THE PRESETTLEMENT VEGETATION

OF THE CALIFORNIA DESERT

June 1980

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W. Geoffrey Spauling
College of Forest Resources

.        and

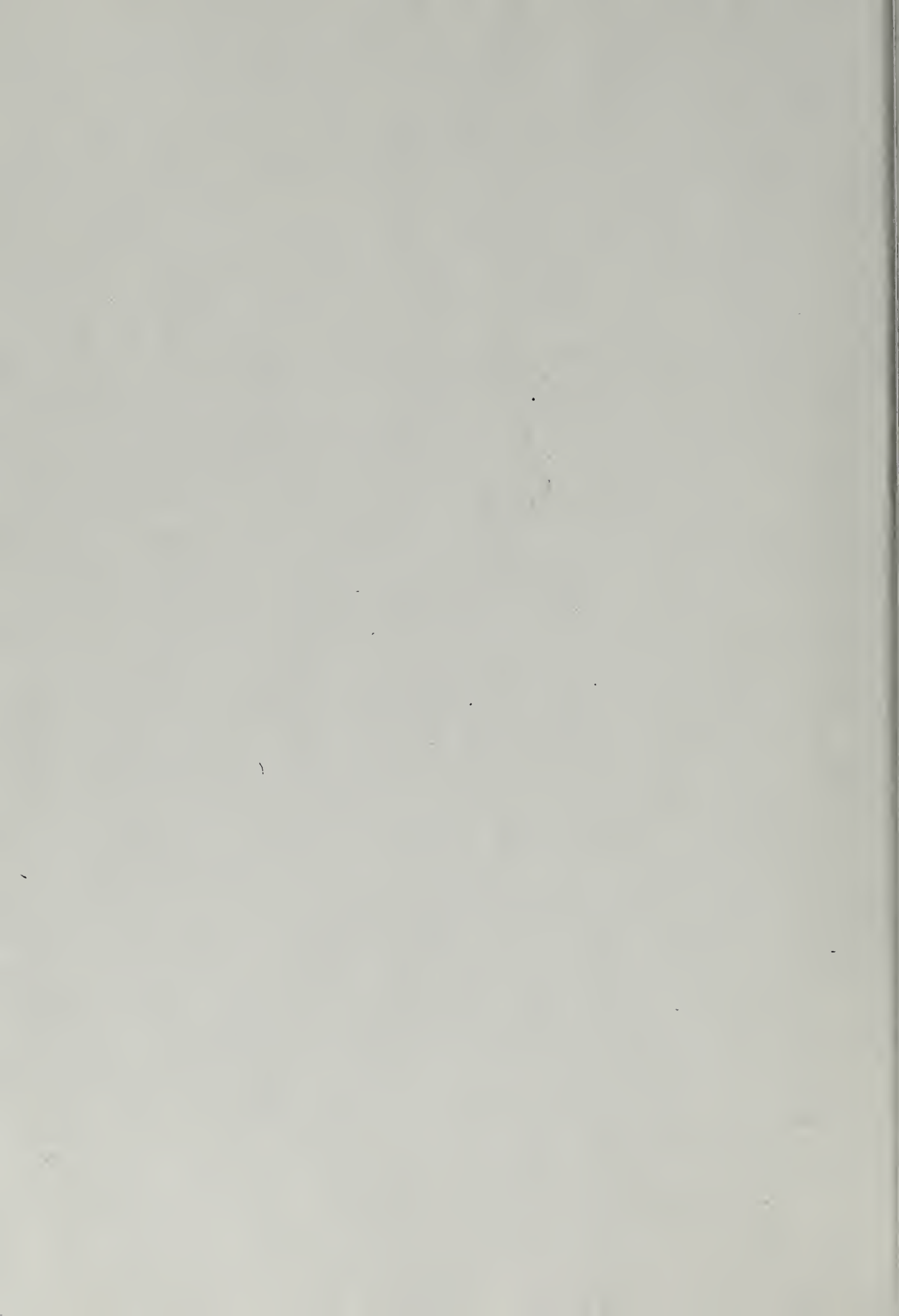Quaternary Research Center
University of Washington
Seattle, Washington  98195

for

THE PRESETTLEMENT VEGETATION

OF THE CALIFORNIA DESERT

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BY

W. Geoffrey Spaulding
College of Forest Resources
and
Quaternary Research Center
University of Washington
Seattle, WA  98195

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INTRODUCTION

The biotic provinces of North America, as we know them now, are
relatively recent developments. The environment of the last Ice Age
was drastically different than today's and, during that time, the dis-
tribution and composition of natural communities differed correspondingly.
For at least the last million and a half years, a period known as the
Pleistocene, the global climate has alternated between long glacial and
shorter interglacial intervals. At least six glacial to interglacial
cycles have occured in the last half million years. The average length
of the cold, glacial periods exceeds 50,000 years while that of the
warmer, interglacials is less than 15,000 years. Superimposed on these
long term oscillations are fluctuations of shorter frequency and lower
amplitude. The climate of the present interglacial, the Holocene,
has been subject to frequent changes of relatively low intensity (Imbrie
and Imbrie 1980; Turekian 1971; Wright 1976; Davis 1976).

The last shift in global environment from an Ice Age to the
warmer climate that we enjoy today occured between 14,000 and 8,000
years ago. One result was the last major episode of plant species
migration and the ultimate segregation of those species into plant
communities of modern aspect. In the strict biogeographic sense, the
Mojave Desert has existed for only the last 8,000 years or so. The
regional vegetation and climate of the preceding Wisconsin glacial age
was different. Hence, at the outset, we are presented with the fact
that the ecosystems under scrutiny in the California Desert Conservation
Area (CDCA) are subject to low frequency perturbations of sufficient
amplitude to alter their aspect considerably. The desert-adapted

-1-

plants and animals being studied are subject to, and are the product of,
selective pressures exerted by a long series of major environmental
changes. This study examines the impact of the last such change, the
end of the Wisconsin Glacial Age, on vegetation of the present Mojave
and Colorado (northwestern Sonoran) Deserts (Fig. 1). The development
of postglacial desertscrub (sensu Brown and Lowe 1974) vegetation
through the last 8,000 years is also discussed.

## METHODS

Paleoecological reconstruction depends upon a reliable source
of fossil material. In temperate regions depositional basins such as
lakes and bogs yield well preserved organic remains. Sites such as
these can provide stratigraphically continuous records of vegetation
that stretch back tens of thousands of years. However, sedimentary
deposits containing well preserved organic remains are scarce in the
deserts of North America.

In the early 1960's a new paleoecological tool was introduced
(Wells and Jorgensen 1964; Wells 1976) and its use has shed a great
deal of light on the biotic history of arid North America. Packrat
(Neotoma spp.) midden analysis (paleonidology) is the reconstruction
of past vegetation using the mummified plant remains gathered and
secreted in rock crevices and caves by packrats. The habit of col-
lecting massive amounts of vegetation and constructing a dwelling
with that debris is a generic trait of this cricetid rodent (Finley
1958; Van Devender 1973). Within a packrat stickhouse or den there
are various functionally specific areas including nesting chambers,

Figure 1.   The California desert and adjacent areas.   Subdivisions of

the CDCA defined by the California Bureau of Land Management,

Desert Planning Staff.   A dashed line delimits the Colorado

(Sonoran) and Mojave Deserts.   EV, Eureka Valley; MM, Marble

Mountains.   Other fossil sites are: 1, Funeral Range; 2, Kofa

Mountains; 3, Lower Grand Canyon; 4, Lucerne Valley and vici-

nity; 5, southern Nevada Test Site; 6, Newberry Mountains;

7, New Water Mountains; 8, Ord Mountain; 9, Owl Canyon; 10,

Picacho Peak; 11, Scodie Mountains; 12, southeastern Sheep

Range; 13, western Sheep Range; 14, Titus Canyon, Inyo Moun-

tains; 15, Turtle Mountains; 16, Wellton Hills; 17, Whipple Mts.
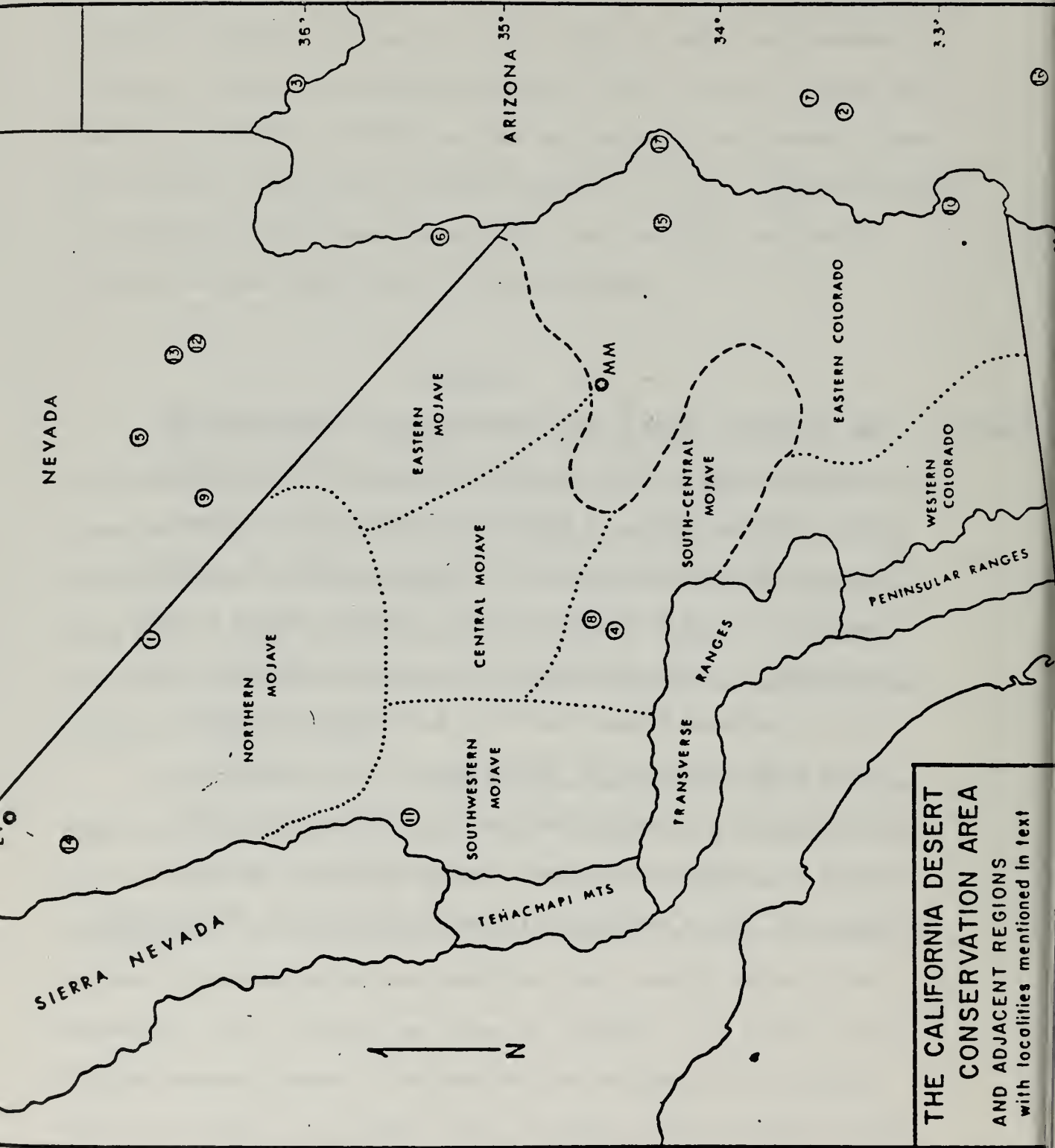
THE CALIFORNIA DESERT
CONSERVATION AREA
AND ADJACENT REGIONS
with localities mentioned in text

food caches, and trash middens. Vegetable debris from the latter areas
is the focus of this study. In rocky habitats packrats often live in
rock shelters or crevices, using the naturally occuring shelter to
augment that provided by their den. Middens often serve as urination
and defecation points and the vegetable debris in sheltered middens fre-
quently becomes cemented in a matrix of crystalized urine (amberat).
These dessicated masses of plant debris, encased in rock-hard amberat,
occur in cavities in the hills and mountains of the North American deserts.
Middens that are protected in a rock shelter may persist as long as the
shelter lasts. Cavities in slow weathering rock types have yielded
middens and associated paleobotanical data for the last 50,000 radio-
carbon years. Ancient middens normally have a thick weathering rind
composed of degraded midden debris, adhering dust, and packrat urine.
Amberat is hygroscopic, it absorbs water from the air during periods
of high atmospheric humidity and, during such times, becomes partially
fluid again. Fresh breaks in a midden are quickly sealed by a new
layer of amberat drawn by capillary action from the interior of the
midden. With time, the amberat becomes convoluted and takes on the
aspect of the original weathering rind. This self-sealing contributes
to the long-term viability of fossil middens.

Several factors combine to make packrat midden analysis a power-
ful paleoecological tool. The most striking is the near perfect pre-
servation of leaves, flowers, seeds, and other delicate plant parts
that may be tens of thousands of years old. Given an adequate reference
collection, more than 60% of the fossil taxa in a midden can be iden-
tified to the species level. Packrats are comprehensive collectors of

vegetation within their limited (generally less than 30 m; Stones and Hayward 1968; Bleich and Schwartz 1975) home range. Modern middens invariably contain all the plants that are common at a site as well as most of the uncommon and rare species. Age determination of fossil middens is achieved through radiocarbon dating.

Field Techniques. Field searches for midden sites were made along outcrops of shelter forming rocks, particularly along cliff bases. Carbonaceous sediments and certain igneous rocks yield ancient middens for this study. Shelters that contain fossil packrat middens occur only in rocky habitats and this study is necessarily restricted to rocky slope vegetation.

Once a midden is located its position in the shelter and exposed stratigraphy is carefully examined. Ancient middens that appear complex or jumbled, without easily discernable layering, are disregarded. Any indurated midden with a heavy weathering rind and of uncomplicated aspect is considered suitable for sampling. The weathering rind is removed from selected middens and they are again examined for evidence of multiple layering. Samples from individual midden units are removed with a hammer and cold chisel or crowbar and carefully wrapped. A list of all the plants occuring within 30 m of the midden site is made. The distribution of plant communities, principal species, and their relationships to the mosaic of available habitats is noted for the entire locality. The quantitative relationships between dominance of species in a plant community and importance of plant fragments in a midden are poorly understood. Quantitative data gathered on packrat midden site vegetation is restricted to qualitative ordinations of abundance.

Laboratory Techniques. Once in the lab midden samples are thoroughly cleaned of weathering rind and other contaminants that adhere to their surfaces. They are then placed in a bucket of water to disolve the amberat and release the plant fragments. The resultant wet mass is poured from the bucket through a nested pair of six mesh (3.35 mm) and 20 mesh (0.84 mm) soil sieves and flushed with water. The captured material is dried and the identifiable plant fragments, bones, etc.... are sorted into plastic vials. The plant fragments are examined under moderate magnification and compared with modern reference specimens. A list is compiled with estimates of the relative abundance of each plant taxon in the fossil assemblage.

Data Treatment. Possible relative abundance values for the fossil plants in a midden sample range from 5 (very abundant), to 4 (abundant), to 3 (common), to 2 (occasional), to 1 (rare), to 0 (one or two fragments, a possible contaminant). The lowest number of fossil taxa (N) in any macrofossil assemblage in this study is 8, the greatest number recorded is 33. The total number of woody perennials, excluding grasses, ($N_p$) in each macrofossil assemblage is presented as well as the percentage of woody perennials ($N/N_p$ x 100). Similarity indices (IS) are used to express the percentage of shared taxa between the macrofossil assemblage and the plants at the site today. The similarity index chosen for this study is that proposed by Sorensen (1948; Mueller-Dombois and Ellenberg 1974) and takes the form :

$$IS = \frac{2\ c}{A + B}\ x\ 100$$

where A is the total number of species (N) noted within 30 m of the midden

site, B is the total number of species occuring in the midden sample,
and c is the number of plants common to both the modern vegetation and
the midden sample. Possible values range from 0 (no species in common)
to 100 (all species shared) although test comparisons between recent
middens and the surrounding plant community have failed to yield IS
values greater than 85. Invariably there seem to be a few plants in the
midden that were not noted on the field list, and a few noted on the
list that are not found in the midden debris.

Age Determination. I prefer to use a single extralocal plant
species from a midden sample for radiocarbon ($^{14}$C) dating. This method,
suggested by Van Devender (1977a) , is desirable since the date is di-
rectly associated with at least one plant species and there is no chance
of contamination by recent plant debris. But desertscrub middens frequen-
tly lack sufficient mass of any one species to radiocarbon date. Many
of the age determinations used for this study are on undifferentiated
twigs or packrat fecal pellets. Whatever the material dated, in the
absence of discordant multiple dates and given a favorable stratigraphic
setting, it is assumed that the $^{14}$C date reflects the age of the entire
macrofossil assemblage. A $^{14}$C date is expressed as a mean date with a
standard deviation reflecting various uncertainties including background
radiation at the counter, sample size, counting time, number of counts,
etc.... (Long and Rippeteau 1974; Sheppard 1975).

A Chronological Framework. Packrat midden analysis is used to
study late Quaternary climates but, for the purpose of this vegetation
analysis, the chronology of climatic change, as it is known, is presented
first. The chronological divisions of the latest Wisconsin and early

Holocene follow those presented by Van Devender and Spaulding (1979)

and Phillips (1977). The latest Wisconsin (Stage III of Phillips 1977)

extends from ca. 14,000 B.P. (radiocarbon years before present) to

ca. 11,000 B.P. and is the waning phase of the last Ice Age. The start

of the early Holocene at ca. 11,000 B.P. is marked by the retreat of

many mesophytic species from the interior basins of the southwestern .

United States (Van Devender and Spaulding 1979; Martin and Mehringer

1965). The extirpation of pinyon pines from the low elevation wood-

lands of the present Chihuahuan, Sonoran, and Mojave Deserts was a near

synchronous event at ca. 11,000 B.P. (Van Devender and Spaulding 1979).

The early Holocene, persisting to ca. 7800 B.P. (Stage IV of Phillips

1977), was a time of transition characterized by an increasingly xeric

climate. Desertscrub species assume gradual dominance throughout this

period, culminating at ca. 7800 B.P. with the disappearance of the last

of the woodland plants (Van Devender 1977b, Phillips 1977). The middle

Holocene bioclimatic phase begins at this time and terminates ca. 3700 B.P.

At about this time in the White Mountains at the northern border of

the CDCA upper tree line retreats dramatically (La Marche 1973, 1974).

The White Mountains record of higher spring through autumn temperatures

during the middle Holocene supports Antevs' (1948, 1955) concept of an

Altithermal climatic phase in this region. Martin (1963) suggests that

the middle Holocene may have been a period of increased summer preci-

pitation in the monsoonal Southwest. This hypothesis is not inconsistent

with a climate characterized by increased warm season temperatures and,

perhaps, increased dryness in the Great Basin Desert. The late Holocene, .

from ca. 3700 B.P. to present, appears in the White Mountains chronology

(La Marche 1973, 1974) to be a time of generally cooler temperatures.
There is evidence for a more mesic late Holocene climatic regime in
pollen and packrat midden data from the northern Mojave and southeastern
Great Basin Deserts of Nevada (Spaulding 1977, unpub.; Madsen 1973).

## THE STUDY AREA

The fossil plant data from two areas, one at the southern boun-
dary of the Mojave Desert and one in the northern Mojave Desert, are
the basis for this study. The significance of other fossil sites in
the vicinity is also discussed. Climatically induced changes in plant
species distribution and abundance may be more pronounced in boundary
region vegetation where more species are at the limits of their habitat
tolerance. Hence, the two main study areas were selected to be near
the biotic boundaries of the Mojave Desert.

The southern limit of the Mojave Desert is gradational and poorly
defined. Describing the borders of the Colorado and Mojave subdivisions
of the CDCA, the floristic boundary is defined by the decreasing number
and importance of species adapted to a bimodal, winter-summer precipi-
tation regime (Fig. 1; Shreve and Wiggins 1964; Hastings et al. 1972).
Plants such as <u>Dalea</u> <u>spinosa</u>, <u>Beloperone</u> <u>californica</u>, <u>Cercidium</u> <u>floridum</u>,
<u>Fouquieria</u> <u>splendens</u>, <u>Hyptis</u> <u>emoryi</u>, and <u>Simmondsia</u> <u>chinensis</u> occur in
the Sonoran Desert (of which the "Colorado Desert" is but a subdivision)
to the south and east. In this southerly region summer rainfall comprises
not only a significant percentage of the annual total but is also pre-
dictable. The staggered distribution limits of these monsoonal-adapted
species form the biogeographic criteria for the southern Mojave boundary.

In contrast, the Mojave Desert's northern boundary is based on the limits of one species, Larrea tridentata (creosote bush), and is correspondingly well defined.  A shrub that is ubiquitous in the warm deserts of North America, the northern limit of Larrea tridentata is controlled by minimum temperatures (Beatley 1974, 1975) and defines both the northern limit of the Mojave Desert and the southern boundary of the Intermountain Region (Cronquist et al. 1971).

The Marble Mountains

The Marble Mountains trend from northwest to southeast and lie at the northern end of the Cadiz Valley (ca. Lat. 34°40' N, ca. Lon. 115°35' W).  The mountain range is immediately south of the juncture of the southern limits of the Central and Eastern Mojave subdivisions of the CDCA (Fig. 1).  Where the mountain slopes meet the bajada elevations range from ca. 300 m (1000 ft) in the south to ca. 920 m (3000 ft) at the northern terminus (Fig. 2).  Castle Peak at 1170 m (3842 ft) is the highest point in the Marble Mountains and the majority of the range lies below 900 m (2950 ft) elevation.

Marble Mountains Locality A.  Near the Iron Hat Mine in the southwestern Marble Mountains (Fig. 2) is an area of steep limestone slopes and ledges designated Locality A (Cadiz, CA, 15' quadrangle: T6N, R14E, NW¼, NW¼, Sec. 19).  These limestone outcrops provide anomalous habitats in a mountain range of Tertiary (?) rhyolite, rhyolitic breccia, and associated volcanic rocks.  The sere south to southwest facing slopes, from 365 m to 490 m (1200 ft to 1600 ft) elevation, support widely scattered vegetation.  The only common shrubs on the rocks are Encelia

Figure 2. The Marble Mountains study area. The Marble Mountains 1, 2 and 3 sites are at Locality A, the MM 4 and 5 sites at Locality B, and the MM 6, 7, and 9 sites at Locality C.

