LATE PLEISTOCENE VEGETATION CHANGE IN THE CHRISTMAS TREE PASS AREA, NEWBERRY MOUNTAINS, NEVADA

by

Paul H. Leskinen

A Thesis Submitted to the Faculty of the

DEPARTMENT OF GEOGRAPHY AND AREA DEVELOPMENT

In Partial Fulfillment of the Requirements
For the Degree of

MASTER OF ARTS
WITH A MAJOR IN GEOGRAPHY

In the Graduate College

THE UNIVERSITY OF ARIZONA

1 9 7 0

STATEMENT BY AUTHOR

This thesis has been submitted in partial fulfillment of requirements for an advanced degree at The University of Arizona and is deposited in the University Library to be made available to borrowers under rules of the Library.

Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgment of source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the head of the major department or the Dean of the Graduate College when in his judgment the proposed use of the material is in the interests of scholarship. In all other instances, however, permission must be obtained from the author.

SIGNED: Paul H. Leshinen

APPROVAL BY THESIS DIRECTOR

This thesis has been approved on the date shown below:

Paul S. Martin
PAUL S. MARTIN
Professor of Geochronology

12 November 1969
Date

ACKNOWLEDGMENTS

I have drawn heavily on advice and information from Paul S. Martin, who initially suggested the project to me, and from Peter J. Mehringer, Jr., Department of Anthropology, University of Utah, who directed me to the Newberry Mountains. I wish to thank D. Robert Altschul and Richard Reeves, Department of Geography, University of Arizona, for manuscript criticism and suggestions. I am grateful for the assistance of Ann Follett, G. K. Lee and R. W. Sherwin. Identification of oaks was done by John Tucker, Department of Botany, University of California, Davis. Radiocarbon information was obtained with the assistance of Paul S. Martin, Austin Long, Department of Geochronology, University of Arizona and Peter J. Mehringer, Jr., who authorized mention of radiocarbon dates I - 3659 and I - 3669.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Continued)

LIST OF TABLES

ABSTRACT

The detailed nature of past environments characterizing Southwestern deserts is not well known. Pleistocene fossil deposits comparable to the plant remains found in Eastern North America have been thought non-existent in desert areas. Recently, Wells (1964, 1966 and 1967) discovered that woodrat middens contain abundant late-Pleistocene plant material. My study deals with a limited portion of the Mohave Desert, the Newberry Mountains, Nevada, which contains a concentration of possible fossil woodrat sites. The purpose of this work is to determine the nature of vegetation change and to suggest climatic correlations based upon evidence derived from fossil woodrat middens. Remains of pinyon and oak are the most significant fossil plant materials noted. Radiocarbon-dated material indicates that 13,380 ± 300 C_{14} years ago pinyon occurred at least 300 meters lower than its present lower limit, and that one oak, Quercus dunnii no longer occurs where it grew 9,500 ± 240 years ago.

CHAPTER I

INTRODUCTION

Recent studies indicate that vegetation changes greatly altered desert landscapes during the last 40,000 years. Advances in palynological techniques and the study of fossil plant remains from ancient woodrat middens are providing new data on past vegetation fluctuations which are widely interpreted as indices of climatic change. Such evidence is of significance to archeologists, climatologists, landscape morphologists and others interested in environmental reconstructions. It is the purpose of this work to determine the nature of past vegetation change in the Newberry Mountains of Nevada, and to suggest climatic correlations based upon the most obvious plant remains from fossil woodrat middens and from pollen analyses. This study also includes an inventory of indurated middens in an area containing an abundance of sites.

P. V. Wells was first to recognize the presence of ancient plant remains in woodrat middens. According to Wells and Jorgensen, 1964, p. 1172; Wells and Berger, 1967, p. 1646) radiocarbon-dated plant remains from woodrat middens indicate that the lower altitudinal limit for

pinyon-juniper woodland in the Mohave Desert was 600 meters lower less than 10,000 years ago, than at present. In the Chisos Mountains, Texas, which are a part of the Chihuahuan Desert, Wells (1966, p. 970) suggests an 800 meter lowering of the woodland zone during the Wisconsin glacial maximum.

The desert woodrat, Neotoma lepida, prefers a type of rock den for its dwelling (Findley 1958, pp. 515-522). The fossil and contemporary woodrat middens I have seen are located under rocks or in crevices similar to those described by Findley (Figure 1). Woodrats eat any plant locally available, and seem to prefer foliage. Most plant remains found in modern middens are gathered within 30 meters of the site (Findley, 1958, p. 520). If fossil middens were made in the same manner, the materials collected would represent the former local vegetation.

The fossil woodrat material I have seen is usually in the form of an indurated compact, blackened mass of plant material and dung cemented with dried urine. However, compaction is evidently not a definite indicator of great age. An extremely hard, dark midden from Death Valley dated only 1,000 B. P. (P. J. Mehringer, personal communication). At the other extreme, the "36 inch rat level" in Rampart Cave in Northwestern Arizona, beneath a layer of Sloth dung, dated 12,000 years old by radiocarbon (Martin, Sabels and Shutler, 1961, p. 104), and is not compacted

Figure 1. A contemporary woodrat midden in the study area.

or blackened. In the Rampart Cave "36 inch level" individual twigs are loosely held together. Without a radiocarbon date, the best criterion for age is the discovery of remains of plants no longer growing at the site.

CHAPTER II

THE STUDY AREA

The study area is located in Clark County, Nevada, east of Christmas Tree Pass in the Lake Mead National Recreational Area, at 35° 20' latitude and 114° 41' longitude. It is approximately four kilometers by two kilometers in area (Figure 2), ranging in elevation from 850 meters (about 2,800 feet) at the midden area (Figure 3), to 1,718 meters (5,639 feet) on the summit of Spirit Mountain. The Newberry Mountains are one of the numerous north-south trending ranges of the Basin and Range physiographic province. According to Longwell, et al. (1965, p. 97) the Newberry Mountains represent a wide exposure of Pre-cambrian rocks.

