TECHNICAL REPORT

70-68-ES

SEASONAL CONTRASTS IN THE EASTERN MOJAVE DESERT

by

Roland J. Frodigh

August 1970

UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760

Earth Sciences Laboratory

ES-58

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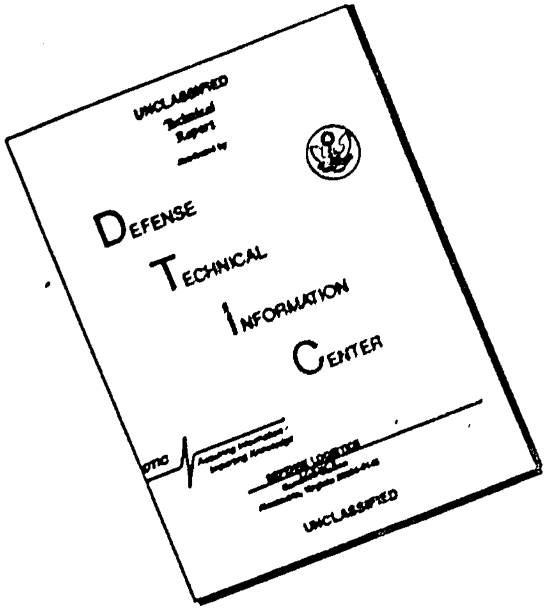

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13. ABSTRACT

Winter and summer seasons in the eastern Mojave Desert are compared in this report, using time-lapse photographic techniques to record seasonal contrasts at nine selected locations. The identical field-of-view from each site, for each season, is printed in full color to realistically portray the differences between the hot and cool periods of the year. Supplementing the photography are narrative descriptions of each landscape, data for the atmospheric conditions at the time of each visit, locational information, and large-scale planimetric views of the local region in the form of aerial photographs and maps. Also included is an introductory section containing information relative to field techniques and equipment used in developing the study, as well as brief chapters dealing with the climate, topography, and vegetation of the Majave Desert.

Military implications of seasonal changes are emphasized, with comments relative to contrasts in vegetation coloration, visibility, ground surface conditions, and trafficability.

Results of this research indicate that there are significant seasonal differences in the physical appearance of much of the desert vegetation in the Mojave Desert. This is shown to be particularly true at lower elevations where summer precipitation is lowest and summer temperatures are highest.

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Seasonal Contrasts in the Eastern Mojave Desert

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Roland J. Frodigh
Geography Division

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Foreword

Few places on earth are unaffected by seasonal change. In some regions, particularly in the mid-latitudes, seasonality is marked by an annual progression of four distinct seasons. Contrasting with the spring, summer, fall, and winter sequence common to much of the temperate regions, are the two-season regimes of many desert and tropical areas of the world, where seasonality is largley determined by marked differences in the annual distribution of precipitation. Here are found such seasonal combinations as wet and dry, wet and less wet, dry and less dry, all representing different environmental situations with different seasonal characteristics.

From a military point of view, the success of a mission could be jeopardized by a lack of knowledge concerning the full implications of seasonality in a particular region, just as it might be adversely affected by inaccurate weather predictions. Among environmental factors often affected by seasonal change are vegetation color and density, visibility, ground surface conditions, trafficability, and drainage.

This study of the eastern Mojave Desert is the second report published by the Earth Sciences Laboratory, describing the use of time-lapse photography in environmental research. The pilot study (Frodigh, 1967), prepared under the ILIR (In-house Laboratory Independent Research) program of the Natick Laboratories, was designed to demonstrate the value of time-lapse photographic techniques in revealing the extent of seasonal change and the military implications of such change. Part of the field work undertaken for this earlier study included photography of selected landscapes in the Mojave Desert during the winter of 1963. In the late summer of 1967 a return trip to Southwestern United States was made to rephotograph these same landscapes, completing the pictorial requirements for this second ILIR Study.

Contents

Abstract

Winter and summer seasons in the eastern Mojave Desert are compared in this report, using time-lapse photographic techniques to record seasonal contrasts at nine selected locations. The identical field-of-view from each site, for each season, is printed in full color to realistically portray the differences between the hot and cool periods of the year. Supplementing the photography are narrative descriptions of each landscape, data for the atmospheric conditions at the time of each visit, locational information, and large-scale planimetric views of the local region in the form of aerial photographs and maps. Also included is an introductory section containing information relative to field techniques and equipment used in developing the study, as well as brief chapters dealing with the climate, topography, and vegetation of the Mojave Desert.

Military implications of seasonal changes are emphasized, with comments relative to contrasts in vegetation coloration, visibility, ground surface conditions, and trafficability.

Results of this research indicate that there are significant seasonal differences in the physical appearance of much of the desert vegetation in the Mojave Desert. This is shown to be particularly true at lower elevations where summer precipitation is lowest and summer temperatures are highest.

1 Introduction

a. **Purpose and Scope:** Seasonal contrasts are generally less pronounced in desert regions than in humid, mid-latitude areas. There are, however, environmental changes which do occur, and which have military significance. It is the purpose of this report to illustrate some of these changes and to supplement the photography with sufficient general information to provide a comprehensive picture of the local geography during the seasons of maximum and minimum temperatures. Although changes in vegetation coloration and surface drainage are the principal differences revealed in the photography, vegetation growth during the 45-month interval between visits is evident in the relatively lush vegetation along washes. This aspect of the study suggests possible use of time-lapse photography in long-term phenological research.

It should be emphasized that this study is not an analysis of the total vegetation complex of the study area, but rather is intended to illustrate a few examples of seasonal change in a desert region.

b. **Study Area:** The Mojave Desert, focus of this report, is the smallest part of the 440,000 square miles that form the North American Desert region (Figure 1). Shreve (1942) establishes its boundaries as follows: "The Mojave Desert lies in Southeastern California, east of the southern end of the Sierra Nevada and north and east of the San Bernardino Mountains, extending east to the Colorado River and north approximately to the 4500 foot contour line in California and Nevada. The northern boundary is very sinuous, with frequent reversions, and may be taken as corresponding with the northern limit of *Larrea* (creosotebush)."

The nine desert landscapes depicted in this report are located along a 200-mile transect trending northwest to southeast through the eastern Mojave Desert (Figure 2). This transect, from Death Valley in the north to the Colorado River in the south, was arbitrarily selected as a route along which to photograph vegetation which is subject to seasonal change. Some of the photographs show vegetation which is very limited in distribution, whereas others are representative of extensive areas of the desert surface. Information relative to plant distribution is included under 5 c., Vegetation, and in the comments for each site.

c. **Color Reproduction:** In photographing the seasonal time-lapse sequences for this report every effort was made to capture the true color of the respective landscapes. Careful attention has also been given to reproduction of the color plates from the transparencies. In some of the time-lapse pairs the viewer may notice seasonal contrasts in the coloration of rocks and soil – contrasts which one might not expect to find in inorganic desert features. It is understandable that some loss in accurate color duplication is inevitable with each reproduction step: i.e., from nature to the photograph, and from the photograph to the press run. However, it is possible that some of these differences may be the result of atmospheric contrasts between winter and summer and/or differences in the angle of the sun relative to the features in question. In general it is felt that deviations from true coloration are slight and that seasonal contrast are realistically portrayed.

2 Field Equipment

The following equipment was used in the field for recording photographic and meteorological information:

16mm Bell & Howell, Model 70 KRM, motion picture camera, with 25mm and 17mm lenses

35mm Kardon camera, with 50mm lens

4 x 5 inch Speed Graphic Camera with 127mm lens

Exposure meter

Transparency viewer

2 Tripods

Film: 16mm and 35mm Kodachrome II (ASA 25) 4 x 5 inch black and white panchromatic, Kodak Superpan Press (ASA 250)

Hand anemometer

Sling Psychrometer

Magnetic compass

Topographic maps

Umbrella

The three cameras listed were selected to give complete photographic coverage. The sling psychrometer was used for recording dry and wet bulb temperatures; the hand anemometer for wind speeds. Wind direction and camera azimuth were determined with the magnetic compass. The umbrella, mounted on one of the tripods, was used during the summer visit to shield the cameras from direct sunlight.

3 Field Techniques

When the point from which to photograph a particular landscape had been selected, the tripod was firmly set to provide a rigid camera base. Nearly all pictures were taken in bright sunlight during the high-sun period of the day (1000 to 1500 hours), in order to insure daylight color temperatures closely equivalent to the color balance of the film. All exposures were calculated from reflected light readings. Normally three exposures were made of each landscape; the first at a setting indicated by the meter, the second at one stop above, and the third at one stop below the suggested aperture. This practice provided three choices from which to select the best exposure, and one of the rejected shots served as a guide in framing the identical scene on the repeat visit. A small hand viewer was found helpful for matching the camera viewfinder image with the landscape as recorded on the first visit. In carrying out this step the author discovered that the film transparencies will be burned if direct sunlight strikes the lens of the hand viewer.

Extensive field notes were taken at each site, including information for locating the camera position on the return visit. Spot locations were also identified by cairns or individual rocks. When such objects could not be located, it was relatively easy to "zero in" on the exact spot by referring to one of the 35mm slides exposed on the first visit, adjusting the camera position until the relative position of objects on the camera viewfinder matched those on the slide.

The film manufacturer cautions against subjecting film, particularly color film to excessively high temperatures. In this regard, every effort was made to protect the film from thermal deterioration while carrying out the summer field work. Loaded cameras and film holders were transported to the various sites in an air conditioned vehicle, and after exposure were returned to temporary storage in air conditioned quarters. When on location, in the absence of natural shade, cameras not in use were covered with a white cloth.

In planning time-lapse studies in hot deserts, or other regions where climatic factors may adversely affect personal comfort, it is suggested that the initial photography be completed during the season of greatest stress. This is recommended because the first visit to any site requires the least "set-up" time compared to subsequent visits when precise matching of views demands more time and patience.

4. Seasonal Coverage

It may be said, from the vegetational point of view, that a new season in the desert begins with each life-giving rainfall. To some extent this is true. Annual plants sprout and bloom whenever adequate moisture becomes available, whether from direct rainfall or from precipitation runoff. Some desert shrubs, like the ocotillo *(Fouquieria splendens)*, also respond quickly to watering and develop new leaves. However, for the purposes of this study, landscapes have been recorded only during the winter and summer, showing contrasts between the cool and hot seasons of the year. Here then we are concerned with the two clearly predictable seasons of the year which reflect the stress of climatic extremes in a region which itself is synonomous with a climatic extreme — aridity.