Locality B

Locality C →

2800

2400

3200

34° 40′ —

2000

1600

34° 35′ —

Locality A

800

115° 35′

Chambless

66
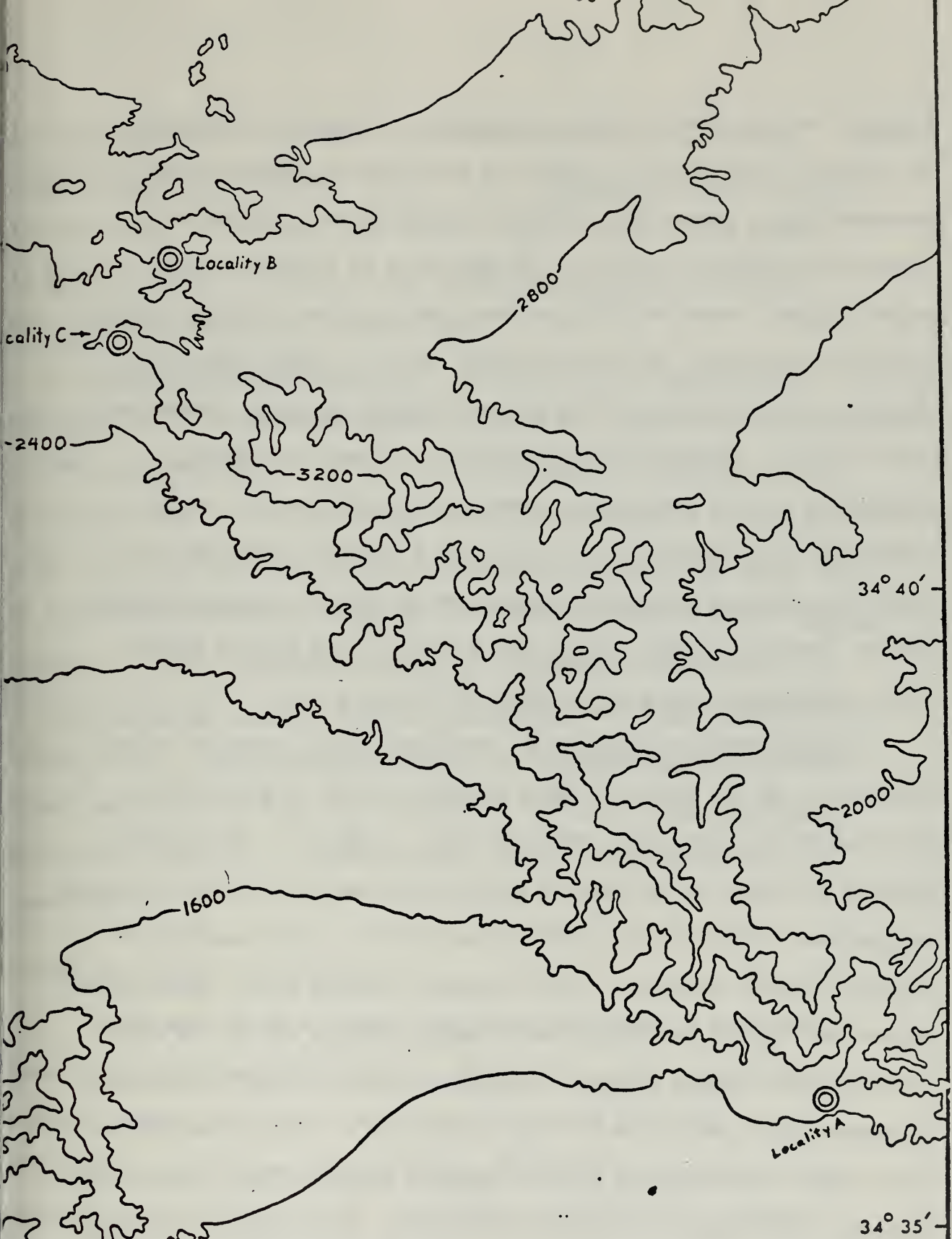
MARBLE MOUNTAINS
STUDY     AREA

2        3            4 mi

2     3     4     5 km

Contours at 400 feet
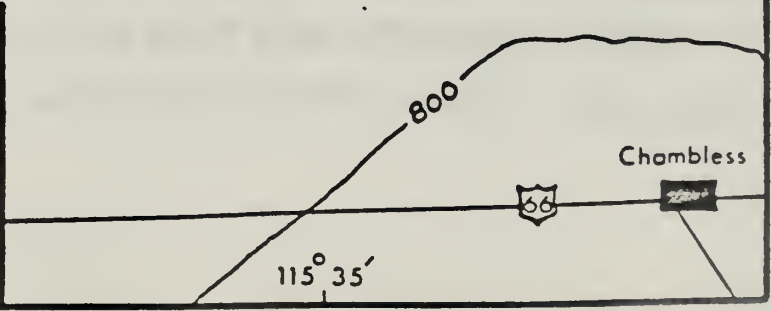
farinosa (brittle bush), Larrea tridentata, and Salvia cf. funerea,
the latter occuring ca. 275 km (165 mi) southwest of its main range in
the Death Valley region (Munz 1974). Its restricted occurence on
calcareous substrate in the Iron Hat Mine area is a hitherto unre-
ported disjunct record of this species. Cacti in the vicinity include
Ferocactus acanthodes (California barrel cactus), Echinocactus poly-
cephalus (cotton-top barrel cactus), and Opuntia basilaris (beavertail
prickly pear). Pleurocoronis pluriseta (arrow leaf) and Physalis
crassifolia (ground cherry) are common at the cliff bases. In the
more mesic canyon bottoms and on the upper bajada away from the rocky
slopes such species as Ambrosia dumosa (white bursage), Hyptis emoryi
(desert lavender), Bebbia juncea (sweet bush), Dalea spinosa (smoke
tree), and Peucephyllum schottii (desert spruce) occur.

Marble Mountains Locality B. This area in the northern Marble
Mountains is at the head of a small canyon ca. 3 km (1.8 mi) east of
the Brown Buttes (T7S, R13E, NW¼, SE¼, Sec. 7; Fig. 2). The locality
presents southwest to west facing talus slopes and cliffs with elevations
varying from 850 m to 915 m (2800 ft to 3000 ft). The substrate of
rhyolitic breccia supports well developed creosote bush - brittle bush
vegetation. Trails and dung piles indicate moderate use of the area
by feral burros (Equus asinus), particularly under the cliff overhangs.
The vegetation is more diverse than at Locality A. Shrubs occuring on
these slopes include Bebbia juncea, Ambrosia dumosa, Hyptis emoryi, and
Eriogonum fasciculatum (California buckwheat). Pleurocoronis pluriseta
and Physalis crassifolia again occur at the cliff bases along with Ditaxis
lanceolata. The cacti at this locality are Ferocactus acanthodes,

Opuntia basilaris and, in more open habitats away from the cliffs,
Opuntia ramosissima (diamond cholla) and O. echinocarpa (golden cholla).
The mesic wash bottoms and upper bajada habitats support such shrubs
as Acacia greggii (catclaw acacia), Lycium californicum (boxthorn),
and Brickellia desertorum (brickel bush).

Marble Mountains Locality C. Locality C is 2.4 km (1.5 mi)
southeast of the Brown Buttes and 1.4 km (0.9 mi) southwest of Locality
B (T7N, R13E, SW¼, NW¼, Sec. 18). It is an area of cliffs and talus
slopes about 100 m above the bajada at ca. 865 m (2840 ft) elevation
(Fig. 2). The slopes are derived from rhyolitic breccia and their south
to southwest facing aspect produces particularly xeric habitats. Encelia
farinosa, Larrea tridentata, and Ambrosia dumosa are codominants here
with Peucephyllum schottii, Lycium californicum, and Bebbia juncea being
common shrubs. Pleurocoronis pluriseta and Ditaxis lanceolata are occa-
sional smaller perennials. A few isolated plants of Yucca schidigera
may be seen about half a kilometer away in mesic wash habitats of the
upper bajada.

The Eureka Valley And Vicinity

An unnamed series of hills that trends northwest to southeast
rims the northeastern Eureka Valley. They form a nearly continuous
highland connection from the north end of the Inyo Mountains to the
northwest end of the Last Chance Range. The hills are upthrust on the
west side of the Furnace Creek Fault Zone and also form the southwest
border of the Fish Lake Valley (Fig. 3). Horse Thief Canyon runs through
the center (Lat. 37°22' N, Lon. 117°50' W; Soldier Pass, CA.-NV., 15'

Figure 3.   The Eureka Valley study area.   EV, Eureka View; HTH, Horse
Thief Hills.

S FISH LAKE VALLEY

117° 50'

Sylvania Mts

6400

HTH A

HTH B

5200

° 20'

4000

EV

Last Chance Range

# EUREKA VALLEY
## STUDY AREA

| 1 | 2 | 3 mi |

| 1 | 2 | 3 | 4 km |
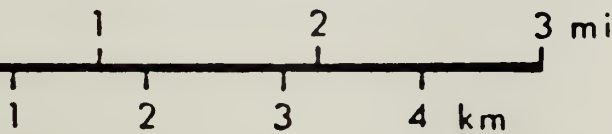
Contours at 400 ft

quadrangle) of this mountain mass and, for the purpose of this study, lends its name to the Horse Thief Hills. The northern limit of _Larrea tridentata_ and, by definition, the northern boundary of the Mojave Desert lies in the Horse Thief Hills. Creosote bush has been noted as far north as the upper Willow Wash Canyon on south facing alluvial slopes at ca. 1635 m (5360 ft) elevation. Elevations in the Horse Thief Hills range from ca. 1430 m (4700 ft) at their southern terminus to 1990 m (6520 ft) near their northern end at Sugarloaf Mountain. Most of the topography lies below ca. 1710 m (5600 ft) elevation. The roughly 1000 m gain in elevation from the Marble Mountains at the north end of the Cadiz Valley (Lat. 34$^{\circ}$40' N) to these hills at the northern end of the Eureka Valley (Lat. 37$^{\circ}$22' N) reflects a general physiographic trend in the Mojave Desert. The increase in base level with increasing latitude is an important factor controlling the northern extent of Mojavean flora (Beatley 1974, 1975). To the north, the next higher tier of valleys (Deep Springs, Fish Lake) have, at least as far as winter months are concerned, Great Basin temperature regimes that effectively exclude many warm desert species, such as _Larrea tridentata_.

Horse Thief Hills Locality A. This area of rugged dolomitic cliffs and talus slopes, outcrops of the Bonanza King Formation (McKee and Nelson 1967), forms the south wall of Willow Wash (Fig. 3). Elevations range from 1585 m to 1645 m (5200 ft to 5400 ft) on these north and east facing slopes that are less than half a kilometer southwest of the foot of the Sylvania Mountains (T7S, R38E, SE¼, NW¼, Sec. 10). _Atriplex confertifolia_ (shadscale) and _Chrysothamnus viscidiflorus_

(rabbit brush) are the most frequent plants on the calcareous slopes. Other shrubs that are common in the diverse mixed desertscrub vegetation include *Ephedra nevadensis* (Mormon tea), *Eurotia lanata* (winter fat), *Eriogonum heermannii*, and *Tetradymia axillaris* (horsebrush). *Symphoricarpos longiflorus* (snowberry), *Ephedra viridis* (joint-fir), *Cercocarpus intricatus* (littleleaf mountain mahogany), *Hecastocleis shockleyi* (Mojave prickle-leaf), and *Forsellesia nevadensis* (greasebush) occur in mesic habitats. Xeric species such as *Dalea fremontii* (indigo bush), *Artemisia spinescens* (bud-sage), *Encelia virginensis* (rayless encelia), *Menodora spinescens* (groundthorn), and *Acamptopappus sphaerocephalus* (goldenhead) occur on the xeric exposures. Creosote bush appears restricted to the alluvial slopes of Willow Wash, only one plant was noted on the hills above. This also seems to be the case with *Yucca brevifolia* (Joshua tree). It is scattered on the xeric exposures of Willow Wash Canyon but not on the bedrock slopes.

   *Horse Thief Hills Locality B.* This low series of hills juts out from the floor of Willow Wash, equidistant between the Horse Thief Hills to the southwest and the Sylvania Mountains to the northeast (T7S, R38E, SW¼, SW¼, Sec. 11; Fig. 3). With a maximum elevation of 1575 m (5160 ft), it rises only 25 m above the floor of the wash. Metamorphosed siltstone and shale of the Campito (?) Formation (McKee and Nelson 1967) support a relatively sparse desert community dominated by *Atriplex confertifolia*. *Dalea fremontii*, *Hymenoclea salsola* (cheeseweed), and *Ephedra nevadensis* are occasional on these shadscale dominated west facing slopes. *Larrea tridentata* and *Yucca brevifolia* occur sporadically on the alluvial fan below.

The Eureka View Locality.  These midden sites are at the extreme southern end of the Horse Thief Hills (T7S, R38E, S½, NW¼, Sec. 23; Fig. 3).  The locality is named for the spectacular view from these walls that tower above the northeast end of the Eureka Valley.  South facing slopes of limestone and dolomites of the Bonanza King Formation, from 1390 m to 1555 m (4560 ft to 5100 ft) elevation, provide a rugged habitat of ledges and talus slopes.  Atriplex confertifolia and Larrea· tridentata share dominance in the surprisingly diverse desertscrub communities occuring here.  Amphipappus fremontii (chaff-bush) and Eriogonum fasciculatum are subdominants at this locality while Brickellia arguta (brickel bush), Erioneuron pulchellum (fluff grass), Stipa sp. (perhaps S. arida, Mormon needlegrass), Haplopappus brickellioides, and Nicotiana trigonophylla (tobacco) are rather common on these slopes.  Viguiera reticulata occurs infrequently, as does Ephedra nevadensis, Ambrosia dumosa, and Scopulophila rixfordii.  Encelia virginensis is restricted to the west facing wall of a nearby  canyon that dissects a large talus slope.  With the exception of Echinocactus polycephalus, cacti do not occur on these rock exposures.  Opuntia basilaris and O. echinocarpa are scattered on the alluvial fan, ca. 60 m from the nearest fossil site, as is Dalea fremontii.  All three species occur on the upper bajada below Eureka View.  The Eureka Valley bajada supports a well developed creosote bush-white bursage community at elevations exceeding 1220 m (4000 ft), an unusually high occurence of this vegetation type.  In contrast to the Eureka View Locality, the upper bajada substrate is gruss derived from extensive outcrops of quartz monzonite in the Sylvania Mountains and Last Chance Range to the east (McKee and Nelson 1967; Fig. 3).  This may account for the occurence of Atriplex polycarpa

here and its absence on the nearby limestone slopes. Yucca brevifolia, restricted to the Willow Wash and Cucomungo Canyon to the east (Fig. 3), does not occur in this part of the Eureka Valley.

## THE FOSSIL RECORDS

Twenty-six macrofossil assemblages were recovered from 19 ancient packrat middens found near the northern and southern boundaries of the California Mojave Desert. The samples date from the late Wisconsin, the final phase of the last Ice Age, through the Holocene, to the sub-recent. At many localities the midden sites lie in close proximity to one another with similar habitats and vegetation. Where this occurs the species lists from each site are combined in a single table that applies to the entire fossil locality. The fossil sites from Marble Mountains Locality A are considered in one group, those from Localities B and C in another, and the sites from the Eureka View in a third. Only the habitats of the Horse Thief Hills sites varied sufficiently from one another to be considered separately.

The Marble Mountains

The age distribution on the Marble Mountains packrat middens is ideal for the study of early Holocene vegetation dynamics. Six of the 11 midden samples that are dealt with in detail radiocarbon date between ca. 11,000 B.P. and ca. 7800 B.P. (Table 1). These macrofossil assemblages provide data on the transition from early Holocene vege- tation to plant communities of essentially modern aspect.

Marble Mountains Locality A. Three fossil packrat middens pro- vide information on the past ecology of these limestone slopes at

Table 1. Packrat midden sites, samples, and radiocarbon dates from the Marble Mountains, San Bernadino County, California. B.P., radiocarbon years before present; GX, Geochron Laboratories, Cambridge, MA.

| Site & sample no. | Elevation | Primary habitat | Radiocarbon date & (lab. no.) | Material dated |
|---|---|---|---|---|
| LOCALITY A | | | | |
| Marble Mountains 1 | 475 m | SW facing limestone talus and ledges | 3080 ± 165 B.P. (GX-6177) | Neotoma feces |
| Marble Mountains 2 | 465 m | W facing limestone ledges and talus slopes | 10,465 ± 330 B.P. (GX-6178) | Neotoma feces |
| Marble Mountains 3 | 450 m | SE facing limestone talus and ledges | 1465 ± 80 B.P. (GX-6179) | Larrea tridentata twigs |
| LOCALITY B | | | | |
| Marble Mountains 4(2) | 885 m | WSW facing andesitic talus slopes | 9515 ± 185 B.P. (GX-6180) | Neotoma feces |
| Marble Mountains 4(3) | " | " | 1680 ± 150 B.P. (GX-6181) | Miscellaneous twigs |
| Marble Mountains 5(1) | 900 m | SW facing andesitic talus slopes | 10,090 ± 380 B.P. (GX-6182) | Misc. twigs and Prunus fasciculata seeds |
| Marble Mountains 5(1) | " | " | 10,325 ± 350 B.P. (GX-6183) | Neotoma feces |
| Marble Mountains 5(2) | " | " | 4360 ± 210 B.P. (GX-6184) | Miscellaneous twigs |

(cont.)

| Site & sample no. | Elevation | Primary habitat | Radiocarbon date & (lab. no.) | Material dated |
|---|---|---|---|---|
| **LOCALITY C** | | | | |
| Marble Mountains 6 | 840 m | S facing andesitic talus slopes and ledges | 7930 + 285 B.P. (GX-6185) | Miscellaneous twigs |
| Marble Mountains 7(1) | 855 m | SE facing andesitic ledges and talus slopes | 8925 + 360 B.P. (GX-6186) | Miscellaneous twigs |
| Marble Mountains 7(2) | " | " | 4475 + 170 B.P. (GX-6187) | Neotoma feces |
| Marble Mountains 9(1)$_1$ | 860 m | SW facing andesitic talus slopes | 8905 + 265 B.P. (GX-6188) | Juniperus sp. twigs and seeds |
| Marble Mountains 9(1)$_2$ | " | " | 10,555 + 210 B.P. (GX-6189) | Miscellaneous twigs |
| Marble Mountains 9(1)$_2$ | " | " | 7635 + 260 B.P. (GX-6190) | Neotoma feces |
| Marble Mountains 9(2) | " | " | 5520 + 190 B.P. (GX-6191) | Neotoma feces |

ca. 475 m (1560 ft) elevation (Fig. 2). Marble Mountains 2 is the oldest
midden, with a radiocarbon age of 10,465 ± 330 B.P. (GX-6178; Table 1).
The fossil assemblage differs considerably from the present sparse creosote
bush-brittle bush vegetation (Table 2). MM 2 contains higher elevation
desertscrub species and is dominated by Ephedra cf. californica and
Lycium sp. (perhaps L. californicum), neither of which presently occur
near the site. Ephedra californica does occur within 6 km (3.6 mi) on
bajadas as low as 490 m (1600 ft) elevation, but never on the low, bedrock
slopes. Lycium californicum occurs in the Marble Mountains at least as
low as 790 m (2600 ft) elevation on south facing rhyolite slopes. The
leaves of Salvia cf. funerea and S. mohavensis (Mojave sage) occur in
the MM 2 assemblage. The former persists at the site today but the latter
does not. Salvia mohavensis occurs today in mixed desertscrub vegetation
above ca. 1100 m (3700 ft) elevation in the Van Winkle Mountains, ca. 18
km (11 mi) to the north. Not only does this macrofossil assemblage lack
Larrea tridentata and Encelia farinosa, the most important plants at the
site today, but it also lacks the woodland species that are common in
contemporaneous middens from low elevation sites further east.

The Marble Mountains 1 and 3 middens contain late Holocene plant
macrofossils. The former midden has a $^{14}$C date of 3080 ± 165 B.P.
(GX-6177), and the latter, 1465 ± 180 B.P. (GX-6179; Table 1). Both
assemblages contain abundant Larrea tridentata and Encelia farinosa,
the current dominants at the sites (Table 2). Neither suggests appreciable
change in the local vegetation in the last 3100 years except, perhaps,
in the distribution of Bebbia juncea and Peucephyllum schottii. Both

Table 2. Plants from Marble Mountains Locality A. Plant species presently occuring at the sites are designated by an X, dominants by an X. Relative abundance classes for the fossil plant remains are: 5, very abundant; 4, abundant; 3, common; 2, occasional; 1, rare; 0, one or two fragments, a possible contaminant. N, total number of plants; $N_p$, total number of woody perennials, excluding grasses; IS, Sorensen's index of similarity between the fossil assemblage and the modern plant community (using N).

| Species | Marble Mountains 1 (3080 ± 165 B.P.) | Marble Mountains 2 (10,465 ± 330 B.P.) | Marble Mountains 3 (1465 ± 180 B.P.) |
|---|---|---|---|
| Argemone sp. | — | 1 | — |
| Aristida adscencionis (X) | — | — | — |
| Atrichoseris platyphylla (X) | — | — | — |
| Bebbia juncea | 1 | 1 | 1 |
| cf. Camissonia sp. | 1 | 1 | — |
| Chorizanthe brevicornu (X) | — | — | — |
| C. rigida (X) | — | — | — |
| Cryptantha cf. angustifolia (X) | — | — | — |
| Ditaxis lanceolata (X) | — | 1 | — |
| Echinocactus polycephalus (X) | — | — | — |
| Encelia farinosa (X) | 5 | 4 | 3 |
| Ephedra cf. californica | — | 1 | — |
| Eriogonum heermannii | — | — | — |
| Eriogonum cf. trichopes (X) | — | — | — |
| Erioneuron pulchellum (X) | — | — | — |
| Ferocactus acanthodes (X) | 2 | 1 | 1 |
| Gilia sp. (X) | 1 | — | — |
| Hyptis emoryi (X) | — | — | — |
| Langloisia setosissima (X) | — | — | — |
| Larrea tridentata (X) | 3 | 3 | 5 |
| Lycium sp. | — | 3 | — |
| Mentzelia sp. (X) | — | — | — |
| Oligomeris linifolia (X) | — | — | — |
| Opuntia basilaris (X) | 2 | 1 | 2 |
| Opuntia cf. polyacantha | — | 1 | — |
| Peucephyllum schottii | 1 | — | — |
| Perityle emoryi (X) | 1 | — | — |

(cont.)

Table 2 (cont.)

| Species | | Marble Mountains 1 | Marble Mountains 2 | Marble Mountains 3 |
|---|---|---|---|---|
| Phacelia cf. crenulata (X) | | - | - | - |
| Phacelia sp. | | 2 | 1 | - |
| Physalis crassifolia (X) | | 3 | 2 | 2 |
| Plantago insularis (X) | | - | - | - |
| Pleurocoronis·pluriseta (X) | | 1 | - | 1 |
| Salvia cf. funerea (X) | | 3 | 1 | - |
| S. mohavensis | | - | 1 | - |
| Sphaeralcea sp. (X) | | 1 | 2 | - |
| Tidestromia oblongifolia (X) | | - | - | - |
| N | (26) | 14 | 14 | 8 |
| $N_p$ | (8) | 10 | 11 | 8 |
| $N_p/N$ (100) | (31%) | 71% | 79% | 100% |
| IS | -- | 60 | 35 | 41 |

are presently restricted to the mesic upper bajada in the vicinity of
Locality A (Fig. 2), but Bebbia juncea occurs in both samples and Peuce-
phyllum schottii in MM 3.

·   Marble Mountains Localities B And C.   The Marble Mountains 4 and
5 sites lie at 885 m and 900 m (2900 ft and 2950 ft) elevation, respec-
tively.   Samples from these two middens provide early, middle, and late
Holocene-age macrofossil assemblages.   The oldest, MM 5(1), is radio-
carbon dated twice.   Miscellaneous twigs and Prunus fasciculata (desert-
almond) seeds yield a $^{14}$C date of 10,090 ± 380 B.P. (GX-6182) while a
second date on Neotoma feces is contemporaneous within one standard
deviation at 10,325 ± 350 B.P. (GX-6183; Table 1).   A single age, aver-
aged from these two values (Long and Rippeteau 1974), is 10,210 ± 260 B.P.

