson 1). The ranch itself suffered especially; the ranch house and other buildings have been burned, and fences destroyed. The grounds both around the fort walls and inside them have been "potted" by relic hunters. The fireplace and one room of the Fort have been dug out and screened. There is another excavation on a low bench along the creek below "Bishop's Fort" (Casebier 1974:80, 141-51 and Appendix 2, Warren 12).

"Bishop's Rock", a large boulder signed by S. A. Bishop in 1859, was pushed into the creek bed and subsequently rescued by the Bureau of Land Management and placed on display in the San Bernardino County Museum (Casebier 1974c).

Other signs of vandalism include sawn off tree limbs along the creek. This activity is probably related to the frequent use of the site for camping. Some of these campers are members of organized youth groups which have visited the site to learn its history and to conduct "clean-up" operations. These groups have erected signs, laid out pathways lined with stones, and built fire pits. While their motives may be commendable, these activities have resulted in obscuring the original orientation of the fort (compare diagram in Casebier 1974:55 and Warren 1979 photographs 6,7,8,14; Wilson Photo 2). Further, the signs marking the site are also damaging. One is supported by posts which have been braced with rocks from the fort. The second sign, apparently older, was originally erected on a wooden post in front of a stone monument erected still earlier. This second sign is now fastened to the monument itself (Appendix 2, compare Wilson 2, and Warren 7).

The signs encourage digging for collectible artifacts in the grounds near the fort. The sign now posted on the stone monument bears the following inscription:

> Old Fort Piute Ruins
>
> This fort served as a stopping place on the old Gov't road. The famed camel express stopped here and got water. A button and camel saddle were found here.

Such a text placed at an unsupervised site encourages further relic hunting.

The original Mohave Road has been obliterated at the fort by indiscriminate use of vehicles and camping. Compare the photographs from 1919 and 1974 in Casebier's publication. Farther from the fort ruins, the trail is occasionally found in good condition unless washed out by floods (Appendix 2, Warren 15).

Cattle are grazing in the vicinity of the fort. While this activity does not appear to be directly destructive to the fort at this time, the potential for damage is present.

Hunting, authorized by California Department of Fish & Game for game species only, is apparently pursued strenuously at Pah-Ute Creek. Spent shotgun shells litter the ground at the fort, along the entire length of the creek, and for a considerable distance on either side of it. This activity should be evaluated to determine if the guns are being used to damage petroglyphs or other important cultural remains. Small calibre guns have been used to shoot at petroglyphs nearby (Casebier 1974c:67).

<u>Summary</u>. Assessing the relative impact of the various kinds

of destructive forces at Fort Pah-Ute, it is apparent that man-caused damage is far greater than natural forces. The Fort stood fairly intact from 1868 to 1946, but the next 20 years witnessed intensive destruction by vandals. This period coincides with the increased accessibility of the remotest parts of the once-isolated California Desert that followed World War II. The marketing of four-wheel drive and other off-road vehicles that burgeoned after the war encouraged more and more use of the desert by adventure-seeking urbanites (Norris and Carrico 1978). While some no doubt enjoyed the Fort and left it alone, others obviously engaged in tearing down the old rock walls, burning up the Irwin Ranch buildings, carrying off and vandalizing petroglyphs, and similar activities.

The local desert inhabitants who used the site for its recreational values from at least 1912 on (Casebier 1974c:59) apparently valued it, protected it and did it no harm. That such major destruction occurred in the scant 20 years after George Irwin left in 1946 also points up the invaluable protective role of on-site ranchers Thomas Van Slyke and later George and Virginia Irwin (Casebier 1974c:66).

<u>Other Military Sites</u>

Other sites which have an early military association include other Government Road spring sites: Rock Springs, Marl Springs, and Fort Soda or Hancock's Redoubt. While these were not personally field checked at this time, Casebier has kindly provided comparative documentation of deterioration from both natural and human causes.

<u>Rock Springs</u>: A 100 year size flood in September 1978 washed away the "tack shed" and corral which were relics of the army's outpost of 1867. A large water tank installed by the Rock Springs Land and Cattle Company in 1910 was demolished in the same flood. The wash through the site now passes through the corral, and is about 8 feet deep at that point. Natural causes seem to be the most important source of damage at this isolated location, farther from major roadways than Fort Pah-Ute, and not as well known (Casebier 1980a:p.c.; 1980b:p.c.).

<u>Marl Springs</u>: There has been attrition of the rock structures here, as well as damage to the arrastra and small ore mill. In 1966, the features were relatively intact (Appendix 2, Casebier 1); by 1979 major differences were noted (Appendix 2, Casebier 2). The arrastra has suffered considerable damage, and the ore mill is entirely gone, probably removed for re-use elsewhere, or as a souvenir. Casebier notes that Marl Springs may be in private ownership and outside BLM jurisdiction (Casebier 1980b:p.c.), but the amount of destruction in 13 years is nonetheless evidence of the rapidity of historic site deterioration. Marl Springs does not receive as much visitation as Fort Pah-Ute, being very isolated, accessible only by an extremely poor road with many washouts.

<u>Soda Springs</u>: This site, sometimes designated Fort Soda or Hancock's Redoubt, has completely changed character since the 1860s, when it was part of a military support system on the Mojave Desert. It is better listed under the category, health resort.

HEALTH RESORTS

Zzyzx

Historically, Soda Springs was first the site of an army redoubt constructed in 1860 by Lt. Milton T. Carr, part of Carleton's command in the Mojave Desert charged with punishing Pah-Ute Indians for alleged depradations along the trail (Casebier 1972). The small, circular redoubt, named for Quartermaster Hancock (Casebier 1975:128), played an important role in securing safe passage of desert travellers in the 1860s. Additional structures were built over the years, at least one man is buried there (Casebier 1974b), and the Arizona Overland Mail Company maintained a relay station there during part of 1867. In the early 1870s, a "nice bathing place" had been built for public use, probably the first bathing pool in the desert. The old relay station was in ruins in 1909 (Mendenhall 1909:62), but large stone buildings were still present, and the stone lined pool, 5 x 8 x 3 feet deep, was located about 150 feet southeast of the largest stone building. In 1906, the Tonopah & Tidewater Railroad (T&T) built a small watering station at the site (Bard 1973; Myrick 1963). Prior to America's entry into World War I, a religious colony occupied the site, mining for gold and building a small community of five frame houses. After the colony was deserted when the proprietors and their German-born followers were imprisoned during the War, apparently casualties of anti-German sentiment, the houses were torn down and used to build new structures at Baker (Jaeger 1958). A salt evaporation plant was also constructed as part of the gold mining operation. An excellent photograph of this portion of the remains and of the T&T tracks at the locality is found in the Frank Green collection recently made available by David Garcia and Art Rader to the University of Nevada, Las Vegas Special Collections Department of the library. These photographs were taken between 1906 and 1915. Unfortunately, Green apparently did not photograph the old station site.

Soda Springs lay virtually deserted throughout the first two decades following World War I. In 1944, Curtis Howe Springer took over the site for a spa which he named Zzyzx, and erected the buildings still in use. Springer remained on the site until 1974, when the Bureau of Land Management ousted him for trespass. In the last few years, BLM has permitted the site to be managed as a scientific research station and certain changes have been made in the Zzyzx (Springer) complex during this time. Dennis G. Casebier has filed a letter with the Bureau of Land Management complaining of the insensitive changes made to the facilities and the exclusion of the general public in favor of the academic and research community (Casebier 1979:p.c.). While we were unable to visit this site personally, the changes made to the site by the scientific community, if substantiated, do indeed constitute significant impact on the historic values. Construction of the Mohave chub pond, for example, may have been accomplished with proper regard for archaeological investigation of the site selected for the holding pond. However, there does not appear to have been consideration of the effect on site integrity of introducing a wholly new pond. Site integrity is also impacted by construction of the power generating shed mentioned by Casebier.

This site is one of the most historic and fascinating on the whole Mojave Desert. Its historic values, cited by the Bureau of Land Management in its case against Springer, should transcend the expedient demands of modern research stations, which can be built and implemented at other locations that would not negatively impact historic sites. The Zzyzx period is one of the most interesting of all the stories that were played out at the Soda Springs site. The physical remains of the resort should not be dismissed lightly as "only" Zzyzx buildings, subject to insensitive and unnecessary intrusions and changes. Springer's project was unique, and it deserves full protective management. Its uniqueness enhances the story of Soda Springs, and should be included in all interpretive plans for the facility. The site is certainly worthy of placement on the National Register of Historic Sites, and with the inclusion of the Zzyzx story, this rare place should certainly receive that status.

Natural erosion at the site is also of significant impact (Hillier 1979:p.c.). The combination of sheet flooding and man-caused changes has definitely resulted in important deterioration of the site's facilities. As early as 1919, the ram pump for the water system had been removed (recycled?) (Thompson 1921). In the mid 1920s, the five frame houses were dismantled and moved to Baker. This recycling of usable wood and equipment is an old tradition in the desert, where there are few trees and equipment has to be shipped in from very great distances. For example, the boiler and engine from the first mill at Salt Creek, the oldest gold mine on the Mojave Desert, were moved to a lumber mill at Holcomb Valley in San Bernardino County just a few years after the site was abandoned in 1852 (Beattie and Beattie 1939). Because this is a hazard to which desert historical sites are frequently subjected, it is virtually impossible to find a site that has not been at least partially dismantled, with buildings removed or changed to suit new uses. The constant factor is the site itself, usually enhanced by a spring and some vegetation.

Recycling activites are quite different in scope, intent and affect than simple vandalism. Examination of the Soda Springs site reveals that some of the changes are arbitrary (removal of old signs, obscuring the original use of structures), although perhaps necessary to preserve the artifacts until such time as historical interpretation at the site is implemented.

MINING CAMPS

Salt Springs

Salt Springs is the site of the first gold mine in the Mojave Desert. It is located a few hundred yards east of California highway 127 between Baker and Tecopa, where a spring-fed creek rises and flows for about one-fourth mile between rugged metamorphic outcroppings. Salt Creek is a tributary of the Amargosa River drainage, but the creek flows only a short distance on the surface. In the very early development of trails through the region, Salt

Springs was an important stop because of the presence of brackish but usable water. It was heavily used until the mid 1850s, when a short cut was developed that avoided the site (Warren and Roske 1978).

In 1849, Porter Rockwell, Jefferson Hunt, Addison Pratt and others were traveling to Southern California from Utah via the northern branch of the Spanish Trail. They detected the presence of gold in the outcroppings next to the salty creek, and some of their party returned to the site in 1850 to extract gold (Hafen 1954). Because of the religious affiliation of these men, the site was sometimes known as the "Mormon Diggings" (Casebier 1974a). An arrastra was constructed to crush the ores; later a small mill was operating. This small endeavor proved unworkable because of the great distance from any source of supplies for the miners, and the hostility of the Indians of the vicinity. Many early stories attest to killings of the few men who attempted to work the site, and of its extreme isolation (Heap 1957, Rousseau 1864; Belden 1958, 1960). Despite the dangers, the diggings were worked for many years, intermittently, with varying reports of the value of the gold recovered. The last gold extraction was attempted in the 1930s, and since that time the site has been idle.

Salt Springs today displays some interesting characteristics that should be more intensively researched. There was reported to have been a 20 stamp mill at the site in 1909 (Mendenhall), while others cite only a 5-stamp mill (Paher 1973). There are today concrete foundations of several large structures, and the outlines of several rock buildings. There is one standing rock structure of uncertain vintage. It is reasonably well constructed, held together with cement. The site was also visited by M. J. Rogers in the late 1920s, and considered of extraordinary value for its prehistoric components (Rogers 1939).

This site is used by many visitors to the northeastern Mojave. Brackish water still flows in the little creek, and a large stand of rushes, mesquite and willows flourishes at the site. Very large athels dominate the vegetation today, their shade attracting campers to the area. The entire site, on both sides of the creek and at both ends of the narrow canyon, is badly scarred with tire tracks, mute witness to the undisciplined use of various vehicles: motorcycles, bikes, trucks and dune buggies. The site is located just a few miles south of the Dumont Dunes, an area set aside for off-road vehicle (ORV) use. Salt Springs is not included in that permitted area, but it has in fact been included by default, since there is no signing, fencing or other protective installation at Salt Spring.