5. Regional Geography

The Mojave Desert is the smallest of the four subdivisions of the North American Desert (Figure 1), located for the most part in southeastern California, with portions extending into Utah, Nevada, and Arizona. Physiographically it is part of the Basin and Range province of North America.

a. Climate: During the warmer part of the year, from late winter through fall, the Mojave Desert comes under the influence of the Pacific High. Descending, stable air, with increasingly higher temperatures, contribute to the aridity of this region. Usually only summer thunderstorms break the long drought, occurring over higher mountain ranges. Such storms frequently bring torrential rains to the high country, with attendant flash flooding along drainage channels. During the cool season the southward retreat of the sun brings the southern edge of the westerlies and its associated cyclonic activity to the desert, causing widespread winter rains over the region as a whole.

Howe (1968) classifies the Mojave Desert as extremely arid, having 10 to 12 months with no more than 1 rainy day per-month (a rainy day has 0.1 inch precipitation), and varying annually from extremely hot to cold. The "extremely hot" category requires that at least two months have mean daily maximum temperatures of 105 degrees F or higher (this implies temperatures exceeding 115 degrees F up to one-half the days and exceeding 95 degrees F on most days). The "cold" category requires at least 2 months with mean daily minimum temperatures 25-44 degrees F (this implies that temperatures will drop to and below freezing up to two-thirds of the nights). Howe's classification, like other world-wide classification systems, is based on climatic data from a network of widely spaced observation stations. Such classifications, because of small map scale and sparse data are generalized and do not reflect small but significant variations in the local climate.

In arid regions the effectiveness of precipitation in sustaining vegetation may be evident many miles from where the precipitation falls, so that on-the-spot rainfall data may not give a true indication of aridity from a practical, military point of view. The most verdant desert vegetation illustrated in this report is nurtured by runoff from summer convectional storms which occur over desert mountains. Many storms of this type develop over relatively inaccessible terrain where few rain gauges are located. An analysis of climatic records in the Death Valley hydrologic basin indicates that annual precipitation increases at a rate of about two thirds of an inch for each 1000 feet of altitude up to 5000 feet. Above 5000 feet there appears to be a sharp increase in precipitation, with an average of about two inches per 1000 feet (Hunt, 1966). The precipitation amounts included with the location data for each site treated in this study has been extrapolated from climatic records from nearby stations or from the precipitation estimates for specific elevations as suggested by Hunt. Hastings and Turner (1965) postulate that some desert mountains may receive more than 30 inches of precipitation per year, placing them well outside the desert classification. Concerning desert microclimates, these authors write: "Even in regions as dry as southwestern Arizona and Northwestern Sonora, the desert is discontinuous. It makes up only one part – an important part to be sure – of a larger area with a considerable variety of climate. And although the desert itself is arid, other parts of the desert region may be only semiarid, on even subhumid. The desert region, then, includes the moist highlands that stud the desert, and those lying immediately adjacent to it. It includes the many microenvironments – streams, marshes, springs, roadsides and the beds of dry washes – that may be wholly surrounded by desert, but are not themselves arid. To talk of the pines and the oaks of the desert region is legitimate; they grow there in abundance. But to speak of them as being plants of the desert is inaccurate, because they can tolerate aridity hardly better than the forests of New England."

b. Topography: Mountains formed by extensive block faulting have been altered by processes of mass wasting, resulting in complexly dissected erosional landforms. Because of the precipitous slopes characteristic of desert mountains, bedrock is exposed everywhere except on some mesas and along narrow canyon floors.

Intermontane valleys on the other hand, are generally broad, gently sloping surfaces, made up of vast amounts of alluvial deposits transported from adjacent mountains.

The elevation of most of the Mojave Desert lies between 2000 and 4000 feet, with the lowest point 282 feet below sea level in Death Valley. Drainage is largely internal, terminating in playas or "soda lakes," featureless alkaline flats that are dry except for brief periods following winter rains and summer thunderstorms. Only streams which are tributaries of the Colorado River drain to the sea.

The most characteristic topographic feature of the Mojave Desert is the alluvial fan. According to the Clements et al. (1957) such fans occupy 31.4% of the region. On aerial photographs they appear as semicircular formations, festooned along the bases of desert ranges, often coalesced with adjacent fans forming bajadas. Deposited by flowing water, the rock fragments which make up the fans, grade from coarse, near the fan apex, to fine, at the edge of the apron where the power of stream flow is spent. Similarly, the extensively braided stream patterns of alluvial fan surfaces are more deeply incised near the fan head than along the apron.

When dry, the fine alluvial sediments of the playas are readily transported by the wind. Dunes are built up on the lee side of the playas, or they may be formed considerable distances from the lake source (on maps of southwestern United States, playas are usually identified as lakes). Sand Dunes, however, make up only 0.6% of the total surface of the North American Desert.

c. **Vegetation:** Illustrations in this study reflect diversity, both in variety of plant species and seasonal contrasts, in a region which is classified as a separate desert entity on the basis of its climatic and vegetational homogeneity. Shreve (1942) writes that "The Mojave Desert resembles the Great Basin Desert in its poor display of life forms. In the simple composition of most of its communities, and in the strong control of the distribution of its vegetation by the texture and salt content of the soil." When viewed from many vantage points it is true that the Mojave Desert displays an apparent uniformity of vegetation cover that might cause the casual observer to overlook variations which exist in the size and spacing of the dominant species as well as in the great contrast between plant communities which are sustained by light, widespread winter rains, and those which are nourished by more lavish supplies of water which periodically flood stream channels.

Most of the desert surface, between playas and mountains, is covered by an open stand of creosotebush *(Larrea tridentata)* and bursage or burroweed *(Franseria dumosa)*. According to Shreve, such stands occupy 70% of the Mojave Desert. Creosotebush, the more prominent of the two species, is one of the most adaptable desert plants, a fact which accounts for its widespread distribution. Dalton (1962) states that "Few plants of the North American Deserts have so great an ability to withstand so wide a range of environmental conditions as this species." Creosotebush is commonly found in association with plants which have more restricted habitats. Its northernmost limit of growth forms the northern boundary of the Mojave Desert. Except for lush vegetation along some stream beds, it is the most important desert plant from a military point of view, providing what little cover is available. The equal spacing between plants is one of the significant characteristics of the creostotebush stand. This spacing is inversely proportional to the size of the individual plants, the smallest being most widely spaced in the most arid parts of the desert. Plants ~~vary most widely spaced in the most arid parts of the desert~~. Plants vary in height from 15 inches to several feet, averaging about 3 feet. Of particular interest is the fact that in any one stand, the plants, almost without exception, are of uniform size. Following sustained dry periods, renewed moisture supplies initiate new growth when daily minimum temperatures are higher than 40° F and daily maximum temperatures are higher than 80° F (Dalton, 1962).

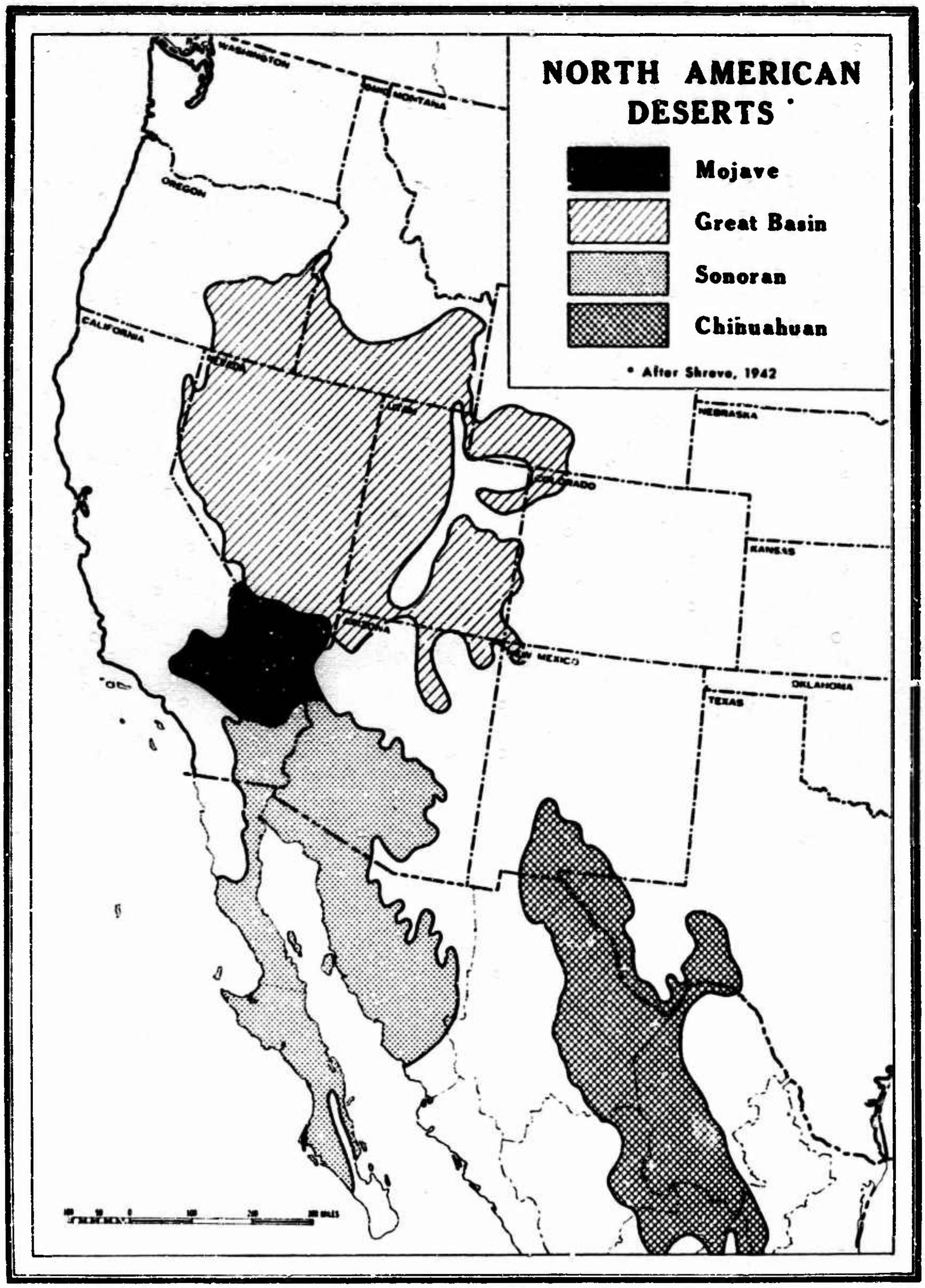

NORTH AMERICAN DESERTS *
Mojave
Great Basin
Sonoran
Chihuahuan
* After Shreve, 1942