Like MM 2 in the southern Marble Mountains, the MM 5(1) assemblage
provides evidence for early Holocene mixed desertscrub vegetation at a
site currently dominated by brittle bush and creosote bush (Table 3).
The MM 5(1) midden sample lacks woodland plants, with the exception of
the rare occurence of Cowania mexicana (Table 3).   Higher elevation
desert shrubs, such as cf. Haplopappus laricifolius (turpentine brush),
H. cuneatus, Prunus fasciculata, Coleogyne ramosissima (blackbrush),
Salvia mohavensis, and Yucca schidigera (Mojave yucca), are most common
in the MM 5(1) assemblage. The diversity of this macrofossil assemblage
is striking compared to the younger midden records from the same locality
or the modern vegetation (Table 3).   It is, however, not unusual relative
to the present mixed desertscrub communities on the north slopes of the
Van Winkle Mountains at ca. 1220 m (4000 ft) elevation, 10 km (6 mi) to

Table 3. Plants from Marble Mountains Locality B.  See Table 2 for an explanation of the symbols.

| Species | Marble Mountains 4 | | Marble Mountains 5 | |
| --- | --- | --- | --- | --- |
| | 4(2) 9515 ± 185 B.P. | 4(3) 1680 ± 150 B.P. | 5(1)* 10,210 ± 260 B.P. | 5(2) 4360 ± 210 B.P. |
| Acacia greggii | 1 | – | – | – |
| Amaranthus sp. | – | – | 1 | – |
| Ambrosia dumosa (X) | 1 | – | 1 | 2 |
| Amsinckia tesselata (X) | – | – | – | – |
| Aristida adscensionis (X) | – | – | 1 | – |
| Aristida sp. | – | 1 | 1 | 1 |
| Asclepias sp. | – | – | 1 | – |
| Astragalus sp. | 1 | 1 | 2 | 2 |
| Bebbia juncea (X) | – | 2 | 1 | 1 |
| Brickellia sp.(X) | 3 | – | 2 | 2 |
| Chorizanthe cf. brevicornu | 1 | – | 1 | 1 |
| Chorizanthe cf. rigida | – | – | – | 1 |
| Coleogyne ramosissima | – | – | 2 | – |
| Cowania mexicana | – | – | 1 | – |
| Cryptantha sp. (X) | – | – | – | 1 |
| Cucurbita sp. | – | – | – | – |
| Ditaxis lanceolata (X) | 2 | – | 1 | – |
| Echinocereus sp. | 3 | 3 | – | 4 |
| Encelia farinosa (X) | – | – | – | – |
| Encelia sp. | – | – | 0 | 0 |
| Eriogonum fasciculatum (X) | 1 | – | 2 | – |
| E. heermannii | – | – | – | – |
| E. inflatum (X) | – | – | – | – |
| E. trichopes (X) | – | – | – | – |
| Ferocactus acanthodes (X) | – | – | 2 | 2 |

(cont.)

**Table 3 (cont.)**

| Species | Marble Mountains 4 | | Marble Mountains 5 | |
|---|---|---|---|---|
| | 4(2) | 4(3) | 5(1) | 5(2) |
| Festuca sp. | – | – | 1 | – |
| Gilia sp. (X) | – | – | – | – |
| Haplopappus cuneatus | – | – | 2 | – |
| cf. Haplopappus laricifolius | 1 | – | 2 | – |
| Hilaria rigida (X) | – | – | – | – |
| Hilaria sp. | – | – | 1 | 1 |
| Hyptis emoryi (X) | – | – | – | – |
| Langloisia sp. | – | 4 | 1 | – |
| Larrea tridentata (X) | 0 | – | – | 3 |
| Lepidium sp. (X) | 1 | – | 1 | – |
| Lycium californicum (X) | – | – | – | – |
| Mirabilis sp. | 2 | – | 3 | – |
| Oenothera sp. | – | – | – | – |
| Opuntia basilaris (X) | 1 | – | 2 | – |
| Pectocarya sp. | 1 | – | 1 | 1 |
| Phacelia cf. crenulata (X) | – | – | – | – |
| Physalis crassifolia (X) | 1 | 1 | 1 | 2 |
| Plantago insularis (X) | – | – | – | – |
| Plantago sp. | 1 | 1 | 2 | – |
| Pleurocoronis pluriseta (X) | – | – | – | – |
| Prunus fasciculata | – | – | 2 | – |
| Salvia mohavensis | 1 | – | 4 | – |
| Salvia sp. | – | – | 1 | – |
| Sphaeralcea sp. (X) | – | – | – | – |
| Thysanocarpus sp. | 1 | – | 1 | – |
| Yucca schidigera | 2 | – | 3 | – |
| N (24) | 18 | 7 | 29 | 14 |
| $N_p$ (11) | 10 | 3 | 14 | 7 |
| $N_p$/N (100) (46%) | 56% | 43% | 48% | 50% |
| IS -- | 29 | 39 | 38 | 53 |

* Radiocarbon age an average of two (Table 1).

the northeast. Larrea tridentata is lacking in MM 5(1) and Encelia
farinosa is represented by a single achene, a possible contaminant.

The Marble Mountains 4(2) macrofosssil assemblage, at 9515 ±
185.B.P. (GX-6180), is ca. 700 radiocarbon years younger than MM 5(1)
and reflects considerable change in the vegetation. Many mesophytic
species that are important in MM 5(1) are rare or lacking in this
younger assemblage (Table 3), only Yucca schidigera and Brickellia sp.
persist in significant quantities. During this ca. 700 year interval
Encelia farinosa apparently became a common plant at this site.
A few fragments of Larrea tridentata indicate that this species may
have just arrived at the site.

Marble Mountains 5(2) is the only middle Holocene-age sample from
Locality B and, at 4360 ± 210 B.P. (GX-6184; Table 1), it is the only
one to contain Ambrosia dumosa, Cucurbita sp. (gourd), and Ferocactus
acanthodes (Table 3). The extralocal mesophytes, present in the early
Holocene samples, are missing and the current dominants at the site,
creosote bush and brittle bush, are the primary constituents of the
midden. MM 4(3), at 1680 ± 150 B.P. (GX-6181; Table 1), is a creosote
bush-brittle bush assemblage quite similar to MM 5(2). Curiously, it
lacks white bursage, gourd, and California barrel cactus and is of unu-
sually low diversity (Table 3).

The Marble Mountains 6, 7, and 9 sites are at the head of steep,
south facing talus slopes at ca. 850 m (2790 ft) elevation (Fig. 2).
One of the most diverse assemblages, Marble Mountains 9(1)$_2$, is radio-
carbon dated twice. This replicate dating demonstrates contamination.

Undifferentiated twigs yielded a radiocarbon age of 10,550 ± 210 B.P. (GX-6189) while associated Neotoma fecal pellets were dated at 7935 ± 260 B.P. (GX-6190; Table 1). The species list from MM 9(1)$_2$ is presented but it is excluded from any consideration of vegetation succession at this site. The MM 9(2) macrofossil assemblage is also rejected. Positioned below MM 9(1)$_2$ in a stratigraphically complex setting, it contains extralocal mesophytes such as Ephedra cf. viridis, Artemisia sec. Tridentatae, and Salvia mohavensis associated with a radiocarbon age of 5520 ± 190 B.P. (GX-6191; Table 1). It is most unlikely that these plants persisted into the middle Holocene at this locality.

The oldest reliably dated samples from Locality C are Marble Mountains 7(1) and MM 9(1)$_1$. Contemporaneous radiocarbon dates of 8925 ± 360 B.P. (GX-6186) and 8905 ± 265 B.P. (GX-6188), respectively, indicate that these assemblages are roughly 600 radiocarbon years younger than MM 4(2) and 1200 radiocarbon years younger than MM 5(1). Like the early Holocene Locality B assemblages, MM 7(1) and MM 9(1)$_1$ are dominated by desert shrubs that are found only at higher elevations today. Haplopappus cuneatus, cf. Haplopappus laricifolius, and Salvia mohavensis are among the most abundant (Table 4A, 4B). The leaves of Yucca whipplei, not found in the Locality B middens, are common in MM 9(1)$_1$ (Table 4B) and occasional in MM 7(1) (Table 4A). Brickellia sp. flowers are abundant in MM 7(1) only, while Yucca brevifolia, Coleogyne ramosissima, and Opuntia acanthocarpa occur only in MM 9(1)$_1$. Paradoxically, MM 7(1) and MM 9(1)$_1$ contain two woodland species that are lacking in the older Locality B samples. Juniperus sp. twigs and seeds are

Table 4A. Plant species from Marble Mountains Locality C, sites 6 and 7. See Table 2 for an explanation of the symbols.

| Species | Marble Mountains 6 (7930 + 285 B.P.) | Marble Mountains 7 MM 7(1) (8925 + 360 B.P.) | MM 7(2) (4475 + 170 B.P.) |
|---|---|---|---|
| Ambrosia dumosa (X) | 1 | 0 | 1 |
| Amsinckia intermedia | – | – | 1 |
| A. tesselata (X) | 1 | 1 | – |
| Aristida adscensionis (X) | – | – | – |
| Aristida sp. | 1 | 1 | 1 |
| Artemisia sec. Tridentatae | – | 1 | – |
| Asclepias sp. | – | 1 | – |
| Astragalus sp. | 3 | 1 | 2 |
| Bebbia juncea (X) | 1 | 4 | – |
| Brickellia sp. | 1 | – | – |
| cf. Calandrinia sp. | 1 | – | – |
| Chorizanthe brevicornu (X) | – | – | 1 |
| Chorizanthe cf. brevicornu | 1 | 2 | – |
| Cryptantha angustifolia (X) | – | – | 1 |
| Cryptantha sp. | – | – | – |
| Cucurbita sp. | – | 1 | – |
| cf. Dalea fremontii | – | 1 | 0 |
| Ditaxis lanceolata (X) | – | – | – |
| Echinocereus engelmannii (X) | 2 | 3 | 3 |
| Encelia farinosa (X) | 1 | 1 | – |
| Ephedra sp. | 1 | 1 | – |
| Eriogonum fasciculatum | 1 | 1 | – |
| Eschscholtzia sp. | 2 | 2 | 1 |
| Ferocactus acanthodes | 3 | 2 | 1 |
| Filago sp. | – | 1 | – |
| Gutierrezia microcephala | – | 3 | – |
| Haplopappus cuneatus | 3 | 2 | – |
| cf. Haplopappus laricifolius | 2 | 2 | – |
| Juniperus sp. | – | 0 | – |
| Larrea tridentata (X) | 5 | 0 | 4 |

(cont.)

**Table 4A (cont.).**

| Species | | Marble Mountains 6 | Marble Mountains 7 MM 7(1) | MM 7(2) |
|---|---|---|---|---|
| Lepidium sp. | | 1 | 1 | 1 |
| cf. Linanthus sp. | | – | 1 | – |
| Mentzelia sp. (X) | | – | – | – |
| Mirabilis bigelovii (X) | | – | – | – |
| Mirabilis sp. | | 1 | 1 | 1 |
| Nicotiana trigonophylla (X) | | – | – | – |
| Opuntia sp. | | – | – | 1 |
| Opuntia cf. acanthocarpa | | 2 | – | – |
| O. basilaris | | – | 1 | – |
| Lycium californicum (X) | | – | – | – |
| Pectocarya sp. | | 1 | 1 | 1 |
| Penstemon sp. | | – | 1 | – |
| Perityle emoryi (X) | | – | – | 1 |
| Perityle cf. emoryi | | 1 | – | 1 |
| Peucephyllum schottii (X) | | 3 | – | 2 |
| Phacelia crenulata (X) | | – | – | – |
| Physalis crassifolia | | 1 | 1 | 1 |
| Plagiobothrys sp. | | – | 1 | – |
| Plantago insularis (X) | | – | – | – |
| Plantago sp. | | 1 | – | 1 |
| Pleurocoronis pluriseta (X) | | 1 | – | – |
| Salvia mohavensis | | 3 | 5 | 0 |
| Salvia sp. | | 1 | 1 | – |
| Sphaeralcea sp. | | 1 | 1 | 1 |
| Stipa sp. | | – | 1 | – |
| Thysanocarpus sp. | | – | 1 | – |
| Yucca schidigera | | 1 | 1 | – |
| Y. whipplei | | – | 2 | – |
| N | (19) | 27 | 33 | 21 |
| Np | (9) | 12 | 18 | 9 |
| Np/N (100) | (47%) | 44% | 54% | 43% |
| IS | -- | 48 | 23 | 55 |

Table 4B. Plants from Marble Mountains Locality C, site 9. See Table 2 for an explanation of the symbols.

| Species | Marble Mountains 9(1)$_1$ (8905 ± 265 B.P.) | Marble Mountains 9(1)$_2$ (10,555 ± 210 B.P.) (7635 ± 260 B.P.) | Marble Mountains 9(2) (5520 ± 190 B.P.) |
|---|---|---|---|
| Agropyron sp. | 1 | 1 | - |
| Amaranthus sp. | - | 1 | - |
| Ambrosia dumosa (X) | - | - | 1 |
| Amsinckia tesselata (X) | 2 | 1 | 1 |
| Aristida adscensionis (X) | - | - | - |
| Aristida sp. | - | 1 | 1 |
| Artemisia sec. Tridentatae | 2 | - | 1 |
| Astragalus sp. | 1 | 2 | 1 |
| Bebbia juncea (X) | 1 | 1 | 2 |
| Brickellia sp. | 1 | 1 | - |
| Chaenactis sp. | - | - | 1 |
| Chorizanthe brevicornu (X) | - | 1 | 1 |
| Chorizanthe cf. brevicornu | - | 1 | - |
| Chorizanthe cf. rigida | 1 | - | - |
| Coleogyne ramosissima | 1 | 2 | - |
| Cryptantha angustifolia (X) | - | - | - |
| Cryptantha sp. | 2 | 1 | 1 |
| Cucurbita sp. | - | - | - |
| Ditaxis lanceolata (X) | - | - | 1 |
| Echinocereus engelmannii (X) | - | - | - |
| Encelia farinosa (X) | 1 | 1 | 3 |
| Ephedra cf. viridis | - | - | 1 |
| Ephedra sp. | 1 | - | - |
| Eriogonum fasciculatum | 1 | 1 | 1 |
| Festuca sp. | - | - | 1 |
| Filago sp. | - | 1 | 1 |
| Haplopappus cuneatus | 2 | 4 | - |
| cf. Haplopappus laricifolius | 3 | 3 | - |
| Juniperus sp. | 4 | 1 | - |

(cont.)

| Species | Marble Mountains 9(1)$_1$ | Marble Mountains 9(1)$_2$ | Marble Mountains 9(2) |
|---|---|---|---|
| Linum sp. | - | - | 1 |
| Larrea tridentata (X) | - | 1 | 2 |
| Lepidium sp. | 1 | 1 | - |
| cf. Linanthus sp. | 2 | 1 | - |
| Mentzelia sp. (X) | - | - | - |
| Mirabilis bigelovii (X) | - | - | - |
| Nicotiana trigonophylla (X) | - | - | - |
| Opuntia cf. acanthocarpa | 2 | - | - |
| O. basilaris | 1 | 1 | 1 |
| Opuntia sp. | - | 1 | - |
| Pectocarya cf. platycarpa | 1 | 1 | 1 |
| Pectocarya cf. recurvata | - | 1 | - |
| Penstemon sp. | 1 | 1 | 1 |
| Perityle emoryi (X) | - | - | - |
| Perityle cf. emoryi | - | 1 | 1 |
| Peucephyllum schottii | - | - | 3 |
| Phacelia crenulata (X) | 1 | 1 | - |
| Phacelia sp. | 0 | - | 1 |
| Physalis crassifolia | - | 1 | - |
| Plantago insularis (X) | 1 | - | - |
| Plantago sp. | - | 1 | - |
| Pleurocoronis pluriseta (X) | 1 | 1 | - |
| Ribes cf. velutinum | 2 | 5 | 2 |
| Salvia mohavensis | 1 | 1 | - |
| Salvia sp. | 1 | 1 | 1 |
| cf. Sarcostemma hirtellum | 1 | - | 1 |
| Sphaeralcea sp. | - | 1 | - |
| Stipa sp. | 1 | 1 | 1 |
| Thysanocarpus sp. | 3 | 1 | - |
| Yucca brevifolia | - | 1 | - |
| Y. schidigera | - | 2 | - |

Table 4B (cont.)

| Species | | Marble Mountains 9(1)$_1$ | Marble Mountains 9(1)$_2$ | Marble Mountains 9(2) |
|---|---|---|---|---|
| | | 3 | 1 | – |
| Yucca whipplei | | | | |
| N | (17) | 29 | 35 | 24 |
| Np | (7) | 15 | 17 | 9 |
| Np/N (100) | (41%) | 52% | 49% | 38% |
| IS | -- | 22 | 35 | 29 |

occassional in MM 7(1) and abundant enough in MM 9(1)$_1$ to provide suf-
ficient mass for radiocarbon dating (Table 1). Ribes cf. velutinum
in MM 9(1)$_1$ represents an intriguing early Holocene occurence (Table 4B).
The leaves of a sagebrush (Artemisia sec. Tridentatae) occur in both
MM 7(1) and MM 9(1)$_1$ and, while not strictly a woodland species, it is
an occurence not replicated by the older Locality B samples.

The xeric desertscrub species that characterize the Locality C
vegetation today are rare or lacking in MM 7(1) and MM 9(1)$_1$, with the
exception of Encelia farinosa (Table 4A, 4B). Brittle bush is the first
of the warm desert dominants to appear in the Locality B fossil record.
Such appears to be the case at Locality C as well. Marble Mountains 6,
at 7930 ± 285 B.P. (GX-6185; Tbale 1), is ca. 1000 years younger than
MM 7(1) and MM 9(1)$_1$ and is a mix of some extralocal desertscrub species
and the xeric shrubs that occur at the site today. Larrea tridentata is
the most abundant fossil species in MM 6. Salvia mohavensis and cf.
Haplopappus laricifolius are common and Opuntia acanthocarpa occassional
extralocals (Table 4A). Juniperus sp., Artemisia sec. Tridentatae,
Coleogyne ramosissima, Haplopappus cuneatus, Yucca brevifolia, and Y.
whipplei are lacking. Accompanying the dramatic increase of Larrea
in the fossil record, and the demise of most mesophytic species, is
the appearance of Peucephyllum schottii and an apparent increase of
Ambrosia dumosa. Two annuals occur in relatively large amounts in MM 6,
Eschscholtzia sp. (California poppy) and Filago sp. (Table 4A).

Marble Mountains 7(2), at 4475 ± 170 B.P. (GX-6187; Table 1),
is the youngest reliably dated Locality C midden sample. There is little
discernable difference between this assemblage and the present vegetation

at the site.  Both are dominated by <u>Larrea tridentata</u> and <u>Encelia farinosa</u>, with smaller amounts of <u>Ambrosia dumosa</u>, <u>Bebbia juncea</u>, and <u>Peucephyllum schottii</u> (Table 4A).  A trace amount of <u>Salvia mohavensis</u> occurs, but this may well be a contaminant.  MM 7(2), as well as the older MM 7(1) assemblage, contains the seeds and spines of <u>Ferocactus acanthodes</u>, which does not occur at Locality C today.

The Eureka Valley And Vicinity

The Horse Thief Hills localities (Fig. 3) are unproductive areas for midden sites, the rocks are fractured and metamorphosed with few cavities.  This is unsurprising since these localities are within half a kilometer of the Furnace Creek Faultzone.  The activity of the fault probably produces an unstable geomorphic setting.  However, the cliffs on the northeast border of the Eureka Valley, several kilometers further south (Fig. 3), are a more productive midden area.

Horse Thief Hills Locality A.  Horse Thief Hills 1 is a small solution cavity ca. 30 m above the bed of an arroyo tributary to Willow Wash (Fig. 3).  The east sloping talus below the cliff containing the cavity, at 1615 m (5300 ft) elevation, is derived from dolomite of the Bonanza King Formation.  The local plant community is dominated by the Great Basin shrubs <u>Atriplex confertifolia</u> and <u>Chrysothamnus viscidiflorus</u>. In contrast to the present Great Basin desertscrub community, the Horse Thief Hills 1 midden contains abundant woodland species.  The twigs and seeds of the most common fossil, <u>Juniperus osteosperma</u> (Utah juniper), are $^{14}$C dated at 10,690 $\pm$ 280 B.P. (GX-6217; Table 5).  <u>Symphoricarpos</u> cf. <u>longiflorus</u> is also abundant while extralocal woodland taxa include,

Table 5. Packrat midden sites, samples, and radiocarbon dates from the northeastern side of the Eureka Valley, Inyo County, California. See Table 1 for an explanation of the symbols.

| Site & sample no. | Elevation | Primary habitat | Radiocarbon date & (lab. no.) | Material dated |
|---|---|---|---|---|
| HORSE THIEF HILLS LOCALITY A | | | | |
| Horse Thief Hills 1 | 1615 m | E facing dolomite cliffs and talus slopes | 10,690 ± 280 B.P. (GX-6217) | Juniperus osteosperma twigs and seeds |
| Horse Thief Hills 2 | 1635 m | E facing dolomite ledges and talus slopes | <200 B.P. (GX-6218) | Miscellaneous twigs |
| HORSE THIEF HILLS LOCALITY B | | | | |
| Horse Thief Hills 3(1) | 1575 m | W facing alluvial slope | <200 B.P. (GX-6219) | Neotoma feces |
| Horse Thief Hills 3(2) | " | " | <200 B.P. (GX-6220) | Miscellaneous twigs |
| Horse Thief Hills 3(2) | " | " | <200 B.P. (GX-6221) | Neotoma feces |
| EUREKA VIEW LOCALITY | | | | |
| Eureka View 1 | 1510 m | S facing dolomite ledges and talus slopes | 2635 ± 140 B.P. (GX-6222) | Miscellaneous twigs |
| Eureka View 2A | 1465 m | SW facing dolomitic talus slope | NO DATE (GX-6223) | Larrea tridentata twigs |

(cont.)

Table 5 (cont.)

| Site & sample no. | Elevation | Primary habitat | Radiocarbon date & (lab. no.) | Material dated |
|---|---|---|---|---|
| Eureka View 2B | 1465 m | SW facing dolomitic talus slope | 1580 + 140 B.P. (GX-6224) | Miscellaneous twigs |
| Eureka View 2C | " | " | 3930 + 180 B.P. (GX-6225) | Organic debris |
| Eureka View 3 | 1450 m | S facing dolomite ledges and talus slope | 535 + 150 B.P. (GX-6226) | _Larrea tridentata_ twigs |
| Eureka View 4(1) | 1435 m | S facing dolomitic talus slope and ledges | 5595 + 210 B.P. (GX-6227) | Organic debris |
| Eureka View 4(2) | " | " | 6795 + 190 B.P. (GX-6228) | cf. _Atriplex confertifolia_ wood |
| Eureka View 4(3) | " | " | 5435 + 220 B.P. (GX-6229) | Miscellaneous twigs |
| Eureka View 5A | 1430 m | S facing dolomitic talus slope and ledges | 14,720 + 530 B.P. (GX-6230) | _Juniperus osteosperma_ twigs |
| Eureka View 5B | " | " | 8330 + 250 B.P. (GX-6231) | Miscellaneous twigs |

besides Utah juniper, _Amelanchier_ _utahensis_ (service-berry), _Chamae-batiaria_ _millefolium_ (fern-bush), _Purshia_ cf. _tridentata_ (bitterbrush), _Ephedra_ cf. _viridis_, and _Cercocarpus_ _intricatus_ (Table 6). The last two species occur in restricted mesic habitats within half a kilometer of HTH 1. Other plants that do not occur at the site today, such as _Artemisia_ sec. Tridentatae, _Prunus_ cf. _andersonii_ (desert-peach), and _Salvia_ _dorrii_, have affinities with mesic desertscrub communities although many are also common in xeric woodlands. _Atriplex_ _conferti-folia_ is the only plant common at the site today that is also abundant in the macrofossil assemblage (Table 6).