The ruins of the several old cabins on the south and west of the site have been greatly vandalized. One of them has been burned down in the last several years, according to Eric Ritter, Desert Planning Staff archaeologist. Most of the rock walls are out of alignment, and recent fire pits have been constructed of rocks fallen from the side walls. The stone and cement cabin has been partially demolished. Situated on the northwest side of the canyon, it appears to be of later date than the other houses, which are on the other side of one of the rock outcroppings from the stream channel. None of the old mill structures remain; it is likely that these were removed and recycled, as first happened here in 1852, and later in 1864 (Casebier 1974a).

At Salt Springs, the most important type of destruction is man-caused. The relentless advance of the ORV tracks into the area and through the site is causing major destruction of the surface remains of the prehistoric component, and hastening natural erosion through the site. Pothunting, demolition of building walls and construction of fire pits are all occurring at a rapid pace. The recycling of machinery and equipment to other booming camps accounts at least partially for the lack of artifacts from the various mining activities. Nearly all of the buildings, headshafts and other structures depicted in the L. Burr Belden article in the San Bernardino Sun-Telegram of June 12, 1960, are gone.

Ivanpah

Ivanpah represents two types of activities: mining and cattle ranching. It is listed under mining camps because that is its most significant role in history.

The town of Ivanpah was a product of the 1860s silver boom in Clark Mountain District. In 1869, a prospectus for the Piute Mining Company of Nevada and California (Anonymous 1869) described the high hopes of the investors for a permanent townsite, mill and mining complex on the eastern slopes of Clark Mountain. Much of this scheme never materialized; however, a townsite of important size and a mill complex of regional significance operated for some 60 years. Most claims for population of the townsite are greatly exaggerated. During the height of the boom, although some historians claim a population of thousands for the district, the townsite itself was only occupied by about 200 people (Dellenbaugh 1876). Given the times and the distance from supplies, this is a town of considerable size, however, and surely one of the few 19th century urban centers of the Mojave Desert. The site has been largely deserted since the 1920s, with the occasional exception of a wandering desert prospector who takes up residence in the old dugout near the ruins of the mill.

The Ivanpah townsite actually has at least three distinct segments, all strung out in a line at approximately the same elevation on Clark Mountain. The first part of the site reached from the valley floor below is the location of the old mill and several dugouts, one of which is still roofed and has a fireplace with stovepipe (Appendix 2, Warren 16 and 17). There are foundations of many adobe buildings which have melted away over the years, a modern water system (Appendix 2, Warren 18-21) and old mine adits visible on the slopes above. The second portion of the townsite, extending toward the west and north is marked by ruins of numerous small and large buildings. Still a third portion of the site, the most northerly, has the most extensive adobe walls, many rock foundations, rock corrals (?), and rock walls (Appendix

2, Warren 22-28). A number of photographs taken in 1977 are available for comparative purposes (Appendix 2, Warren 29,30,31). This entire linear complex comprises Ivanpah, sometimes called Old Ivanpah to distinguish it from later sites with the same name (Myrick 1963).

Besides the mining operations at Ivanpah, there are structures relating to grazing of cattle in the area. Ivanpah is in the grazing district used by the Yates Ranch, and earlier by the Rock Springs Land and Cattle Company. At Ivanpah, there are several watering tanks, pipelines (Appendix 2, Warren 32,33,34) and the ruins of an old cabin that has been burned out. A chimney and foundation remain. This cabin was occupied until at least the early 1950s (Lowe 1980:p.c.).

Natural erosion seems to have made little impact on these remains other than on the adobe bricks and walls, where the destruction has been severe (Appendix 2, Warren 35). It is not known what type of roofs the buildings may have had, and once they were gone, the walls were not protected from the weather. The washes appear very stable, with no scouring and many mature yucca and other slow growing plants in them (Appendix 2, Warren 36). The largest foundation ruins extant are located on high ground, out of the washes, but even corrals and other simple structures that were situated in drainage channels have not been greatly disturbed by flooding. The adobe ruins, however, are melting away at a slow but relentless rate. Lacking any protection, the bricks are crumbling fairly rapidly, and the walls are easily knocked down. The rock foundations, where protected by the adobe walls, are not affected as yet.

Human activity has caused a great deal of disturbance at all three segments at Ivanpah. Many people visit the site to camp, bring treasure detectors and dig whenever their equipment reveals the presence of buried metal. Despite this type of activity, which has been going on there for a considerable time, the site is still so rich that artifact fragments dot the surface. The site is totally unprotected, and seemingly only the conscience of the metal detector user prevents the complete demolition of the townsite. That it has not been completely demolished probably reflects the adobe/rock construction of the structures rather than an active conscience on the part of the visitor. Adobe/rock walls have no metal in them, no square nails to attract relic hunters. However, the ground at the townsite is pockmarked with small and large potholes. The interior and exterior of all major buildings show this evidence of relic hunting (Appendix 2, Warren 33-35).

Another source of destruction and accelerated site deterioration is the cattle operation. Pipes run into two springs at the site, and there has been excavation for installation of portions of these pipelines (Appendix 2, Warren 36). Watering tanks there were placed at several locations within the boundaries of the historic townsite. These structures are now in great disrepair, but water is still flowing into them. Overflow and leakage are causing some problem now for the adobe buildings in the path of the runoff, and, of course, the intrusion of these structures has penetrated the integrity of the mining camp ruins.

The cause of the burning of the old cabin at the site is as yet undetermined. Further research should be able to uncover when the cabin was erected, when it was burned, and its purpose. There are other cabins in the vicinity situated close to principal mines of the district. These cabins are intact and in use. The destruction of the cabin at the lower segment of the townsite may be a function of its high visibility; it is the first structure visible from the road leading up to the townsite from the valley below.

Comparison of the appearance of the site today with a few years ago reveals that there is accelerating damage to the old dugout. The roof leaks at one corner, and the gap in the wall under the leaky roof was larger in 1979 than 1977 (Appendix 2, compare Warren 29 with Warren 17). The building has not been vandalized, however, and the roof remains. The mill walls are still standing in about the same configuration (Appendix 2, compare Warren 30 with Warren 16), and there is little litter at the site. Off-road vehicles do not seem to be causing any appreciable problem. There is no network of impromptu roads leading to and from the site, and this is all the more remarkable because sturdy vehicles are needed to travel from Ivanpah to the mines and over to Kingston Wash. Nonetheless, any off-road vehicle users are maintaining caution here about creating new tracks, which is a pleasant change from many areas of the Mojave Desert.

Relic hunters have caused the most visible human damage to the grounds at Ivanpah. The floors of virtually all buildings have been excavated to a greater or lesser degree (Appendix 2, Warren 37,38). Artifacts still litter the surface, attracting treasure hunters. On the 27th of December, 1979, upon our arrival at Ivanpah in mid-afternoon, a man and woman were parked there in their camper (Appendix 2, Warren 39, 40). Neatly laid side by side on the ground next to their truck were two metal detectors. While this couple did not operate the equipment during our visit to the site, and, in fact, secluded themselves inside their camper, obviously relic hunting was the reason for their visit. Freshly turned soil was detected at several places near buildings and on the old trail between townsite segments (Appendix 2, Warren 41,42).

That this site is not more badly disturbed is probably less due to its isolation than the absence of any note of its presence on such tourist maps as the Auto Club of Southern California (ACSC) map of San Bernardino County. This is undoubtedly a protective measure, unplanned but effective. Fort Pah-Ute, on the other hand, is on the Auto Club of Southern California (ACSC) map of the county, and has been visited by many people who would otherwise not be aware of the site. The amount and kinds of vandalism at Fort Pah-Ute exceed greatly those at Ivanpah, and in part the mining camp's survival despite its adobe buildings appears to be due to the simple factor of less visitation. Furthermore, it does not seem to have "benefitted" from youth group adoption as a historic site.

RAILROAD SITES

Amargosa Canyon

Amargosa Canyon has a variety of cultural resources. It has been placed in the category of Railroad Sites for the purposes of this investigation because the railroad has produced most of the significant historic sites on public lands within its boundaries.

Amargosa Canyon was designated a natural and scenic reserve in the late 1970s as a result of local pressure. The canyon is designated an Area of Critical Environmental Concern (ACEC) in the draft Desert Plan. The various roadways into the canyon were fenced and locked gates installed with control of the gates under the jurisdiction of the District Bureau of Land Management office (Appendix 2, Warren 43). The intent of fencing and gating is protection of the canyon from intrusion by motorized vehicles. The southern portal of the canyon is just north of Dumont Dunes, an area which has been dedicated by the Bureau of Land Management for off-road vehicle use. Investigation of the cultural resources in this canyon was included here in order to determine if the protection afforded by the fences is indeed sufficient to protect the canyon, its cultural resources and scenic values. These include an isolated segment of the Tonopah & Tidewater Railroad bed, with some small bridges or trestles, the Sperry and Acme sidings, and a connection at Acme to borax deposits above China Ranch in Willow Creek Canyon. Amargosa Canyon is thus an excellent example of a multiple use historic resource with the main historic focus the railroad complex. Evaluation of the protective measures attempted in deterring motor vehicles through the canyon was an extra added inducement. In a one-day field trip, Willow Creek was explored from the China Ranch to Amargosa Canyon, where the Acme siding was once situated. Documentation was made of a small cabin made of tuff blocks, its attendant outbuildings and ditch, and the trail leading to China Ranch, privately owned property.

Tonopah & Tidewater at Acme

The Tonopah & Tidewater Railroad (T&T) was built through Amargosa Canyon in 1906. Heat, isolation and the extremely primitive conditions combined to delay completion of the 13 mile section of roadbed for a full year. The spur to Acme was constructed in 1915, a distance of 1.3 miles up Willow Creek Canyon from the mainline in the Amargosa Canyon (Myrick 1963:586). The T&T was constructed by Francis G. "Borax" Smith to move borax from Death Valley to Los Angeles, and extended northward to serve the mining camps of Rhyolite, Bullfrog, Goldfield and Tonopah. It operated from 1907 until 1940. The Acme spur was in use only until 1919 (Myrick 1963:587), and the rails and ties were removed in 1927 to be recycled as the Carrara spur (Myrick 1963:588).

During the years of active operation along the main line of the T&T, flash floods proved to be a major problem for the railroad. Landslides caused by road cuts through springs and seeps also caused major problems in Amargosa Canyon (Myrick 1963). The railroad was not used after June 1940, and the tracks and other scrap iron were requisitioned by the War Department in 1942. Removal was accomplished in 1943. Bridge timbers were removed by U.S. Borax in 1946 and re-used in the Kramer borax operations (Art Rader 1980:p.c.). Myrick (1963:593) indicates that other bridge timbers were reused in various construction projects in the Mojave, notably in Apple Valley Inn, the El Rancho Motel in Barstow, and smaller private projects. Flash floods have also greatly affected the old roadbed in the Canyon. The roadbed was constructed by means of making long fills and large cuts, with three major trestles up to 500' long, necessitated by the need to cross and recross the river at several points. Shorter trestles were constructed at the mouths of small side canyons which offered dangerous flood potential (Appendix 2, Warren 44-47).

The roadbed for the Acme spur was abandoned earlier than the mainline bed. In the 52 years since the Acme roadbed was dismantled and the ties and tracks taken up, floods have taken their toll. However, the main natural factor affecting the condition of the railroad bed in Willow Creek canyon is the growth of the native mesquite thicket (Appendix 2, Warren 48-50). At many places the roadbed is completely obscured by these thorny shrubs, and traffic that cannot be accommodated along portions of the old roadbed is forced to detour alongside it for varying distances. It appears that most of the water produced in Willow Creek drainage is used by the extensive thickets of mesquite, rushes and other plants; there is no live stream at the lower end of the Canyon.

Human activity has also had extensive impact on the old T&T facilities (Appendix 2, Warren 51,52). Most important, of course, was the dismantling of the railroad in 1943. Major wooden structures were demolished later, some by the U.S. Borax Company and some by unknown parties. The small trestles were left intact. Since then, in a span of 35 years, all major trestles have been demolished, and the smaller ones as well. There is only one trestle remaining intact in the Canyon, about one mile south of Acme. The Willow Creek bridge or trestle is gone. The burning and other forms of destruction that have caused all the small trestles to disappear has encouraged off-road vehicle traffic to turn aside and continue parallel to the roadbed until they reach another intact stretch. There has been speculation by some of the people at China Ranch that the trestles were destroyed by local residents to discourage motorized vehicles from coming up the canyon from Dumont Dunes. If in fact that was the intention, this "solution" to one problem has spawned new ones for managers of the canyon lands.