Figure 1

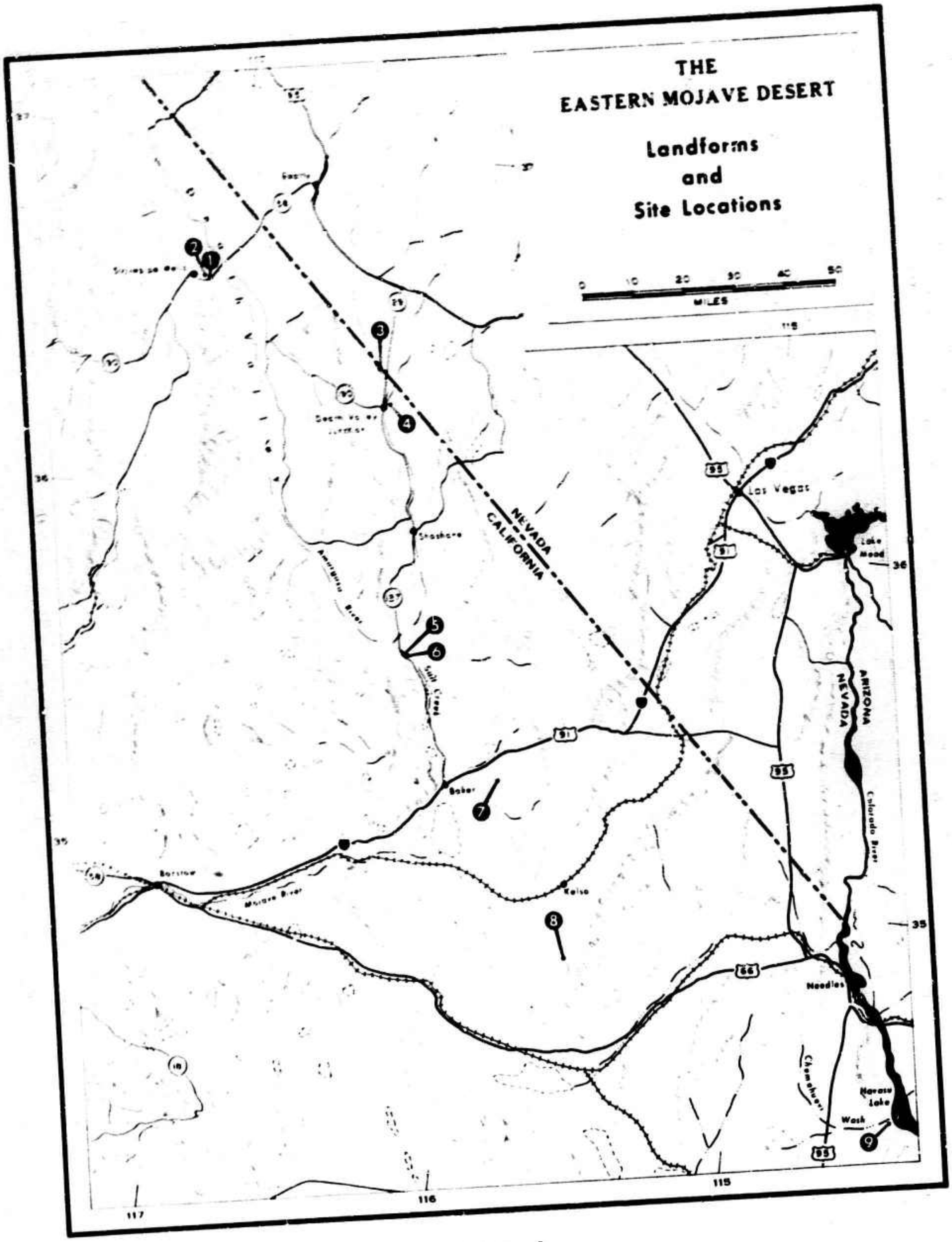

THE
EASTERN MOJAVE DESERT
Landforms
and
Site Locations
MILES
NEVADA
CALIFORNIA
ARIZONA
NEVADA
Las Vegas
Lake Mead
Shoshone
Baker
Barstow
Kelso
Needles
Mojave River
Colorado River
Havasu Lake
Wash
117
116
115
35
36

Figure 2

DISTRIBUTION OF DESERT TYPES

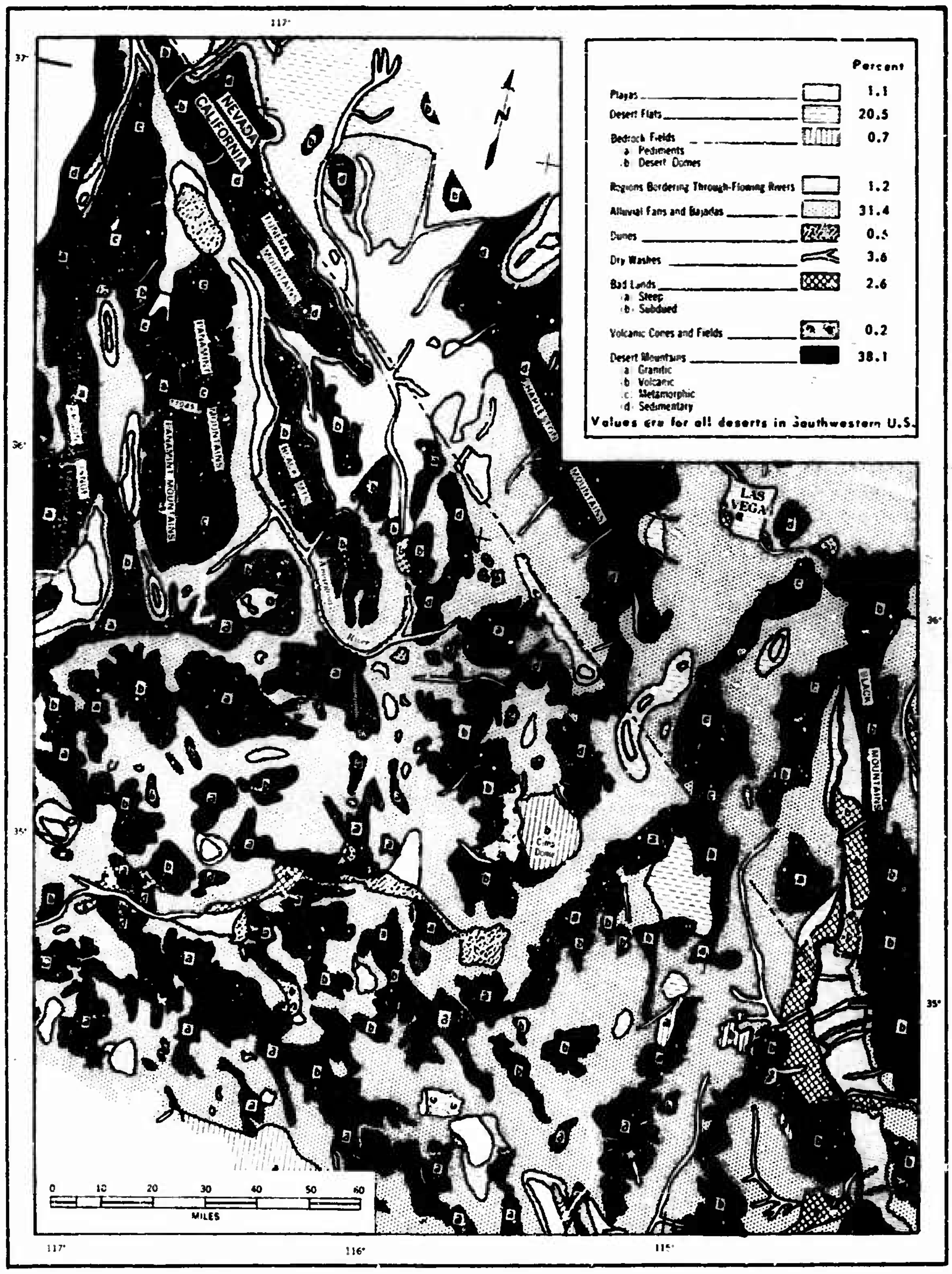


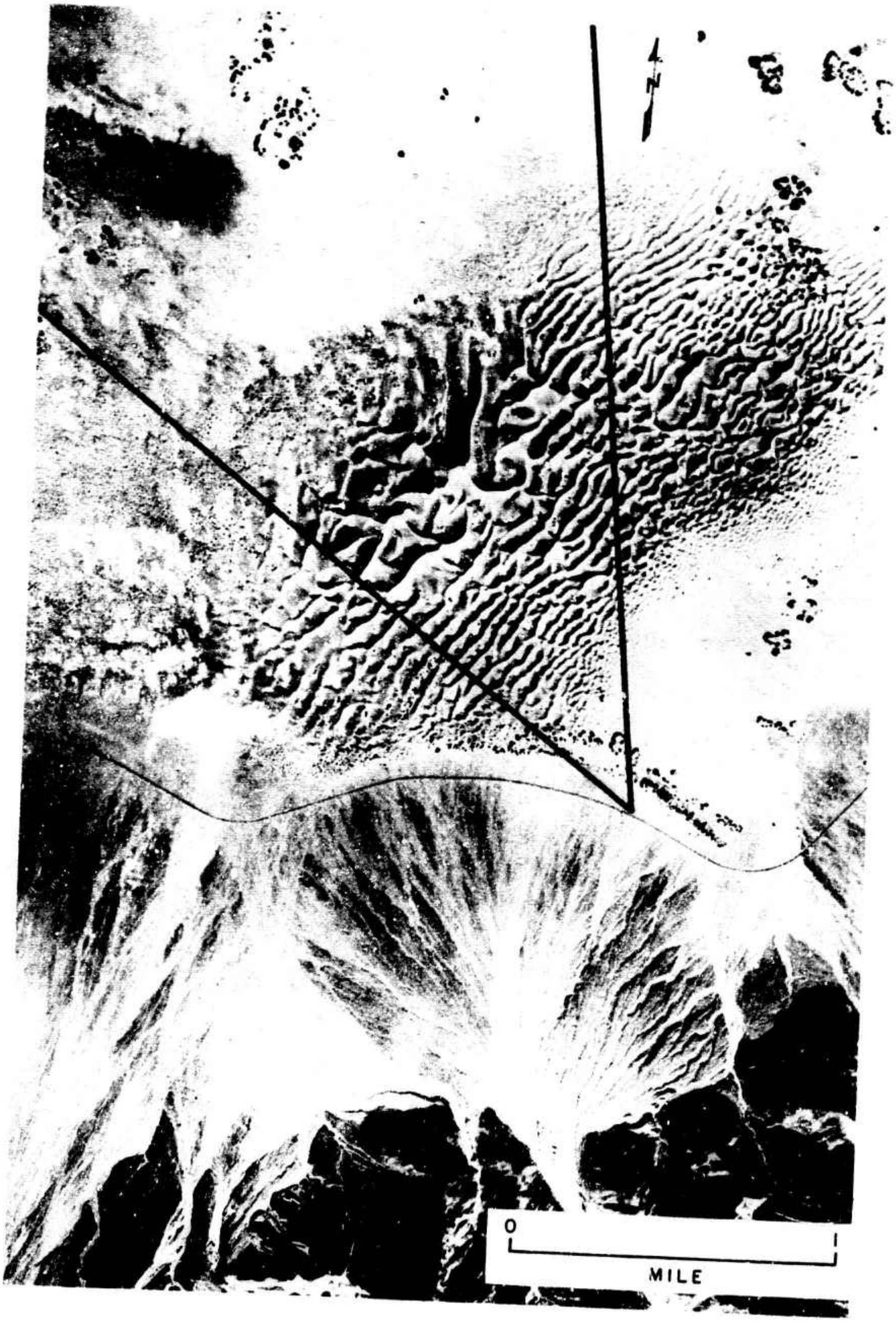
Figure 3

Location: Death Valley (2.4 miles east of Stove Pipe Wells Hotel on California Route 190). Lat. N 36°36', Long. 117°06' W. Elevation: Sea level. Camera azimuth: 325°. Mean annual precipitation: 2 inches.