The Horse Thief Hills 2 site, at 1635 m (5360 ft) elevation, is near a crest overlooking Willow Wash. The site is not as protected as HTH 1 and the plant community is correspondingly more xeric. _Atriplex_ _confertifolia_ dominates the local community with _Eurotia_ _lanata_, _Ephedra_ _nevadensis_, and _Hecastocleis_ _shockleyi_ being common. The HTH 2 packrat midden is a partly indurated mass with a radiocarbon date of <200 B.P., confirming its young appearance (GX-6218; Table 5). The most common plants in the midden appear to be the most common in the surrounding vegetation (Table 7).

Horse Thief Hills Locality B. The single midden site at Locality B, HTH 3, is isolated in the middle of Willow Wash canyon with a less rugged topography than the preceding sites. A west sloping alluvial fan leads away from the rock outcrop, coalescing with the Willow Wash fan ca. 35 m from the midden site. _Atriplex_ _confertifolia_ is the dominant shrub with _Dalea_ _fremontii_ and _Hymenoclea_ _salsola_ common associates. The latter is

Table 6.  Plants from the Horse Thief Hills 1 site.  See Table 2 for an explanation of the symbols.

| Species | Horse Thief Hills 1 (10,690 ± 280 B.P.) |
|---|---|
| Amelanchier utahensis | 2 |
| Amsinckia intermedia | 1 |
| Aristida sp. (X) | – |
| Artemisia sec. Tridentatae | 3 |
| Astragalus sp. | 1 |
| Atriplex confertifolia (X) | 4 |
| Brickellia sp. | 1 |
| Cercocarpus intricatus | 2 |
| Chamaebatiaria millefolium | 1 |
| Chenopodium sp. | 1 |
| Chrysothamnus viscidiflorus (X) | – |
| cf. Chrysothamnus sp. | 1 |
| Cryptantha sp. | 1 |
| Dalea fremontii (X) | – |
| Ephedra nevadensis (X) | – |
| Ephedra cf. viridis | 2 |
| Eriogonum heermannii (X) | – |
| Eriogonum sp. | 1 |
| Eurotia lanata (X) | 2 |
| Fendlerella utahensis (X) | – |
| Forsellesia nevadensis (X) | – |
| Forsellesia sp. | 1 |
| Galium sp. (X) | – |
| Hecastocleis shockleyi (X) | – |
| Hilaria jamesii (X) | – |
| Juniperus osteosperma | 5 |
| Mirabilis multiflora (X) | – |
| Mortonia utahensis | 1 |
| Opuntia basilaris (X) | – |
| Opuntia cf. polyacantha | 3 |
| Oryzopsis hymenoides (X) | 1 |
| Penstemon sp. | 1 |
| cf. Prunus andersonii | 3 |
| Purshia cf. tridentata | 1 |
| Salvia dorrii | 1 |
| Scopulophila rixfordii | 1 |
| Sphaeralcea sp. | 2 |
| Stanleya cf. pinnata (X) | – |
| Symphoricarpos cf. longiflorus (X) | 4 |
| Tetradymia axillaris (X) | – |
| Tetradymia cf. canescens (X) | – |
| Tetradymia sp. | 1 |

| | | |
|---|---|---|
| N | (19) | 27 |
| $N_p$ | (14) | 19 |
| $N_p/N$ (100) | (74%) | 70% |
| IS | –– | 35 |

Table 7. Plants from the Horse Thief Hills 2 site. See Table 2 for an explanation of the symbols.

| Species | Horse Thief Hills 2 (<200 B.P.) |
|---|---|
| Agropyron sp. | 1 |
| Artemisia spinescens (X) | 2 |
| Atriplex confertifolia (X) | 5 |
| Brickellia sp. | 1 |
| Chrysothamnus viscidiflorus (X) | 2 |
| Ephedra nevadensis (X) | 3 |
| Eriogonum heermannii (X) | – |
| Eurotia lanata (X) | 3 |
| Fendlerella utahensis (X) | 2 |
| Forsellesia nevadensis | 1 |
| Gilia cf. latifolia (X) | 2 |
| Hecastocleis shockleyi (X) | 2 |
| Hilaria jamesii (X) | – |
| Lepidium cf. fremontii | 1 |
| Menodora spinescens (X) | 2 |
| Mirabilis sp. | 1 |
| Opuntia basilaris | 2 |
| Oryzopsis hymenoides (X) | 1 |
| Prunus fasciculata (X) | – |
| Scopulophila rixfordii (X) | 2 |
| Sphaeralcea sp. | 1 |
| Stanleya cf. pinnata | 1 |
| Symphoricarpos cf. longiflorus (X) | 3 |
| Tetradymia axillaris (X) | 3 |

| | | |
|---|---|---|
| N | (16) | 21 |
| $N_p$ | (13) | 16 |
| $N_p/N$ (100) | (81%) | 76% |
| IS | -- | 70 |

a disturbance plant normally restricted to washes. Both midden samples are well indurated but both yield subrecent radiocarbon dates (<200 B.P.; Table 5). The date on Horse Thief Hills 3(1) is on <u>Neotoma</u> feces (GX-6219) while the two subrecent dates on HTH 3(2) are on <u>Neotoma</u> feces and undifferentiated twigs (GX-6221 and GX-6220, respectively; Table 5). Both midden assemblages agree with the present plant community in that they are dominated by <u>Atriplex confertifolia</u> with common <u>Dalea fremontii</u> and <u>Ephedra</u> sp. (probably <u>E. nevadensis</u>; Table 8). However, both samples diverge from the modern vegetation in other aspects. <u>Opuntia echinocarpa</u>, present at the locality but not within 30 m of the midden site, is abundant in HTH 3(1) and probably represented by abundant <u>Opuntia</u> sp. spines in HTH 3(2) (Table 8). HTH 3(1) contains no <u>Hymenoclea salsola</u> but does contain the frequent remains of <u>Lycium</u> sp. and <u>Menodora spinescens</u>, both absent at the locality today. <u>Hymenoclea salsola</u> and <u>Menodora spinescens</u> are occassional in HTH 3(2) and <u>Lycium</u> sp. represented by rare fragments (Table 8). <u>Larrea tridentata</u> and <u>Yucca brevifolia</u> are scattered at Locality B, although none occur at the HTH 3 site. The remains of these two plants are found only in the HTH 3(2) assemblage.

The Eureka View Locality. Eureka View is a network of midden sites on rugged exposures of limestone and dolomite rising above Eureka Valley (Fig. 3). The desertscrub communities on the dark, south to west facing calcareous slopes are diverse. All the sites occur within 100 m of each other and offer a time transgressive series of fossil middens from one locality and one community type, dominated by <u>Atriplex confertifolia</u> and <u>Larrea tridentata</u>.

Table 8.  Plants from the Horse Thief Hills 3 site.  See Table 2 for an explanation of the symbols.

| Species | Horse Thief Hills 3 | |
| | HTH 3(1) (<200 B.P.) | HTH 3(2) (<200 B.P.) |
| --- | --- | --- |
| Acamptopappus sphaerocephalus (X) | – | – |
| Amsinckia tesselata | 1 | – |
| Aristida sp. (X) | – | – |
| Artemisia spinescens | – | 1 |
| Atriplex confertifolia (X) | 5 | 5 |
| Chaenactis sp. | 1 | 1 |
| Chrysothamnus viscidiflorus (X) | – | – |
| Dalea fremontii (X) | 3 | 3 |
| Ephedra nevadensis (X) | – | – |
| Ephedra sp. | 3 | 3 |
| Eriogonum fasciculatum (X) | 1 | – |
| E. heermannii (X) | – | – |
| E. inflatum (X) | – | – |
| Eriogonum sp. | – | 1 |
| Erioneuron pulchellum (X) | – | – |
| Eurotia lanata (X) | 1 | 1 |
| Grayia spinosa (X) | – | – |
| Haplopappus laricifolius (X) | – | – |
| cf. Haplopappus laricifolius | 2 | 2 |
| Hilaria jamesii (X) | – | – |
| Hymenoclea salsola (X) | – | 2 |
| Larrea tridentata | – | 1 |
| Leucelene ericoides (X) | – | – |
| Lycium sp. | 2 | 1 |
| Menodora spinescens | 3 | 2 |
| Opuntia basilaris (X) | – | 1 |
| O. echinocarpa (X) | 4 | – |
| Opuntia sp. | – | 4 |
| Oryzopsis hymenoides (X) | 1 | – |
| Prunus fasciculata (X) | – | – |
| Scopulophila rixfordii | – | 1 |
| Sphaeralcea sp. (X) | – | 1 |
| Stanleya cf. pinnata (X) | 1 | – |
| Tetradymia axillaris (X) | – | – |
| T. canescens (X) | – | – |
| Yucca brevifolia (X) | – | 2 |

| | | | |
| --- | --- | --- | --- |
| N | (25) | 13 | 13 |
| $N_p$ | (19) | 10 | 13 |
| $N_p/N$ (100) | (76%) | 77% | 76% |
| IS | -- | 47 | 48 |

Eureka View 5, at ca. 1430 m (4690 ft), is the lowest elevation site and provides the two oldest macrofossil assemblages. It is about 10 m above the head of the alluvial fan that slopes away to the Eureka Valley bajada. EV 5A contains abundant Utah juniper twigs and seeds, $^{14}$C dated at 14,720 $\pm$ 530 B.P. (GX-6230; Table 5). Other extralocals in this late Wisconsin woodland assemblage include Ephedra cf. viridis, Artemisia sec. Tridentatae, Forsellesia nevadensis, Salvia dorrii, Hecastocleis shockleyi and, remarkably, Pinus cf. flexilis (limber pine; Table 9). Atriplex confertifolia is the only common desertscrub species in the EV 5A sample and the only fossil plant that is well-represented in the modern vegetation. Eureka View 5B, at 8330 $\pm$ 250 B.P. (GX-6231), is the only early Holocene macrofossil assemblage and documents an apparent decline in species diversity at this site (Table 9). The woodland and Great Basin desertscrub species, common in the late Wisconsin EV 5A sample, are lacking in EV 5B along with most of the species present at the site today. Shadscale is the abundant fossil in EV 5B and Ephedra sp. is common with the extralocal Lepidium cf. fremontii (Mojave peppergrass) occassional (Table 9).

The Eureka View 4 site, located ca. 20 m west of the EV 5 site, contains the next oldest suite of middens (Table 5). EV 4(2), at 6795 $\pm$ 190 B.P. (GX-6228 on cf. Atriplex confertifolia wood), is dominated by shadscale and contains common Haplopappus brickellioides and Encelia virginensis (Table 9). The latter does not occur at the site today. Opuntia basilaris, Lycium sp., and Dalea fremontii are other frequent extralocals in the EV 4(2) assemblage. Ambrosia dumosa first appears in this sample.

| Species | Eureka View 1 2635 ± 140 B.P. | Eureka View 2 EV 2A NO DATE | EV 2B 1580 ± 140 B.P. | EV 2C 3930 ± 180 B.P. | Eureka View 3 535 ± 150 B.P. | Eureka View 4 EV 4(1) 5595 ± 210 B.P. | EV 4(2) 6795 ± 190 B.P. | EV 4(3) 5435 ± 220 B.P. | Eureka View 5 EV 5A 14,720 ± 530 B.P. | EV 5B 8330 ± 250 B.P. |
|---|---|---|---|---|---|---|---|---|---|---|
| Ambrosia dumosa (X) | 3 | 1 | - | - | - | 2 | 2 | 1 | - | - |
| Amphipappus fremontii (X) | - | - | 2 | - | 2 | - | - | - | - | - |
| Amsinckia intermedia | - | - | - | - | - | 1 | - | - | 1 | 1 |
| A. tesselata | 2 | 2 | - | 1 | - | - | - | - | - | - |
| Amsinckia sp. (X) | - | - | - | - | - | - | - | - | - | - |
| Aristida adscensionis (X) | - | - | - | - | - | - | - | - | 2 | - |
| Artemisia sec. Tridentatae | 0 | 4 | 5 | 4 | 3 | 5 | 5 | 4 | 4 | 5 |
| Atriplex confertifolia (X) | 5 | - | - | - | - | - | - | - | - | - |
| Brickellia arguta (X) | - | - | - | - | - | - | - | - | - | - |
| Cheilanthes feei (X) | - | - | - | - | - | - | - | - | - | - |
| Chorizanthe cf. brevicornu | 1 | 1 | 1 | 1 | - | - | - | - | - | - |
| Chorizanthe cf. rigida (X) | - | 1 | 1 | - | 2 | 1 | 3 | 1 | 2 | - |
| cf. Chrysothamnus sp. | - | - | 2 | - | - | - | 3 | 4 | 1 | - |
| Cryptantha sp. | 2 | - | 3 | 2 | - | 3 | 3 | - | - | - |
| Dalea fremontii | - | 0 | 1 | - | - | - | - | - | 0 | 1 |
| Echinocactus polycephalus (X) | - | - | - | - | - | - | - | - | - | - |
| Encelia virginensis | - | - | - | - | - | - | - | - | - | - |
| Ephedra nevadensis (X) | 2 | 1 | 2 | 1 | 2 | - | - | 2 | 3 | - |
| Ephedra cf. viridis | - | 1 | 2 | - | - | 2 | 1 | 1 | - | - |
| Ephedra sp. | - | 2 | - | - | 1 | - | - | - | - | 3 |
| Eriogonum inflatum (X) | - | 1 | 3 | 2 | 2 | 2 | 1 | 2 | 3 | - |
| E. fasciculatum (X) | 1 | - | - | - | - | - | 1 | 1 | - | - |
| Eriogonum sp. | 1 | 1 | - | - | 1 | - | - | - | 1 | - |
| Erioneuron pulchellum (X) | - | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 1 | - |
| Eucnide urens (X) | 1 | 1 | - | - | 1 | 1 | 1 | 1 | - | - |
| Euphorbia sp. | - | - | - | - | - | - | 1 | 1 | 2 | - |

(cont.)

| Species | Eureka View 1 | EV 2A | EV 2B | EV 2C | Eureka View 3 | EV 4(1) | EV 4(2) | EV 4(3) | EV 5A | EV 5B |
|---|---|---|---|---|---|---|---|---|---|---|
| Festuca sp. | - | 2 | - | - | - | - | - | - | - | 1 |
| Forsellesia nevadensis | - | 1 | - | - | - | - | - | - | 1 | 1 |
| Gilia sp. (X) | 1 | - | 1 | - | 1 | - | - | - | - | 1 |
| Gutierrezia microcephala (X) | - | - | 1 | 1 | 2 | 1 | 3 | 2 | - | 1 |
| Haplopappus brickellioides (X) | - | - | - | - | - | - | - | - | - | - |
| H. laricifolius (X) | - | - | - | - | - | - | - | - | - | - |
| Haplopappus sp. | 1 | 1 | - | - | - | - | - | - | - | - |
| Mecastoclcis shockleyi | - | - | - | 1 | - | 0 | - | 1 | 3 | - |
| Juniperus osteosperma | 4 | 5 | 5 | 2 | 5 | 0 | 1 | 0 | 5 | 2 |
| Larrea tridentata (X) | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | - |
| Lepidium cf. fremontii | - | - | - | - | - | 2 | 2 | 1 | 1 | - |
| Lepidium sp. | - | - | - | - | - | - | - | - | - | - |
| Lycium sp. | - | - | - | - | - | - | - | - | 1 | 1 |
| cf. Machaeranthera sp. | - | - | - | - | - | - | - | - | - | - |
| Mirabilis sp. | - | - | - | 1 | - | 1 | - | - | 1 | - |
| Nama sp. (X) | 1 | 1 | 3 | 3 | - | 3 | 4 | 4 | 1 | - |
| Nicotiana trigonophylla (X) | 2 | - | 2 | 3 | 2 | 2 | - | - | 1 | - |
| Opuntia basilaris | - | - | 2 | 1 | 2 | - | - | - | 1 | - |
| O. echinocarpa | - | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | - |
| Opuntia sp. | - | - | 2 | - | 2 | - | - | - | - | - |
| Penstemon sp. | 1 | 1 | 1 | 1 | - | 1 | 2 | 1 | 1 | 1 |
| Peucephyllum schottii | - | - | - | - | - | - | - | - | - | - |
| Phacelia crenulata (X) | 3 | 1 | 1 | 1 | - | - | 2 | 1 | 1 | - |
| Phacelia sp. | - | - | - | - | - | - | - | - | 1 | - |
| Physalis cf. crassifolia (X) | - | - | - | - | - | - | - | - | 1 | - |
| Pinus cf. flexilis | - | - | - | - | - | - | - | - | 1 | - |
| Salvia dorrii | - | - | - | - | - | - | - | - | 1 | - |
| cf. Sclerocactus sp. | - | - | - | - | - | - | - | - | 1 | - |
| Scopulophila rixfordii (X) | 1 | 1 | - | 1 | 1 | 1 | 2 | 1 | 1 | 1 |
| Sphaeralcea sp. | - | - | - | - | - | - | - | - | - | - |
| Stipa sp. (X) | - | 1 | 2 | 1 | 1 | - | - | - | 1 | - |
| Symphoricarpos cf. longiflorus | - | - | - | - | - | - | - | - | 1 | - |

| Species | Total | View 1 | EV 2A | EV 2B | EV 2C | View 3 | EV 4(1) | EV 4(2) | EV 4(3) | EV 5A | EV 5B |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Tidestromia oblongifolia | | 1 | - | - | 1 | - | - | - | - | - | - |
| Vaguiera reticulata (X) | | 3 | - | - | - | 2 | - | - | - | - | - |
| $N$ | (26) | 19 | 18 | 22 | 18 | 14 | 16 | 13 | 13 | 22 | 12 |
| $N_p$ | (15) | 12 | 8 | 13 | 11 | 9 | 11 | 10 | 10 | 14 | 6 |
| $N_p/N$ (100) | (58%) | 63% | 44% | 59% | 61% | 64% | 69% | 77% | 77% | 64% | 50% |
| LS | -- | 62 | 64 | 58 | 54 | 50 | 38 | 31 | 41 | 17 | 37 |

| Species | Eureka View 1 | EV 2A | EV 2B | EV 2C | Eureka View 3 | EV 4(1) | EV 4(2) | EV 4(3) | EV 5A | EV 5B |
|---|---|---|---|---|---|---|---|---|---|---|
| Festuca sp. | - | 2 | - | - | - | - | - | - | - | 1 |
| Forsellesia nevadensis | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Gilia sp. (X) | - | 1 | 1 | - | 1 | - | - | - | - | - |
| Gutierrezia microcephala (X) | - | - | 1 | 1 | 2 | 1 | 3 | 2 | - | 1 |
| Haplopappus brickellioides (X) | - | - | - | - | - | - | - | - | - | - |
| H. laricifolius (X) | - | - | - | - | - | - | - | - | - | - |
| Haplopappus sp. | 1 | - | - | - | - | - | - | - | - | - |
| Hecastocleis shockleyi | - | - | - | - | - | - | - | - | 3 | - |
| Juniperus osteosperma | 4 | 5 | 5 | 2 | 5 | 0 | - | 0 | 5 | 2 |
| Larrea tridentata (X) | 2 | 1 | 1 | - | 1 | 1 | 1 | 1 | 1 | - |
| Lepidium cf. fremontii | - | - | - | - | - | - | - | 2 | - | - |
| Lepidium sp. | - | - | - | - | - | 2 | 2 | 1 | 1 | - |
| Lycium sp. | - | - | - | - | - | 1 | - | - | 1 | - |
| cf. Machaeranthera sp. | - | - | - | - | - | - | - | - | 1 | 1 |
| Mirabilis sp. | - | - | - | 1 | - | - | - | - | - | - |
| Nana sp. (X) | - | - | - | 3 | - | - | - | - | - | - |
| Nicotiana trigonophylla (X) | 1 | 1 | 3 | - | 2 | 3 | 4 | 4 | - | - |
| Opuntia basilaris | 2 | - | 2 | 3 | - | 2 | - | - | - | - |
| O. echinocarpa | - | - | 1 | 1 | 2 | - | - | - | - | - |
| Opuntia sp. | - | - | 2 | - | 2 | - | - | - | - | - |
| Penstemon sp. | - | - | - | - | - | - | - | - | - | - |
| Peucephyllum schottii | 1 | 1 | 1 | 1 | - | 1 | 2 | 1 | 1 | 1 |
| Phacelia crenulata (X) | 3 | 1 | 1 | 1 | 1 | 1 | - | 1 | 1 | - |
| Phacelia sp. | - | - | - | - | - | - | - | - | - | - |
| Physalis cf. crassifolia (X) | - | - | - | - | - | - | - | - | 1 | - |
| Pinus cf. flexilis | - | - | - | - | - | - | - | - | - | - |
| Salvia dorrii | - | - | - | - | - | - | - | - | 1 | - |
| cf. Sclerocactus sp. | 1 | 1 | - | 1 | 1 | 1 | - | 1 | 1 | 1 |
| Scopulophila rixfordii (X) | - | - | - | - | - | - | - | - | - | - |
| Sphaeralcea sp. | - | 1 | 2 | 1 | 1 | 1 | - | 1 | 1 | 1 |
| Stipa sp. (X) | - | - | - | - | - | - | - | - | - | - |
| Symphoricarpos cf. longiflorus | - | - | - | - | - | - | - | - | - | - |

| Species | | Eureka View 1 | Eureka View 2 | | | Eureka View 3 | Eureka View 4 | | | Eureka View 5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | EV 2A | EV 2B | EV 2C | | EV 4(1) | EV 4(2) | EV 4(3) | EV 5A | EV 5B |
| Tidestomia oblongifolia | (26) | 1 | - | - | 1 | - | - | - | - | - | - |
| V. guiera reticulata (X) | (15) | 3 | - | - | - | 2 | - | - | - | - | - |
| N | (58%) | 19 | 18 | 22 | 18 | .14 | 16 | 13 | 13 | 22 | 12 |
| Np | -- | 12 | 8 | 13 | 11 | 9 | 11 | 10 | 10 | 14 | 6 |
| Np/N (100) | | 63% | 44% | 59% | 61% | 64% | 69% | 77% | 77% | 64% | 50% |
| IS | | 62 | 64 | 58 | 54 | 50 | 38 | 31 | 41 | 17 | 37 |

Eureka View 4(1) and Eureka View 4(3) have radiocarbon dates that are contemporaneous within one standard deviation and are ca. 1300 years younger than EV 4(2). A date of 5595 ± 210 B.P. (GX-6227) for EV 4(1) is slightly older than a date of 5435 ± 220 B.P. (GX-6229; Table 5) for EV 4(3). Atriplex confertifolia is the primary constituent of both assemblages with Encelia virginensis and Opuntia basilaris being abundant extralocals in EV 4(3) and common in EV 4(1) (Table 9). EV 4(1) is the oldest midden sample to contain the spines of Opuntia sp. (perhaps O. echinocarpa). Erioneuron pulchellum, which made its earliest appearance in EV 4(2), is occassional in both EV 4(1) and EV 4(3). Dalea fremontii, common in EV 4(2), is represented by only rare occurrences in these two younger samples. A few fragments of Larrea tridentata occur in the youngest assemblage, EV 4(3) (Table 9). A single twig of Juniperus osteosperma in EV 4(1) is a presumed contaminant.