Unauthorized motor vehicle traffic through the canyon has diminished since the installation of the gates and fences in the mid 1970s. However, it is not clear just which people are being kept out. When this researcher visited the Willow Creek-Amargosa

Canyon system in late 1979, our vehicle was parked at China Ranch up Willow Creek and we walked to the main canyon. During the several hours we were down in the canyon, however, we were constantly bombarded with the whining sound of dirt bikes traveling up the canyon, but not coming into view by the time we left. Local people, and apparently many others as well, use unfenced, ungated side canyons to gain entry to the main channel and to Willow Creek Canyon. Numerous ORV tracks traverse the landscape, entering and leaving the canyon at frequent spots. Vehicle tracks lead up Willow Creek Canyon from the Amargosa all the way to the China Ranch gate (Appendix 2, Warren 53-56). One local citizen explained where to find a side canyon leading into the Amargosa, and then confessed that she used it "only on weekdays"--evidently convinced that somehow weekday use is less damaging than weekend use, perhaps because she did not wish to set a bad example for weekend visitors to the Dumont Dunes.

The ORV use is very damaging to the Amargosa Canyon/Willow Creek systems. The soils in parts of these canyons are very soft and filled with bentonite. The crust is extremely fragile, and once broken through, quick, severe erosion results. The softness of the material also produces extremely deep initial ruts when vehicles run over the surface. The combination of natural and man-caused factors is devastating to this region's resources and integrity.

Rasor Ranch

Rasor Ranch was a watering stop on the T&T between Ludlow and Soda Springs. Art Rader has kindly provided documentation of the deterioration of this site over a span of twelve years, 1968-80. Rader reports that in 1968, the site was intact. Surviving were the depot, station agent's home, water tower, section gang house, wooden building covering a cistern, and a pump house over the well. In 1974, the station agent's house and depot were burned down. Since that time, every structure has been either burned or demolished, until nothing remains today (Rader 1980:p.c. and response to Inquiry Form). Rader attributes the rapid destruction of this site, which had remained intact from 1940-68, but was destroyed in an eight year span (1968-76), to the construction of a road paralleling the Union Pacific tracks which provided access for the first time to this remote, sandy stretch of the Mojave. Even though ORVs were available prior to that time, the destruction of Rasor did not occur until the opening up of the area by the new Union Pacific Railroad (UPRR) road.

TRAILS, WAGON ROADS AND RELATED STRUCTURES

Relay station

In Willow Creek Canyon, between Amargosa Canyon and the China Ranch, is an interesting historic structure in whose lintel is carved the date, 1903. The building is well constructed of tuff blocks, mortared with adobe. Door and window openings apparently were once framed in wood. McKinney (1971) speculated that this building was associated with the construction of the Acme T&T spur. However, the T&T did not construct the spur until 1915, and the building apparently dates from 1903, the early period of talc and borax mining and the time of intensive exploration of the nitrate beds in the vicinity (Noble et al. 1922). Deke Lowe, a resident of the area for over fifty years, believes the building was constructed for the miners working talc deposits across from Acme siding in the main Amargosa channel. He remembers this building was occupied as late as the early 1950s (Lowe 1980:p.c.).

McKinney speculates that the building was a relay station or saloon. Examination of the site underscores the possibility of such use, based on its location and lack of any features characteristic of family dwellings, such as a kitchen. There is a small store room dug into the side of the canyon wall behind the building. It is braced with small tree limbs, but has a framed doorway and wooden door. Shelves line the walls. The door is now riddled with bullet holes, some of them quite recent. A second room or other structure, now demolished, at one time was attached to the south end of the building. The roof of the main structure is intact although in bad shape. It is made of trimmed branches and mud. The doorway into the now-vanished second room appears to be very crudely constructed, perhaps made by the simple expedient of removing some of the tuff bricks. There is a ditch extending from behind the cabin for perhaps one-fourth mile up the canyon in the direction of China Ranch. This may have supplied water to the building, which otherwise lacks any provision for water.

The building and the store room are badly vandalized. In the building there are remains of poles placed in the walls to support springs in a crude bunk arrangement, and there are still some wires extending across the ceiling which apparently were used to support curtains. Many bed springs are still found in the structure, but the bunk poles have been sawn or broken off and are gone. There is no door on the back doorway, although there is a front door (which cannot close). There are fragments of window frames, but no windows. They are very large and extend completely to the roof line. The doorways, however, have lintels. Lowe does not remember if the cabin had glass in the windows (Lowe 1980:p.c.).

The window sills, many bricks and the door lintel have been scarred by initials, names and dates. A recent visit, by "The Bushwhackers," apparently took place between Thanksgiving and Christmas, 1979. The Bushwhackers memorialized their trip by scratching their name and the year in the lintel above the front door. Brian Brown, one of the residents on the China Ranch, informed us that this vandalism was committed after Thanksgiving, the last time he had personally visited the site (Brown 1980:p.c.). The damage is recorded in photos 57-74 (Appendix 2, Warren).

Mohave Trail/Old Government Road

The portions of this trail and later wagon road that were observed are found in the vicinity of Fort Pah-Ute. Close to the Fort ruins, the old trail is being obscured by indiscriminate use of motor vehicles and campers. This trail occupied part of the stream channel in the section between the Fort and Rock Springs to the west. The stream channel portion is subject to periodic flash floods and is not discernible from the rest of the stream bed. However, where the trail leaves the channel, the route is plainly seen. Deep ruts have been worn into the rocky outcroppings to the west, and the trail can be followed easily to Rock Springs (Appendix 2, Warren 75-77). Eastward toward Fort Mojave, the trail is visible across the desert. Nearer the Fort, it is difficult to distinguish just which of several roads is the original one. An old road parallels the one now used; it is in poor condition due to washouts, evidence of the effect of flash flooding and heavy rains on these crude tracks. The road currently used is very rough and passes across several stream channels between the paved road and the Fort site, a distance of about 6 miles.

Other portions of the Government Road are badly washed out. Casebier reports that Marl Springs is probably no more isolated than Fort Pah-Ute, but it receives less visitation. The road into the site is also worse than the Fort road, with very deep channels not cut by flash floods.

Old Spanish Trail, North Branch

Portions of this trail were visited in conjunction with the investigations in Amargosa Canyon and at Salt Springs. In both places, the old trail has been obliterated by both natural and man-caused forces. Erosion from sheet and stream floods has taken its toll. However, even where these impacts are less, the old roadbed is nonetheless obscured by modern vehicular traffic. In the instances examined, the roadway passes through the only possible route of travel. Consequently, all traffic passes over the same ground as the original trail.

Automobile Roads

The only old automobile road visited during the field excursions is a short portion of the old U.S. 91, paralleling modern I-15 between Stateline, Nevada and Yates Well. The old roadbed is discernible, in fact can be used easily although it is now silted over. At some places, washouts are occurring as the road is no longer maintained. There is no discernible human activity that has had negative impact on the roadbed.

MANAGEMENT RECOMMENDATIONS

On the Draft Preview of the California Desert Conservation Area Plan and Environmental Statement, several of the cultural resources discussed in this report are identified as Areas of Critical Environmental Concern (ACEC). These include Salt Springs, Amargosa Canyon, Fort Pah-Ute, Clark Mountain (Ivanpah), and Fort Soda (Zzyzx). According to the Draft Preview, specific management programs will be forthcoming for these areas. The nature of those management programs is of primary concern.

Fort Soda ACEC

First, this ACEC should be identified as Zzyzx, with its unique value as a health resort especially recognized. Although it is commonly called Fort Soda now, it was known as Hancock's Redoubt in the 1860s. While its origins as a military fort or base are important, it is the later developments that are the unique ones, and since the site has participated in a very special way in recent forces that affected the Mojave Desert, these special attributes should be emphasized. Zzyzx should be placed on the National Register of Historic Places and every attention be paid to fulfilling the intent of that status.

Additionally, Zzyzx would function well as the western portal of a trail using the Old Government Road for hiking, biking and horseback riding. More comments will be found below, Fort Pah-Ute section, in this regard.

Amargosa Canyon ACEC

The Amargosa Canyon has been given protection since 1977 as a scenic and wildlife preserve. Nonetheless, there is penetration virtually at will by people driving pickup trucks, dune buggies, dirt bikes, and even ordinary sedans. Passive management in the form of gates, fences and warning signs is not protecting the area's scenic and cultural resources. Noise intrudes from the Dumont Dunes. Stronger management policies and tactics must be adopted to ensure that the quality of these resources is not further diminished. In drawing up the management plans for this, the failure of signing and fencing should be acknowledged and more active management instituted in addition to these measures. There should be effective patrolling by rangers/interpreters in order to control the future of these resources.

Salt Springs

Salt Springs should be given protection and interpretive signing. This attractive camp site will continue to lure visitors, particularly with the heavy use of the Dumont Dunes area. Archaeological values should be intensively investigated, historical structures documented and protected. This ACEC, perhaps, should have a campground developed, primitive if necessary, but some control of the indiscriminate camping at the site must be established. Ranger patrol would be definitely needed.

Clark Mountain

It is presumed that this designated ACEC includes Ivanpah. Ivanpah is a very valuable historic site. It is best left in obscurity until, and unless, active protection is given to it by the presence of a resident ranger and positive interpretive programs. At all costs it's location should not be revealed to the public, unless these protective measures are taken.

Tonopah & Tidewater Railroad

The only attention paid to these remains in the Draft Preview is in conjunction with other resources, such as the stretch that would be part of the Amargosa Canyon ACEC. In many other places, however, the railroad beds could be managed for public use. The roadbed would have to be minimally maintained to make it usable after any floods, and patrolled periodically to insure that no damage has resulted from using the roadbeds. However, traffic on the roadbeds would curtail the overgrowing of the beds by native vegetation such as is occurring now at Willow Creek. Railroad grades are exceptionally suitable for bicycling, since they are built with gentle curves and gradual changes in elevation. Use of them would provide an unusual opportunity for the bicycling recreationist to tour the desert, pass through some of the most rugged terrain and sparsely settled areas, and at the same time maintain a comfortable pace. Use by horseback riders and hikers should also be encouraged. Motorized vehicles could be permitted in some sections of the old roadbed, and excluded from those where the noise intrusion is too great, as in enclosed canyons such as the Amargosa.

Automobile Roads

Early auto roads should be identified and,where possible, signed and interpreted. These roads have frequently been obscured by new road construction, but there are several stretches of the Arrowhead Trail between Searchlight, Nevada and Goffs, California that could be identified, and a short stretch of the old U.S. 91 through Ivanpah Valley that would be usable. Motorized vehicle traffic could be encouraged on these old roads, which would have to be patrolled occasionally to discover need for maintenance, provide public safety measures, and perhaps for interpretation in the field.

Fort Pah-Ute

This remarkable site needs to be actively managed if it is to be preserved from complete destruction. The old Fort should be stabilized, the recent intrusive pathways, signs and firepits should be removed. Appropriate signing should be installed in conjunction with a management plan that allows public use of the site. Appropriate activities to encourage would be hiking and horseback riding. Motorbikes and other motorized recreation should not be permitted, so that the natural environment, and particularly the sense of isolation and loneliness so much a part of this fort since its construction, are not compromised. These qualities have characterized Fort Pah-Ute since before the 1860s, and any management plan should address this central theme.

Mohave Trail/Government Road

Mohave Trail/Government Road plans could easily incorporate two important sites recognized at either end of the trail through the eastern Mojave: Fort Pah-Ute and Zzyzx (Fort Soda). The trail/road connecting these two sites lends itself well to developing a use system that operates the two sites as portals for the ends of a hiking and horseback riding trail. If personnel were stationed at each end of the portal, and groups and individuals using the trail were required to register at the portal, a high level of control over use of the trail could be attained. Abusers could be quickly identified, and trail safety relatively assured.

At Fort Pah-Ute, a staging area could be developed for the aforementioned activities. It is advisable to keep the staging area some distance away from the Fort and from the ranch too, if possible. The level of occupation and activity encouraged at the site should not be permitted to destroy the loneliness characteristic of the Fort and ranch. It would be most inappropriate to rebuild the Fort structures, for example, and re-create military activites of the past. The quality of both sites would be diminished by such interpretive programs.

Zzyzx (Fort Soda) on the other hand could well absorb a high activity level. It has had a high level of use in the recent past, unlike either Fort Pah-Ute or the Irwin Ranch. The station is not a military fort any longer, but rather a health resort. It would be highly appropriate for it now to enter a new phase of human activity at the site, related in some respects to the health of the participants, and certainly to their enjoyment of the starkly beautiful Mojave Desert.

At both sites, Zzyzx and Pah-Ute, resident rangers must be stationed. No amount of fencing and other passive protective measures can be as effective as the presence of a person charged with management of the site and trained in law enforcement. Without this commitment to preserve the heritage of the Mojave Desert, in a few more years the historic and prehistoric resources at these sites will be all gone.