The study area is arid, becoming more mesic at higher elevations on Spirit Mountain. The nearest town with weather records from a comparable elevation, Searchlight, Nevada, has a minimum and maximum January temperatures of 2.0°C (about 36.0°F) and 12.0°C (about 54.2°F) respectively, July figures of 21.0°C (about 69.3°F) and 35.0°C (about 95.2°F) (U. S. Weather Bureau, 1969, p. 2 and 76), and an annual precipitation of 20.3 centimeters (about

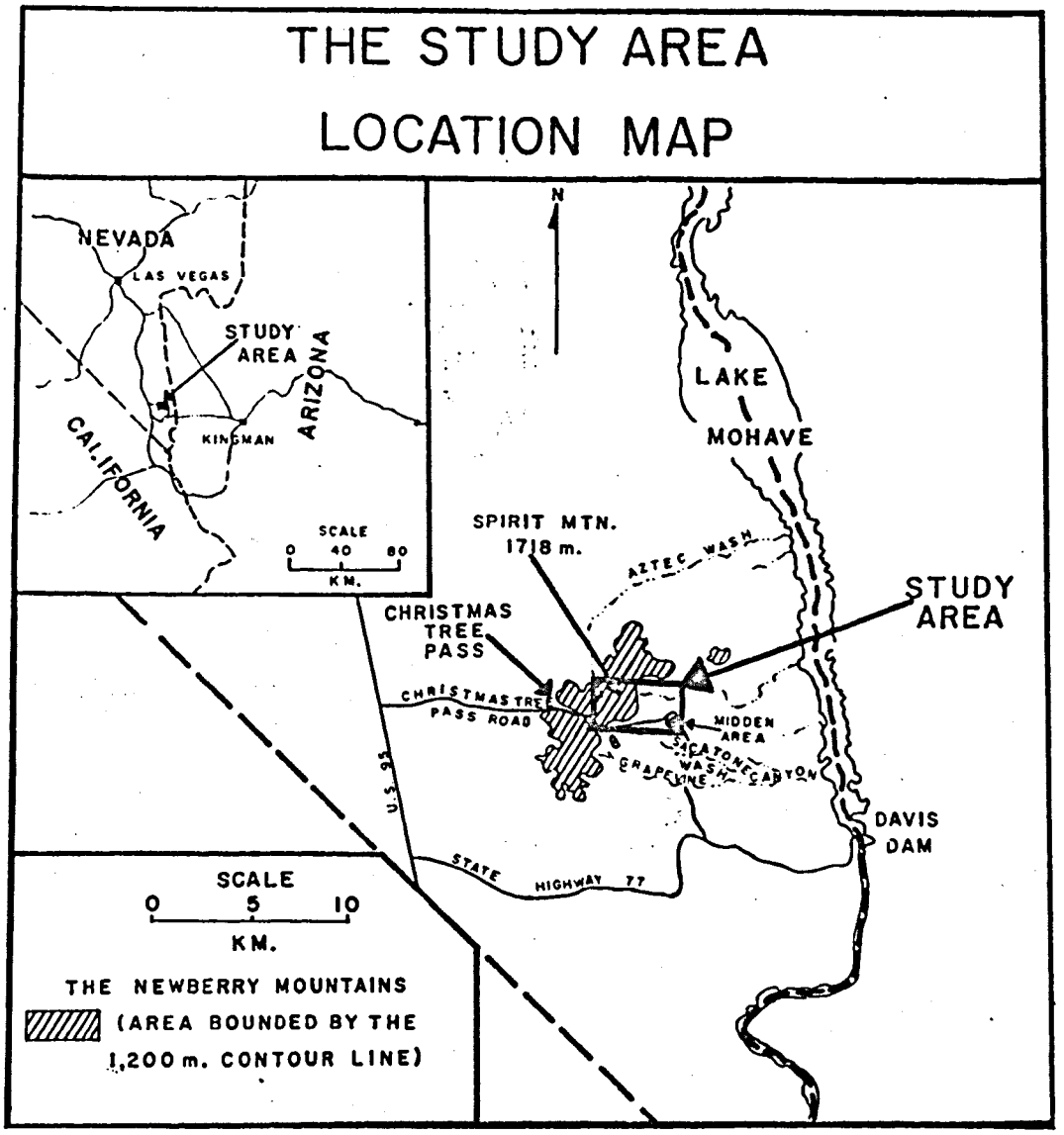

Figure 2. The study area - location map.

Figure 3. The study area.

Scale: 3 cm. = 1 km.

eight inches) (U. S. Weather Bureau, 1969, p. 6). The mean annual precipitation of the study area according to the eigenvector method, a way to estimate the precipitation of an area devised by Stidd (1967) is 25.4 centimeters (about 10 inches) at 1,500 meters (about 5,000 feet) and 16.6 centimeters (about 6.5 inches) at 900 meters (about 3,000 feet).

The contemporary vegetation in alluviated areas up to 1,100 meters (about 3,600 feet) is dominated by creosote bush (Larrea divaricata) (Figure 4). In protected drainages, scrub oak (Quercus turbinella) and juniper (Juniperus californica) are present in pockets that seem to be slightly more mesic, receiving runoff from large rock exposures in the midden area at 850 meters (Figure 5). This occurrence is exceptional because it is below the normal altitudinal level for these species in this area (Figure 6). At 1,100 meters pinyon reaches its present lower limit (Figure 7). On the summit of Spirit Mountain, 1,718 meters, I found a small population of Quercus chrysolepis (Figure 8), a species which has not previously been reported from the area. Table 1 is a list of most of the species of plants in the study area.

It is unlikely that the vegetation has been significantly altered in either recent or historic times. Wildfires do not spread in the Southwestern deserts and

Figure 4. Creosote dominated desert scrub with scattered juniper, 1,000 meters.

Figure 5. A mesic habitat at 850 meters.