The Eureka View 2C macrofossil assemblage, dated at 3930 ± 180 B.P. (GX-6225; Table 5), is ca. 1500 radiocarbon years younger than EV 4(3) and the youngest middle Holocene sample. Like the preceding assemblages, EV 2C is dominated by Atriplex confertifolia and contains common Opuntia basilaris. It contains two other cacti, Opuntia sp. and Echinocactus polycephalus (Table 9). This is the oldest midden sample to contain cotton-top barrel cactus as well as appreciable quantities of Larrea tridentata and Peucephyllum schottii. Desert spruce was not found in the census of the modern vegetation. The nearest population known to me occurs on south facing slopes in lower Hanging Rock Canyon at ca. 1370 m (ca. 4500 ft) elevation, 12 km (7 mi) to the southwest in the Last Chance Range.

Eureka View 1, at 1510 m (4950 ft), is the highest elevation site. At 2635 ± 140 B.P. (GX-6222; Table 5) it is the oldest assemblage with an array of species closely resembling the modern community (Table 9). The twigs and leaves of creosote bush and shadscale are abundant. Viguiera reticulata and Ambrosia dumosa are both common in this sample, the former appearing in the fossil record for the first time. Echino-cactus polycephalus, Lepidium cf. fremontii, and Opuntia echinocarpa are occassional in EV 1, but they do not occur at the site today.

A radiocarbon date of 1580 ± 140 B.P. (GX-6224) for EV 2B places it ca. 2400 radiocarbon years younger than EV 2C, its companion midden from the same site (Table 5). The most important plants in EV 2B are the dominant species in the present vegetation, although it contains common beavertail prickly pear, Opuntia sp. (probably O. echinocarpa), Peucephyllum schottii, and Dalea fremontii, desertscrub species not pre-sent at the site today. (table 9). Amphipappus fremontii, a common plant at the Eureka View Locality today, makes a belated appearance in the fossil record in EV 2B.

Eureka View 3 is the youngest radiocarbon dated midden from this locality. A $^{14}$C date of 535 ± 150 B.P. (GX-6226; Table 5) is associated with a macrofossil assemblage containing abundant Larrea tridentata and common Atriplex confertifolia (Table 9). It contains only two species that cannot be found at the site today, Opuntia sp. and Peucephyllum schottii. The last midden from this series, EV 2A, has no radiocarbon date. This sample of Larrea twigs was lost at the radiocarbon lab. Its similarity to other late Holocene macrofossil assemblages suggests that it is less than 3500 years old.

The Regional Fossil Record

Late Quaternary age packrat middens have been found throughout the Southwest, from Mexico as far south as Lat. 26° N (Van Devender 1978), to Trans-Pecos Texas and southern New Mexico (Van Devender et al. 1978, 1979; Van Devender and Everitt 1977; Wells 1966), west to the inland flanks of the Sierra Nevada (Van Devender and Spaulding 1979), north to east-central Nevada (Thompson 1978). Fossil packrat middens from within the California Desert Conservation Area and adjacent Nevada and Arizona provide a biogeographic and temporal framework from which to assess the records presented up to this point. The latest Wisconsin (14,000 B.P. to 11,000 B.P.), early Holocene (11,000 B.P. to 7,800 B.P.), and then middle and late Holocene (7,800 B.P. to present) midden records will be dealt with in that order. The presentation is further separated into low ( $\leq$ 1000 m; $\leq$ 3280 ft) and intermediate (1000 m to 1800 m; 3280 ft to 5900 ft) elevation sites. Ancient packrat middens have been recovered from elevations as great as 2400 m (7870 ft) in Mojave Desert mountain ranges (Van Devender and Spaulding 1979).

The Latest Wisconsin At Low Elevations. Five midden sites from the Kofa (Lat. 33°20' N, Lon. 114°00' W) and New Water Mountains (Lat. 33°36' N; Lon. 113°55' W; Fig. 1) of Yuma County, Arizona were studied by Van Devender (1973). The sites range in elevation from 550 m to 860 m (1800 ft to 2820 ft) in paloverde-saguaro (Cercidium microphyllum-Cereus giganteus) vegetation more characteristic of the Arizona Uplands section of the eastern Sonoran Desert (Shreve and Wiggins 1964). Palo-verde-saguaro communities are zoned at higher elevations in the mountains to the east of the Colorado River Valley (Brown and Lowe 1977). The

fossil middens provide evidence for a xeric juniper woodland with lesser amounts of shrub live oak (Quercus turbinella). Only the oldest midden from the highest elevation site (Burro Canyon #1(1)), $^{14}$C dated at 14,400 ± 330 B.P. (A-1315), contains abundant Pinus monophylla. Other woodland plants such as Rhus trilobata (skunk-bush), Berberis sp. (barberry), and northern desert species like Thamnosma montana (turpentine-broom), Yucca brevifolia, and Atriplex confertifolia are present in the middens. The data also suggests the absence of typical, frost-sensitive Sonoran Desert species including Cercidium microphyllum and Cereus giganteus (Van Devender 1973).

Packrat middens from the Newberry Mountains in extreme southern Nevada (Lat. 35°15' N, Lon. 114°37' W; Fig. 1) were studied by Leskinen (1975). A midden sample from 850 m (2790 ft) elevation in modern creo-sote bush vegetation documents an ancient pinyon-juniper-live oak wood-land. The oak species are identified as Quercus chrysolepis and Q. dunnii and are associated with a radiocarbon date of 13,380 ± 300 B.P. (GaK-1988).

The most comprehensive study of Mojave Desert paleocommunities to date is that by Phillips (1977). His Lower Grand Canyon study area (Lat. 36°06' N; Lon. 113°55' W; Fig. 1) encompasses 25 midden sites ranging from 440 m to 675 m (1440 ft to 2215 ft) elevation on calcareous slopes of the Inner Gorge. The present open slope desertscrub communi-ties are often dominated by Larrea tridentata and Encelia farinosa. Other important species include Fouquieria splendens (ocotillo), Echino-cactus polycephalus, and Viguiera deltoidea (desert marigold). The The latest Wisconsin of the Lower Grand Canyon, corresponding to Phillips' vegetational Stage III, was characterized by a woodland dominated by

juniper (as _Juniperus_ sp.) and single-leaf ash (_Fraxinus anomala_).

Important associates include _Atriplex confertifolia_, _Symphoricarpos_ sp.,

_Mortonia scabrella_ (tick-weed), _Nolina microcarpa_ (bear-grass), _Prunus_

_fasciculata_, and _Yucca baccata_ (banana yucca). Various Mojave Desert

plants that do not occur in the Inner Gorge today were widespread in-

cluding _Coleogyne ramosissima_, _Yucca brevifolia_, and _Salvia dorrii_

(Phillips 1977). Only one high elevation midden from a north slope

records a pinyon-juniper woodland. Desert Almond #10A at 635 m (2080 ft)

contains both _Pinus monophylla_ and _P. edulis_ (Rocky Mountain pinyon)

associated with a radiocarbon date of 12,650 ± 380 B.P. (A-1720;

Phillips 1977).

The Owl Canyon midden site is on the southeastern edge of the

Amargosa Desert (Lat. 36°25' N, Lon. 116°15' W; Fig. 1), immediately

outside the CDCA in the low hills east of Ash Meadows, Nevada (Mehringer

and Warren 1976). Creosote bush and white bursage are widely scattered

on west facing calcareous slopes at ca. 790 m (2600 ft) elevation.

The macrofossil assemblage contains abundant _Juniperus osteosperma_ and

_Agave utahensis_ (Utah agave), the former yielding a $^{14}$C date of

13,150 ± 500 B.P. (I-4237; Mehringer and Warren 1976). Other extralocal

perennials that are common in this fossil midden include _Ribes_ cf.

_velutinum_ and _Petrophytum caespitosum_ (Table 10).

Few macrofossil records date from 14,000 B.P. to 11,000 B.P. at

low elevation sites within the CDCA. A midden from 730 m (2400 ft)

elevation in the Turtle Mountains of the Eastern Colorado Subdivision

(Lat. 34°15' N, Lon. 114°50' W; Fig. 1) contains both pinyon and juniper.

A $^{14}$C date of 13,900 ± 200 B.P. is reported for this assemblage but

Table 10. Plants from the Owl Canyon 1 midden, Amargosa Desert, Nye
County, Nevada, ca. 790 m (ca. 2600 ft) elevation. Radiocarbon
age: 13,150 ± 500 B.P. (I-4237) on Juniperus osteosperma
(Mehringer and Warren 1976). See Table 2 for an explanation
of the symbols.

| Species | Relative abundance |
|---|---|
| Agave utahensis | 4 |
| Ambrosia dumosa | 0 |
| Artemisia sec. Tridentatae | 1 |
| Atriplex confertifolia | 2 |
| Chrysothamnus cf. viscidiflorus | 2 |
| cf. Eriastrum sp. | 1 |
| Eriogonum heermannii | 1 |
| Gutierrezia cf. microcephala | 0 |
| cf. Haplopappus nanus | 1 |
| Juniperus osteosperma | 5 |
| Larrea tridentata | 1 |
| Opuntia sp. | 1 |
| Petrophytum caespitosum | 3 |
| Ribes cf. velutinum | 3 |
| Salvia dorrii | 1 |
| Scopulophila rixfordii | 1 |
| Sphaeralcea sp. | 1 |
| Symphoricarpos cf. longiflorus | 1 |

N = 18; $N_p$ = 18

few species are recorded as associates (Wells and Berger 1967). The Whipple Mountains of eastern San Bernadino County (Lat. 34°16' N, Lon. 114°25' W; Fig. 1) have yielded a number of ancient packrat middens (Van Devender 1977b, King and Van Devender 1977; Mead et al. 1978) but the bulk of the data from these sites remains unpublished. The Redtail Peak #5 midden, radiocarbon dated at 12,960 ± 210 B.P. (A-1666), is the only midden to contain both juniper and single-needle pinyon. At an elevation of only 510 m (1670 ft) it is the lowest altitude record of Ice Age pinyon-juniper woodland (Van Devender and Spaulding 1979). Other associates of the latest Wisconsin woodland in the Whipple Mountains include <u>Yucca brevifolia</u>, <u>Y. whipplei</u>, <u>Nolina bigelovii</u>, and <u>Cercocarpus intricatus</u> (Mead et al. 1978; Van Devender and Spaulding 1979).

The Latest Wisconsin At Intermediate Elevations. Two packrat midden sites in the South Central Mojave Subdivision of the CDCA document xeric juniper woodlands in the Lucerne Valley and on Ord Mountain, north of the San Bernadino Mountains (Fig. 1). The fossil midden from the north side of Ord Mountain at an elevation of 1220 m (4000 ft; Lat. 34°40' N, Lon. 115°50' W) contains abundant <u>Juniperus osteosperma</u> and <u>Purshia glandulosa</u> (cliff-rose) associated with a $^{14}$C date of 11,850 ± 550 (UCR-149; King 1976 a,b). <u>Pinus monophylla</u> occurs in the midden. <u>Larrea tridentata</u> and <u>Haplopappus cooperi</u> are the dominant shrubs at the site today while <u>Yucca schidigera</u> and <u>Y. brevifolia</u> are common (King 1976 a,b). None of these species were noted in the macrofossil assemblage. Southwest of Ord Mountain, the Lucerne Valley midden at 1010 m (3300 ft; Lat. 34°35' N; Lon. 115°50' W) elevation

provides a complex sequence of macrofossil assemblages (King 1976 a,b).
The two oldest samples are radiocarbon dated at 12,100 ± 400 B.P.
(UCR-181; Samp. #13) and 11,100 ± 420 B.P. (UCR-187; Samp. #10) and
contain abundant juniper but no pinyon. The present xeric desertscrub
vegetation is dominated by Larrea tridentata and Ephedra californica.

The Scodie Mountains lie on the western edge of the South Western
Mojave Subdivision of the CDCA (Lat. 35°36' N, Lon. 117°57' W; Fig. 1),
forming part of the southern terminus of the Sierra Nevada. Three midden
samples from the Robber's Roost area at 1130 m (3710 ft) elevation are
radiocarbon dated from 13,800 ± 400 B.P. to 12,820 ± 400 B.P. (A-1763
and A-1762, respectively; Van Devender and Spaulding 1979). They docu-
ment the occurence of a pinyon-juniper woodland in what is now creosote
bush desert. A detailed analysis has yet to be published but the middens
contain a diverse fossil flora including Cercocarpus ledifolius, Yucca
brevifolia, Quercus turbinella, Purshia glandulosa, and Artemisia
tridentata (Van Devender and Spaulding 1979).

Numerous ancient packrat middens have been collected in the Sheep
Range of southern Nevada (Fig. 1; Spaulding 1977; Van Devender and Spaul-
ding 1979). However, only one midden from intermediate elevations is
of latest Wisconsin age. The Penthouse 2 site, at 1580 m (5180 ft)
elevation, is at the crest of a limestone ridge in the southeastern Sheep
Range (Lat. 36°28' N, Lon. 115°15' W). The xeric east slope about the
site supports a mixed Mojave desertscrub community dominated by Gutierrezia
sarothrae (snakeweed), Ephedra torreyana, Coldenia canescens, and Stipa
arida. The Penthouse 2(2) macrofossil assemblage is radiocarbon dated

at 11,550 ± 150 B.P. (A-1774) and contains abundant Utah juniper and
Forsellesia nevadensis (greasebush). The remains of Pinus monophylla
and Ephedra viridis are common while Ceanothus greggii (Mojave buckbrush)
and Prunus fasciculata occur occasionally (Table 11).

Wells and Berger (1967) report a midden site from 1280 m (4200 ft)
elevation in the Funeral Range in the Eastern Mojave Subdivision of
the CDCA (ca. Lat. 36°50' N, ca. Lon. 117°05' W; Fig. 1). A woodland ·
assemblage with abundant Juniperus osteosperma and Prunus fasciculata
and common Symphoricarpos longiflorus is associated with a $^{14}$C date of
11,600 ± 160 B.P. No pinyon was found although the presence of other
mesophytes, such as Chamaebatiaria millefolium, Fraxinus anomala, and
Cercocarpus ledifolius, is extraordinary in this arid range in the
Death Valley region. Another ancient midden from 1250 m (4100 ft)
elevation on Mercury Ridge in the Nevada Test Site of south-central
Nevada (ca. Lat. 36°40' N, ca. Lon. 115°50' W; Fig. 1) contains abun-
dant juniper but no pinyon. The radiocarbon date for this low diversity
midden sample is 12,700 ± 200 B.P. (Wells and Berger 1967).

The Early Holocene At Low Elevations. Fossil records of desert-
scrub vegetation from the Wellton Hills in Yuma County, Arizona are
reported by Van Devender (1973; 1977b). These low hills at the
north end of the Lechuguilla Desert (Lat. 32°36' N; Lon. 114°11' W;
Fig. 1) are surrounded by sparse creosote bush-white bursage vegetation.
The Wellton Hills #1 midden at 160 m (530 ft) elevation is dated by
two statistically equivalent radiocarbon ages run on Larrea tridentata
(A-1407) and extralocal Ephedra nevadensis (A-1406; Van Devender 1973;

Table 11. Plants from late Wisconsin and early Holocene packrat midden sites in the Sheep Range, Clark County, Nevada. BC, Basin Canyon; Ph, Penthouse; now, plants currently growing at the midden site. See Table 2 for an explanation of all other symbols.

| Species | Penthouse | | | Basin Canyon | | |
|---|---|---|---|---|---|---|
| | now | Ph 2(2) 11,540 ± 150 B.P. | Ph 1(1) 8070 ± 120 B.P. | now | BC 2B 19,200 ± 580 B.P. | BC 2A 9365 ± 320 B.P. |
| Agave utahensis | X | 1 | 2 | X | – | 1 |
| Agropyron sp. | – | – | – | – | 1 | – |
| Arabis sp. | – | 1 | – | – | – | – |
| Arceuthobium divaricatum | – | – | – | – | – | 1 |
| Artemisia bigelovii | X | – | – | X | – | – |
| A. ludoviciana | – | – | – | X | – | – |
| Artemisia sec. Tridentatae | – | 1 | 1 | – | 1 | 1 |
| Astragalus mohavensis | X | – | – | X | – | – |
| Atriplex canescens | – | – | – | – | 3 | 3 |
| A. confertifolia | – | – | – | – | 3 | – |
| Brickellia watsonii | X | 1 | – | – | – | – |
| Brickellia sp. | – | – | 1 | – | – | – |
| Buddleja utahensis | X | 1 | – | X | – | – |
| Camissonia walkeri | X | – | – | – | – | – |
| Castilleja chromosa | – | – | – | X | – | – |
| Ceanothus greggii | – | 2 | – | – | – | – |
| Cercocarpus intricatus | – | 1 | 2 | – | – | – |
| Chrysothamnus nauseosus | X | – | – | – | – | – |
| Chrysothamnus sp. | – | – | – | – | 2 | 1 |
| Coldenia canescens | X | – | 1 | – | – | – |
| Coleogyne ramosissima | – | – | – | – | – | – |
| Cowania mexicana | – | – | – | X | – | – |
| Cryptantha confertiflora | X | – | – | – | – | – |
| C. flavoculata | – | – | – | X | – | – |
| Cryptantha sp. | X | – | 1 | X | – | – |
| Dalea fremontii | X | – | – | – | – | – |
| Descurainia sp. | – | – | – | X | – | – |

(cont.)

Table 11 (cont.)

| Species | Penthouse | | | Basin Canyon | | |
| --- | --- | --- | --- | --- | --- | --- |
| | now | Ph 2(2) | Ph 1(1) | now | BC 2B | BC 2A |
| Draba sp. | - | 1 | - | - | - | - |
| Echinocereus triglochidiatus | - | - | - | X | - | - |
| Echinocereus sp. | - | - | 1 | - | - | - |
| Ephedra nevadensis | X | - | - | X | - | - |
| E. torreyana | - | - | - | X | - | - |
| E. viridis | - | 3 | 2 | - | - | - |
| Ephedra sp. | - | - | - | - | ! | 1 |
| Erigeron sp. | X | - | - | X | - | - |
| Eriogonum brachypodium | X | - | - | X | - | - |
| E. heermannii | X | - | - | - | - | - |
| E. inflatum | - | - | - | - | - | - |
| Eriogonum sp. | X | 1 | - | - | - | - |
| Eucnide urens | X | - | - | - | - | - |
| Euphorbia incisa | - | - | - | X | 1 | 1 |
| Eurotia lanata | X | 1 | 1 | X | - | - |
| Fallugia paradoxa | X | 1 | 1 | - | - | - |
| Ferocactus acanthodes | - | 4 | 2 | - | - | - |
| Festuca octoflora | - | 1 | 1 | - | - | - |
| Forsellesia nevadensis | X | - | - | X | - | - |
| F. pungens | X | 1 | 3 | - | - | - |
| Gaura coccinea | - | 1 | - | X | - | - |
| Gutierrezia sarothrae | - | - | - | - | - | - |
| Gutierrezia sp. | - | 4 | 1 | - | 1 | - |
| Hilaria jamesii | - | 0 | 1 | X | 2 | - |
| Holodiscus microphyllus | - | - | - | - | 5 | 5 |
| Jamesia americana | X | 1 | - | - | - | - |
| Juniperus osteosperma | X | - | 1 | - | - | - |
| Larrea tridentata | - | - | - | - | - | - |

(cont.)

*Table 11 (cont.)*

| Species | Penthouse | | | Basin Canyon | | |
| --- | --- | --- | --- | --- | --- | --- |
| | now | Ph 2(2) | Ph 1(1) | now | BC 2B | BC 2A |
| Machaeranthera tortifolia | X | - | - | - | - | - |
| Nicotiana trigonophylla | X | - | - | - | - | - |
| Opuntia polyacantha | - | - | - | - | - | 1 |
| Opuntia sp. | - | 1 | - | - | - | - |
| Oryzopsis hymenoides | - | - | - | - | 1 | 1 |
| Penstemon petiolatus | X | - | - | X | - | - |
| Penstemon sp. | - | - | 1 | - | - | 1 |
| Perityle megalocephala | X | - | - | X | - | 1 |
| Petrophytum caespitosum | - | - | 1 | - | - | 1 |
| Physalis sp. | - | - | 2 | - | - | - |
| Pinus monophylla | - | 3 | - | X | - | - |
| Poa fendleriana | X | - | - | - | - | 3 |
| Prunus fasciculata | - | 2 | 2 | X | - | - |
| Rhus trilobata | - | - | - | X | - | 3 |
| Ribes cf. velutinum | - | - | 1 | - | 1 | - |
| Salvia dorrii | X | 1 | - | X | - | 1 |
| Sphaeralcea ambigua | - | 1 | - | - | - | - |
| Sphaeralcea sp. | X | - | - | - | - | 1 |
| Stephanomeria pauciflora | X | - | 1 | - | - | - |
| Stipa arida | X | - | - | - | - | - |
| S. speciosa | X | - | - | - | - | - |
| Symphoricarpos longiflorus | - | 1 | - | X | - | 3 |
| Tetradymia sp. | - | - | - | - | 2 | - |
| Thamnosma montana | X | - | - | - | - | - |
| Yucca brevifolia | X | 1 | 2 | X | 0 | - |
| Y. schidigera | X | - | - | - | - | - |
| N | 32 | 25 | 20 | 26 | 12 | 16 |
| Np | 21 | 20 | 17 | 19 | 10 | 13 |
| Np/N (100) | 66% | 80% | 85% | 73% | 83% | 81% |
| IS | -- | 28 | 40 | -- | 10 | 38 |

Mead et al. 1978). They yield an average date (Long and Rippeteau 1974)
of 10,665 ± 325 B.P. Ambrosia dumosa is also present while other extra-
local species, besides Ephedra, are Encelia frutescens (common),
Brickellia atractyloides, and Holacantha emoryi (both rare). Extralocal
shrubs are the most important component of the Wellton Hills #1 midden
although it contains the plants that dominate the vegetation today.
Other dates on extralocal Ephedra nevadensis from the Wellton Hills are
8750 ± 320 B.P. (A-1399, WH #2) and 8150 ± 320 (A-1364; WH #5) while
creosote bush fossils yield dates of 7950 ± 370 B.P. (A-1400, WH #2) and
6600 ± 370 B.P. (A-1365, WH #5; Van Devender 1973, 1977b; Mead et al. 1978).