Area Description: Three distinct features of the desert are shown in this landscape. Barren, deeply eroded mountains rise more than seven thousand feet above the floor of Death Valley, forming a backdrop for sand dunes (center) and the apron of an alluvial fan (foreground). Contrasts in vegetation coloration between winter and summer seasons reflect differences in temperature, seasonal availability of water, and specialized plant characteristics. A scattered stand of mesquite *(Prosopis juliflora)* grows along the periphery of the dunes as a narrow, distinctive plant zone between the sand deposits and the rocky, abraided surface of the alluvial fan, with its dominant, but sparse cover of creosotebush. Mesquite, most verdant during the hot summer period, develops roots which reach as much as 60 feet below the surface to tap ground water sources. Creosotebush, on the other hand, with its shallow, laterally extended roots, depends for its water requirements on light, but widespread winter rains. Green in the cooler months of the year in Death Valley and other parts of the Mojave Desert (Plate 7) below 3000 feet, this highly adaptable desert plant takes on a thoroughly dried-out appearance during the summer. It is considered a plant indicator of the hot desert region (Lower Sonoran life zone) of North America. Although the two photographs were taken nearly four years apart, the configuration and location of prominent sand dunes are strikingly alike in each scene. Some dune migration, however, has occurred, and an example of this can be seen in Plate 2.

ATMOSPHERIC CONDITIONS RECORDED AT THE TIME OF EACH VISIT

	Winter	Summer
Date	3 Dec 1963	14 Sep 1967
Hour (PST)	1545	1645
Temperature	60°	104°
Dewpoint	45°	24°
Relative Humidity	57%	6%
Wind speed & direction	Calm	Calm
Sky cover	Clear	Clear


N
0
1
MILE

WINTER

SUMMER

Site 2

Location: Death Valley, 1.4 miles east of Stove Pipe Wells Hotel, 200 yards north of California Route 190, Lat. N 36°37′ Long. 117°07′ W. Elevation: Sea level, Camera azimuth: 254°. Annual precipitation: 2 inches.

Area Description: The most striking difference between these two scenes is the dune migration which has occurred during the intervening 45 months. From among the dunes and mesquite shown on Plate 1 this view faces along the fringe of the "Mesquite Flat" sand deposits in Death Valley, revealing in the center and left background (below the serrated Panamint Range) the long, sloping surface of an alluvial fan. This fan is the depositional product of periodic flooding through Mosaic Canyon (out of view to the left). From this viewpoint the scattered fan vegetation (mostly creosotebush) blends into a solid mass, giving the surface its apparent color – brown in the summer and olive-green in the winter. The sparse growth on the left, between the mesquite and the road, affords a closer view of a similar alluvial surface, with the same xerophytic vegetation. Evident here is the even spacing between individual creosotebush shrubs, a distinctive characteristic of this species. A common desert tree, mesquite often forms luxuriant, impenetrable thickets. Here in Death Valley the mesquite – sand dune association considerably reduces surface-to-surface visibility. This plant also offers some protection from air-to-ground detection. Mesquite, like other growth sustained by ground water (Plates 3, 5, 6 and 9), shows seasonal changes in color, but reveals little evidence of much seasonal contrast in density. In a region where natural fuels are very scarce, mesquite is considered an excellent firewood.

ATMOSPHERIC CONDITIONS RECORDED AT THE TIME OF EACH VISIT

	Winter	Summer
Date	5 Dec 1963	14 Sep 1967
Hour (PST)	0900	1000
Temperature	52°	102°
Dewpoint	28°	31°
Relative humidity	38%	8%
Wind speed & direction	W 3 mph	NNW 2 mph
Sky cover	2/10 ci	Clear

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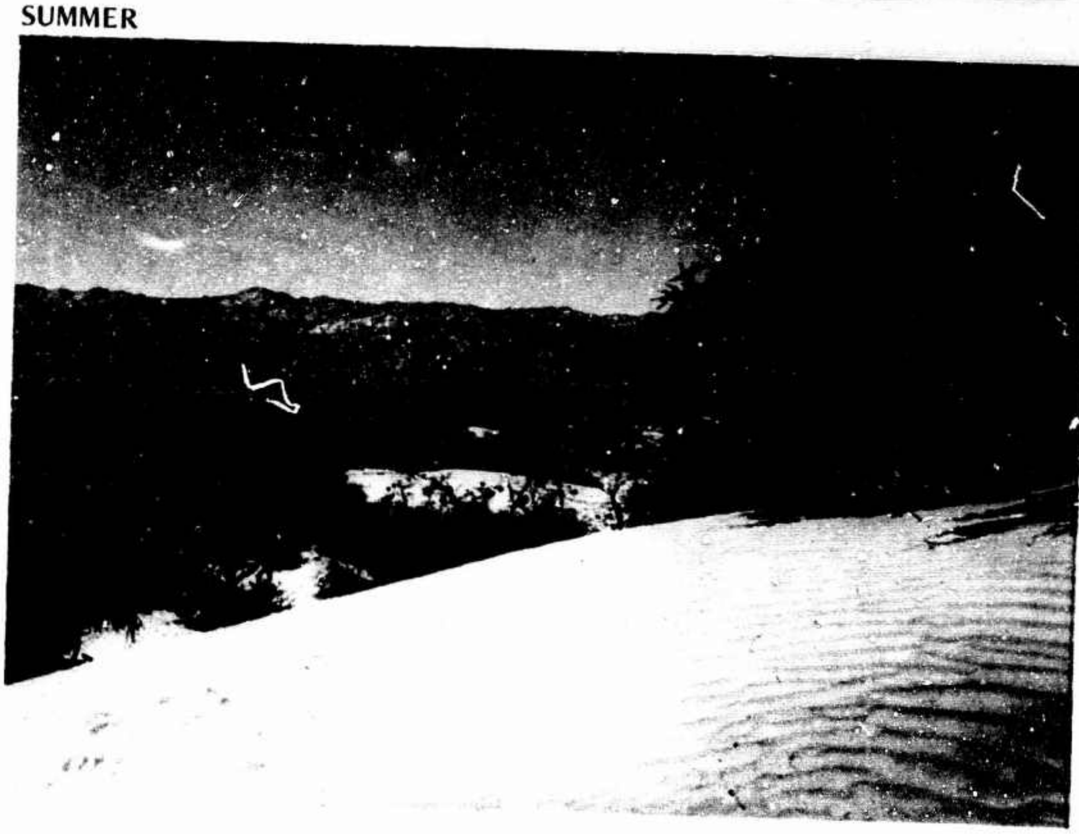
1
MILE

PLATE 2

WINTER

SUMMER



Site 8

Location: Amargosa River, Amargosa Desert (Franklin Well), 10 miles north of Death Valley Junction. Lat. N 36°25′, Long. 116°28′ W. Elevation: 2180 Feet, Camera Azimuth: 265°. Stream gradient: 23 feet/mile. Mean annual precipitation: 3.5 inches.

Area description: An east-west road crosses the bed of the Amargosa River at Franklin Well, cutting across a stretch of riparian vegetation three miles long and two-tenths of a mile wide. Largest of the streams originating in the Mojave Desert, the Amargosa River drains an area of about 5000 square miles. Flowing southward intermittently for 100 miles, it swings north into Death Valley, terminating in a saltpan. Seasonal contrasts in vegetation at this site are like those at other locations in the Mojave Desert where ground water is adequate to support lush perennial growth. Although leaf density is somewhat greater in the summer, protective cover is available throughout the year. During the night previous to the winter visit, ice has formed on standing water (visible in the road), and shaded puddles were partly frozen at 1100 hours on the following morning. This freeze-thaw cycle reflects the winter diurnal range of temperatures at basin locations in the Mojave Desert, where sub-freezing periods are normally limited to hours between sunset and sunrise. At the time of the summer visit mosquitoes were very bothersome, and it was clear that, without insect repellant or protective clothing, this microenvironment would be difficult to endure for more than brief periods. Nowhere else, during either the summer or winter field trips, were mosquitoes encountered. As at other sites, surface salt is more apparent in the winter view.

ATMOSPHERIC CONDITIONS RECORDED AT THE TIME OF EACH VISIT

	Winter	Summer
Date	6 Dec 1963	16 Sep 1967
Hour (PST)	1010	1030
Temperature	53°	95°
Dewpoint	20°	33°
Relative humidity	27%	11%
Wind speed & direction	0	0
Sky cover	1/10 ci	Clear