SUMMARY

On balance, it is apparent that the greatest impact on the historic resources of the Mojave Desert has been from human activity. This activity should be distinguished by two different purposes: recycling and vandalism. Recycling has removed many of the valuable metal objects, some of the larger wooden structures, and mining equipment. However, the fundamental integrity of the site remained after the materials were removed. Wherever vandalism has occurred, the senseless destructive activities have often resulted in completely compromising the site itself, destroying the orientation of structures, disturbing buried deposits, and the like. The accelerated deterioration of the many sites investigated during the course of the three-day field trip illustrates the scope of the problem faced by the Bureau of Land Management in attempting to meet the demands for multiple use and wise management. Strong measures are urged to stop the rapid destruction of these non-renewable historic resources.

OTHER APPROACHES TO IMPACTS STUDIES

In discussing the effects of conservation archaeology's focus on sites under threat of imminent destruction, J. Jefferson Reid observed that this overemphasis "has had the effect of inhibiting archaeological research while leaving unscathed the agents truly destructive of cultural resource (sic) (Reid 1979:16)." In the California Desert it is clear that the damage to archaeological sites, prehistoric and historic, is a primary consequence of increased access to and use of the desert. Impacts resulting from open use of public lands are more diffuse and more difficult to attack than the site destruction that may result from construction of a dam or a highway. Present federal laws, policies and practices are designed to protect cultural resources from specific projects or actions. They do not speak effectively to the problems of public use of public lands. Nonetheless, it is the users of the desert who damage and destroy prehistoric and historic properties therein. For the most part, they are private citizens. Protection of the desert's cultural resources will only be achieved when land managers acknowledge these impacts and are enabled to deal with them effectively.

Reid argued that the archaeological profession had been slow to develop the capacity to identify, measure and project estimates of such impacts, and thus had found itself in a poor position to argue persuasively that they must be taken into account in an effective cultural resource management plan. Reid proposed a framework for the estimation of future vandalism in a specific area, and identified the following key variables:

1. Population densities such as the actual density of an area or its weekend-holiday density.

2. Degree of existing pot-hunting expressed as some frequency per unit time.

3. Number of sites in the area.

4. Site accessibility.

5. "Potting value" expressed as an arbitrary probability of visibility, "attractive" artifacts, ease of digging, etc. (Reid 1979:17).

Reid also suggested a complementary program to document and quantify indirect impacts as they occur. These studies would serve as a primary source for some of the values needed to project realistic estimates of damage that will occur from animals, vandals, ORVs and other sources when access to and use of an area increases. Reid speaks in terms of measuring indirect impacts of specific projects, but his recommendations for minimal requirements of such a study are necessary to any study of indirect impacts. He says,

> What seem to be minimally required is: (1) that surveys expand areal coverage to include a healthy

buffer zone between the area of project activity and the nether region beyond, (2) that surveys document a site's condition prior to the beginning of a project's modification activities, and (3) that monitoring of selected sites or a variable sample of sites continue at intervals throughout the period of a project's modification activities (Reid 1979:17).

Many such studies are apparently underway, but few have been reported. Leslie Wildesen, archaeologist for USDA Forest Service Northwest Region, Portland, is compiling a volume of reports dealing with a variety of impacts on cultural resources. Three studies reflecting diverse approaches to estimating and managing impacts to cultural resources on public land in the west are summarized below.

VANDALISM IN THE ROCKY MOUNTAIN WEST

Lance R. Williams prepared a report entitled Vandalism to Cultural Resources of the Rocky Mountain West (1978) for the USDA Forest Service Southwestern Region. While it differs from the California Desert Cultural Resources Impact Study in several respects, there are interesting points of comparisons.

The core area that Williams dealt with included nine states: Arizona, Colorado, Idaho, Montana, New Mexico, North Dakota, South Dakota, Utah and Wyoming. The information he gathered was opinion, collected from resource managers of land management agencies, primarily the Bureau of Land Management, the National Park Service and the Forest Service. Most of the people he contacted were not professionals in cultural resource fields. Williams' results, therefore, are the impressions that land managers expressed regarding the nature and causes of vandalism. He has no controlled data or field observations against which to check their impressions. In the Desert Impacts Study, we pointed out some differences between the results of the inventory field work and the opinions expressed on the Inquiry form. Williams might have found similar contrasts if he had comparable data, but that was not his objective. One of Williams' themes was the extent to which vandalism of cultural resources is an expression of, or related to, more general problems of vandalism on public lands.

Williams' respondents perceived a high level of vandalism, reporting that 50% or more of most types of sites were vandalized. Site types and the percent vandalized are summarized on Table 32.

Williams' questionnaire suggested 4 factors considered to result in vulnerability of cultural resources. His respondents ranked "Resource is well-known, people seek it out," first; "Resource has obviously been vandalized previously," second; "Resource located in area of concentrated visitor use," third; and "Resource is obviously deteriorating...weathering" a close fourth. Two other factors were written in frequently by respondents: "remote locations" and "value to persons or market value" (Williams 1978:49).

Table 32. Site Types with the Highest Proportion of Reported Vandalism, Rocky Mountain West (data from Williams 1978:31)

Site type	Percent vandalized
rock art	80%
rock shelters or caves	78%
stone or adobe-walled dwellings	77%
building ruins	75%
open camp sites or chipping stations	74%
ceremonial sites or structures	66%
log building	65%
battlefields	65%
all buildings	64%
mining structures	64%

It is interesting to compare these with criteria developed by Coombs, who worked in the northeast Mohave Desert, to classify sites according to their relative potential for destruction or vandalism. They are:

1. Accessibility: In the Northeast Mohave, at least, contemporary activity seems to be limited almost exclusively to existing roads and trails and their immediate environs. Comparatively inaccessible sites thus seem to be naturally protected, at least for the moment, and thus require less imposed protection. Mountain sites, in particular, tend to fall into this category.

2. Familiarity: Clearly, some sites or artifacts are more easily recognized by the general public than others (In the _____Springs area, for example, we met a middle-aged couple who were searching for "arrowheads". They told us that they had heard that this was a choice location. Not surprisingly, in this area we recorded a large number of crude bifaces and other tools, but very few projectile points; recognizable artifacts had been looted, unfamiliar ones remained intact). Since collecting and the looting of dump sites have become widespread "hobbies" and because vandalism continues to be a problem, familiarity is a crucial concern.

3. Value: The value of the artifact to the collector is also important. This is perhaps clearest in the case of historic sites. Dumps, for example, are selectively looted on the basis of value, either to the collector himself or in the collector's market. Clearly, sites containing familiar materials and ones which are of significant value should be afforded relatively greater protection.

4. Delicacy: Delicacy refers to the overall vulnerability of a site to destruction. Here, we are concerned with the ease with which the information contained in a site may be disrupted. This may involve intentional or unintentional human intrusions, as well as environmental disruptions. In general, the more complex or structured a site is, the more delicate it will be. Isolated artifacts, for example, represent the least delicate type of site, deep middens the most delicate (Coombs 1979:127).

Williams' respondents think that most vandals are local. Eighty-three percent of his responses indicated that vandals come from 100 miles or less. They also believed that personal acquisition of objects was more frequently the motivation than commercial sale, and that cultural resource vandals tend to be "repeaters" (Williams 1978:65-72).

Williams' respondents generally believed that vandalism to cultural resources is either remaining the same or increasing, and that greater visitation to the management area is the primary factor accounting for rising vandalism of cultural resources. Other frequently cited reasons were "greater access by the visitor to locations of cultural resources; greater knowledge of locations of resources by the visitor; and little law enforcement activity and prosecution (Williams 1978:79)."

A list of vandalism control techniques was provided by Williams' questionnaire, and he was able to rank the techniques by the frequency of their reported use, and by their perceived effectiveness (Table 33). It was clear to him, based on responses, that decisions regarding what techniques to apply to what kinds of situations were not based on knowledge of successful prior experience, but were primarily techniques selected from agency guidelines because they could be implemented despite low funding levels (Williams 1978:88-89).

When Williams asked what control techniques other than those already implemented might be effective, the most common response was education or interpretation, followed by increased ranger patrol and enforcement. As Williams notes, these choices are surprising, given the low relative effectiveness rating given to these techniques by managers who had tried them (Williams 1978:92-94).

Two of Williams' closing observations are particularly of note in that they identify characteristics of vandalism that are common to public lands in the west. He concludes:

> The incidence of vandalism is very much affected by the level of visitation to these management areas, which is on the increase in most areas, and by the fact that many visitors now have off-road vehicles which are capable of providing access to formerly isolated areas.
>
> Many vandals are people living in the vicinity who know the land and its resources. These people are generally adult males, who go out in groups, and, most of the time when doing so, have specific purposes in mind. Their transportation is largely by two-wheel and four-wheel drive vehicles. From repeated visits, they often know the habits of resource managers and visitors, and thus learn to avoid them while pursuing their vandalistic activities. Many other people who vandalize seem to have no intention of being destructive, but because of their ignorance, carelessness, and curiosity regarding cultural resources they become destructive without really being aware of it (Williams 1978:130).

Table 33. Vandalism Techniques Used in Rocky Mountain West, Ranked by Frequency of Use and Perceived Effectiveness (data from Williams 1978:80-84).

Technique	Rank by frequency of use	Rank by perceived effectiveness
ranger patrol as preventative	1	6.5
posting signs	2	9
interpretation or education conducted for visitors	3	5
erection of physical barriers	4	3.5
punitive action for apprehended vandals	5	8
closing off of roads or trails	6	2
removal of resource itself by staff or authorized personnel	7	1
working with local organizations	8	6.5
no disclosure of site locational information (written in frequently)	9	3.5

COLLECTING IN THE LOWER COLORADO PLANNING UNIT

The effects of surface collecting have been documented in the Lower Colorado Planning Unit of the Apache-Sitgreaves National Forests in Arizona (Plog 1978). Lightfoot and Francis showed that within lithic assemblages, sites in Chevelon drainage exhibit greater densities and greater tool/non-tool ratios than sites in the Little Colorado Planning Unit. Based on Fred Plog's observation that generally, Chevelon has suffered less from collecting than the Lower Colorado Planning Unit, they attribute the depletion of the lithic assemblages in the Lower Colorado Planning Unit to collecting. Within the Lower Colorado Planning Unit, they tested the hypothesis that the greatest amount of casual collection and excavation occurs on sites near the most heavily traveled roads. They found that the most severely looted sites were situated near unimproved jeep trails. They noted that in several instances, the apparent cause-effect relationship between access and illegal excavation was reversed, for some jeep trails had no other apparent purpose than to provide direct access to sites in remote portions of the planning unit (Lightfoot and Francis 1978).

Lightfoot tested for the effects of collection on surface ceramic assemblages in the Lower Colorado Planning Unit. He categorized sites as having suffered (1) no apparent impact; (2) minor impact such as grazing and/or minimal disturbance by pothunters; or (3) major impact such as on-site destruction, or major vandalism. He found the frequency of black-on-white sherds was significantly reduced at sites with both major and minor impact, although frequencies of corrugated sherds were not diminished. He also found that sites with minor impact had smaller sherds than either sites with no impact or sites with major impact. A secondary test showed that within the category of sites with minor impact, sites that had been grazed had a smaller mean sherd size than non-grazed sites, although the difference was not judged statistically significant (Lightfoot 1978).

Lightfoot also tested for the effect of accessibility as indicated by distance to roads, and visibility as indicated by vegetation density, on three characteristics of ceramic assemblages: percentages of black-on-white sherds; size of sherds; and sherd density. He found that ceramic density and size of sherds were significantly different within the following categories of distance: 0-0.25 mi; 0.26-0.50 mi, and 0.51-1.00 miles. He also found significant differences in percentages of black-on-white between sites with high and low vegetation densities. Lightfoot concludes that both accessibility and visibility account for much of the variation in ceramic assemblages, and that these two variables can be used to predict pothunting and collecting of a site. As a result, he recommends that archaeological surveys should cover a minimum of 0.25 miles (1350 ft) on either side of the proposed right-of-way.

LIVESTOCK AND LITHICS

John Roney of the Winnemucca District, Nevada Bureau of Land Management, reported an experiment which assessed the effects of trampling by cattle on a surficial lithic scatter. He placed 50 obsidian artifacts of his own manufacture and 10 obsidian nodules in a corral prior to its use in a roundup. Previous use several months earlier had destroyed most of the vegetation and softened the soil. Roney recorded the location and condition of the obsidian pieces. The corral was then used for 1311 bovine-hours, the equivalent of 12 years of grazing at a density on one cow per 20 acres.