An early Holocene midden from 245 m (800 ft) elevation on Picacho
Peak, Imperial County, California (Fig. 1) contains a desertscrub assem-
blage radiocarbon dated at 8650 ± 280 B.P. (Van Devender and Spaulding
1979). Of the common species in the midden, only Ephedra nevadensis is
lacking in the modern flora (K.L. Cole, pers. comm.). This contrasts
with the early Holocene Marble Mountains desertscrub assemblages which
are dominated by extralocal plants.

Other packrat midden sites that date from 11,000 B.P. to 7800 B.P.
document the occurence of juniper woodland (Van Devender 1977b). Ancient
middens from the Lower Grand Canyon in Arizona (Fig. 1) provide an ela-
borate record of this period (Phillips 1977). They contain abundant
woodland species although Phillips (ibid.) notes a progressive decrease
in mesophytic plants and a corresponding increase in xeric species through
the early Holocene. In this area, many of the desert shrubs destined to
dominate the middle and late Holocene vegetation were apparently present
during the preceding woodland phase. Phillips (1977, 87-88) summarizes

this phenomenon in the Lower Grand Canyon thusly ( parentheses mine):

> "The Stage III and Stage IV (latest Wisconsin and early
> Holocene, respectively) changes in vegetation involved
> not a replacement of woodland by desert from other areas,
> but a gradual decrease in abundance and number of wood-
> land species and a relative increase in importance of
> desert species, most of which were already there."

Fouquieria splendens is one of the desert plants that apparently did not enter the area until after the close of the early Holocene.

Fossil sites from 365 m (1200 ft) to 520 m (1700 ft) elevation in the Whipple Mountains of the Eastern Colorado Subdivision of the CDCA (Fig. 1) document early Holocene juniper woodland (Van Devender 1977b; King and Van Devender 1977; Mead et al. 1978). Associated extralocal species include Salvia mohavensis, Nolina bigelovii, Yucca brevifolia, and Y. whipplei. A complete analysis of these sites has yet to be published. Extensive early Holocene juniper woodland in the Whipple Mountains contrasts with the fossil record of desertscrub vegetation from the higher elevation Marble Mountains to the northwest (Fig. 1).

Early Holocene Middens From Intermediate Elevations. A packrat midden from modern creosote bush desert at 850 m (2790 ft) elevation in the Newberry Mountains of extreme southern Nevada contains the fossils of Juniperus sp., Quercus dunnii, and perhaps Q. chrysolepis (Leskinen 1975). A radiocarbon date on oak acorns from this assemblage is 9500 ± 240 B.P. (A-1077).

Further north in Nevada the Sheep Range and several small ranges in the southern Nevada Test Site have early Holocene midden records (Fig. 1). The Basin Canyon 2 site, in mixed Mojave desertscrub vegetation on

the west side of the Sheep Range (Lat. 36°43' N, Lon. 115°15' W), is at 1630 m (5340 ft) elevation. Gutierrezia sarothrae, Artemisia bigelovii, Fallugia paradoxa, and Yucca brevifolia are common today on this north-west·facing limestone slope. The Basin Canyon 2B midden, radiocarbon dated at 19,200 ± 580 B.P. (A-1741), provides a full glacial perspective with an assemblage containing abundant Juniperus osteosperma, common Atriplex confertifolia, and some montane species (Table 11). The early Holocene BC 2A midden still contains abundant extralocal juniper, dated at 9365 ± 320 B.P. (UCR-727). However, the other common fossil plants, Prunus fasciculata, Atriplex canescens (four-wing saltbush), and Symphori-carpos longiflorus, persist at the site today. Atriplex canescens appears more abundant in BC 2A than in the present community and Gutierrezia saro-thrae, the most common plant at the site today, is lacking in BC 2A (Table 11).

Penthouse 1(1), at an elevation of 1600 m (5240 ft) on a xeric lime-stone ridge in the southeastern Sheep Range, has a $^{14}$C date of 8100 ± 120 B.P. (A-1771). Gutierrezia sarothrae is the most abundant species in the present community and the midden sample. Ph 1(1) contains extralocal species that can be grouped into.three types. The occasional twigs of Juniperus osteosperma and Forsellesia nevadensis, among others (Table 11), represent plants that were important in the preceding late Wisconsin but are now restricted to woodland communities some distance away. A second group is represented by Coleogyne ramosissima and Buddleja utahensis, desert shrubs that occur nearby but only in more mesic habitats. The third and most unusual group is represented by the remains of Larrea tridentata and cf. Lycium andersonii (Table 11). Neither species occurs near the site today and their presence in the Ph 1(1) assemblage represents

a displacement upward relative to their current position on the lower, warmer talus slopes in this part of the Sheep Range.

Wells and Berger (1967) discuss a suite of six early Holocene fossil assemblages from the mountain ranges in the southern Nevada Test Site from Lat. 36°37' N to Lat. 36°55' N (ca. Lon. 115°50' W; Fig. 1). The midden sites range from 1100 m to 1830 m (3610 ft to 6000 ft) elevation and record juniper woodland in what is now desertscrub vegetation. An exception is the Spotted Range #2 midden (9450 ± 90 B.P.; 1550 m, 5080 ft) which contains common *Pinus monophylla*. Other early Holocene variations include the Ranger Mountains #2 midden (10,100 ± 160 B.P.; 1100 m, 3610 ft elevation) in which *Atriplex confertifolia* shares dominance with juniper and Mercury Ridge #1 (9000 ± 250 B.P.; 1390 m, 4560 ft elevation) in which *Cowania mexicana* exceeds juniper in abundance (Wells and Berger 1967). The Spotted Range #2 occurence of *Pinus monophylla* is anomalous. The macrofossil record from throughout the Southwest indicates that pinyon was eliminated from low elevations by 11,000 B.P. (Van Devender and Spaulding 1979).

The Lucerne Valley midden in the South Central Mojave Subdivision of the CDCA at 1010 m (3300 ft; Fig. 1) elevation records a juniper woodland in current creosote bush desert (King 1976 a,b). Two samples with $^{14}$C dates of 8300 ± 780 B.P. (UCR-186) and 7800 ± 350 B.P. (UCR-249) contain common juniper and *Encelia frutescens* but no *Larrea tridentata* is reported. One sample also contains common *Purshia glandulosa* (King 1976 a,b). The Lucerne Valley midden substantiates the early Holocene record from Negro Butte, ca. 5 km northwest of King's site at 1070 m (3510 ft) elevation (Wells and Berger 1967). The Negro Butte midden contains abundant *Juniperus osteosperma* and *Purshia glandulosa* as well as some *Yucca brevifolia* (ibid.). The midden

samples discussed by King (1976 a,b) contain a yucca identified only to the generic level.

Middle and Late Holocene Packrat Middens.  Other than the Marble Mountains and Eureka Valley fossil sites, only middens from the Lucerne Valley (King 1976 a,b) and the Sheep Range provide vegetational data on this time period.  The Sunset Cove (5880 ± 250 B.P.; UCR-134) and Lucerne Peak (5800 ± 250 B.P.; UCR-135) middens from above Lucerne Valley at 970 m (3080 ft) and 1100 m (3610 ft) elevation, respectively, suggest some vegetation change over the last 5800 years (King 1976 a,b).  The Lucerne Peak midden contains little Larrea tridentata, in contrast to its present abundance at the site, and Encelia frutescens, common in the midden, is not noted in the modern species list.  The Sunset Cove midden contains Opuntia basilaris and Opuntia sp. which are both lacking in the modern flora (King 1976 a,b).  Ambrosia dumosa and Opuntia sp. are not noted for the present vegetation of the Lucerne Valley midden site but it is common in midden samples ranging in age from ca. 4300 B.P. to ca. 3600 B.P.

Middle to late Holocene records in the Sheep Range span the last 5200 radiocarbon years.  The Desert View midden site, on the range's west flank at 1810 m (5940 ft) elevation, lies near the upper limit of blackbrush desertscrub.  A single pinyon tree grows in a crack above the midden site today but the lower limit of woodland lies at about 1950 m (6400 ft) elevation, ca. ½ km away.  The Desert View macrofossil assemblage is radiocarbon dated at 5210 ± 95 B.P. (WSU-2044) on extralocal Juniperus osteosperma. Prickly pears (Opuntia phaeacantha and O. polyacantha) in the Desert View sample do not presently occur on the bedrock slopes near the site (Table 12).

The Willow Wash 2 packrat midden site (not to be confused with the Willow Wash at the northern Eureka Valley) is in the bottom of a canyon at

...are those currently growing at the site.  See Table 2 for an explanation of all other symbols.

| Species | Desert View | | Willow Wash 2 | | Basin Wash | | | Canyon Two | | | Sawmill Canyon | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | now | 5210 ± 95 B.P. | now | 4125 ± 85 B.P. | now | recent debris | 3520 ± 100 B.P. | now | CT(1) 3310 ± 100 B.P. | CT(2) 1990 ± 70 B.P. | now | SaC 1A 3530 ± 90 B.P. | SaC 1b 3040 ± 75 B.P. |
| Agave utahensis | X | 3 | — | 1 | — | — | — | X | — | — | X | — | — |
| Amsinckia sp. | — | — | — | — | — | — | — | — | — | 2 | — | — | — |
| Arabis sp. | — | 1 | — | — | — | — | — | — | — | — | — | — | — |
| Arceuthobium divaricatum | X | 1 | — | — | — | — | 1 | X | — | — | X | 1 | 1 |
| Artemisia bigelovii | X | 1 | X | — | X | — | — | — | — | — | X | — | — |
| A. ludoviciana | — | 2 | — | — | — | 1 | 1 | X | 1 | — | X | 1 | 1 |
| Artemisia sec. Tridentatae | — | — | — | 1 | — | 1 | — | — | — | 1 | — | — | — |
| Astragalus mohavensis | — | — | X | — | X | — | 1 | — | 1 | 1 | X | 1 | 1 |
| Atriplex canescens | — | — | — | — | — | 4 | — | — | — | — | — | — | — |
| Atriplex sp. | — | — | — | — | X | — | — | — | — | — | — | — | — |
| Berberis fremontii | — | 1 | — | — | — | — | 1 | — | 1 | — | X | — | 1 |
| Brickellia longifolia | — | — | — | 3 | — | — | — | — | — | — | — | — | 3 |
| Brickellia sp. | — | — | — | — | — | — | — | — | — | — | — | — | — |
| Buddleja utahensis | — | — | X | — | — | — | — | X | — | — | — | — | — |
| Castilleja sp. | — | — | — | 2 | X | 1 | 1 | — | 1 | — | — | — | — |
| Ceanothus greggii | — | — | — | — | — | 1 | — | — | — | 1 | — | — | — |
| Cercocarpus intricatus | X | — | X | 2 | — | — | — | X | — | — | X | — | — |
| Cheilanthes feei | — | — | — | — | — | — | — | — | — | — | — | — | 1 |
| Chenopodium sp. | — | — | — | 2 | — | — | — | — | — | — | — | — | — |
| Chilopsis linearis | X | — | X | — | X | — | — | X | — | — | X | — | — |
| Chrysothamnus nauseosus | — | — | — | 1 | — | 2 | — | — | 1 | — | X | — | — |
| Chrysothamnus sp. | — | — | — | — | — | — | — | — | 2 | 2 | X | 1 | 1 |
| Cirsium sp. | — | — | — | — | — | — | — | — | 2 | 1 | — | — | — |
| Coleogyne ramosissima | X | 3 | — | — | X | 4 | — | X | — | 2 | X | 1 | 2 |
| Coryphantha vivipara | — | — | — | — | — | 1 | — | — | — | — | X | — | — |

(cont.)

| Species | Desert View now DV | | Willow Wash 2 now WW 2 | | Basin Wash now | deb. | BW | Canyon Two now | CT(1) | CT(2) | Sawmill Canyon now | SaC 1A | SaC 1D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cowania mexicana | X | 1 | X | – | X | 1 | 1 | X | 2 | 3 | X | – | – |
| Cryptantha flavoculata | X | 1 | X | – | X | – | – | X | – | – | – | – | – |
| Cryptantha sp. | – | – | X | – | – | – | – | – | – | – | – | – | – |
| Dalea fremontii | – | – | X | – | – | 1 | – | – | – | – | – | – | – |
| Descurainia pinnata | X | – | X | 1 | – | – | – | – | – | – | – | – | – |
| Descurainia sp. | – | – | – | – | – | – | – | X | 1 | 1 | – | – | – |
| Draba cuneifolia | X | – | – | – | – | – | – | – | – | – | – | – | – |
| cf. Draba sp. | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Echinocactus polycephalus | X | – | – | – | – | – | – | X | – | – | – | – | – |
| Echinocereus engelmannii | X | – | – | – | – | – | – | X | – | – | – | – | – |
| E. triglochidiatus | – | – | – | – | – | – | – | – | – | – | X | – | – |
| Echinocereus sp. | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Encelia frutescens | X | 1 | – | – | X | 3 | 1 | X | – | – | – | – | – |
| Ephedra nevadensis | X | – | X | – | X | – | – | X | – | – | – | – | – |
| E. torreyana | X | – | – | – | X | – | – | X | – | – | – | – | – |
| E. viridis | X | 1 | X | – | X | 2 | 1 | X | 3 | 3 | X | 1 | 1 |
| Ephedra sp. | – | 1 | – | 3 | – | – | – | – | – | – | – | – | – |
| Erigeron sp. | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Eriogonum fasciculatum | X | 1 | X | – | X | – | 1 | X | 3 | 3 | X | 1 | 1 |
| E. heermannii | – | – | – | – | X | 1 | – | X | – | – | – | – | – |
| E. inflatum | X | – | X | – | X | – | 1 | X | – | – | – | – | – |
| Eriogonum cf. shockleyi | – | – | – | – | – | – | – | – | – | – | – | – | – |
| Erioneuron pulchellum | X | – | – | – | X | – | 1 | X | – | – | – | – | – |
| Erodium texanum | – | – | X | – | – | – | – | X | – | – | – | – | – |
| Euphorbia incisa | – | – | X | 1 | – | – | – | – | – | – | – | – | – |
| E. robusta | – | – | – | 1 | – | – | 1 | – | 1 | 2 | – | 1 | 1 |
| Eurotia lanata | X | 3 | X | 3 | X | 3 | 3 | X | 1 | 2 | X | 1 | 1 |
| Fallugia paradoxa | – | – | X | – | – | – | – | X | 1 | 2 | – | – | – |
| Fendlerella utahensis | – | – | – | – | – | – | – | – | – | 1 | – | – | – |
| Festuca octoflora | – | – | – | – | – | – | – | – | 2 | – | – | – | – |
| Forsellesia nevadensis | – | – | X | – | X | – | – | – | 2 | 3 | X | 1 | 1 |

| Species | Desert View | | Willow Wash 2 | | Basin Wash | | | Canyon Two | | | Summit Canyon | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | now | DV | now | WW 2 | now | deb. | BW | now | CT(1) | CT(2) | now | SaC 1A | SaC 1D |
| Forsellesia pungens | - | - | - | 1 | - | - | - | - | - | - | - | - | - |
| Galium stellatum | x | - | x | - | - | - | - | x | - | - | - | - | - |
| Gutierrezia sarothrae | x | - | x | - | x | - | - | x | - | - | x | - | 1 |
| Gutierrezia sp. | - | 1 | - | 1 | - | 1 | - | - | - | - | - | - | - |
| Haplopappus linearifolius | - | - | - | 1 | - | 1 | - | - | - | - | - | - | - |
| Hilaria rigida | x | - | x | - | x | - | - | - | - | - | - | - | - |
| Juniperus osteosperma | - | 4 | - | 0 | - | 0 | 4 | - | 2 | 4 | x | 5 | 4 |
| Larrea tridentata | - | - | - | 1 | - | - | - | - | - | - | - | - | - |
| Lepidium fremontii | x | - | x | - | x | - | - | x | - | - | - | - | - |
| L. lasiocarpum | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Lepidium sp. | - | - | - | 1 | - | - | 1 | - | - | - | - | - | - |
| cf. Leptodactylon pungens | - | 1 | - | 1 | - | - | - | - | - | - | - | - | - |
| Lesquerella sp. | - | 1 | - | - | - | - | - | - | - | - | - | - | - |
| Lycium andersonii | x | - | x | - | x | - | x | x | - | - | x | - | - |
| Machaeranthera grindellioides | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Menodora spinescens | x | - | x | - | x | 1 | 1 | x | - | - | x | - | - |
| Mirabilis sp. | x | - | x | 1 | - | 0 | 1 | - | 3 | 1 | - | 2 | - |
| Opuntia basilaris | - | - | - | 1 | - | - | - | - | 1 | - | - | - | 1 |
| O. echinocarpa | - | - | - | 1 | - | - | 1 | - | 1 | 1 | - | - | - |
| O. erinacea | - | - | - | - | - | - | - | - | - | - | - | - | 3 |
| O. phaeacantha | - | 2 | - | - | - | - | 1 | - | - | - | - | 2 | 1 |
| O. polyacantha | - | 1 | - | 1 | - | 1 | - | - | 1 | 1 | - | - | - |
| O. whipplei | - | - | - | - | - | - | - | - | - | - | x | - | 1 |
| Opuntia sp. | - | - | - | 1 | - | - | - | - | 1 | - | - | - | - |
| Oryzopsis hymenoides | - | - | - | 1 | - | 1 | - | - | 1 | 1 | - | - | - |
| Penstemon petiolatus | - | - | - | 1 | - | 1 | - | x | 1 | 1 | - | - | - |
| Penstemon sp. | - | - | - | 1 | - | 2 | - | - | 1 | - | - | - | - |
| Petrophytum caespitosum | - | 1 | - | - | - | - | - | - | - | - | x | 1 | 1 |
| Physalis sp. | - | - | - | - | - | - | - | - | 1 | - | - | - | 1 |

(cont.)

| Species | Desert View | | Willow Wash 2 | | Basin Wash | | | Canyon Two | | | Sawmill Canyon | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | now DV | DV | now WW | WW 2 | now | deb. | BW | now | CT(1) | CT(2) | now | SaC 1A | SaC 1D |
| hysaria chambersii | - | - | - | - | X | - | - | - | - | - | - | - | - |
| Pinus monphylla | X | 2 | - | - | X | 1 | 2 | - | - | 2 | X | 3 | 3 |
| Poa fendeleriana | X | - | - | - | - | - | - | - | - | - | - | - | - |
| Prunus fasciculata | X | 2 | X | 5 | X | 1 | 1 | X | 1 | 2 | X | 2 | 1 |
| Ranunculus juniperinus | - | - | - | - | - | - | - | - | - | - | X | 1 | 1 |
| Rhus trilobata | X | - | X | 1 | X | 1 | 1 | X | - | - | X | 1 | - |
| Salvia dorrii | - | - | X | - | X | 3 | 1 | X | - | 1 | X | - | - |
| Sphaeralcea ambigua | X | - | X | 1 | X | 1 | 1 | X | 1 | 2 | X | - | - |
| Sphaeralcea sp. | - | 1 | - | 2 | - | - | - | - | - | - | - | - | - |
| Stanleya cf. pinnata | X | - | - | - | - | - | - | - | - | - | - | - | - |
| Stipa sp. | - | - | - | 1 | - | - | - | - | - | - | - | - | - |
| Symphoricarpos longiflorus | - | - | X | - | X | 2 | 1 | X | 1 | 1 | X | 1 | 1 |
| Tetradymia canescens | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Tetradymia sp. | - | 1 | - | - | X | 2 | 1 | X | 1 | 1 | - | - | - |
| Thamnosma montana | X | 1 | - | - | - | - | - | - | - | - | - | - | - |
| Yucca baccata | X | 2 | X | 3 | X | 3 | - | X | 3 | 3 | X | 1 | 1 |
| Y. brevifolia | - | - | - | - | - | - | 1 | - | - | - | - | - | - |
| Yucca sp. | | | | | | | | | | | | | |
| N | 29 | 26 | 26 | 26 | 27 | 30 | 24 | 31 | 23 | 25 | 29 | 17 | 23 |
| Np | 24 | 22 | 16 | 20 | 25 | 25 | 23 | 23 | 19 | 20 | 26 | 16 | 22 |
| Np/N (100) | 83% | 85% | 61% | 77% | 93% | 83% | 96% | 74% | 83% | 80% | 90% | 94% | 92% |
| IS | -- | 58 | -- | 46 | -- | 70 | 63 | -- | 44 | 54 | -- | 67 | 64 |

1540 m (5040 ft) elevation in the southeastern Sheep Range. The site is surrounded by diverse ripparian desertscrub vegetation. The Willow Wash 2 macrofossil assemblage is radiocarbon dated at 4125 ± 85 B.P. (WSU-2039) and is dominated by the species that presently occur at the site (Table 12). Four taxa that are in the midden but not at the site now are Chilopsis linearis (desert willow), Brickellia sp., Opuntia basilaris, and Agave utahensis (Table 12). Two frost damaged desert willows grow at the mouth of the canyon, ca. 1 km downstream at 1470 m (4880 ft) elevation and are the only known representatives of this tree from the main mass of the Sheep Range.

The Canyon Two midden at 1800 m (5920 ft) elevation, again in the southeastern Sheep Range, provides assemblages that are radiocarbon dated at 3310 ± 100 B.P. (A-1531, top layer) and 1990 ± 70 B.P. (A-1532, bottom layer; Spaulding 1977). Like Desert View, the site is near the present lower limit of woodland which extends down to 1980 m (6500 ft) elevation. The midden samples contain the desertscrub species that dominate the modern vegetation but Juniperus osteosperma occurs in both and is one of the most important speices in the younger, bottom layer (CT(2)), which also contains Pinus monophylla (Table 12). The presence of these conifers at the Canyon Two site suggests a slight downward displacement of the lower limit of woodland at ca. 3300 B.P. with a larger displacement occuring by ca. 2000 B.P. (Spaulding 1977).

The Basin Wash midden site, from the west flank of the Sheep Range at 1650 m (5420 ft) elevation, is near the bottom of an arroyo in a ripparian desertscrub community. It contains the shrubs currently important at the site as well as abundant Utah juniper and common single-needle pinyon (Table 12). Juniper twigs and seeds yield a $^{14}$C date of 3520 ± 100

B.P. (WSU-1854). Both conifers occur sporadically in the vicinity of the site. Modern midden debris from the Basin Wash site reflects their rarity (Table 12). The present lower limit of woodland in this part of the Sheep Range lies at ca. 1790 m (5860 ft) elevation, about 1.5 km west of the Basin Wash site. Like the Desert View and Canyon Two middens, the data from Basin Wash suggests a depression of the lower woodland boundary by at least 100 m.

The Sawmill Canyon middens on the east flank of the Sheep Range at 1755 m (5760 ft) elevation provide late Holocene macrofossil records from within the current pinyon-juniper woodland. Located immediately east of the highest part of the Sheep Range, the site is in an area where forest and woodland vegetation extends to unusually low elevations. The Sawmill Canyon 1A and 1D macrofossil assemblages are radiocarbon dated at 3530 ± 90 B.P. (WSU-2045) and 3040 ± 75 B.P. (WSU-2041), respectively. They show no appreciable departure from the current vegetation (Table 12).