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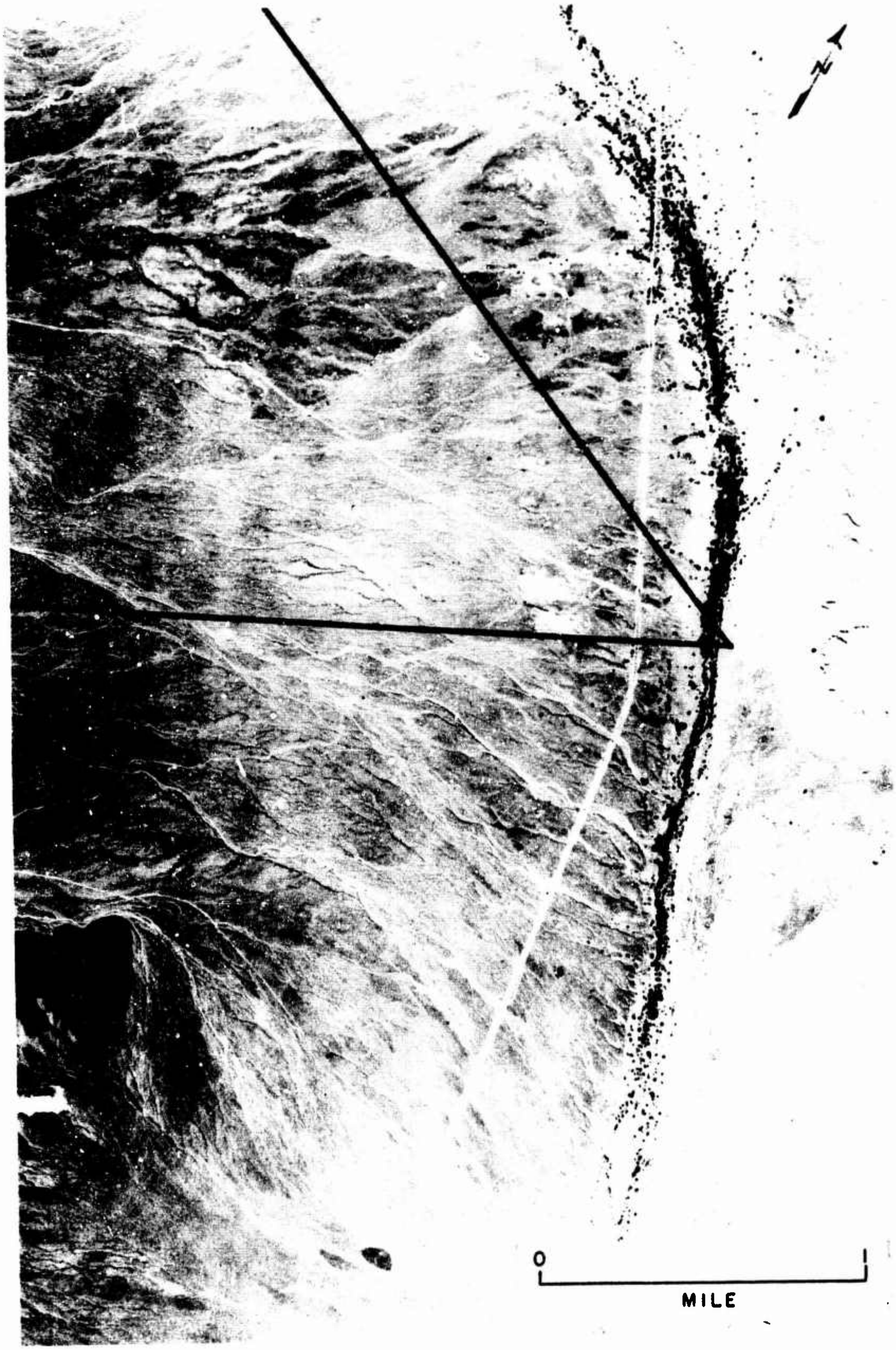
0
1
MILE

PLATE 3

WINTER

SUMMER

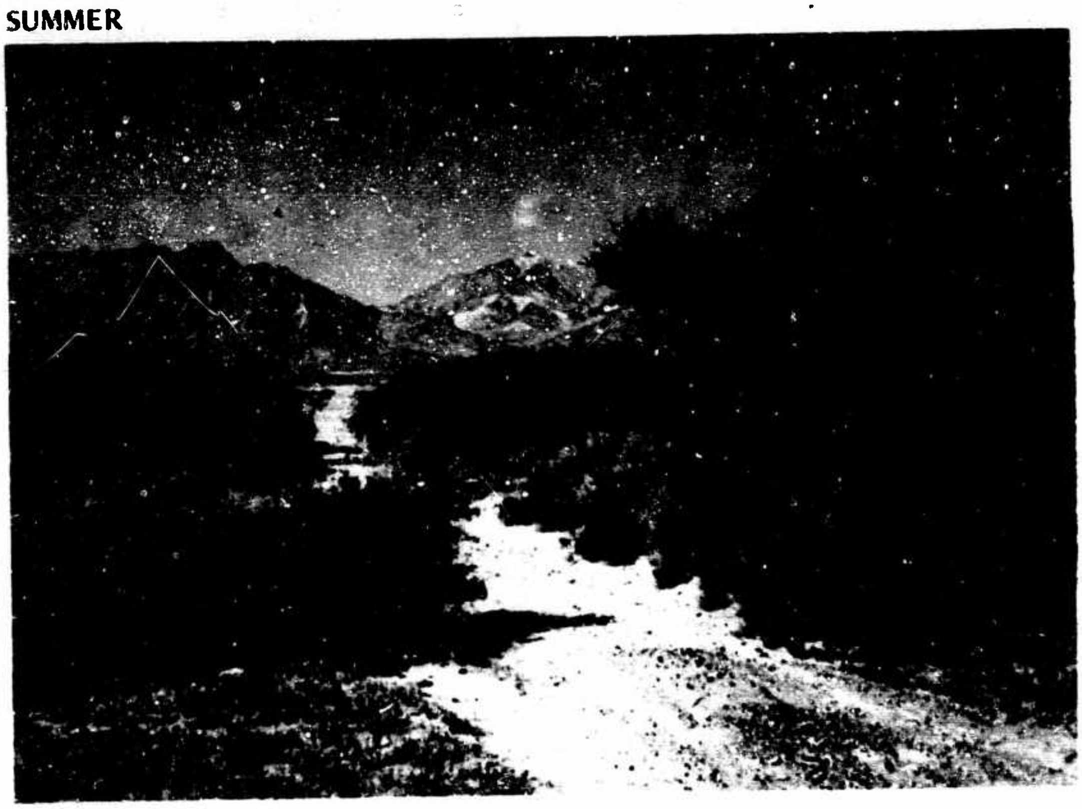

Plate 4

Location: Carson Slough, Amargosa Valley, 2.7 miles east of Death Valley Junction. Lat. N 36°19', 116°22' W. Elevation: 2040', Camera azimuth: 010°. Stream Gradient: 14'/ mile. Annual precipitation: 3.5 inches.

Area Description: Eight miles south of Franklin Well (Plate 3) the Amargosa Valley broadens into a relatively flat, nearly featureless plain. Numerous perennial and ephemeral springs flow from aquifers in the uplands to the east, meandering across the valley floor. One of these, Carson Slough, which is perennial only near its source, is shown cutting a very shallow course across the desert as it drains toward the Amargosa River.

Normal runoff in the Amargosa catchment area is not sufficient to account for the large volume of water discharging from these springs, and it is postulated that much of the flow originates beyond the Death Valley hydrologic basin (Hunt, 1966). The winter scene depicts a desert paradox – evidence of extreme aridity (salt-encrusted surface and dormant vegetation), contrasted with a copious flow of surface water. The summer landscape, although lacking surface flow, exhibits some green vegetation, mostly grasses. Cover from aerial surveillance is almost nonexistent along this stretch of the Amargosa Valley. Very sparse shrub growth, grass, and road embankments offer limited protection from surface-to-surface detection. There is little restriction to cross-country mobility.

ATMOSPHERIC CONDITIONS RECORDED AT THE TIME OF EACH VISIT

	Winter	Summer
Date	7 Dec 1963	16 Sep 1967
Hour (PST)	1115	1600
Temperature	61°	95°
Dewpoint	23°	33°
Relative humidity	23%	11%
Wind speed & direction	N 8 mph	S 10 mph
Sky cover	1/10 ci	Clear

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N
0
1
2
MILES

WINTER

SUMMER

Site 5

Location: Salt Creek (tributary of the Amargosa River), three tenths of a mile north of California Route 127, between Shoshone and Baker, Calif. Lat. N 35°37', Long. 116°16' W. Elevation: 560'. Camera azimuth: 120°. Stream Gradiant: 30'/mile. Mean Annual Precipitation: 2.5 inches.

Area Description: The eastern slopes of the Avawatz Mountains (to the right of this view) drain into Salt Creek, the course of which is delineated here by dense perennial vegetation. Dominant species are tamarisk *(Tamarix)*, saltbush *(Atriplex polycarpa)*, and giantreed or common reed *(Phragmites communis)*. Looking upstream, the verdant river bed contrasts sharply with sparse growth among the dunes to the left, and on the alluvial fan to the right. Several days before the summer visit, widespread flash flooding in the Mojave Desert resulted in numerous road washouts. Downstream, a short distance from this site, grass wrapped around a shrub in mid-channel indicated a peak water depth in excess of two feet. Photography in this study shows that seasonal contrasts in plant growth along such streams are primarily contrasts in coloration, with variations in vegetation density of lesser significance. Natural cover, affording concealment from ground-to-ground air-to-ground detection, is greatest along stream channels, although, as revealed in this study, density of such vegetation varies considerably from place to place. Some stretches have little or no plant life (Plate 4), while others have dense growth as illustrated here. Desert stream bed morphology also varies greatly, with narrow, deeply incised channels contrasting with broad, extensively braided drainage systems.

ATMOSPHERIC CONDITIONS RECORDED AT THE TIME OF EACH VISIT

	Winter	Summer
Date	8 Dec 1963	19 Sep 1967
Hour (PST)	1420	1030
Temperature	62°	84°
Dewpoint	11°	55°
Relative humidity	13%	37%
Wind speed & direction	SE 6 mph	N 6 mph
Sky cover	1/10 ci cu 4/10 ci st	7/10 st cu

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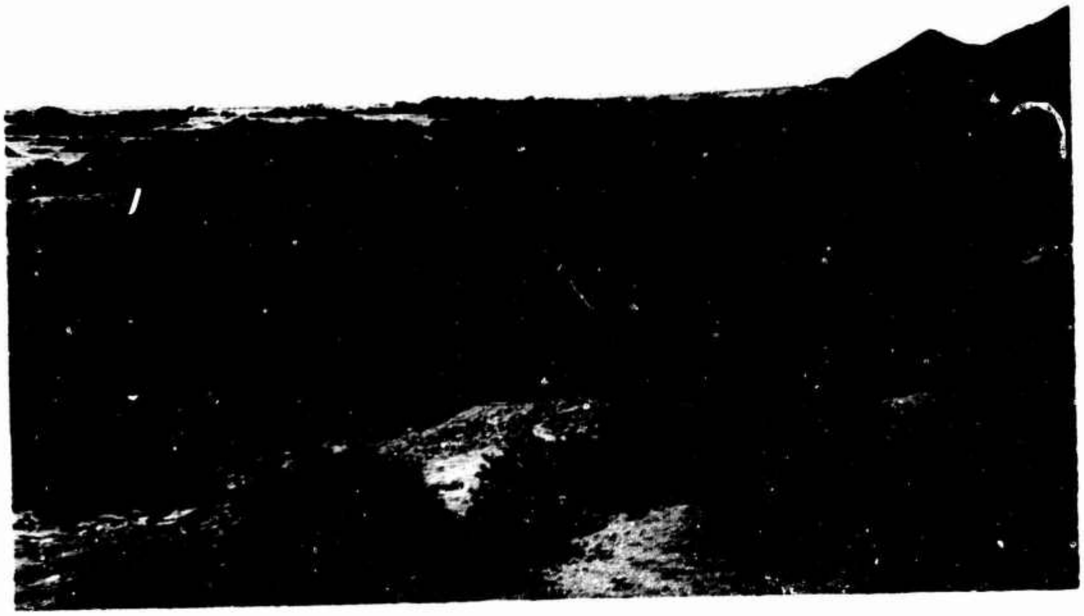
1
MILE