Inspection of the surface after the cattle were moved revealed only one nodule, one artifact and one fragment remaining on the surface. Four weeks later, he divided the corral into grid units and excavated the disturbed soil which constituted the top 5 cm. He recovered 8 nodules and 48 artifacts. Forty-eight percent of the recovered artifacts showed damage, including 8 of them (17%) which had sustained major breakage.

Roney was only able to control partially for horizontal displacement. Sixteen pieces were recovered in place, and of them 13 had been dislocated by the cattle. Displacement of these pieces ranged from 0.1 m to 2.0 m, with a mean displacement of 0.75 m. He was able to demonstrate movement of 23% of the remaining pieces as well (Roney 1977).

MANAGEMENT GOALS, STRATEGIES AND TECHNIQUES

It remains to be seen whether the Bureau of Land Management will implement effective management strategies for the protection of cultural resources in their own right in the California Desert, or whether prehistoric and historic sites will receive protection only when they coincide locationally with natural scenic or ecological values. The goals of an effective management program should include:

1. positive protection of a representative sample of prehistoric and historic properties and their surroundings for future generations to investigate;

2. reduction of the rate of attrition of cultural resources caused by manageable impacts, specifically vandalism, development, ORVs, and some forms of animal damage;

3. a program of data recovery when a property's information value will be diminished either by primary or secondary impacts--in other words, a program which acknowledges that vandalism, ORV and animal damage are all more common than development on public lands in the desert (Table 15) and that vandalism and ORV damage are as destructive as development when they affect a site (Table 18);

4. a public information program to provide for learning at a variety of levels about desert prehistory and history for interested weekenders, high school and college field classes, and groups of avocational archaeologists.

PROTECTING GROUPS OF RELATED SITES

Over the years a variety of methods for the positive protection of cultural resources has been developed. Many of them are common sense in origin, and there is little information regarding their relative effectiveness. Within the diversity of sites and situations in the California Desert, each of them can be of use however. Groups of related sites are perhaps most important to protect for long-term research values.

The draft California Desert Plan (Bureau of Land Management 1980) proposes several forms of protection for groups of archaeological sites. Some sites or site clusters will be designated as Archaeological Areas of Critical Environmental Concern. Other prehistoric and historic areas, called Cultural Resource Areas (Prehistoric-Historic), will receive special management, but that management will be limited to restricting use to the lowest level of intensity allowable in the Multiple Use Class into which the locality falls (Bureau of Land Management 1980:52). Unless the area is in a zone designated for Limited Use, Class L, the Bureau of Land Management's protective and management options will be severely limited. It appears, then, that Archaeological ACECs may become the most explicit and adaptable management tool for the creation of archaeological preserves.

Archaeological Preserves

William D. Lipe has spelled out the importance of archaeological preserves for the future. As Lipe explains it, they will:

> become increasingly important arenas for problem-oriented or leisurely research,... if our efforts to slow the rate of site destruction elsewhere are not very successful. Furthermore, such areas may increasingly become the only areas where groups of sites can be studied as settlement systems, and in relation to something approaching their original context (1974:227).

Lipe suggests that the criteria for selection of localities for archaeological preserves should be based on the guiding principle of representativeness rather than significance. He points out that ideas of significance change with the evolution of archaeological research. I believe that he underestimates the core of lasting interest and curiosity that attracts the public and researchers to the material remains of man's past. He may also have been mistrustful of the ability of archaeologists and historians to take a sufficiently broad view of significance to assure the protection of diverse kinds of cultural properties. The past few years have shown that researchers are surprisingly resourceful in making arguments for the significance of many kinds of prehistoric and historic sites. Yet Lipe's point regarding representativeness should be an important consideration in the designation of a set of archaeological preserves.

The Archaeological ACECs designated on the draft California Desert Plan are small areas. Some of them are apparently single sites or points rather than areas. At least some of them, such as Fort Soda, have already sustained substantial damage. If ACECs are identified when a serious problem is demonstrated rather than as a protective strategy before an important and vulnerable locality begins to deteriorate, and if they are not sufficiently extensive to include networks of sites, they will not be suited for the kind of archaeological preserves that are needed in the California Desert.

Wilderness Areas

The severe restriction or banning of motorized travel in areas that Congress designates wilderness areas, if enforced, should convey some passive protection to archaeological sites that fall within them. Purposeful vandalism is more difficult without motorized transportation for equipment and finds. ORV damage should cease, and development will be proscribed. Mining, however, is permitted with controls under the 1964 Wilderness Act. This activity, which respondents to our inquiry listed as the form of development which most frequently affects sites in the desert, would continue to be a threat to sites in wilderness areas.

Several other drawbacks limit the capacity of wilderness areas to protect archaeological sites. Among them are over-zealous restoration of wilderness, the non-representativeness of cultural resources in areas selected for wilderness designation, and restrictions on transportation that prevent rangers from patrolling in vehicles. There have been sad instances where land managing agencies have attempted to erase the traces of man's use in areas declared wilderness. In so doing, they have destroyed historic properties. Cabins have been burned, mining structures pulled down and obliterated. Such destruction of historic values can be prevented by more sensitive management of wilderness areas. Non-representativeness, on the other hand, is inherent in the nature of wilderness areas. Since inaccessibility is one criterion in their selection, they tend to be created where there is little use, either past or present, and so include little of the record of people's use, whether historic or prehistoric. Wilderness areas will encompass only a skewed and disproportionately small sample of cultural resources.

The Wilderness Study Areas designated in the California Desert Final Wilderness Inventory (Bureau of Land Management 1979a) tend to coincide with mountain ranges. Scanning the use alternatives illustrated in the Draft Preview of the California Desert Conservation Area Plan and Environmental Statement (1979b), the "Balanced Alternative" and the "Use Alternative" show progressively restricted amounts of land in the controlled use category, which is how proposed wilderness areas are indicated. The tendency for these areas to coincide with mountain ranges becomes more marked and appear to approach 100% in the "Use Alternative," where the Saline Valley is the only non-mountainous terrain suggested for controlled use. The archaeological inventory of the California Desert shows that the occurrence of sites by frequency and site type varies substantially from one to another landform. Because wilderness areas will consist primarily of mountainous areas, they are not suitable as primary tools for the protection of archaeological and historic properties, either on the grounds of a prior significance of the resources within them or on the grounds of representativeness. On the other hand, they might provide one component of a management strategy in which other measures provide the protection for non-montane resources in proximity to mountainous wilderness areas.

Just what the other components of such a protection strategy might be is less than clear. When cultural resources which fall into zones of limited, moderate or intensive use, their fate may be mitigation of the impacts on them rather than protection or avoidance, according to the Conflict Resolution Criteria (Bureau of Land Management 1980:28).

In summary, the draft California Desert Plan falls short of providing positive protection for a substantial series of archaeological preserves. The Archaeological ACECs are too small and scanty, and in many of them, research values are already substantially diminished. Wilderness areas do not encompass representative sample of cultural resources. Other cultural resource areas remain at the mercy of the activities permitted in the zone in which they fall, or may be subjected to mitigation. The draft California Desert Plan does not venture an estimate of the costs of mitigation in the form of data recovery which might be called for if the Balanced Alternative or the Use Alternative are used to shape the final plan for the California Desert Conservation Area. These costs will be substantial if information recovery is to be a widespread prescription, perhaps beyond the Bureau's resources. We can only urge that protective measures such as the designation of Archaeological ACECs be more broadly applied.

REDUCING THE EFFECTS OF ORV DAMAGE

Damage to cultural resources by ORVs and animals is but an expression of the greater problems of managing the impacts by these agents on the desert, in the sense that the damage is not purposeful.

The forms of destruction that are grouped as vandalism, in comparison, are intentional, and require programs of protection specifically designed to protect prehistoric and historic properties from damage.

ORV Damage

The amount of ORV damage that will occur to sites in the desert is directly proportional to the amount of unrestricted use of ORVs that continues and spreads to new areas. If substantial amounts of land are placed in the limited use class, which restricts vehicles to designated roads and trails, and if these restrictions are successfully enforced, new damage should be limited. Even the moderate use classification, where motorized vehicles are restricted to existing roads and trails would confer considerable protection if the restriction were enforced, and if the network of existing roads and trails did not expand. Four-wheel and two-wheel drive vehicles can create a road or trail easily, one that later users will not be able to differentiate from a road or trail that existed before the limitations were imposed. There is reason to fear that the network of existing roads and trails will continue to expand in the desert in areas classed for moderate use. In moderate use areas, sites will then continue to suffer from ORV damage.

Placing extensive areas of the desert in the limited use class could protect sites from vandalism where ORVs are used for access. If the set of designated roads and ways were to leave substantial contiguous portions of the desert isolated from motorized travel, we would expect vandalism of cultural resources to diminish there, for accessibility is surely a major factor in the rate of vandalism.

Robert Badaracco, recreation planner for the California Desert Plan Program, Bureau of Land Management, has stated the situation very clearly.

> ...the California Desert is a very highly accessible, dispersed recreation environment. It is probably one of the most accessed recreational environments of so large a size anywhere in the world....our problem in the future will not be one of identifying further recreational access but in somehow limiting and making sense of what we have (Badaracco 1979).

According to a study undertaken at the University of California, Riverside, at least 95% of the California Desert is within 2.96 miles of a road, and 50% of it is within one mile of a road. Those figures are derived from conservative estimates of the extent of existing dirt roads in the desert (Badaracco 1979).

A substantial proportion of the remaining cultural resources in the desert must be considered unprotected from vandalism on the grounds of accessibility unless access by motorized vehicles is greatly reduced.

Control of Intentional Vandalism

Williams' report, Vandalism to Cultural Resources of the Rocky Mountain West (1978), provides a list of management techniques which are employed by resource managers to control vandalism. His list appears above as Table 33. There is as yet no good information on the actual effectiveness of any of these techniques. Williams' respondents rated "Removal of the resource itself..." as the most effective technique. That is a drastic measure, however, and it would be dangerous to let its evaluation as "most effective" stand without comment.

Few prehistoric or historic "resources" are in themselves portable, for resources are rarely objects. The resource is the information contained in a prehistoric or historic property, and removal of objects from their original surroundings generally destroys that information, and thus the resource. All that remains is the object--stone tools in a museum case or drawer, a petroglyph cemented into a base along a walk. The decision to relocate a resource is a very sensitive one. It must involve evaluation of the loss of information that will occur, and archaeological investigations must be part and parcel of any such removal.

Closing roads and trails was rated second in effectiveness. As a technique, closure should be appealing for the limited costs, its apparent effectiveness, and its protection of other desert values in the locality.

Non-disclosure of site locations is rated effective by managers, and that should be desert-wide policy. Hopefully the time is past when visitors can walk into a BLM office to inquire where there is a good place to collect arrowheads, but I know from personal experience that it is not long past. If active management of prehistoric and historic resources becomes a reality in the desert, visitors will have a variety of archaeological and historic sites available to them for non-destructive enjoyment and learning. Aspects of this kind of development are discussed under Consumptive Education Activities below.

PROTECTIVE STRATEGIES FOR PETROGLYPH/PICTOGRAPH SITES

Isaac C. Eastvold (1973) prepared a report for the BLM detailing the nature and extent of problems of vandalism to rock art sites in the California Desert. Eastvold recommends a two-pronged strategy for the preservation of these sites. As long as a site remains unknown and inaccessible, let well enough alone. As soon as it begins to be visited, Eastvold recommends erection of barriers and interpretive signs, in other words, a positive informational, educational program. He suggests that with proper development, rock art sites near major routes would attract steady-stream visitation that in itself protects rock art. He says that this has worked in other states, although he does not cite particular cases of its success.

Ritter reported (1977) that the Bureau of Land Management has tried a variety of protective techniques for rock art sites in the California Desert. He observes that the Bureau of Land Management has developed treatment on a site-by-site basis. Much of the emphasis has been on control of vehicular access. Other techniques employed sporadically include erection of judicious signs, patrol, and in one case electronic surveillance. Although the sites where protective measures were employed have not been regularily monitored, Ritter concludes, "between 1974 and 1978 there appears to have been a significant, although unquantified, decrease in rock art loss and vandalism (1977:8)."