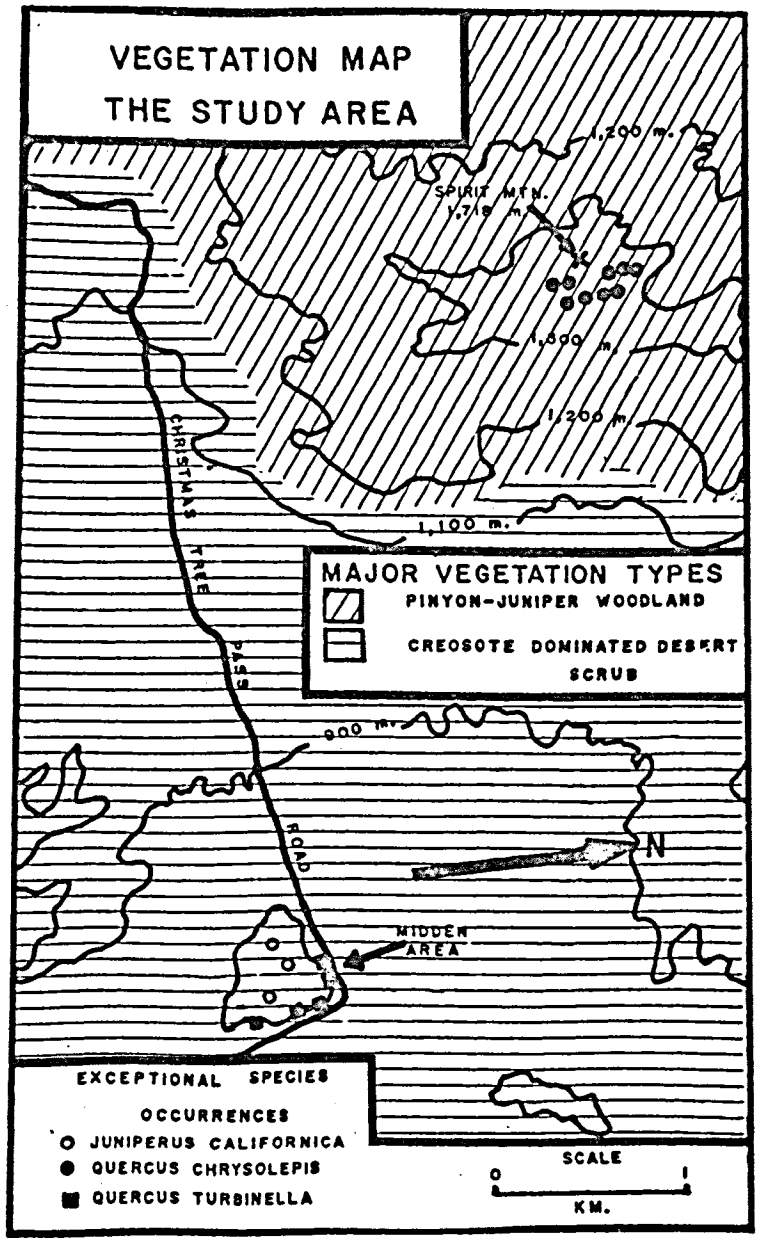

Figure 6. The study area - vegetation map.

Figure 7. Normal lower limit of pinyon and Quercus turbinella, 1,100 meters.

Figure 8. Quercus chrysolepis at the summit of Spirit Mountain.

Table 1. Prevalent plants from the study area.

Latin name	Common name	Family
Occur at 850 meters (about 2,800 feet)		
Amsinckia sp.	Fiddle-neck	Boraginaceae
Cirsium sp.	Thistle	Compositae
Delphinium sp.	Larkspur	Ranunculaceae
Echinocereus sp.*	Hedgehog cactus	Cactaceae
Ephedra sp. (Nevadensis type)	Mormon tea	Ephedraceae
Eriogonum inflatum	Wild buckwheat	Polygonaceae
Eriogonum sp.	Wild buckwheat	Polygonaceae
Eriogonum sp.	Wild buckwheat	Polygonaceae
Erodium cicutarium	Heron-bill	Geraniaceae
Eucnide urens	Rock-nettle	Loasaceae
Ferocactus sp.*	Barrel cactus	Cactaceae
Franseria dumosa	Bursage	Compositae
Hymenoclea sp.*	Burro brush	Compositae
Juniperus californica*	Juniper	Cupressaceae
Krameria sp.	Ratany	Leguminosae
Lupinus sp.*	Lupine	Leguminosae
Oenothera sp.	Evening-primose	Onagraceae
Opuntia sp.*	Prickly pear	Cactaceae

*Also occurs above 1,220 meters (about 4,000 feet).

Table 1. (Continued)

Latin name	Common name	Family
Porophyllum gracile		Compositae
Phacelia sp.		Hydrophyllaceae
*Quercus turbinella**	Scrub oak	Fagaceae
Sphaeralcea sp.	Globe-mallow	Malvaceae
*Yucca baccata**	Soap weed	Liliaceae
Yucca schidigera	Spanish bayonet	Liliaceae
Occur above 1,100 meters (about 3,600 feet) on Spirit Mountain		
Baccharis sp.	Desert-broom	Compositae
Baileya multriradiata	Desert-marigold	Compositae
Calochortus Nuttallii	Sego lily	Liliaceae
Cercocarpus sp.	Mountain-mohogany	Rosaceae
Coleogyne ramosissima	Black-brush	Rosaceae
Cuscuta sp.	Dodder	Convolvulaceae
Eriogonum sp.	Buckwheat	Polygonaceae
Pinus monophylla	Pinyon	Pinaceae
Quercus chrysolepis		Fagaceae
Tamarix pentandra	Salt-cedar	Tamaricaceae
Tetradymia axillaris	Horse-brush	Compositae
Thamnosma montana		Rutaceae

human activities have been minimal. Limited human use is indicated by a single area of aboriginal pictographs in upper Grapevine Canyon, several abandoned small mines in upper Aztec Wash, and a water catchment and corral in Sacatone Wash. The area is now lightly used for recreation.

CHAPTER III

INDURATED MIDDEN INVENTORY

I have chosen to inventory the ancient middens in a particular area of granitic outcrops of about 0.5 square kilometers (Figure 9). In an area of 25 contemporary nests and 251 possible sites, there are 30 indurated, and therefore potentially fossil, middens. The "possible sites" are locations which would appear to be protected from the elements but do not contain middens. Only about 8% of the available sites are presently occupied. My field survey notes giving the dimensions of middens and indicating the obvious macro-fossil content are simply to identify a particular site. Plant remains from several species are almost always present in a midden, but in all of the following instances the midden seems to be dominated by a particular species.