WINTER

SUMMER

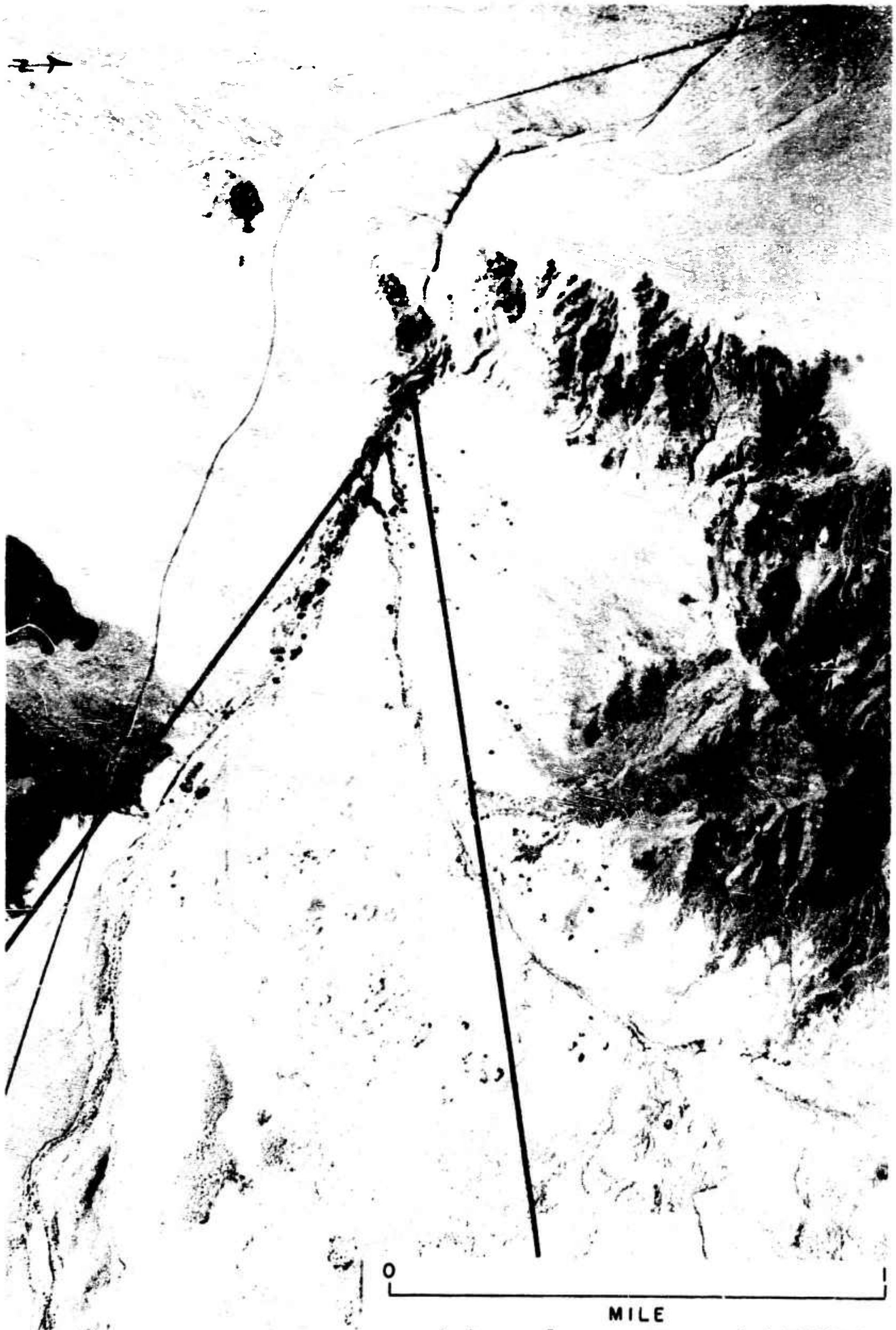


Location: Salt Creek (tributary of the Amargosa River), three-tenths of a mile north of California Route 127, between Shoshone and Baker, Calif. Lat. N 35°37', Long. 116°16' W. Elevation: 540' Camera azimuth: 110°. Stream Gradient: 30'/mile. Mean annual precipitation: 2.5 inches.

Area description: This is a close-up view of the Salt Creek vegetation shown in Plate 5. Whereas the preceeding view was photographed from a site well above, and some distance from the stream, this scene was recorded from the edge of the main channel, about eleven feet above its bed. Clearly evident are giantreeds growing among the trees and shrubs. No flowing water was seen here, or along any of the drainage systems visited in the Mojave Desert, with the exception of Carson Slough (Plate 4). From a practical military point of view, canyons, washes, and playas may be considered as being dry a greater part of the time. Standing water or mud may persist for several days following flash flooding, but in general such conditions represent highly ephemeral features in the desert. They do not, therefore, constitute major obstacles to personnel or vehicular mobility. In a transient military situation the protection afforded by vegetation and/or landform configuration along desert stream courses might well outweigh the negative aspect of potential flood danger inherent in such locations.

ATMOSPHERIC CONDITIONS RECORDED AT THE TIME OF EACH VISIT

	Winter	Summer
Date	18 Dec 1963	19 Sep 1967
Hour (PST)	1445	1100
Temperature	62°	84°
Dewpoint	11°	55°
Relative humidity	13%	37%
Wind speed & direction	SE 6 mph	N 6 mph
Sky cover	1/10 ci cu 4/10 ci st	7/10 st & st cu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MILE

WINTER

SUMMER

Site 7

Location: 12 miles NE of Baker, California, ½ mile NW of Henry Spring. Lat. N 35°19', Long. 115°52' W. Elevation: 2735'. Camera azimuth: 270°. Slope (desert surface): 200'/mile. Mean annual precipitation: 4 inches.

Area Description: Beyond the erosional spur in the foreground a typical stand of creosotebush and bursage or burro-weed extends to the base of the distant mountains. The summer view records the effect of heat and aridity on this shallow-rooted xerophyte, depicting hot-season conditions which are most pronounced at low elevations, where dormancy (retarded leaf growth) is more evident than it is near the upper limit of this plant's natural habitat (approximately 4000 feet in the Mojave Desert). Creosotebush stands, in which individual plants are fairly large, might provide limited cover from surface-to-surface or air-to-ground detection. A single plant might offer concealment for one man, especially during the cool season when leaf growth is at its maximum. In the summer the relatively bare branches of the creosotebush would offer less protection. Where a line of sight between an observer and the observed is parallel to, and close to the ground surface, the cumulative effect of even widely spaced vegetation interupting such a line of sight would reduce visibility considerably. This is clearly shown in the photographs even though they were exposed from a point 25 feet above the desert surface.

ATMOSPHERIC CONDITIONS RECORDED AT THE TIME OF EACH VISIT

	Winter	Summer
Date	9 Dec 1963	19 Sep 1967
Hour (PST)	1010	1100
Temperature	58°	93°
Dewpoint	32°	48°
Relative humidity	37%	21%
Wind speed & direction	SW 10 mph	NE 12 mph
Sky cover	2/10 cu	3/10 cu