The Grimes Point petroglyph site in western Nevada provides an encouraging example of the management of a rock art site incorporating several of the techniques discussed in Lance Williams' report, Vandalism to Cultural Resources of the Rocky Mountain West (1978). The Grimes Point site was in terrible condition. The area had been traditionally used as a trash dump and that use continued. In addition, petroglyphs had been painted and used as target for rifles, and some had been hauled away. The BLM cleaned up the site by removing the trash from the area and the paint from the petroglyphs. They erected barriers and signs, and constructed walkways. Renovation of the site was completed in August 1977. The site has not been regularily monitored or patrolled since. According to Brian Hatoff, District Archaeologist, Carson City, dumping and vandalism at the site have been substantially reduced, and the BLM signs now serve as target for the rifles (Hatoff 1980:p.c.).

The effectiveness of the cleaning and restoration work at Grimes Point suggests that these activities should be important components of the manager's array of techniques. Williams reports that his respondents believed that weathering and the evidence of prior vandalism encourage additional vandalism. Careful maintenance and prompt repair would seem to be effective responses, but these were not among the techniques that Williams listed for his respondents to rank by effectiveness (1978:51,81).

CONTROL OF CONSUMPTIVE EDUCATIONAL ACTIVITIES

Damage to desert archaeology by archaeologists is one of the most galling forms of attrition, even though it accounts for a minor proportion of the removal of archaeological materials from the desert. There are two common manifestations of consumptive archaeological activity related to education. One is poorly thought out, or undersupported, research activity involving collecting or excavation. The other is "field class" activities that involve removal of artifacts. Land managers should be aware that an archaeologist affiliated with a college or university has no more inherent right to collect or excavate on public lands than does anyone else, whether the objectives are for education, research or both. An archaeologist does have the training to collect or excavate in a responsible manner, and is thus qualified to apply for an Antiquities Act Permit, and to respond in a professional and responsible manner to the obligations that such a permit entails. Land managers should realize, at the risk of stereotyping, that many archaeologists are well-intentioned. When proposing a project they will promise to provide site sheets and reports in a timely fashion. Unless such requirements and deadlines are enforced, however, the records may never be received. Cases of this, in the California Desert as elsewhere, are unfortunately numerous.

An Antiquities Act Permit or its equivalent under the Archaeological Resources Protection Act of 1979 (PL 96-95) is required for any such activity on public lands. The permitting procedure includes reporting requirements. An institution or individual which has not completed past reports need not be issued a permit renewal. A permit can also be cancelled if reports are not submitted in a timely manner, or if their contents are inadequate.

Requests to undertake either collection or excavation for "field classes" will require a permit and should be treated no differently than those for research. The same obligations of reasonable research design and adequate reporting fall to the archaeologist-instructor, and the Bureau of Land Management should expect and enforce them. On the whole, however, one element of the protection of desert archaeology should be the development of non-consumptive educational activities that would become the destination of public school, college and university field trips and classes, as well as of museum groups and avocational societies.

The proximity of urban populations and the mild winter weather in the desert makes it well suited for the educational interests of the urban populations that live on its edges. The desert is readily accessible for one- to four-day field trips. If destinations and non-consumptive activities were developed to meet these interests, requests to collect and excavate would diminish substantially. Further, when such requests were received, they could be refused if they were not in the best interests of the desert's archaeology, and an alternative activity could be suggested. Among such activities and destinations might be:

1. archaeological areas where observation and recording without collecting would provide valuable experience and training. Historic sites and foundations are just as suitable for this as prehistoric surface and rock art sites are. Care must be exercised to direct this kind of activity to sites that are already well-known, for the activity itself could bring attention to sites whose survival depends on inaccessibility and low visibility, and would increase the likelihood of vandalism;

2. long term projects of monitoring of sites where field classes would record the content and condition of selected sites at regular intervals and compare them with previous records;

3. visiting and participation in recording and mitigation projects underway in the desert. It is reasonable to require a project to provide modest interpretive services while excavations for research are underway, if it is in an accessible locale. Interpretive services should be considered reasonable costs in evaluating proposals for mitigation projects in the desert. The integration of field classes and other interested adults into field operations requires increases in supervisory personnel, and should be encouraged as part of the BLM's and archaeology's responsibility to the public. It will not result in substantial economy of the cost of an excavation.

INFORMATION RECOVERY PROGRAM

A coordinated program of information recovery is needed in the desert now, and the need for it will not be eliminated by the implementation of a conservation plan for the California Desert. At best, such a plan will identify preserves to be protected, and will place a selection of additional locales under management at a variety of levels of effectiveness. If there is no BLM-sponsored program of information recovery in the remaining vulnerable but unprotected areas, a great portion of the prehistoric and historic record of the desert will be lost.

Initiation of data recovery projects can serve the needs of conservation of desert resouces in a variety of ways. Most such projects would be in accessible localities, and while underway, the field investigations could serve as destinations in themselves. If appropriately organized, they could absorb the labor and interest of educational groups in search of field trip activities in the desert. With the development of suitable storage, curation and display facilities, the information and objects recovered could form a portion of the public information network that should be a primary objective of management of desert cultural resources.

The program of data recovery should meet professional standards of research design, recording, reporting, and curation. Responsibility to the public, in terms of project visitation and, as often as is practicable, educational participation should be explicit elements of data recovery projects. Production of illustrated pamphlets, booklets and other informational materials should also be part of contractual requirements. In many cases, contractors should be required to provide the services of a writer as part of their proposed project.

This is not the place to spell out the details of such a data recovery program further. Such a program is an essential element in the responsible management of the cultural resources of the California Desert, however.

RECOMMENDED MONITORING PROGRAMS

We do not have the figures that permit us to project the rate of removal of surface artifacts as a function of visitor-hours in the desert, nor can we predict quantitatively how many cubic meters of midden will be screened by pothunters each weekend. As Reid said, "we know them to be real but we lack the ability to predict and measure them accurately (1979:16)." As a result of the California Desert Inventory, however, the results of unmanaged use and uncontrolled vandalism are not only evident, but are documented. Vandalism and ORV damage are on the increase as threats to sites (Table 4), and vandalism is regarded as the major threat to archaeological sites in the desert (Table 7). Thirty-six percent of inventoried sites in the desert are already damaged so extensively that their condition has been reduced to only fair to poor. Prehistoric villages and historic sites have suffered more. Less than 40 percent of the villages and historic sites recorded in the inventory are in good condition. I believe that the condition of sites in the California Desert is prima facie evidence of the impacts of ORV damage and vandalism. It is time for the BLM to initiate a management program for prehistoric and historic properties, a program explicitly designed to test and compare the effectiveness of alternate management techniques, in a variety of situations.

Perhaps some of the proposed Archaeological ACECs will be the first areas to be brought under active management to protect their cultural resources. Whatever the nature of the first actively managed areas, they should be the scene of experiments matching resource-types with appropriate management and protective strategies. The object of the experiments is to determine the effectiveness of various techniques at different sites and under differing circumstances.

The more accessible and visible a site is, the more active the strategies should be. On the other hand, availability of money and manpower will limit how often the more active strategies can be employed. There should be no difficulty, then, in identifying sets of equivalent sites in similar situations and with comparable levels of accessibility and visitation which are subjected to a variety of management techniques. The experiment must include the regular monitoring of these sites at intervals to determine their visitation rates and the modifications that occur to the resources there. Table 34 lists a matched set of site types and appropriate management techniques to be employed.

PATROLLING AND MONITORING "INACCESSIBLE" SITES

Sites in less accessible portions of the desert are thought to suffer less from the thoughtless vandalism that is a by-product of visitation or "discovery" by the casual desert recreationist. Difficulty of access is not an impediment to a serious collector, pothunter or commercial scavenger unless restrictions of motorized vehicles can be enforced. Inaccessibility provides privacy and

Table 34. Site types and Recommended Management Techniques for California Desert Cultural Resources Protection and Monitoring Program

Site type	Management techniques
Historic sites with standing structures or evident foundations	1. active interpretive program with ranger-interpreter present during periods of heavy visitation
	2. remove traces of vandalism, modern trash
	3. erect barriers to keep vehicles at a substantial distance, with signing for protection and information
	4. when 1 or 2 are not possible, close roads at a distance (½ mile minimum) plus no release of information as to location
	5. patrol, by air if access is closed off
	6. apprehend and prosecute vandals
prehistoric villages and historic sites without architecture	1. closure of access roads at some distance (½ mile minimum)
	2. no release of locational information
	3. remove signs of past vandalism
	4. patrol, by air if access is closed off
	5. apprehend and prosecute vandals

(continued)

Table 34. continued

Site type	Management techniques
caves and shelters	1. remove traces of past vandalism
	2. no release of locational information
	3. when visible from road, post signs (small enough so they are observable only in immediate environs of site) prohibiting disturbance
	4. patrol
	5. apprehend and prosecute vandals
rock art sites	1. develop steady-stream visitation when site is near heavily used areas
	2. erect barriers, informational signs and walkways
	3. provide ranger-interpreter
	4. remove signs of previous vandalism, and trash
	5. patrol frequently during periods of low use
	6. do not release locational information for undeveloped sites
lithic scatters and quarry sites	1. close roads at a distance, at least ½ mile away
	2. do not release locational information
	3. post signs
	4. patrol

concealment that is ideal for illicit activities. Whether or not the culprits are aware of the illegality of their activities, they do not desire to share their finds with uninvited strangers. They may return to the locality at intervals to remove more materials. In a short time, the effect can be more devastating than several years of casual collecting. So-called "inaccessible" sites should be included in initial management-monitoring plans.

Two objectives are suggested for inaccessible sites: first, monitoring a variety of them to determine the rate of attack on them, along with its seasonality (winter? summer? year-round?) and scheduling (during the week? weekends? holidays?); and second, apprehension and conviction of the offenders. The first objective will permit effective deployment of patrols. The second will show that the Bureau of Land Management means to enforce the laws which protect cultural resources on its lands.

Two observations from Williams' study Vandalism to Cultural Resources of the Rocky Mountain West (1978) are pertinent here. Williams' respondents believed that purposeful vandals tended to be from the local area, and to be repeaters. Those facts suggest a smaller target population for the apprehension of vandals and the possibility of some real effects from convictions. Local people are quick to recognize patterns of patrol, however, and will evade them, Williams notes.

Convictions for Antiquities Act violations have been difficult to obtain, and agencies have been reluctant to prosecute. Williams' respondents listed the vagueness of the wording of the Antiquities Act and the low risks and insufficient penalties among reasons for its non-enforcement. The Archaeological Resources Protection Act of 1979 (P.L. 96-95) is designed to supplement the 1906 Antiquities Act. It provides for criminal penalties for illegal excavation and removal, transportation and trading in artifacts taken from public lands. The 1979 Act should be enforceable, and more forceful.

The USDA Forest Service has reported a successful prosecution for pothunting in Utah. It was accomplished by staking out the scene of illicit excavations. The apprehended persons matched the ideas about cultural resource vandals of Williams' respondents in at least two respects. They were from the local area, and they repeatedly returned to the scene of their excavations. The conviction was obtained on a violation of Forest Service regulations [36CFR 291 (e)] (DeBloois 1979:16-19).

LITERATURE CITED

Amsden, Charles Avery
1937 The Lake Mohave artifacts. In The Archaeology of Pleistocene Lake Mohave, by Elizabeth Crozier Campbell, William H. Campbell, Ernst Antevs, Charles Avery Amsden, Joseph A. Barbieri and Francis D. Bode. Southwest Museum Papers No. 11.

Anstey, R. L.
1965 Physical characteristics of alluvial fans. Technical Report ES-20, U.S. Army Material Command, Natick, Massachusetts.

Anonymous
1869 Prospectus, Piute Company of California and Nevada. San Francisco, Edward Bosqui & Co., Printers.

Badaracco, Robert
1979 Summary report on the mileage of roads in the California Desert. Memorandum to Desert Plan Director, California Desert Planning Staff, Bureau of Land Management, Riverside.

Bard, Robert Charles
1973 Settlement pattern of the eastern Mojave Desert. Unpublished Ph.D. Dissertation, University of California, Los Angeles.

Bassett, A. M. and D. H. Kupfer
1964 A geologic reconnaissance in the southeastern Mohave Desert, California. California Division of Mines and Geology Special Report no. 83.

Beattie, George and Helen P. Beattie
1939 Heritage of the valley. San Pasqual Press, Pasadena.

Belden, L. Burr
1958 Salt Spring in Desert Site of 1849 Gold Find, San Bernardino Sun-Telegram, Dec. 7, 1958, p. B8, cols. 1-4.

1960 Lost Gold Mine in County was Dangerous Spot, San Bernardino Sun-Telegram, June 12, 1960.

Bryan, R. B.
1968 The development, use and efficiency of indices of soil erodibility. Geoderma (2:5-26).