Midden Descriptions

To locate individual sites refer to Figure 10.

Site 1: Location - about seven meters above the ground, well protected by an overhang, consisting of both an upper and a lower element. Dimensions - the upper element is inaccessible, but appears to be 6 or 10 cm. thick,

Figure 9. The midden area from the summit of Spirit Mountain.

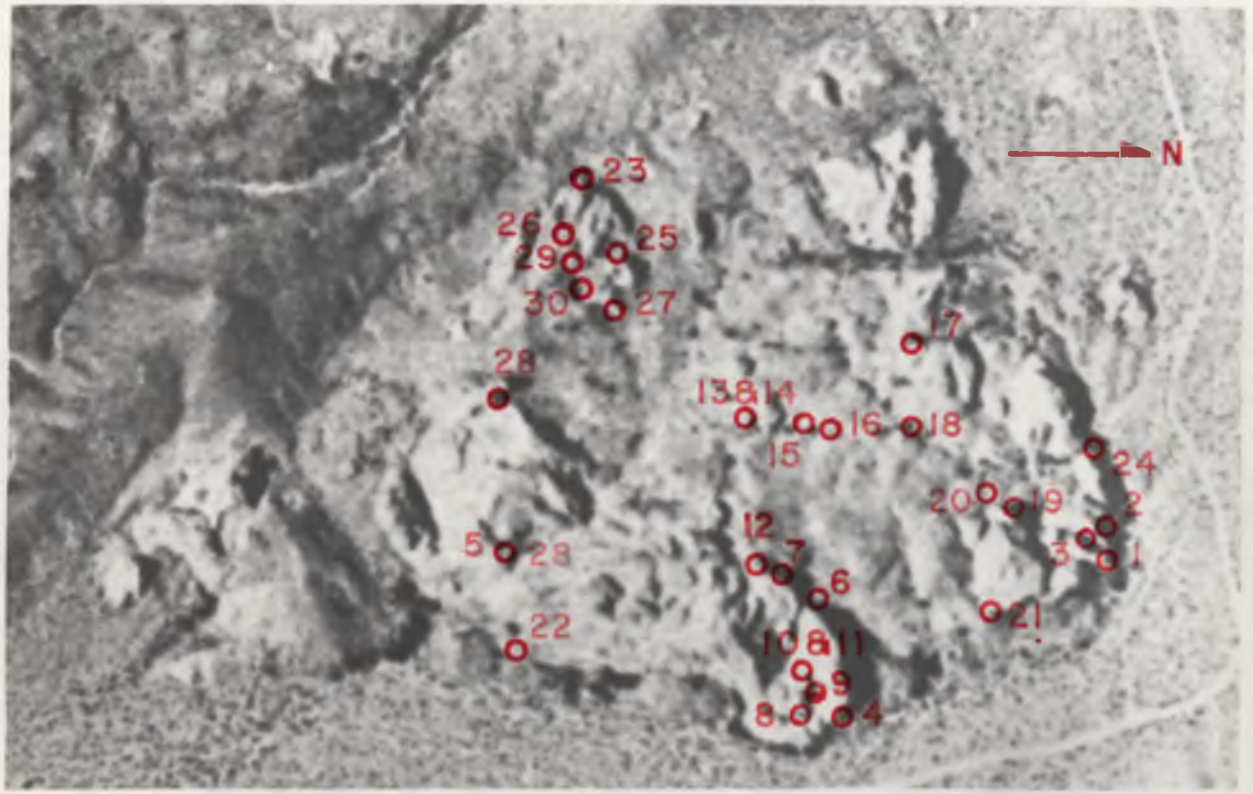

Figure 10. The midden area showing locations of specific middens.

Scale: 1 cm. = 70 meters

extending intermittently horizontally for about two meters. The lower, situated in a horizontal crack, is about four meters long and at least 10 cm. thick. Contents - predominately remnants of scrub oak, Quercus turbinella.

Site 2: Location - in a well protected vertical crevice 30 meters to the west of Site 1. Dimensions - a single block of material about eight liters in volume. Contents - not determined.

Site 3: Location and Contents - located about 40 meters above and slightly to the west of Site 1. As can be seen in Figures 11 and 12 the material is well protected in a cave. Dimensions - the greatest quantity of midden material found in the study area is contained in this site, several hundred liters of pinyon-juniper material (Figure 13) and 10 liters of material in which oak predominates (Figure 14) (Quercus dunnii and Quercus chrysolepis).

Site 4: Location - horizontal crevice midway on a cliff face. Dimensions - several liters of material in four separate occurrences. Contents - juniper.

Site 5: Location - horizontal crevice 60 meters from the base of a cliff. Dimensions - a small elongated block of material about three liters in volume. Contents - juniper.

Figure 11. Northwest corner of the midden area showing locations of Sites 1 and 3.

Creosote bush in the center and left foreground, yucca on the right foreground.