## DISCUSSION

The last 14,000 years have seen the decline of Ice Age plant associations and the ultimate demise of many mesophytic species in the interior basins of western North America. The concommitent expansion of xerophytic plants led to the development of the present interglacial plant communities. The fossil packrat midden record is complex and reflects changes that are, to some degree, unique to each area. The timing of the retreat of mesic plants, as well as the advent of xeric species, varies from place to place and from plant to plant. Some

desert shrubs apparently migrated considerable distances in post-Wisconsin times, while others were present in the preceding late Wisconsin vegetation.
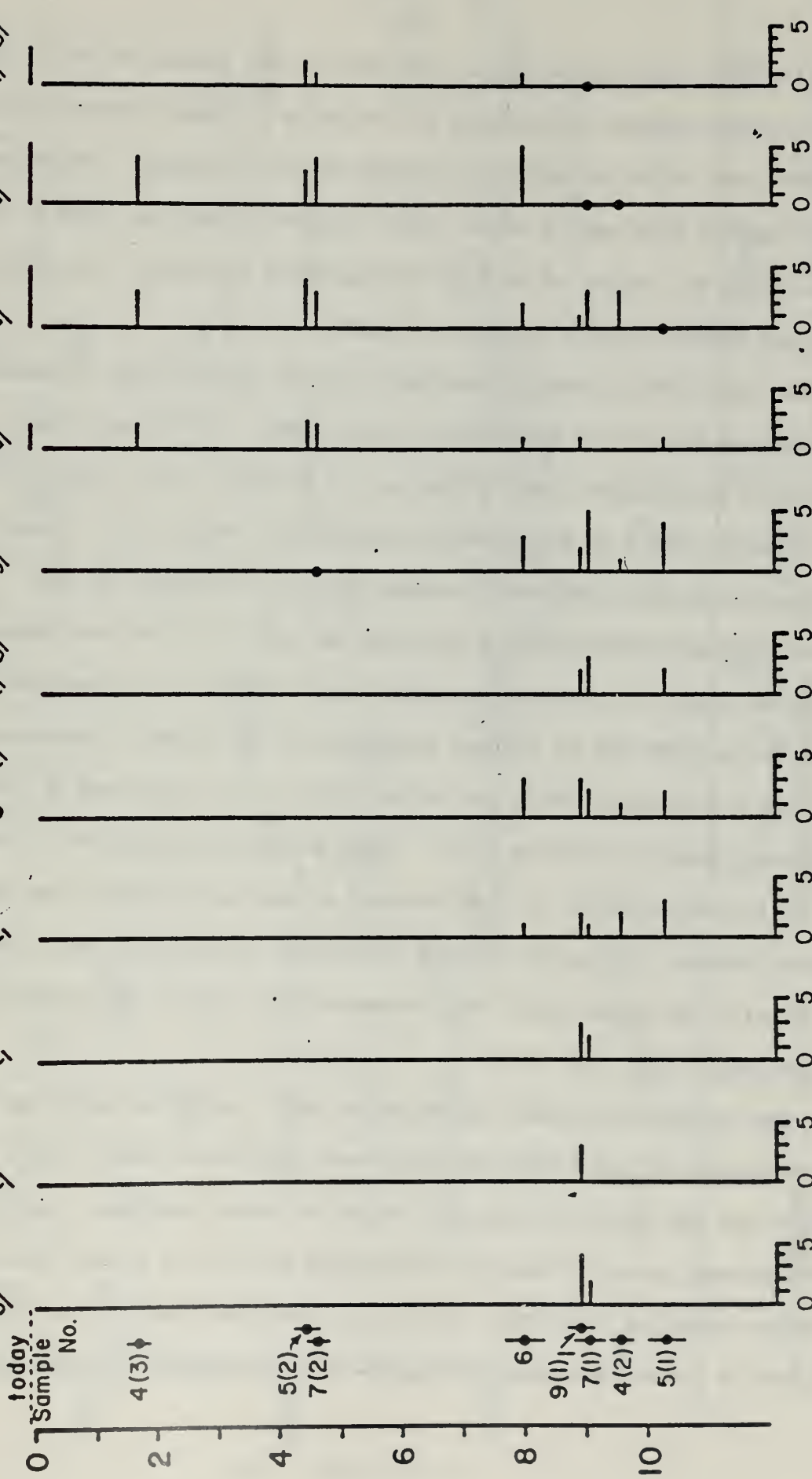
## Vegetation Dynamics

The Marble Mountains. The early Holocene vegetation of this area (Fig. 1,2) was dominated by mesic desertscrub plants. The fossil record at Marble Mountains 2 (465 m elevation) implies vegetation in which Ephedra cf. californica and Lycium sp. were important. Larrea tridentata and Encelia farinosa, the dominant taxa today, are not in the fossil sample. At higher elevations, from 840 m to 900 m elevation, contemporaneous early Holocene middens record diverse, mixed desertscrub vegetation in what is now creosote bush-brittle bush desert. Salvia mohavensis, Yucca schidigera, cf. Haplopappus laricifolius, and H. cuneatus are among the most common species in these shrub assemblages (Fig. 4). None of these early Holocene plants occur near the fossil sites today, although most may be found in higher elevation (ca. 1400 m) desertscrub communities with similar aspect.

An exception to the early Holocene record of desertscrub vegetation is found in two Marble Mountains middens, both dated at ca. 8900 B.P. They are the only samples to contain Juniperus sp., Yucca brevifolia, and Y. whipplei (Fig. 4) and represent either a reversal in the early Holocene trend toward a xeric climate, or a stochastic, developmental phase of vegetation not directly related to any forcing climatic factor. The juniper represented in these two assemblages may be either the mesic Juniperus osteosperma, or the xerophytic J. californica (California juniper). The latter is found in higher elevation desertscrub vegetation

Figure 4.  The estimated relative abundance of selected plants in

Neotoma midden samples from Marble Mountains Locality B and C

plotted against radiocarbon age.  5, very abundant; 4, abun-

dant; 3, common; 2, occasional; 1, rare; closed circle, one

or two fragments, a possible contaminant.

Ambrosia dumosa

Larrea tridentata

Encelia farinosa

Bebbia juncea

Salvia mohavensis

Haploppapus cuneatus

cf. Haploppapus laricifolius

Y. schidigera

Y. whipplei

Yucca brevifolia

Juniperus sp.

Estimated   Relative   Abundance

today
Sample No.

4(3)

5(2)
7(2)

6
9(1)
7(1)
4(2)

5(1)

0   2   4   6   8   10

Years  b.p. x10

0 5   0 5   0 5   0 5   0 5   0 5   0 5   0 5   0 5   0 5   0 5

within the CDCA today, associated with many of the plants found in these early Holocene middens. Reversals in the early Holocene drying-warming trend have yet to be consistently defined in the Southwest. Mehringer (1967) suggests that such a mesic phase occured between ca. 8500 B.P. and ca. 8,000 B.P. based on pollen stratigraphic data from Tule Springs in the Las Vegas Valley of southern Nevada.

The minor role played by woodland species in the early Holocene vegetation of the Marble Mountains is surprising. The three oldest macrofossil assemblages, dating from ca. 10,500 B.P. to ca. 9500 B.P., are virtually devoid of any woodland indicators (Table 2,3). However, contemporaneous early Holocene woodland is well documented in the eastern Colorado Subdivision of the CDCA as well as the Mojave Desert of Arizona (Fig. 5). Woodland records range upward from elevations as low as 365 m (1200 ft) on igneous substrate of the Whipple Mountains (King and Van Devender 1977) and 460 m (1520 ft) on limestone of the Lower Grand Canyon (Phillips 1977). Only middens from the low eleva- tion Wellton Hills sites in Yuma County, Arizona and Picacho Peak in Imperial County, California contain additional evidence of early Holo- cene desertscrub communities (Van Devender 1973, 1977b; Van Devender and Spaulding 1979; Fig. 1,5).

The conclusion appears inescapable that, during the early Holocene, the vegetation of the Marble Mountains was desertscrub while sites of similar age and aspect to the east supported xeric woodland. However, a contributing cause to these discrepancies may lie in a bias introduced by midden sampling technique. Extralocal woodland species have been employed as a field index of antiquity. In the Whipple Mountains and

Figure 5.  Packrat midden samples from the CDCA and adjacent regions
plotted against radiocarbon age and elevation.  Open circles
indicate desertscrub assemblages, closed circles juniper
woodland, and closed squares pinyon-juniper woodland.  The
broad dashed line indicates the present lower limit of
woodland in the Sheep Range of southern Nevada.  The short
dashed line, the approximate lower limit of woodland in
the Granite Mountains, ca. 5 km north of the Marble Mountains.

Lower Grand Canyon only middens containing obvious extralocal woodland taxa were chosen for analysis. The consequence is sampling biased against ancient middens that may contain records of desertscrub vegetation.

Sampling bias cannot account for differences between the Marble Mountains record and contemporaneous woodland samples from the systematically excavated Lucerne Valley midden (King 1976 a,b; Fig. 5). The Lucerne Valley site is at ca. 1010 m (3310 ft) elevation, ca. 110 m (400 ft) higher than the Marble Mountains sites, and apparently lay above the lower limit of woodland during the early Holocene.

Questions of sampling aside, it is plausible that an early Holocene east-west gradient of increasingly xeric vegetation existed in the southern Mojave and eastern Colorado Deserts. Low elevations may have supported xeric juniper woodland in the Colorado River Valley but only desertscrub vegetation further west. Today perennial vegetation becomes increasingly sparse and of more xeric aspect on a similar east-west gradient.

Excepting an apparent reversal about 8900 B.P. (Fig. 4,5), the early Holocene fossil record from the Marble Mountains reflects the progressive development of xeric desertscrub vegetation  Of the perennials that occur at the sites today, only Bebbia juncea is reliably documented in the oldest fossil sample. Most of the current dominant species were probably absent during the latest Wisconsin and immigrated to the area during the early Holocene. Encelia farinosa was the first to appear, in trace quantities at ca. 10,200 B.P., and then commonly in the next youngest fossil sample at ca. 9500 B.P. (Fig. 4). It is an important element in all younger midden samples. The apparent immigration of Larrea tridentata, Ambrosia dumosa, and Peucephyllum

schottii occured later (Fig. 4). Trace amounts of creosote bush first appear at ca. 8900 B.P. but it apparently did not become important until sometime between ca. 8900 B.P. and ca. 8000 B.P.

Figure 6 presents the total number of fossil taxa in midden samples from Marble Mountains Locality B and C. It is assumed that the sample diversity is directly proportional to the diversity of the vegetation at the sites. There is no dramatic early Holocene species diversity decrease since the local extinction of mesophytes was accompanied by the near synchronous immigration and expansion of xeric plants (Fig. 4,6). There is a notable diversity decrease in the middle and late Holocene, but more samples are needed to establish the validity of this trend.

The little evidence for vegetation change at the Marble Mountains during the middle and late Holocene is equivocal. More samples of this age are needed for analyses of vegetation changes which, at this area, appear to have been quite subtle.

The Eureka Valley. Plant macrofossils from the northern boundary of the California Mojave Desert (Fig. 1,3) document changes in high elevation (1430 m to 1635 m) desertscrub vegetation. Ancient middens of latest Wisconsin and early Holocene age are scarce, but the record of the middle and late Holocene is good.

The two oldest midden samples are dated at ca. 14,700 B.P. (Eureka View 5A) and ca. 10,700 B.P. (Horse Thief Hills 1) and suggest the presence of a juniper-shadscale woodland. Juniperus osteosperma and Atriplex confertifolia are abundant in both samples while other shared taxa include desertscrub (Salvia dorrii, Artemisia sec. Tridentatae) and woodland (Symphoricarpos cf. longiflorus) species. The HTH 1 site is

Figure 6. The total number of identified plant species (N) in <u>Neotoma</u>
midden samples from Marble Mountains Locality B and Locality
C plotted against their radiocarbon age.
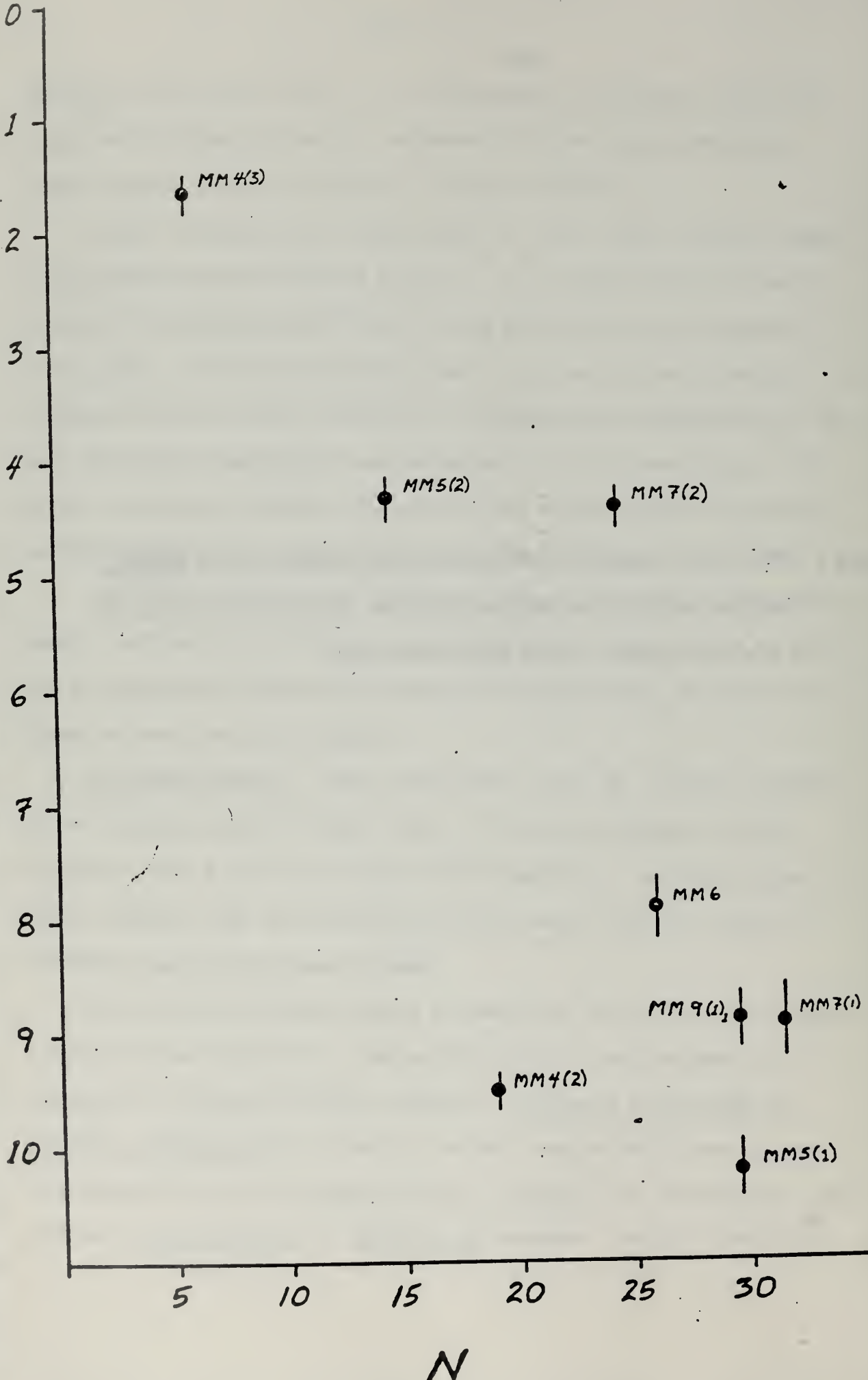
more mesic and the midden contains records of <u>Amelanchier utahensis</u>,
<u>Chamaebatiaria millefolium</u>, and <u>Prunus</u> cf. <u>andersonii</u>. Hecastocleis
<u>shockleyi</u> is present at the Horse Thief Hills 1 site today but absent
from the midden. It is common, however, in the Eureka View 5A assemblage
implying that, during the Ice Age, the distribution of Mojave prickleleaf
had shifted from north facing to south facing slopes. The remains of
<u>Pinus</u> cf. <u>flexilis</u> in EV 5A suggest a nearly continuous extension of
this subalpine species from the Inyo Mountains to the arid Last
Chance Range.

The abundance of <u>Atriplex confertifolia</u> in the two oldest Eureka
Valley middens points to an important difference between the record
of changing vegetation here and that from the Marble Mountains. In the
latter area there was a near complete turnover in the composition of
plant communities from the early Holocene to present. Plants that are
important in the current Marble Mountains vegetation are almost totally
lacking in the earliest fossil assemblages (Fig. 4). In contrast, for
the last ca. 15,000 years shadscale has played an important role in the
plant communities bordering the northern Eureka Valley. Terminal Wis-
consin and Holocene vegetation change took place within a persistent
matrix of <u>Atriplex confertifolia</u> (Fig. 7).

The only early Holocene sample from Eureka View lacks <u>Juniperus</u>
<u>osteosperma</u>. It is uncertain when, between ca. 14,700 B.P. and the
EV 5B date of ca. 8300 B.P., juniper-shadscale woodland gave way to
shadscale desertscrub (Fig. 7). It appears that desertscrub vegetation
may have developed earlier here than further to the southeast in the
highlands of the Nevada Test Site (Wells and Berger 1967), Sheep Range,

Figure 7.   The estimated relative abundance of selected plant species

in macrofossil assemblages from the Eureka View Locality

plotted against radiocarbon age.   Note the change in time

scale.   5, very abundant; 4, abundant; 3, common; 2, occasional;

1, rare; Closed circle, one or two fragments, a possible

contaminant.
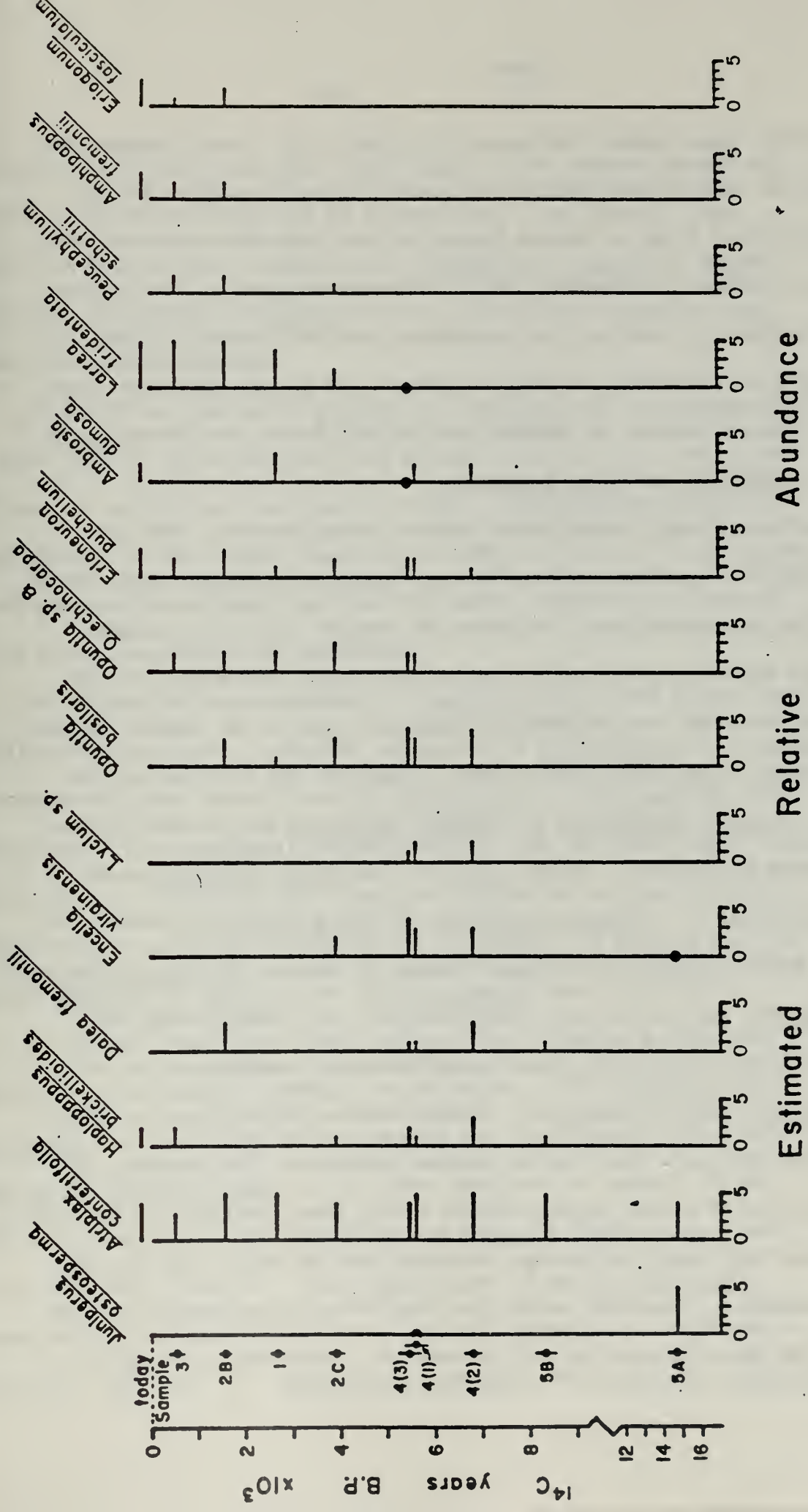
or the Lower Grand Canyon (Phillips 1977; Fig. 1,5). Such a phenomenon would not be unusual considering the Eureka Valley's position in the immediate lee of both the Sierra Nevada and the Inyo Mountains and the subsequent intense rainshadow. The EV 5B assemblage is of low species diversity (Fig. 8), lacking the mesophytes that were present during the preceding late Wisconsin, as well as many of the desert shrubs occuring today. It does contain two shrubs that are not found here today, Lepidium cf. fremontii and Dalea fremontii.

Four macrofossil assemblages ranging in age from ca. 6800 B.P. to ca. 3900 B.P. provide evidence for an anomalous shadscale desertscrub association at Eureka View. The array of species from these midden samples is anomalous relative to the current vegetation since several desert shrubs that were apparently important then are no longer present at the fossil sites while other plants, common at the site today, were lacking. Encelia virginensis and Opuntia basilaris are the most common mid-Holocene extralocals, while Lycium sp. and Dalea fremontii occur frequently (Fig. 7). Opuntia basilaris and Dalea fremontii persist into the late Holocene while the youngest sample to contain Encelia virginensis and Lycium sp. is dated at ca. 3900 B.P. (Fig. 7). Compounding the unusual floristic aspect of these middle Holocene assemblages is the nature of the samples themselves. Midden samples dating from ca. 6800 B.P. to ca. 3900 B.P. are rich in calcium carbonate. The carbonate is presumed to be of eolian origin, rather having been leached into the middens, since both older and younger samples from the same sites contain little carbonate. Leaching would also lead to rapid degradation of the middens but these samples are well preserved. The edaphic effect of a

carbonate dust fallout may have contributed to the unusual aspect of
the middle Holocene vegetation at Eureka View. The nearest areas
supporting mid-Holocene elements such as Encelia virginensis, Dalea
fremontii, and Opuntia basilaris are the caliche-rich alluvial fans
below the bedrock outcrops.

At least two species of Opuntia, O. basilaris and O. echinocarpa,
are important in the middle and late Holocene Eureka View assemblages.
Neither can be found at the locality today. Peucephyllum schottii
first appears in the fossil record at ca. 3900 B.P. (Fig. 7) and occurs
in all younger assemblages, but like the cacti, could not be located
in the modern vegetation at the sites.