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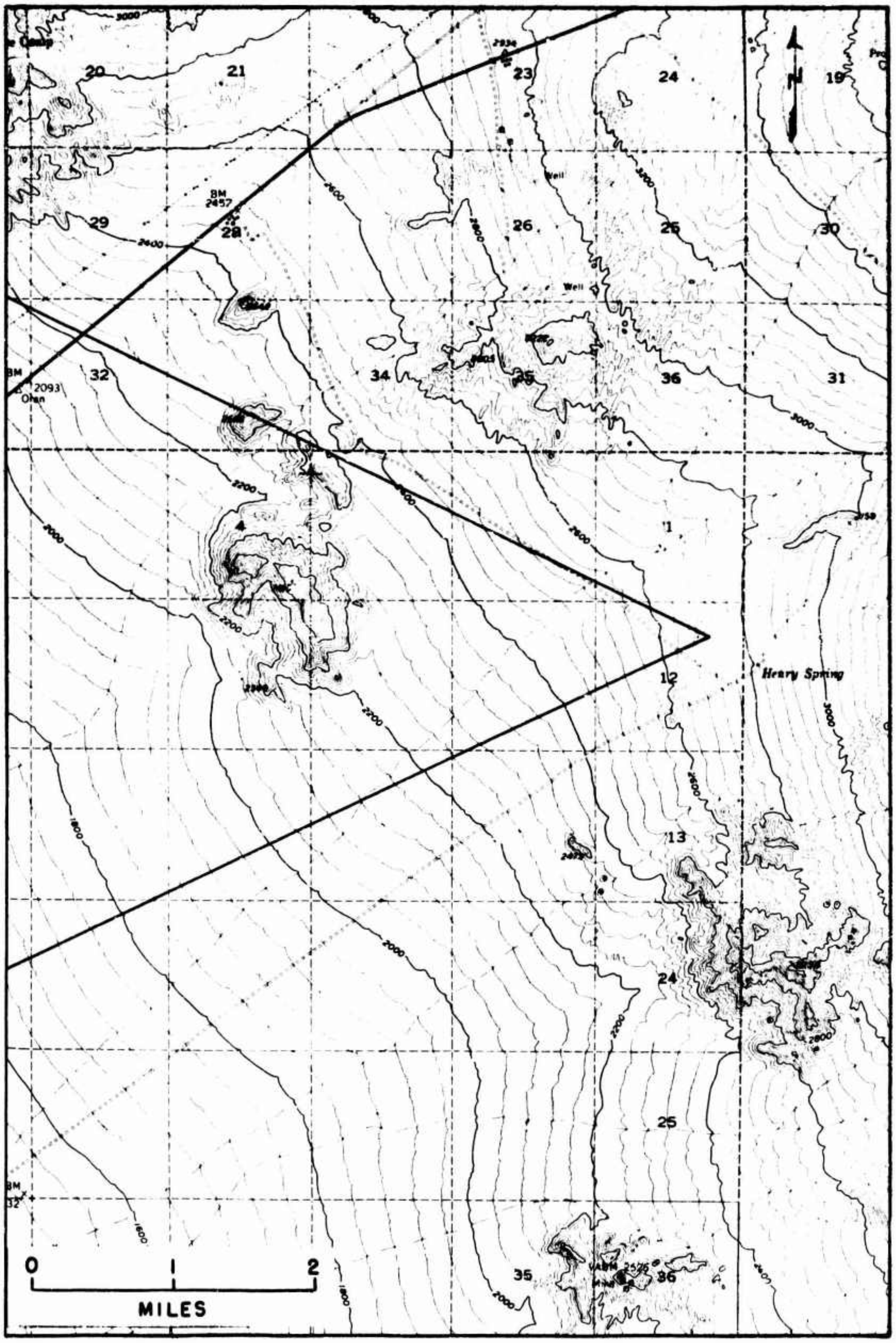
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BM
2093
Ohan
32
34
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36
31
Well
Well
1
12
Henry Spring
13
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35
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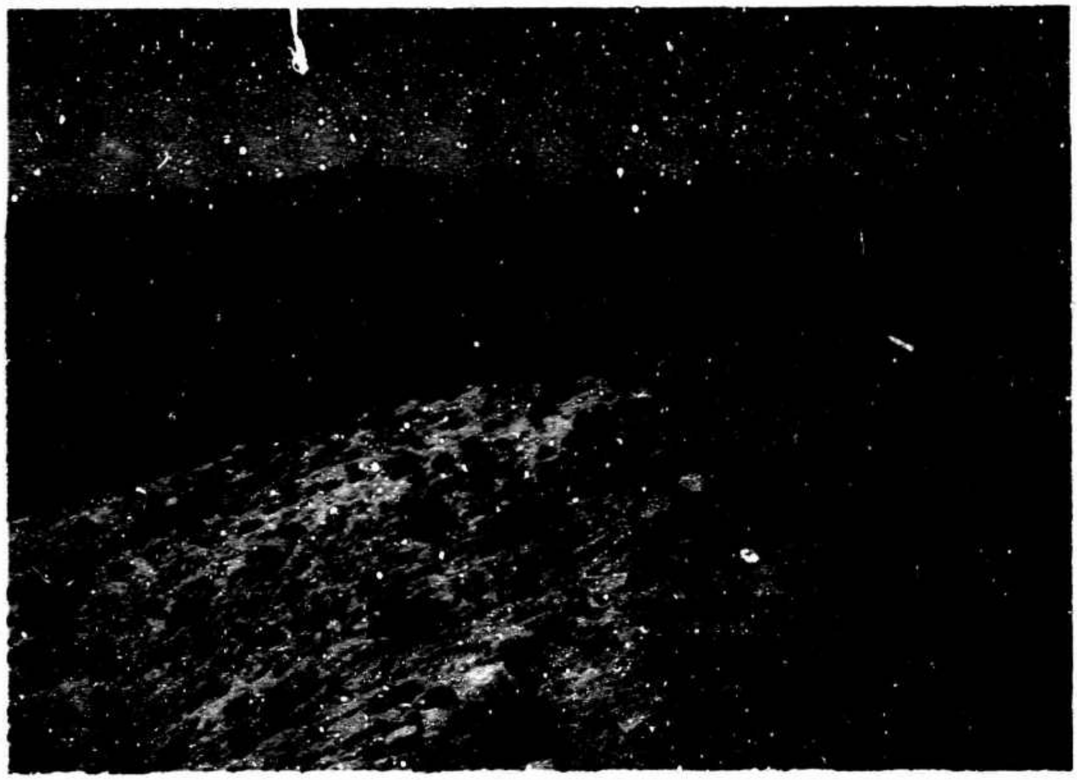
1
2
MILES

WINTER



SUMMER

Site 8

Location: Granite Pass (between the Granite and Providence Mountains). Lat. N 34°49′, Long. 115°27′ W. Elevation: 4060′. Camera azimuth: 040°. Mean annual precipitation: 8 inches.

Area Description: The southern end of the Providence Mountains is viewed across Granite Pass (4024 feet), from a site on the northeast slopes of the Granite Mountains. Vegetation on the alluvial surfaces shown here is similar in appearance to that at lower elevations, although buckwheat *(Eriogonum polifolium)* is becoming abundant. Approximate vertical distribution of the buckwheat association spans the 2800 to 6000 foot range, varying with exposure and surface material (Gaines, 1956). This is a zone intermediate between the creosotebush-bursage association below and the black bush and piñon association above. The transition from creosotebush-bursage to buckwheat is gradual and even in this landscape, where the low buckwheat is considered dominant, the larger, dark green creosotebush growth appears more prominent. Scattered Mojave yucca *(Yucca mohavensis)* also is visible in the foreground of these photographs. When the winter-summer contrasts in vegetation color, as illustrated here, are compared with those at lower levels (exclusive of stream-bed vegetation), summer growth appears to be much greener at the higher elevations. This difference probably can be accounted for by the greater incidence of summer convectional precipitation along the upper slopes of mountain ranges. Essentially a study of selected basin vegetation, this report does not purport to illustrate seasonal variations in the many associations in the uplands and mountains. In the Providence Mountain area alone, Gaines (1956) identifies eleven major and six minor associations of vegetation.

ATMOSPHERIC CONDITIONS RECORDED AT THE TIME OF EACH VISIT

	Winter	Summer
Date	9 Dec 1963	19 Sep 1967
Hour (PST)	1245	1530
Temperature	50°	77°
Dewpoint	29°	63°
Relative humidity	44%	23%
Wind speed & direction	SW 15 mph	S 12 mph
Sky cover	3/10 cu	1/10 ci 2/10 ni st 2/10 cu

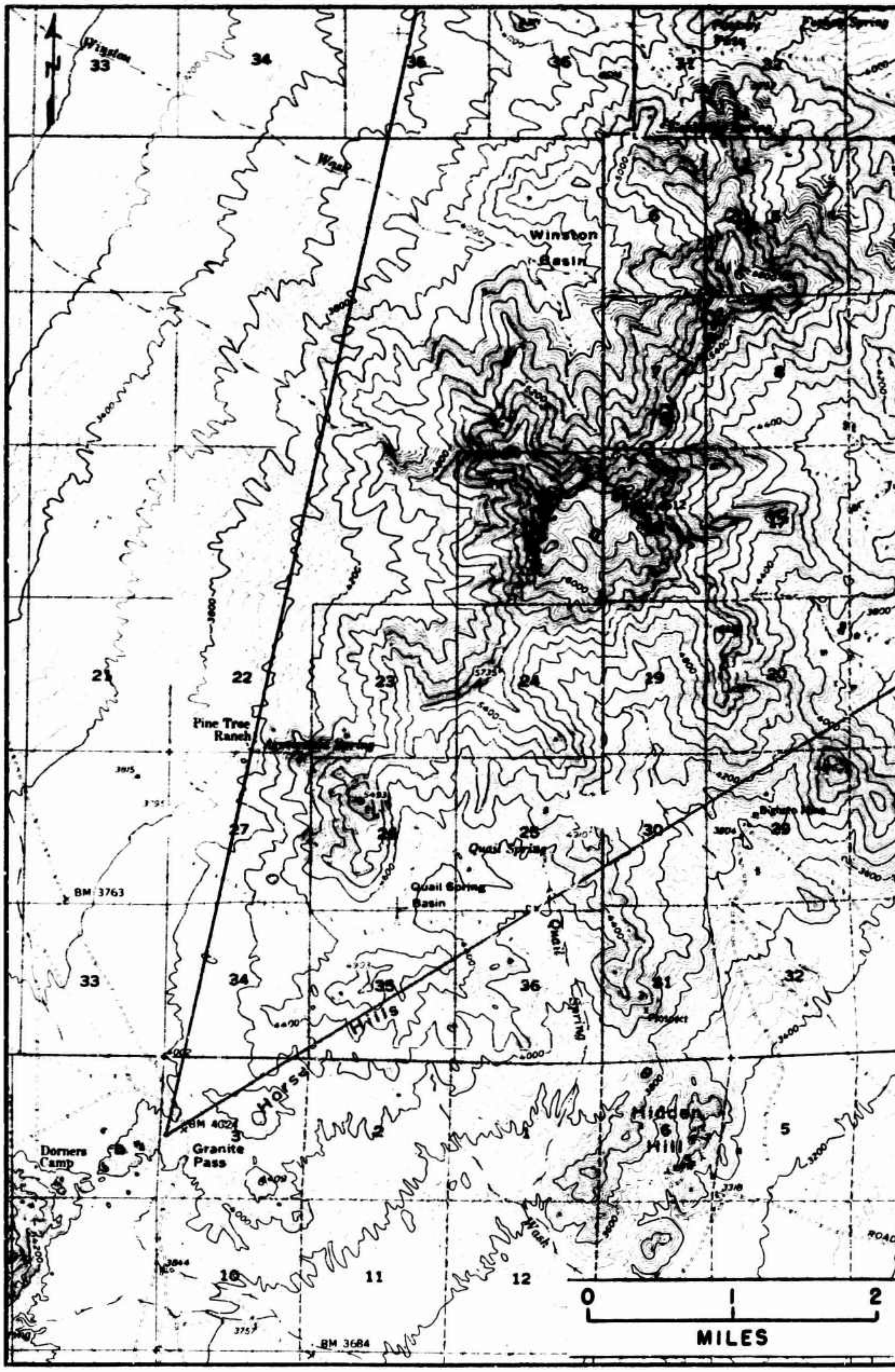
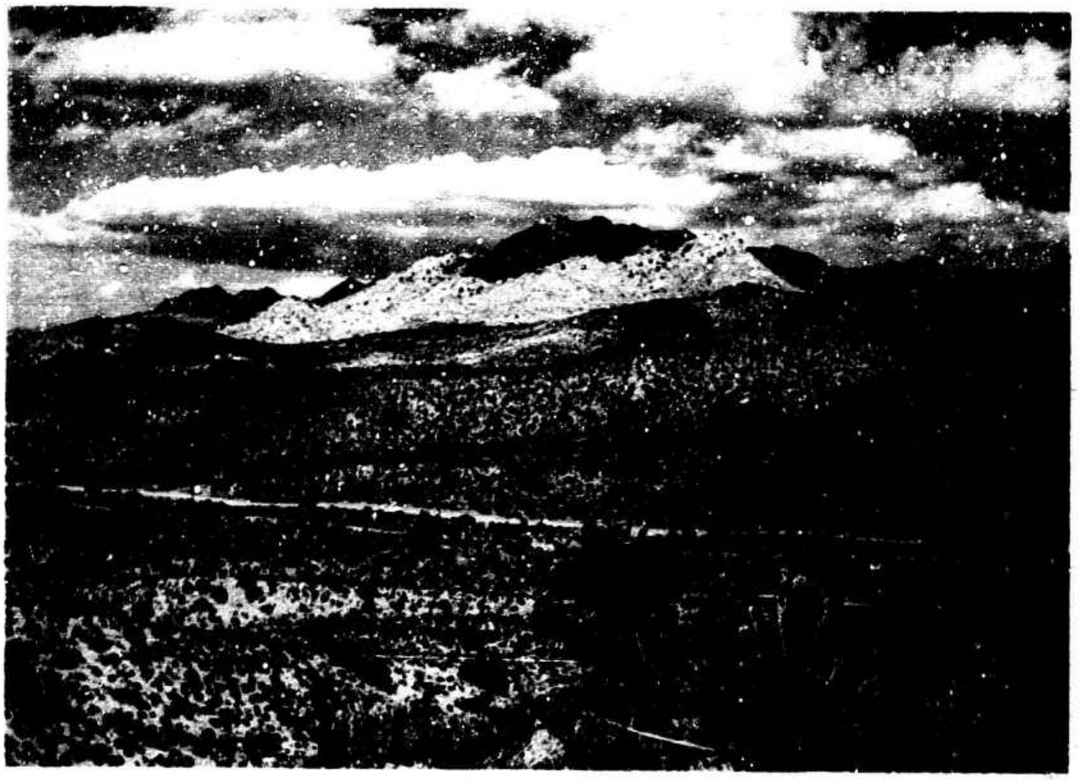
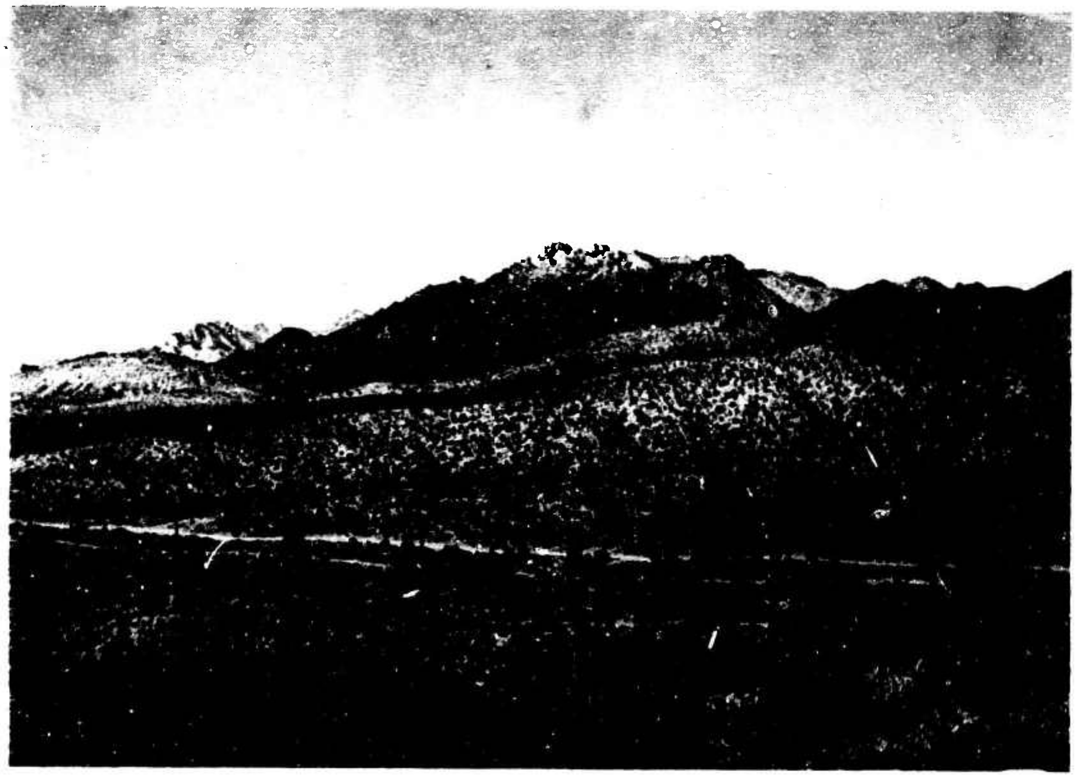