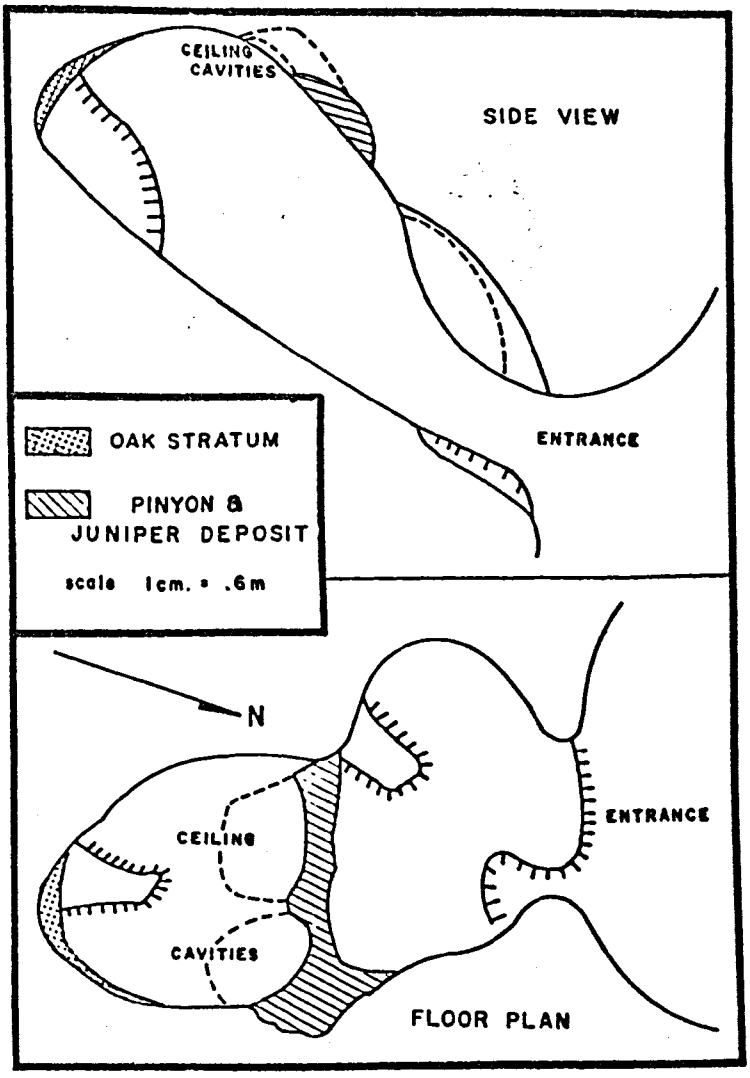

Figure 12. Cave, Newberry Mountains, Nevada, (Site 3) showing fossil midden locations.

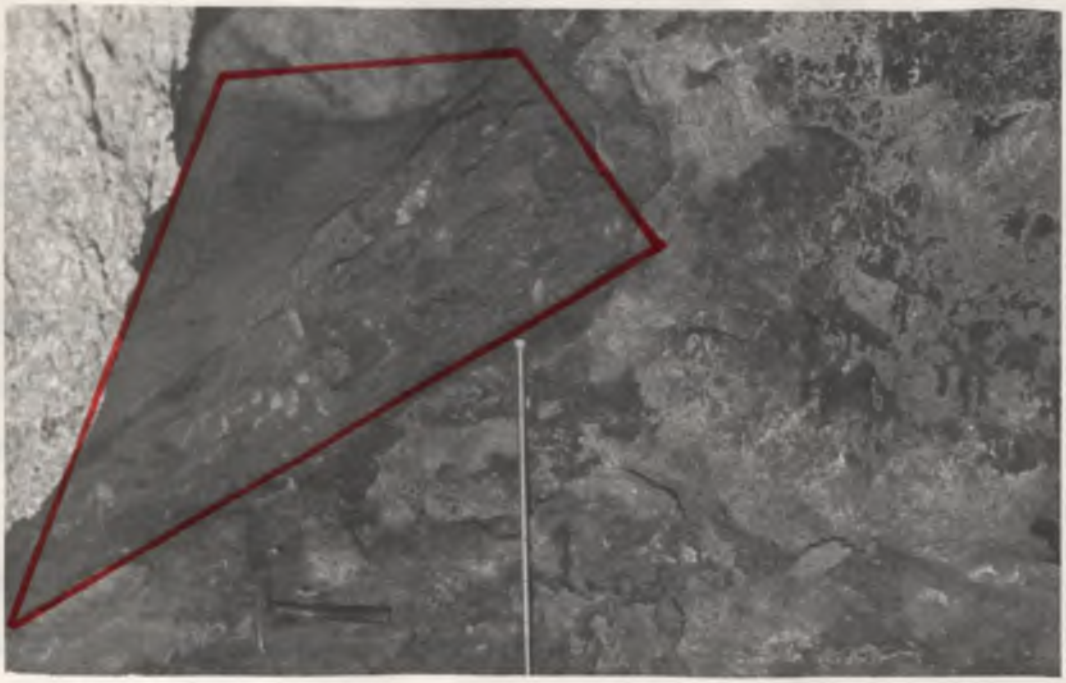

Figure 13. A portion of the pinyon-juniper material in the cave (Site 3) (outlined in red).

Figure 14. Acorns in matrix from Site 3.

Scale: 10 cm.

Site 6: Location - a minor rock shelter. Dimensions - 1 meter by 30 cm., six liters in volume. Contents - juniper.

Site 7: Location - under a small overhang. Dimensions - a maximum of 12 cm. thick, extending horizontally intermittently for four meters. Contents - juniper.

Site 8: Location - the upper corner of the floor in a minor rock shelter. Dimensions - a 5 cm. thick floor coating. Contents - juniper.

Site 9: Location - a horizontal crevice. Dimensions - 1 cm. thick. Contents - juniper.

Site 10: Location - below Site 11. Dimensions - several small blocks, the largest being a dozen liters in volume. Contents - juniper and oak (Quercus turbinella).

Site 11: Location - 10 meters above and slightly to the west of Site 10, small chunks of material in an oblique trending crack. Dimensions and Contents - site is inaccessible, therefore its size and contents are unknown.

Site 12: Location - under a minor overhang. Dimensions - small blocks of material up to 12 cm thick. Contents - juniper.

Site 13: Location - an almost horizontal crack, protected by a slight overhang. Dimensions - a maximum of

20 cm. thick, extending discontinuously for five meters laterally. Contents - juniper.

Site 14: Location - in a slightly sloping crack. Dimensions - a maximum of 10 cm. thick and is intermittent in its six meter horizontal extent. Contents - juniper.

Site 15; Location - 40 meters to the north of Site 14 in a sloping crack, composed of two elements. Dimensions - the lower element is 10 cm. thick and 10 meters long the upper being .5 meters wide and 10 cm. thick. Contents - juniper.

Site 16: Location - five meters to the north of Site 15 under a minor overhang. Dimensions - a maximum of 15 cm. thick, extending intermittently for eight meters laterally. Contents - juniper.

Site 17; Location - the material is located in an inaccessible crevice under a downsloping overhang, about 10 meters from the base of a cliff. Dimensions - not determined. Contents - unknown.

Site 18: Location - under a downsloping overhang. Dimensions - 30 cm. thick and two meters long. Contents - juniper.