The middle Holocene abundance of Opuntia spp. at the Eureka View
Locality is not unique. A similar expansion of Platyopuntia is recorded
in the mid-Holocene Desert View (O. phaeacantha, O. polyacantha) and
Willow Wash 2 (O. basilaris) packrat middens from the Sheep Range (Table 12).
Middle Holocene midden samples from the Lucerne Valley area display a
rather dramatic increase in Opuntia (O. basilaris and Opuntia sp.) as
well as Encelia (E. farinosa and E. frutescens; King 1976 a,b).

The Eureka View fossil data reflect the differing migrational
histories of the plants currently at the sites. Only Atriplex con-
fertifolia is present through the entire ca. 14,700 years of record.
Haplopappus brickellioides is the first immigrant to appear, by ca.
8300 B.P., and Erioneuron pulchellum and Ambrosia dumosa appear next
by ca. 6800 B.P. (Fig. 7). Trace quantities of Larrea tridentata
appear at ca. 5400 B.P. and creosote bush is frequent ca. 1500 years
later in EV 2C (Fig. 7). Amphipappus fremontii and Eriogonum fasciculatum

are among the latest to appear in the fossil record at ca. 1600 B.P. The development of vegetation of essentially modern aspect, that is the demise of most extralocal plants and the dominance of both shadscale and creosote bush, occured sometime between ca. 3900 B.P. and ca. 2600 B.P. (Fig. 7).

The total number of fossil taxa in each Eureka View midden sample is plotted against radiocarbon age in Fig. 8. A drop in diversity at the end of the early Holocene, followed by a gradual increase during the last ca. 5000 radiocarbon years, reflects the general vegetation history. It is a classic response. Low diversity communities are expected following major, rapid climatic change since there are few species present (such as Atriplex confertifolia) that are preadapted to the new environmental regime (Wolfe 1978). Diversity gradually increases at the Eureka View Locality as xerophytes migrate into the area. As previously mentioned, the Marble Mountains samples show no drastic early Holocene diversity decrease (Fig. 6), due to the relatively early arrival of xerophytic plants at the Marble Mountains (Fig. 5). The early establishment of vegetation of essentially modern aspect at the Marble Mountains is consistent with trends described by Van Devender and Spaulding (1979). The anomalous nature of mid-Holocene vegetation at Eureka View and the late arrival of important perennial plants to this locality is unexpected. The delayed development of modern plant communities here is contrary to a model calling for little middle and late Holocene vegetation change (Van Devender and Spaulding 1979).

Three midden samples from the Horse Thief Hills Localities A and B (Fig. 3) are associated with subrecent radiocarbon ages (Table 5). None are more than 200 radiocarbon years old and it is impossible to determine

Figure 8.   The total number of identified plant species (N) in macro-

fossil assemblages from the Eureka View Locality plotted

against radiocarbon age.   Note the change in time scale.
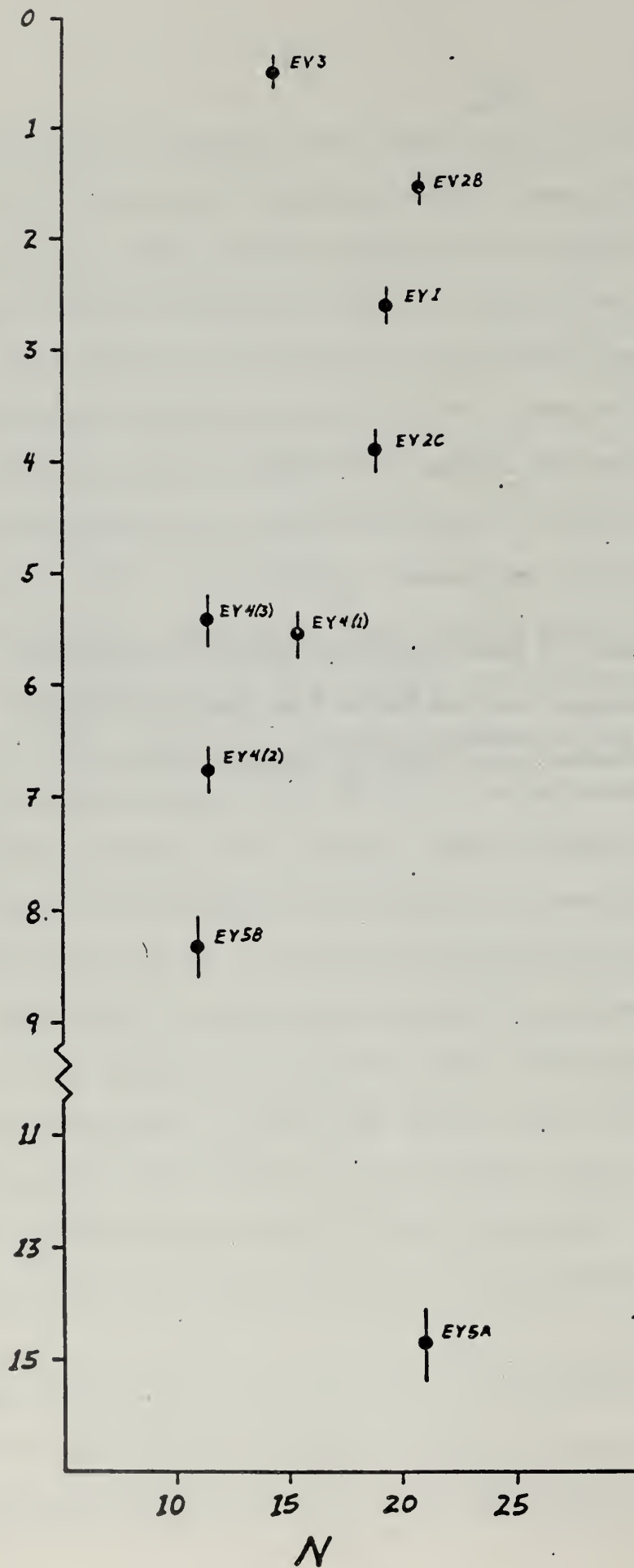
where they fall within that interval. The HTH 2 assemblage (Locality A)
reflects the current vegetation at the site (Table 7), but HTH 3(1) and
HTH 3(2) vary more from the present plant community and each other (Table 8).
It appears that the plant associations in the bottom of this canyon (Fig. 3)
have undergone considerable alteration in the last ca. 200 years. These
changes may reflect the impact of historic overgrazing but it is a prema-
ture assumption without finer chronological control. Similar changes are
not evident in young middens from hillslope sites at Eureka View and HTH
locality A.

The Sheep Range. Latest Wisconsin and early Holocene packrat mid-
dens from the Sheep Range reflect the chronology of vegetation development
proposed by Van Devender and Spaulding (1979). Diverse woodland vegetation
with juniper and pinyon gave way to xeric juniper woodland by ca. 9500 B.P.
which in turn gave way to middle Holocene desertscrub at elevations below
ca. 1740 m (5700 ft). A single high elevation (2080 m; 6820 ft) midden in
the present pinyon-juniper woodland, dated at ca. 9550 B.P. (Fig. 5), con-
tains abundant juniper but only rare pinyon. It lacks any extralocal meso-
phytes and is similar to the present woodland at the site. Contemporaneous
records from lower elevations document woodland in what is now desertscrub
vegetation.

Middle to late Holocene middens from the upper elevation desert com-
munities (1540 m to 1810 m; 5050 ft. to 5940 ft.) suggest a shifting lower
woodland boundary. It appears that, at present, the lower limit of woodland is
ca. 100 m to 150 m (330 ft to 490 ft) higher than it was for much of the
preceding 5000 radiocarbon years. The only middle to late Holocene

midden not documenting woodland is from the lowest elevation site. It provides evidence for the prior expansion of <u>Chilopsis</u> <u>linearis</u> and suggests the presence of a more mesic middle Holocene riparian desertscrub community than currently exists at the site.

Precipitation Gradients

Wisconsin and early Holocene middens south of ca. Lat. 36$^{\circ}$ N document the occurence of evergreen oaks from the Chihuahuan Desert (Wells 1966; Van Devender et al. 1978; Van Devender and Riskind 1979) west to extreme southern Nevada (Van Devender 1973; Van Devender and Spaulding 1979; Leskinen 1975; Wells 1979). Ancient packrat middens north of ca. 36$^{\circ}$ N Lat., as well as west of the Colorado River in the CDCA, yield no evidence for the Ice Age occurence of live oaks (Van Devender and Spaulding 1979; Wells and Berger 1967; Wells 1979; King 1976 a,b). The discovery of <u>Quercus</u> <u>turbinella</u> in the Scodie Mountains packrat middens, near the southern terminus of the Sierra Nevada, is the single exception (Fig. 1; Van Devender and Spaulding 1979). The apparent westerly limit of fossil live oaks along the Lower Colorado River Valley may reflect the extent of significant summer precipitation during the early Holocene and late Wisconsin, roughly congruent (Wells 1979) or some 100 km to the east (Huning 1978) of the current boundary of the monsoonal precipitation regime.

Additional evidence for the former boundary between summer-wet and summer-dry bioclimatic regions may be found in the distribution of fossil pinyon pine (Wells 1979). <u>Pinus</u> <u>monophylla</u> occured in Ice Age woodlands to elevations as low as 510 m (1670 ft) in the Whipple

Mountains and 615 m (2020 ft) in the New Water Mountains (Fig. 1; Van Devender 1973; Van Devender and Spaulding 1979). However, Pinus monophylla is lacking in almost all fossil assemblages below ca. 1550 m (5080 ft) elevation north of ca. 36° N Lat. (Spaulding 1976; Wells 1979). There is a modern corollary to the southerly decrease in the lower elevational limit of pinyon during the Wisconsin. Wells and Berger (1967) point to the decline in the elevational limit of current woodland from north to south and suggest that increasing effectiveness of summer precipitation is the cause. While speculation as to whether this cline was steeper during Wisconsin and early Holocene times (Wells 1979) begs an incomplete fossil record, the northwestern and western boundary of monsoonal climate appears to be a persistent feature of the late Quaternary climate of the Southwest (Wells 1979).

As mentioned previously, the records of early Holocene desertscrub in the Marble Mountains apparently indicate a gradient of decreasing precipitation effectiveness west of the Colorado River Valley. This may reflect a more intense rainshadow caused by the proximity of the Peninsular and Transverse Ranges (Fig. 1). But, of perhaps greater significance, is the distance from the Colorado River Valley to the Marble Mountains and the valley's function as a trough for the northward movement of moist tropical air from the Gulf of California (Huning 1978; Hales 1974). Sites near the Colorado River Valley receive a greater proportion of late summer and fall precipitation from this source than areas further inland (Huning 1978). The current limit of this secondary summer precipitation maximum delineates the western boundaries of the

Eastern Colorado and Eastern Mojave Subdivisions of the CDCA (Fig. 1;

Huning 1978). The contrast during the early Holocene between the Marble

Mountains desertscrub and contemporaneous lower elevation woodland to

the east (Fig. 5) implies that the former area may have been west of

the bounadry of effective summer precipitation. That is, prior to

ca. 8000 B.P., the effective limit of precipitation associated with

maritime tropical air from the Gulf of California (Houghton et al. 1975)

appears to have been to the east of its current limit.

Creosote Bush And Glacial Refugia

Wells and Hunziker (1978) point to the "intriguing possibility

of a late, intercontinental dispersal (of Larrea tridentata) from

South America" (parentheses mine). Cytological and biogeographic

evidence indicate that creosote bush may well have originated in South

America (ibid.). But, however intriguing the possibility may be, the

assertion that "Larrea has not been detected in the full-glacial Neotoma

record" (ibid.) is inconsistent with the fossil data (Table 13). The

fossil record offers unequivocal evidence for the Ice Age presence of

Larrea tridentata in North America. Of particular interest is the

presence of Larrea cuticles in middle and late Wisconsin-age ground

sloth (Nothrotheriops shastense) dung from Rampart Cave in the Lower

Grand Canyon (Table 13; Hansen 1978). Small amounts of creosote bush

in Neotoma middens may always be attributed to post-Pleistocene conta-

mination but its inclusion in extinct herbivore dung cannot.

There are only ten fossil records of creosote bush spanning the

ca. 20,000 year duration of the late middle and late Wisconsin Glacial

TR, this report.

| Area | Site | Elevation | Age | Reference |
|------|------|-----------|-----|-----------|
| Artillery Mts., Mohave Co., AZ | Artillery Mts. #2 | 725 m | 18,320 + 400 B.P. (A-1101) | Van Devender 1973 |
| | Artillery Mts. #3 | 725 m | 21,000 + 400 B.P. (USGS-196) | Van Devender and Spaulding 1979 |
| Grand Canyon, Mohave Co., AZ | Rampart Cave, lower Unit A sloth dung | 535 m | 12,050 + 400 B.P. – 13,140 + 320 B.P. | Hansen 1978 |
| | Rampart Cave, upper Unit C sloth dung | " | 32,560 + 730 B.P. | " " |
| | Desert Almond #7 | 560 m | 8560 + 260 B.P. (A-1469) | Phillips 1977 |
| | Vulture Canyon #14 | 645 m | 11,870 + 190 B.P. (A-1587) | " " |
| Sheep Range, Clark Co., NV | Eyrie 5(2) | 1860 m | 30,470 + 740 B.P. (WK-168) | TR |
| | Penthouse 1(1) | 1600 m | 8100 + 120 B.P. (A-1771) | " |
| | Penthouse 2(2) | 1580 m | 11,550 + 150 B.P. (A-1774) | " |
| Amargosa Desert, Nye Co., NV | Owl Canyon 1 | 790 m | 13,150 + 500 B.P. (I-4237) | " |
| New Water Mts., Yuma Co., AZ | New Water Mts. #4 | 615 m | 10,880 + 390 B.P. (A-1285) | Van Devender and Spaulding 1979 |
| | New Water Mts. #7 | 605 m | 11,000 + 505 B.P. (A-1295) | King and Van Devender 1977 |
| Wellton Hills, Yuma Co., AZ | Wellton Hills #1 | 160 m | 10,580 + 550 B.P. (A-1407) | Van Devender 1973 |
| | Wellton Hills #2 | " | 7950 + 370 B.P. (A-1400) | " " |

(cont.)

Table 13 (cont.)

| Area | Site | Elevation | Age | Reference |
|---|---|---|---|---|
| Whipple Mts., San Bernadino Co., CA | Tunnel Ridge #2 | 365 m | 10,330 $\pm$ 300 B.P. (A-1470) | King and Van Deventer 1977 |
| | Whipple Mts. #2 | 520 m | 9980 $\pm$ 180 B.P. (A-1538) | " |
| | Redtail Peak #1 | 520 m | 8910 $\pm$ 380 B.P. (A-1580) | " |
| Marble Mountains, San Bernadino Co., CA | Marble Mts. 4(2) | 885 m | 9515 $\pm$ 185 B.P. (GX-6180) | TR |
| | Marble Mts. 7(1) | 855 m | 8925 $\pm$ 360 B.P. (GX-6186) | " |
| | Marble Mts. 6 | 840 m | 7930 $\pm$ 285 B.P. (GX-6185) | " |

Age (Table 13). An additional 10 sites document creosote bush during the brief ca. 3000 year span of the early Holocene, reflecting the post-Pleistocene expansion of this xerophyte. During the last Ice Age *Larrea* appears to have occured sporadically as far north as the Lower Grand Canyon (Lat. 36°06' N), the Amargosa Desert (Lat. 36°25' N), and the Sheep Range (Lat. 36°38' N; Table 13; Fig. 9). Nor is this record for creosote bush an exception; desert plants such as *Encelia* spp., *Ferocactus acanthodes*, *Ambrosia dumosa*, and *Yucca brevifolia* occur sporadically in Wisconsin-age packrat middens as far north as ca. 36°30' N Lat. (Van Devender 1973; Phillips 1977; Van Devender and Spaulding 1979). In many cases the documented southward displacement of desert plants appears to have been unaccompanied by an equivalent contraction of their northern range (Spaulding 1976).

The macrofossil evidence for glacial refugia, areas of favorable Ice Age climate into which desert plant communities were displaced, is non-existent. Glacial-age woodlands occured in areas that presently support xeric desertscrub vegetation as far south as Lat. 26° N in Coahuila, Durango (Van Devender 1978), Sonora, and Baja, California (Wells 1976, 1979). There is abundant evidence for the southward displacement of many Mojave and Great Basin Desert species but they are inevitably associated with woodland fossil assemblages.

Van Devender (1978) suggests an alternative to the classic concept of a desert refugium that is consistent with the fossil record. In discussing the occurence of characteristic desert species in xeric Ice Age woodlands far south of the U.S.-Mexico border, he suggests "a biotic refugium in dramatically altered communities rather than a relict core
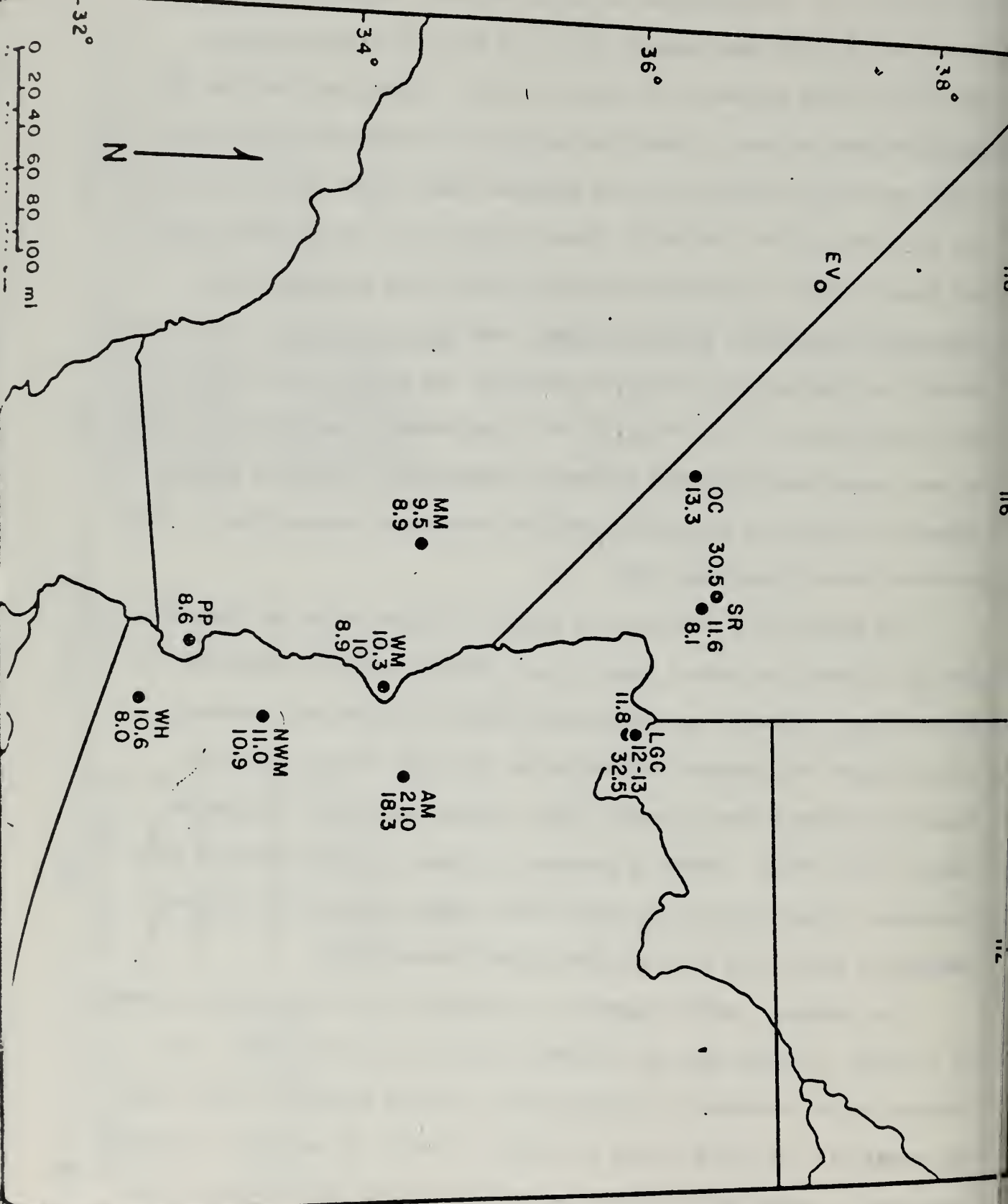
Figure 9.  Fossil sites of Wisconsin and early Holocene age containing

creosote bush.  Numbers refer to the radiocarbon ages of the

sites in thousands of years brfore present (x $10^3$ B.P.).

AM, Artillery Mountains; LGC, Lower Grand Canyon; MM, Marble

Mountains; NWM; New Water Mountains; OC, Owl Canyon; PP,

Picacho Peak; SR, Sheep Range; WH, Wellton Hills; WM, Whipple

Mountains.  The Eureka Valley study area (EV) is added for

reference.

desert" (ibid.). This concept is equally applicable to current warm desert areas north of the Mexican border. Desert species, such as _Larrea tridentata_, may have persisted throughout much of their present range in restricted habitats. This would result in a sporadic fossil record (Table 13) and is not inconsistent with the observed cytogeographic differentiation of creosote bush (Barbour 1969; Yang 1970; Wells and Hunziker 1976). A widespread but spotty Wisconsin distribution of creosote bush may account for its relatively early advent at sites spread over a wide geographic area (Table 13; Fig. 9). The delayed arrival of _Larrea_ at the northerly Eureka Valley study area (Fig. 7,9) may reflect the distance between that area and the nearest Wisconsin-age population.

## CONCLUSIONS

1. Prior to ca. 11,000 B.P. desertscrub vegetation was lacking or extremely rare in the California Desert Conservation Area. Juniper and pinyon-juniper woodland dominated the present California desert.

2. The developmental trend toward desertscrub vegetation of modern aspect began at the close of the late Wisconsin, at least 11,000 years ago. In some areas, such as the Marble Mountains in the central CDCA, the transition may have been completed by ca. 7800 B.P. In other areas, such as the Eureka Valley, vegetation of essentially modern aspect did not develope until ca. 2500 B.P.

3. There is no evidence for desert refugia during the last Ice Age. Instead, many desert plants appear to have persisted throughout much of their present range in xeric woodland vegetation. This may not be true for certain frost sensitive Sonoran Desert species, but

it appears to be the case for many xerophytes important in the CDCA.

4.   The boundary between summer-wet (monsoonal) and summer-dry climatic regimes in the CDCA has persisted throughout the last ca. 14,000 years.  During the early Holocene it may have lay ca. 100 km to the east of its present position.

5.   Differential and lengthy migration rates are indicated for certain desert plants.  Creosote bush, with a widespread but sporadic distribution, does not appear in the fossil records of many sites until well into the early Holocene.  Its arrival near its present northern limits was delayed until well into the middle Holocene.

6.  The history of vegetation development is unique to each site. Climatic changes may be widespread and broadly synchronous, but their impact at each locality is modulated by unique biotic and environmental factors.

7.   Desert plants communities are in a state of flux.  Perturbations within the present climatic regime result in vegetation changes that may be marked at sites that lie near current vegetation boundaries. In the Eureka Valley, mid-Holocene environmental changes and migrational lag times resulted in anomalous desertscrub communties.  In the Sheep Range the lower limit of pinyon-juniper woodland fluctuated more than 100 m during the last ca. 5000 years.

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