Winston Basin
Pine Tree Ranch
Quail Spring
Quail Spring Basin
Horse Hills
Hidden Hill
Dorners Camp
Granite Pass
BM 3763
BM 4022
BM 3684
0 1 2
MILES
ROAD

PLATE 8

WINTER



SUMMER



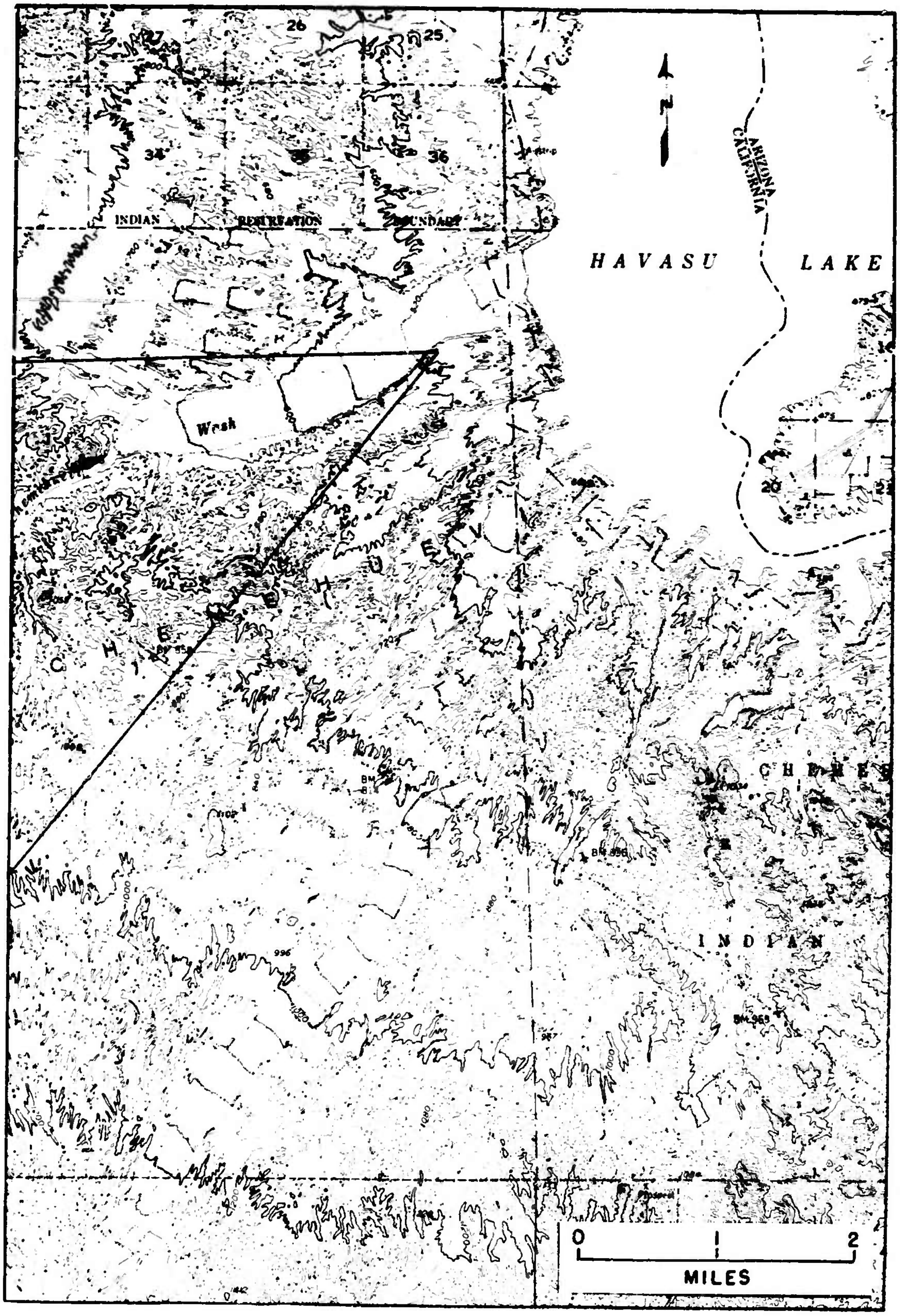
Site 9

Location: Chemehuevi Wash, Chemehuevi Valley, one mile west of Havasu Lake (Colorado River). Lat. N 34°28′, Long. 114°25′ W. Elevation: 640′. Camera azimuth: 240°. Wash gradient: 80′/mile. Mean annual precipitation: 5 inches.

Area Description: An ephemeral tributary of the Colorado River, Chemehuevi Wash is representative of broad desert stream beds which are not deeply abraided, and which display comparatively dense vegetation. For a distance of three miles upstream from the Colorado River this wash is approximately one-half mile in width, and has a gradient of about 80 feet per mile. Viewed here from a point 50 feet above the wash, seasonal color differences in the dominant vegetation, smokethorn *(Dalea spinosa)*, are quite evident. As in other environments where ground water is available, the growth is most luxuriant in summer. Branching of the smokethorn is so dense that even when leafless it significantly restricts surface-to-surface visibility. Although not affording complete ground cover from the air, its branching characteristics and 10-to-12 foot height could provide considerable protection from aerial surveillance. Use of camouflage would substantially augment the concealment afforded by this natural cover. Any vehicle with a capability for over-sand mobility could operate on a wash of this type when the surface is not inundated or the sub-surface saturated by periodic flooding.

ATMOSPHERIC CONDITIONS RECORDED AT THE TIME OF EACH VISIT

	Winter	Summer
Date	10 Dec 1963	20 Sep 1967
Hour (PST)	1000	1015
Temperature	51°	98°
Dewpoint	34°	49°
Relative humidity	50%	19%
Wind speed & direction	E 5 mph	SE 6 mph
Sky cover	2/10 cu & st cu	2/10 cu



HAVASU
LAKE
ARIZONA
CALIFORNIA
INDIAN
RESERVATION
BOUNDARY
Wash
INDIAN
0
1
2
MILES

WINTER

SUMMER

7 Conclusions

The use of time-lapse photography as a tool for analyzing seasonal changes is relatively new. A pilot study, undertaken in 1967 by the author, concerned the New England region, an area noted for its marked seasonality.

Techniques of the pilot study have been applied to an arid region with the realization that visibly apparent seasonality is considerably less in a climate where vegetation is generally sparse. The findings in this report, however, reveal that even in a region classified as extremely arid (Death Valley) there is sufficient plant growth and seasonal change to be recognizable in a study of this type. In the New England region the period of vegetation dormancy is coincident with the winter season, a time of restricted growth for all plant life. In the Mojave Desert, where winter temperatures are much less severe, periods of dormancy vary for different plants and are related more to adaptations of root and stem systems to available moisture than to annual temperature regimes. This is brought out through a comparison of the seasonal characteristics of shallow-rooted plants of the alluvial surfaces and deep-rooted plants associated with dry washes and other locations where there is more moisture available.

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