Site 19: Location - under a downsloping overhang 10 meters from the base of a cliff, therefore inaccessible. Dimensions - not determined. Contents - unknown.

Site 20: Location - five meters from the base of a cliff and inaccessible. Dimensions - not determined, consists of a large block and several minor chunks. Contents - unknown.

Site 21: Location - about six meters above the ground and inaccessible. Dimensions - appears to be about six liters. Contents - unknown.

Site 22: Location - in a steeply dipping crack, six meters above the ground. Dimensions - a discontinuous seam with a maximum thickness of 8 cm. Contents - juniper.

Site 23: Location - under a substantial overhang. Dimensions - about 20 liters of material, a maximum of 15 cm. Contents - juniper and oak (Quercus turbinella).

Site 24: Location - an alcove 20 meters above an intermittent stream channel. Dimensions - not determined. Contents - unknown.

Site 25: Location - under an overhang. Dimensions - a maximum of 12 cm. extending intermittently horizontally for five meters. Contents - juniper.

Site 26: Location - in a horizontal crevice. Dimensions - 15 cm. thick, 1.5 meters wide, about 8 liters in volume. Contents - juniper.

Site 27: Location - under an overhang. Dimensions - 12 cm. thick and .5 meters wide, about six liters in volume. Contents - juniper.

Site 28: Location - under an overhang. Dimensions - .8 cm. by .5 meters by 6 liters in volume. Contents - juniper.

Site 29: Location - under a contemporary woodrat nest. Dimensions - approximately three liters in volume. Contents - juniper.

Site 30: Location - a large niche approximately 80 meters above an arroyo. Dimensions - several blocks, the largest being a maximum of 12 cm. thick, 2 meters long and 12 liters in volume. Contents - juniper.

Of the 30 above listed middens, 19 contain primarily juniper, 2 juniper and oak (Quercus turbinella), 1 oak (Quercus turbinella), 1 juniper and pinyon, 1 oak (Quercus dunnii) and possibly Quercus chrysolepis and 6 are undetermined. The acorns of Quercus dunnii, Quercus chrysolepis and Quercus turbinella are distinctive and can be differentiated. The acorns of Quercus dunnii have thick shells composed of several layers, whereas Quercus chrysolepis and Quercus turbinella have thin shells. Quercus dunnii has a very furry inner surface, Quercus chrysolepis a slightly furry inner surface and Quercus turbinella a smooth inner surface. In outward appearance both Quercus chrysolepis and Quercus dunnii are similar in that they have elongated acorns as compared to Quercus turbinella

which has an almost spherical acorn. Other morphological differences are discussed by Tucker and Haskell (1960, pp. 196-218).

In the middens in the inventory the presence of juniper is not reasonable proof of age, because juniper as well as oak (Quercus turbinella) presently occur in mesic pockets in this area. However, it seems likely that many of the undated middens containing juniper are thousands of years old, since some of the sites are several hundred meters from presently occurring juniper, and juniper remnants occur in close proximity with the ancient radiocarbon-dated pinyon material. Although the juniper middens are not of interest in this study, they could be of interest in a study dealing specifically with juniper, since the species of juniper which occurs in at least some of the fossil middens is not the same species presently growing in the area (P. J. Mehringer, personal communication). The contemporary species occurring in southernmost Nevada is Juniperus californica (Vasek, 1966, p. 367).

CHAPTER IV

C_{14} AND POLLEN ANALYSIS OF MATERIAL FROM SITE 3

Of the indurated middens listed in the inventory, Site 3 is the most valuable for study. It contains remnants of pinyon and two species of oak, Quercus dunnii and Quercus chrysolepis, woody plants no longer growing near this site. Furthermore, this site is the most significant in the study area since it has the greatest capacity to shelter midden material and it is located immediately above a mesic habitat. The pinyon needles (Pinus monophylla) in Figure 15 (showing needles before pre-treatment for C_{14} dating) were derived from the lens shown in the upper left of the block of midden material from Site 3, shown in cross-section in Figure 16. Because there was an ample quantity of needles available, I pretreated the sample to retain only needles. First, washing and screening removed the clastic and other non-soluble foreign material. Next hydrocloric acid was added to remove carbonates and sodium hydroxide to eliminate humates. Finally, the sample was washed with water and oven dried. This sample was determined to be 13,380 ± 300 years B. P. (Gak - 1988). The acorns shown in Figure 14 were not

Figure 15. Pinyon needles before radiocarbon dating.

Figure 16. Sectioned material containing pinyon.

pre-treated by me, but picked from the matrix and submitted for dating without pre-treatment. Remnants of about two dozen acorns were dated 9,500 ± 240 years B. P. (A - 1017).

Since alluvial strata which contain fossil pollen have not been found in this area, ancient middens are the only source of such pollen. Only the radiocarbon-dated material containing pinyon and oak was used since the juniper material is not dated. I treated these pollen samples in accordance with the method suggested for the extraction of alluvial pollen (Mehringer, 1967a, p. 137) with minor modifications. Materials from a location in granite does not contain significant carbonates, so the initial hydrochloric acid wash was bypassed. However, in midden material humates are significant, so an initial sodium hydroxide treatment was used. Silicates are not as abundant as in alluvial material, therefore the hydrofloric acid treatment was shortened.