Bull, W. B.
1974 Effects of Holocene climate on arid fluvial systems, Whipple Mountains, California. American Quaternary Association Biennial Conference Paper.

Bull, W. B. and A. P. Schick
1979 Impact of climatic change on an arid watershed: Nahal Yael, southern Israel. Quaternary Research, 11(2):153-171.

Bureau of Land Management
1975a 1974 Barstow-Las Vegas motorcycle race. Evaluation Report prepared March 1975. State Office, Sacramento.

1975b Yuha Intaglio destruction. Memorandum to State Director from District Manager, Riverside. July 14.

1979a California desert wilderness inventory, final. Desert Planning Staff, Riverside. March 31.

1979b Draft preview of the California Desert Conservation Area plan and environmental statement. Desert Planning Staff, Riverside. December.

1980 The California Desert Conservation Area plan alternatives and environmental impact statement: draft. Desert Planning Staff, Bureau of Land Management, Riverside.

Casebier, Dennis G.
1972 Carleton's Pah-Ute campaign. Dennis G. Casebier, pub., Norco, California.

1974a Notes Pertaining to Salt Springs. Unpublished ms., compilation of newspaper accounts on file, Bureau of Land Management, Desert Planning Staff, Riverside.

1974b Source Materials on Soda Springs. Unpublished compilation of newspaper articles on file at Bureau of Land Management, Desert Planning Staff, Riverside.

1974c Fort Pahute, California. Tales of the Mojave Road, no.4. Tales of the Mojave Road Publishing Company, Morco, California.

1975 The Mojave Road. Tales of the Mojave Road, no. 5. Tales of the Mojave Road Publishing Company, Norco, California.

1976 Historical sketch of the East Mojave Planning Unit. In Background to historic and prehistoric resources of the East Mojave Desert Region, by Chester King and Dennis G. Casebier. Desert Planning Staff, Bureau of Land Management, Riverside.

1979 Letter concerning Zzyzx Springs (Soda Springs). To Gerald Hillier, District Manager, BLM, Riverside, March 28, 1979.

Casebier, Dennis G.
1980a Personal Communication, telephone interview with Elizabeth Warren 1-26-80.

1980b Correspondence to Elizabeth Warren 1-26-80.

Cooke, R. U. and A. Warren
1973 Geomorphology in deserts. Batsford, London.

Coombs, Gary B.
1979a Introduction to the site record analysis. An analysis of California Desert cultural resource data, report 17. Desert Planning Staff, Bureau of Land Management, Riverside. Prepared by Institute for American Research, Goleta.

1979b Written communication to D. L. Weide.

1979c The archaeology of the northeast Mohave Desert. Desert Planning Staff, Bureau of Land Management, Riverside. Prepared by Archaeological Research Inc., Santa Barbara.

Davis, E. L. (editor)
1978 The Ancient Californians: Rancholabrean hunters of the Mojave lakes country. Natural History Museum of Los Angeles County.

Davis, Emma Lou and Sylvia Winslow
1965 Giant ground figures of the prehistoric deserts. Proceedings of the American Philosophical Society 109(1):8-21.

DeBloois, Evan
1979 Another successful prosecution of pothunting activity. American Society for Conservation Archaeology Newsletter 5(6):16-19.

Dellenbaugh, Fredrick Samuel
1875-76 Record of a sketching tour to N. Arizona and S. Utah, 1875-1876. Unpublished journal, ms. on file, Arizona Historical Society Library, Tucson.

Eastvold, Isaac C.
1973 Petroglyph site descriptions, protective strategies. USGS coordinated. Prepared for BLM.

1979 A lost heritage. New West, January 29, 1979, p. 53.

Euler, R. L.
1977 Notes and memoranda to the Office of Resource Management, Grand Canyon National Park.

Fors, J. R.
1977 Tropical cyclone Kathleen. NOAA Technical Memorandum NWS WR-114 Washington D.C., National Oceanic and Atmospheric Administration.

Gallegos, Dennis, (editor)
1979 Cultural resources inventory of the central Mojave and Colorado Desert regions. Desert Planning Staff, Bureau of Land Management, Riverside. Prepared by WESTEC Inc., San Diego.

Geological Society of America
1977 Impacts and management of off-road vehicles. Special Report of the Committee on Environment and Public Policy.

Gillette, D. A., John Adams, Albert Endo and Dudley Smith
1979 Threshold friction velocities on typical Mojave Desert soils, undisturbed and disturbed by off-road vehicles. In Proceedings of the 1979 powder and bulk solids conference, Philadelphia.

Glancy, P. A. and L. Harmsen
1975 A hydrologic assessment of the September 14, 1974 flood in Eldorado Canyon, Nevada, U.S. Geological Survey Professional Paper 930.

Hafen, LeRoy and Ann Hafen
1954 The Old Spanish Trail. Far West and Rockies Series, Vol. 1, Arthur H. Clark Company, Glendale, CA.

Hatoff, Brian
1980 Telephone interview with M. Lyneis, 2-14-80.

Heap, Gwin Harris
1957 Central route to the Pacific. Far West and Rockies Series, Vol. 4. Arthur H. Clark Company, Glendale, CA.

Heizer, Robert F.
1965 Site surveys in California or a California site survey. Archaeological Newsletter no. 9. Archaeological Survey, Department of Anthropology, University of California, Los Angeles.

Heizer, Robert F. and John A. Graham
1967 A guide to field methods in archaeology. National Press, Palo Alto.

Hill, James N. and James T. Toney
1967 Activities of the Archaeological Survey, Los Angeles - 1967. Archaeological Survey Annual Report 1967. Department of Anthropology, University of California, Los Angeles, pp. i-xii.

Hillier, Gerald E.
1979 Correspondence to Dennis G. Casebier, 6-28-79.

Hinds, James
1980 Telephone interview with Elizabeth Warren, 1-26-80.

Hooke, R. L.
1967 Processes on arid-region alluvial fans, The Journal of Geology 75(4):438-460.

Hunt, C. B. and D. R. Mabey
1966 Stratigraphy and structure, Death Valley, California, U.S. Geological Survey Professional Paper 494-A.

Iverson, R. W. and B. S. Hinckley
1979 Accelerated pluvial erosion on desert hillslopes modified by vehicular traffic, (abs.) Geological Society of America Annual Meeting, San Diego, California.

Jaeger, Edmund C.
1958 Life on an ancient Mojave playa. Desert Magazine 21(2):24-26.

Kendeigh, S. Charles
1961 Animal ecology. Prentice-Hall.

King, Tom
1967 Report of the interim site survey planning committee. Newsletter for the Society for California Archaeology 1(5).

Lathrop, D. T.
1978 Plant response parameters to recreational vehicles in the California Desert Conservation Area. Desert Planning Staff, Bureau of Land Management, Riverside.

Lightfoot, Kent
1978 The Impact of casual collection on archaeological interpretation through regional surface collection. In An analytical approach to cultural resource management, edited by Fred Plog. Arizona State University Anthropological Papers no. 13, USDA Forest Service Cultural Resource Report no. 19, pp. 92-114.

Lightfoot, Kent and Julie E. Francis
1978 The effect of causal surface collecting on behavioral interpretations of archaeological data. In An analytical approach to cultural resource management, edited by Fred Plog. Arizona State University Anthropological Research Papers no. 13; USDA Forest Service Cultural Resources Report no. 19; pp. 83-91.

Lipe, William D.
1974 A conservation model for American archaeology. The Kiva 39:213-243.

Lowe, Deke
1980 Telephone interview with Elizabeth Warren, 2-4-80.

Lusby, G. C.
1977 Determination of runoff and sediment yield by rainfall simulation. In Erosion: research techniques, erodibility and sediment delivery, edited by T. J. Toy. Geobooks, Norwich, England.

McInnis, Helen
1969 Monorail to oblivion. Desert Magazine 32(11):8-9,35.

McKinney, Aileen
1971 A report on the China Ranch. Pacific Coast Archaeological Society Quarterly 7(2):1-48.

Meighan, Clement W.
1959 Activities of the archaeological survey, Los Angeles: 1958-59. Archaeological Survey Annual Report 1958-1959. Department of Anthropology and Sociology, University of California, Los Angeles, pp. i-viii.

Mendenhall, W. C.
1909 Some desert watering places in southeastern California and southwestern Nevada. Government Printing Office, Washington D.C.

Monkhouse, F. J. and H. R. Wilkenson
1971 Maps and diagrams. Methuen & Co., London.

Myrick, David F.
1963 Railroads of Nevada and eastern California, volume 2: The Southern Roads. Howell-North Books, Berkeley.

Nakata, J. L., Wilshire, H. G. and G. G. Barnes
1976 Origin of Mojave Desert dust plumes photographed from space, Geology 4(11):644-648.

Neal, Howard
1974 The mines of Rand. Desert Magazine 37(6):12-15, 34-35.

Noble, L. F., G. R. Mansfield, and others.
1922 Nitrate deposits in the Amargosa region, southeastern California. U.S. Geological Survey Bulletin 724.

Norris, Frank and Richard L. Carrico
1978 A history of land use in the California Desert Conservation Area. Bureau of Land Management, Desert Planning Staff, Riverside.

Paher, Stanley
1973 Death Valley ghost towns. Nevada Publications, Las Vegas.

Parker, R. B.
1963 Recent volcanism at Amboy Crater, San Bernardino Co., California. California Division of Mines and Geology Special Report No. 76.

Plog, Fred (editor)
1978 An analytical approach to cultural resource management: the Little Colorado Planning Unit. Arizona State University Anthropological Research Papers no. 13. Tempe.

Rader, Arthur
1979 Response to Desert Impacts Inquiry.

Rader, Arthur
1980 Telephone interview with Elizabeth Warren, 2-5-80.

Randerson, D.
1976a Meteorological analysis for the Las Vegas, Nevada, flood of 3 July, 1975, Monthly Weather Review 104(6):719-727.

1976b Summertime radar echo distribution of moist convection over southern Nevada and adjacent areas for 1971 and 1972. NOAA Technical Memorandum ERL ARL-58, Washington D.C., National Oceanic and Atmospheric Administration.

1979 Personal communication to D. L. Weide.

Rector, Carol H., James D. Swenson and Philip J. Wilke
1979 Archaeological Studies at Oro Grande, Mojave Desert, California. Victor Valley Wastewater Reclamation Authority, Victorville. Prepared by Archaeological Research Unit, University of California, Riverside.

Reid, J. Jefferson
1979 To soothe the salvage beast. 1978 Proceedings. The American Society for Conservation Archaeology Newsletter, vol. 5.

Ritter, Eric W.
1977 Management of rock art in the California Desert. American Indian Rock Art IV:1-8, edited by Ernest Snyder, A.J. Bock and Frank Bock. American Rock Art Research Association.

Robarchek, Carole
1972 A survey of archaeological resources in the Saline-Eureka Valley area. Ms. on file, Bureau of Land Management, Riverside.

Roney, John
1977 Livestock and lithics. Preliminary draft. Bureau of Land Management, Winnemucca.

Rousseau, Mrs. J. A.
1958 Rousseau Diary, across the desert to California from Salt Lake City to San Bernardino in 1864. San Bernardino County Museum Quarterly 6(2).

Rogers, Malcolm J.
1939 Early lithic industries of the lower basin of the Colorado River and adjacent desert areas. San Diego Museum Papers 3.

Schumm, S. A.
1956 Evolution of drainage systems and slopes in badlands at Perth Amboy, New Jersey, Geological Society of America Bulletin 67(3):597-646.

1973 Geomorphic thresholds and the complex response of drainage systems. In Fluvial geomorphology, edited by Marie Morisawa. Publication in Geomorphology, State University of New York, Binghamton.

1977 The fluvial system, John Wiley and Sons.

Schumm, S. A. and R. A. Lichty
1965 Time, space and causality in geomorphology, American Journal of Science 263:110-119.

Sheridan, David
1978 Dirt motorbikes and dune buggies threaten deserts. Smithsonian Magazine 9(6):66-74.

Thompson, David G.
1921 Routes to some desert watering places in the Mohave Desert region. U.S. Geological Survey Water Supply Paper 490-B.

Toy, T. J. (editor)
1977 Erosion: research techniques, erodibility and sediment delivery. Geobooks, Norwich, England.

U.S. Department of Interior
1970 Surface water supply of the United States, Part 10, Great Basin. U.S. Geological Survey Water Supply Paper 1927.