Four pollen samples were removed from stratified midden material (Figures 15 and 17, samples 2-5). Photos taken through a scanning electron microscope of two pollen types from this material are shown in Figures 18 and 19. Pollen counts made from this material show higher pine and artemisia counts than a modern surface sample from the same area (Sample 1, Figure 17). However, it is unlikely

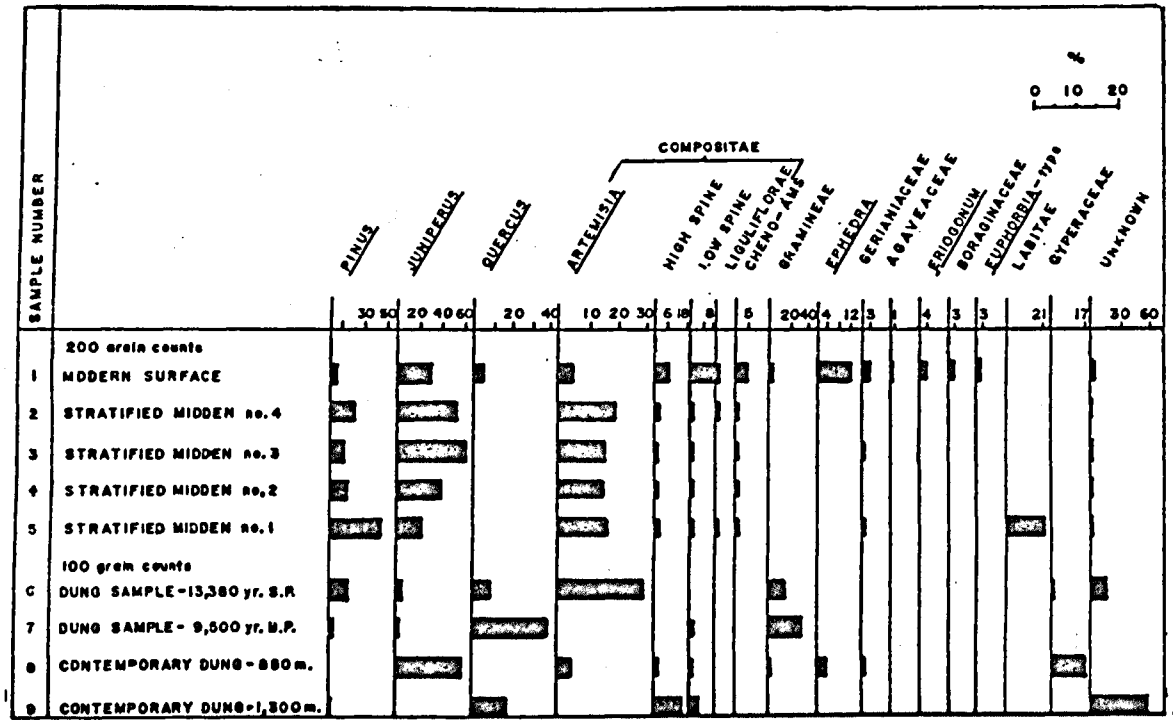

Figure 17. Woodrat nest pollen counts.

Figure 18. Fossil high-spine composite pollen.

From Sample 3, stratified midden material from Site 3. Photo courtesy of C. M. Drew and P. S. Martin. 2000x

Figure 19. Fossil *Artemisia* pollen.

From Sample 4, stratified midden material from Site 3. Photo courtesy of C. M. Drew and P. S. Martin. 5000x

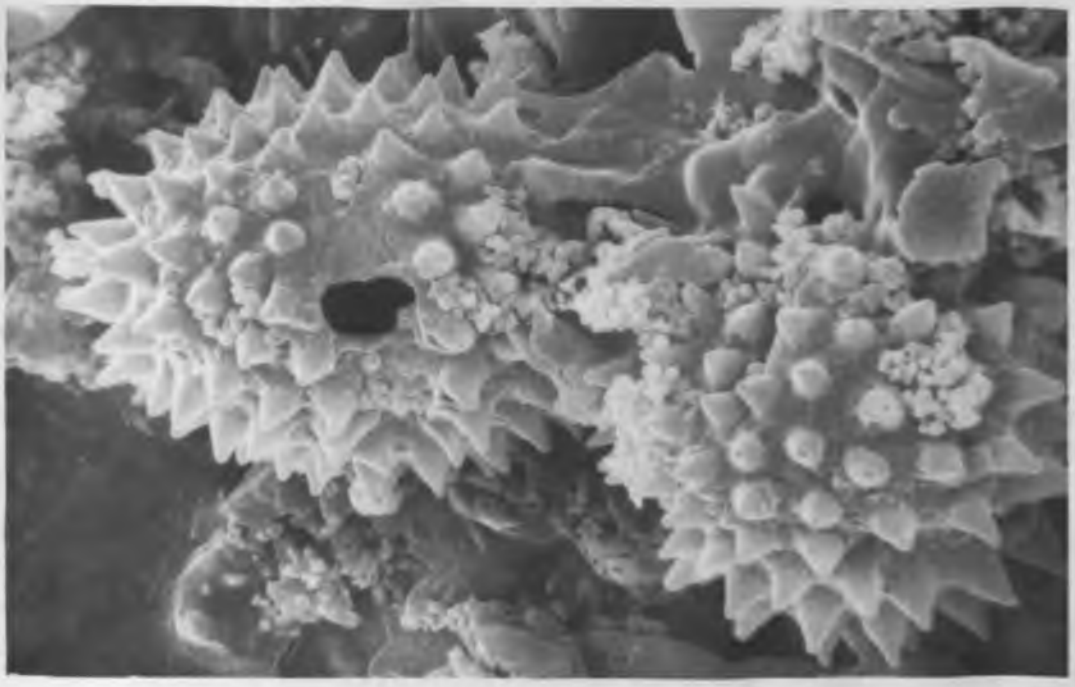

Figure 18. Fossil high-spine composite pollen.