1974 Surface water supply of the United States, Part 10, Great Basin. U.S. Geological Survey Water Supply Paper 2127.

U.S. National Park Service
1979 Proposed feral burro management and ecosystem restoration plan and draft environmental statement, Grand Canyon National Park, U.S.D.I. National Park Service.

Van Devender, T. R. and W. G. Spaulding
1979 Development of vegetation and climate in the southwestern United States, Science 204:701-710.

Warren, Elizabeth von Till and Ralph Roske
1978 Cultural resources of the California Desert 1776-1880: historic roads and trails. Desert Planning Staff, Bureau of Land Management, Riverside. Prepared by Department of History, University of Nevada, Las Vegas.

Weaver, R. L.
1962 Meterology of hydrologically critical storms in California Hydrometerological Report no. 37, Environmental Science Services Administration, U.S. Department of Commerce, Weather Bureau, 196-203.

Weaver, R. S.
1972 Status of feral burros in California, report to State of California, Department of Fish and Game, Wildlife Management Branch.

Weide, Margaret L. and James P. Barker
1974 Background to the prehistory of the Yuha Desert region. USDI Bureau of Land Management, Desert Planning Program, Riverside. Also published as Ballena Press Anthropological Papers no. 5, edited by Philip J. Wilke (1976).

Wheeler, First Lt. George M.
1889 Report upon U.S. geographical surveys, west of the hundredth meridian, in charge of First Lt. George M. Wheeler, ...under the direction of the Chief of Engineers, U.S. Army, Vol. 1. Government Printing Office, Washington.

Williams, Lance R.
1978 Vandalism to cultural resources of the Rocky Mountain west. Cultural Resources Report no. 21. USDA Forest Service, Southwestern Region, Albuquerque.

Wilshire, H. G. and J. K. Nakata
1976 Off-road vehicle effects on California's Mojave Desert, California Geology 29(6):123-132.

Wilson, William H.
1979 Response to Desert Impacts Inquiry.

Wischmeier, W. H.
1975 Estimating the soil loss equation's cover and management factor for undisturbed areas. In Present and prospective technology for predicting sediment yields and sources. U.S. Agricultural Resource Service, Publication ARS-S-40 (118-124).

APPENDIX 1.

LIST OF PERSONS AND ORGANIZATIONS CONTACTED

INDIVIDUALS

John Adams
Raymond Alf
J. A. Alsoszatai-Petheo
E.N. Anderson, Jr.
A. Apostoledes
Dick Bailey
Tilly Barling
Robert S. Begole
James Benton
Robert Bettinger
Walt Bickel
Sylvia M. Broadbent
Richard Brooks
Clark W. Brott
Mary A. Brown
Ralph Cameron
Dennis G. Casebier
Helen Clough Castillo
Paul G. Chace
Wes Chambers
T. Clements
Bob Crabtree
M. Suzanne Crowley
Emma Lou Davis
Mary Dedecker
Jeff Dickman
C.B. Donnan
Chris Drover
Isaac C. Eastvold
Dan Eddy
Gail Egolff
Al Endo
Rollin O. and Grace Enfield
Alan P. Garfinkel
Jane R. S. Gothold
Andy Green
Roberta S. Greenwood
Arda Haenszel
Matt Hall
Herrick Hanks
Vance Haynes
Ronald A. Henry
Charles B. Hunt
E. Henry James
Hyrum Johnson
Francis Johnston
Russell L. Kaldenberg
John Kelly
Roger Edward Kelly
Lyle Kenny
Joanne H. Kerbavaz
Thomas F. King
Tom J. King, Jr.
Charles L. Kniffen
Michael W. Kuhn
Charles A. Lamb
R. E. Lane
N. Nelson Leonard, III
Joanne MacGregor-Hanifan
Ronald V. May
Maggie McShane
Daniel F. McCarthy
B.E. McCown
Michael J. McIntyre
Clement W. Meighan
Herb Minshall
Eric Montizambert
Jan B. Moore
Ruth A. Musser
Carolyn J. Panlaqui
Willy Pink
Garth Portillo
Art Rader
Carol Rector
Francis Riddell
Harry Riddell
Nancy B. Ridgeway
Eric Ritter
Gregg Robbinson
Roger Robinson
Stan Rolf
Charles E. Rozaire
Matt Ryan
Robert A. Schiffman
Roy J. Shlemon
Tina Silvey
Ruth DeEtte Simpson
G. I. Smith

Bernice Sorrells
Mary Frances Strong
Mark Sutton
Janet E. Townsend
D. L. True
Tom Venner
Larry Vredenburgh
Delcie Vuncannon
William J. Wallace
Nancy Peterson Walter
Claude N. Warren
Richard Weaver
Henry G. Welcome
Jay von Werlhof
David R. M. White
Philip J. Wilke
Howard Wilshire
William H. Wilson
Sylvia Winslow

ORGANIZATIONS

Archaeological Survey Association of Southern California
Archaeological Research Inc.: Gary Coombs
Arizona Historical Foundation: Bert M. Fireman
Arizona Historical Society: Sidney B. Brinckerhoff
California Historical Society: J. S. Holliday
Colorado River Indian Tribes Museum and Library
Eastern California Museum: Charles N. Irwin
History Preservation Section, California State Department of Parks and Recreation: William Siedel
Imperial Valley College Museum: Morlin Childers
Little Lake Hotel: Proprietor
Los Angeles Corral of Westerners
Kern-Antelope Historical Society: Frank Ruff
Mohave County Historical Society: Karin Goudy
Mohave Historical Society: Lillian B. King
Mohave-Sierra Archaeological Society: Maturango Museum: Eric Montizambert
Mojave River Valley Museum: Germain Moon
Nevada Historical Society: John M. Townley
Nevada State Museum: Donald Tuohy
Pacific Coast Archaeological Society
Palm Springs Desert Museum: Deep Springs Research Center
Riverside County Historical Commission: John R. Brumgardt
Riverside Municipal Museum: Charles A. Hice/Chris L. Moser
San Bernardino County Museum: Gerald Smith
San Bernardino County Museum: Robert Reynolds
San Diego County Archaeological Society
San Diego Historical Society: James E. Moss
San Diego Museum of Man
Save Our Heritage Organization: Marc Tarosude
Westec Services, Inc.: Dennis Gallegos
Western Archaeological Center
The Westerners: San Diego Corral
Yuma County Historical Society: Peter J. Urban, Jr.

APPENDIX 2.

HISTORIC SITES PHOTOGRAPHS
(Filed with Desert District, Bureau of Land Management)

CASEBIER PHOTOGRAPHS

Photo No.	Subject
1.	Marl Springs, November 1966.
2.	Marl Springs, November 1979.

WILLIAM H. WILSON PHOTOGRAPHS

Photo No.	Subject
1.	Fort Pah-Ute, 1972.
2.	Monument at Fort Pah-Ute, 1972. Fort ruins in background, walkway lined with stones leading from parking area near Piute Creek to fort.

ELIZABETH WARREN PHOTOGRAPHS

Photo No.	Subject
1.	Fort Pah-Ute, looking east from Fort site toward Fort Mojave on Colorado River, 1979.
2.	View of Fort Pah-Ute from west, showing Fort location on high bank of old wash, 1979.
3.	Corrals at Fort Pah-Ute, viewed across wash, from Fort, 1979
4.	Corrals viewed from west, showing location relative to wash and to Piute Creek, 1979.
5.	Fort Pah-Ute, standing walls, 1979.
6.	View of Fort Pah-Ute from monument, 1979.
7.	Sign on monument identifying Fort Pah-Ute, 1979.
8.	Wooden sign identifying Fort Pah-Ute, 1979.
9.	Exterior of north wall, Fort Pah-Ute, 1979.

Warren photographs' continued

10. Interior of north wall, Fort Pah-Ute, 1979

11. North and west walls, Fort Pah-Ute interior, 1979.

12. Pot Hole, Fort Pah-Ute, north wall exterior, 1979.

13. Mohave Road and Piute Creek vegetation, 1979.

14. Recent campsite, Piute Creek at Fort Pah-Ute, 1979.

15. Mohave Trail route in creek channel, 1979.

16. Old Ivanpah, mill foundation at eastern section, 1979.

17. Old Ivanpah, eroded corner of dugout near mill site, 1979.

18. Ivanpah Spring, 1979.

19. Water line from spring to cattle tank, 1979.

20. Tent clearing near Ivanpah Spring, 1979.

21. Adobe ruin, west of mill site at Old Ivanpah, 1979.

22. Adobe ruin, westernmost section of Old Ivanpah, 1979.

23. Weathered adobe walls, western section of Old Ivanpah, 1979.

24. Adobe walls at western section of Old Ivanpah. Ivanpah Dry Lake in distance, 1979.

25. Adobe remains on rock foundation, Old Ivanpah, western section, 1979.

26. Post/rock feature in wash, Old Ivanpah, western section, 1979.

27. Remains of rock buildings or foundations, in wash at Old Ivanpah, western section, 1979.

28. Adobe ruins on rock foundations, Old Ivanpah, western section, 1979.

29. B/W photograph of dugout at Old Ivanpah, 1977.

Warren photographs' continued

30. B/W photograph of mill site at Old Ivanpah, 1977.

31. Adobe structure at western section of Old Ivanpah, 1977. This building is the same as photo #22.

32. Cattle watering tank, Old Ivanpah, western section. Water leaking from tank, 1979.

33. Cattle watering tank, Old Ivanpah, completely filled in with debris, 1979.

34. Whiskey Spring at western section of Old Ivanpah, 1979. The spring is running well, but an oily scum covers the surface. There is no visible reason for this scum.

35. Badly weathered adobe remains on rock foundation. Old Ivanpah, western section, 1979.

36. Old Ivanpah, western section. Rock foundations in wash, mature vegetation evident, 1979.

37. Pot hole, Old Ivanpah, western section, 1979.

38. Pot hole near adobe building, Old Ivanpah, 1979.

39. Treasure hunters at Old Ivanpah, 1979.

40. Artifacts on surface at Old Ivanpah, 1979.

41. Old road between eastern and western sections of Old Ivanpah, 1979.

42. Old road between eastern and western sections of Old Ivanpah, 1979.

43. BLM gate at China Ranch, leading to Willow Creek, 1979. The gate is signed and chained. Recent vehicle tracks leading from Willow Creek to this gate despite the designation as area closed to traffic.

44. T & T spur between China Ranch and Acme Siding, in Willow Creek channel, 1979.

45. T & T main line roadbed at Acme Siding, 1979.

46. Acme Siding, T & T main line, 1979.

Warren photographs' continued

47. Amargosa Canyon at Acme Siding, 1979.

48. Willow Creek at Acme Siding. Mesquite growth near end of stream channel, 1979.

49. Willow Creek at China Ranch, 1979.

50. T & T Acme spur below China Ranch in Willow Creek channel. Mesquite growth obscures roadbed, 1979.

51. One of several dump sites along T & T Acme spur, below China Ranch, Willow Creek, 1979.

52. Water bucket and stand in ruins, along Acme spur below China Ranch, 1979.

53. ORV tracks in bentonite soils, Willow Creek channel below China Ranch, 1979.

54. ORV tracks in bentonite soils, Willow Creek below China Ranch, 1979.

55. Tire tracks in mud from rainstorm day previous to visit, December 1979.

56. ORV tracks in side of channel walls, Willow Creek near historic tuff house, 1979.

57. Tuff house viewed from west, 1979.

58. East side, tuff house, 1979.

59. Tuff house, roof detail, west wall, 1979.

60. Tuff house, front (facing west/south), 1979.

61. Tuff house, west and north walls, 1979.

62. Tuff house, demolished south room, 1979.

63. Vandalism, tuff house, 1979. Wall bricks.

64. Dugout door, ripped by bullets, 1979.

65. Window detail, tuff house, 1979. Wooden window frame gone, initials scratched in tuff bricks, 1979.

66. Doorway, tuff house, 1979.

Warren photographs' continued

67. Interior tuff house, south wall, 1979. Match striker on wall.

68. Tuff house, interior east wall, 1979.

69. Tuff house, shelves by back door, 1979.

70. Tuff house, interior, view toward dugout behind building, 1979.

71. Interior of tuff house, north wall, cut off pole embedded in wall by door, 1979.

72. Tuff house interior, bed springs on floor, 1979.

73. North wall, tuff house interior, showing poles embedded in wall, roof detail, 1979.

74. Lintel of front door, tuff house, vandalized 1979.

75. Mojave trail at Piute Creek, 1979. Leading west from creek to Rock Springs.

76. Mojave trail leading to Piute Creek from west, 1979.

77. Mojave trail, possible cairn, near Piute Creek, 1979.