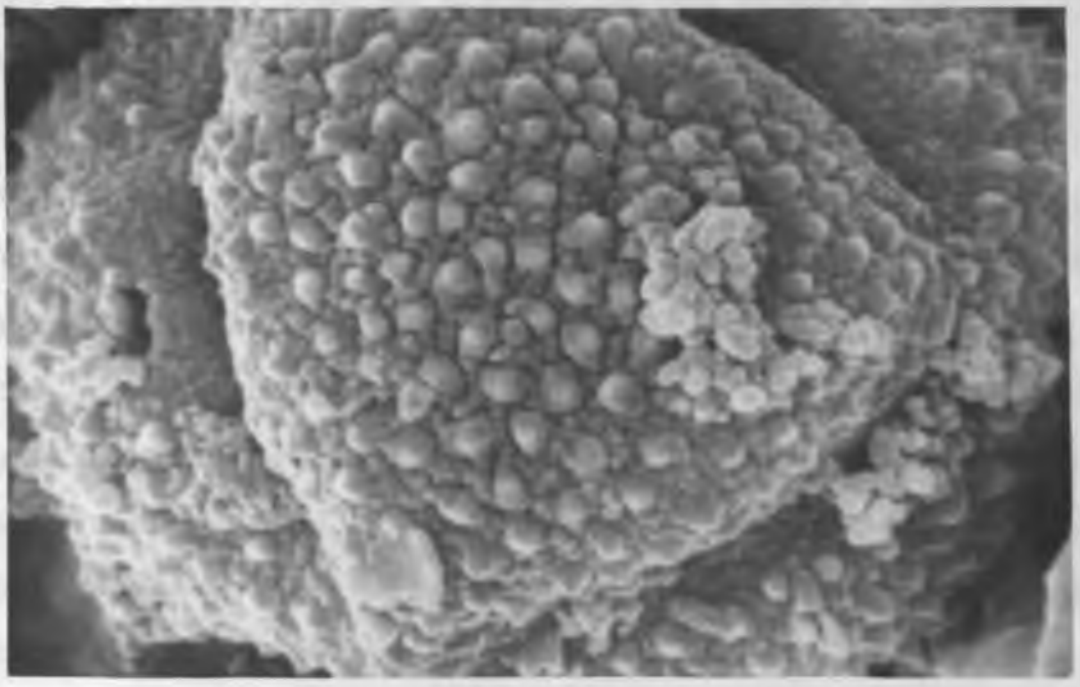

Figure 19. Fossil Artemisia pollen.

that these pollen counts are indicative of a former vegetation assemblage, since the woodrat must have been somewhat selective when he chose the vegetation remnants which compose the midden. A comparable modern comparison is unavailable, since present nests are unstratified.

For a more reliable fossil-modern pollen comparison I have analyzed the pollen contained in dung. Pollen from dung was first used to study the diet of the Shasta ground sloth (Nothrotherium) by Laudermilk and Munz (1934, p. 273). A pollen analysis of fossil hyrax dung, radiocarbon dated 4,680 ± 300 years B. P., shows a vegetation with more mesic elements than at present in the Ahaggar Mountains, Algeria (Pons and Quezel, 1958, p. 2290).

Pollen from the dung of the short-ranging woodrat might be from the vegetation in the immediate vicinity, but may not be representative of that vegetation since the animal is a selective feeder. However, a comparison of the present and fossil pollen counts derived from dung is probably indicative of the woodrat's diet during the two different periods. Although the percentages indicated do not document in detail the former vegetation assemblages, they can at least provide the basis for a relative comparison, and may be significant if some of the pollen types shown no longer occur in the contemporary vegetation.

Pine and artemisia percentages from samples 2-5, associated with the fossil pinyon material, are significantly higher than from contemporary surface or dung samples (Figure 17, samples 1, 8 and 9). Sample 7 from dung found in association with the fossil oak remnants shows significant percentages of oak and grass suggesting that both were previously more common than at present. This suggests a more mesic climate, or at least an increase in moisture in a mesic microhabitat a few meters away.

Sample 9 with a high percentage of a tricolporate, reticulate unidentified pollen type (Figure 20), poses a possible problem. Since this pollen type does not occur in any other pollen sample from this area, it is probably not from a significant element in the vegetation which composes the pinyon-juniper zone. But, as this unknown makes up a high percentage of the sample, perhaps other dung samples also over represent some elements. However, sample 8 (Figure 17) seems to be representative of at least the main elements of the modern surface sample. On the basis of this limited number of samples it appears that the fossil pollen substantiates the macrofossil evidence, indicating that more cold-tolerant or more mesic vegetation elements that do not occur at present, occurred formerly in this area at 850 meters.

Figure 20. Unknown pollen type.

Average grain size, 17 microns. Photo courtesy of P. S. Martin.

CHAPTER V

SUMMARY AND CONCLUSIONS

The study of fossil woodrat middens containing pinyon and oak in the Newberry Mountains, Nevada, shows that vegetation zones were depressed since the Wisconsin glacial maximum. Pinyon (Pinus monophylla) was present at 850 meters 13,380 ± 300 years B. P. (Gak - 1988). In Sacatone Wash, 3.6 kilometers to the south of Site 3 at an elevation of 730 meters pinyon was present 19,620 years ± B. P. (I - 3659) (P. J. Mehringer, personal communication). The second component of Site 3 contains Quercus dunnii and possibly Quercus chrysolepis, which are dated 9,500 ± 240 years old (A - 1017). In Sacatone Wash, near Mehringer's pinyon location there are remnants of acorns which dated 9,490 ± 150 years B. P. (I - 3669) (P. J. Mehringer, personal communication). Quercus dunnii does not presently occur in the area. Quercus turbinella occurs only in special mesic habitats below 1,100 meters and Quercus chrysolepis occurs only as a small population 800 meters higher than its fossil counterpart. The habitat preferences of Quercus dunnii indicate it could occur on Spirit Mountain (J. Tucker, personal communication); however, it has not yet been reported there.

It seems likely that the presence of Quercus chrysolepis as fossil acorn remnants in the midden area at 850 meters must be parallel to the contemporary presence of Quercus turbinella there. The normal lower limit is 1,100 meters and Juniperus californica descends to 1,000 meters. The midden area has sufficient rock exposed to rapidly channel runoff into the pockets of soil which have developed at the base of cliffs. These cliffs provide the shade which minimizes evaporation and supports the growth of Quercus turbinella below its average altitudinal limit. Quercus chrysolepis could have formerly occupied this habitat in a similar manner.

Since pinyon is more tolerant of cold than the oaks, its presence before 12,000 B. P., is to be expected under the cold-dry climatic conditions associated with the glacial maximum in the Mohave Desert. The radiocarbon dates agree with the late glacial chronology in which pluvial conditions lasted until 12,000 B. P. (Mehringer, 1967b, p. 98). The occurrence of Quercus chrysolepis at 850 meters indicates the climate may have been warmer and more mesic at least in the particular location where this oak occurred. Quercus chrysolepis is the most mesic of the three local oaks.

To the east of Christmas Tree Pass paleo-botanical evidence derived from fossil woodrat middens indicated a vegetational transition from cold climatic conditions of

the last glacial maximum to warmer and more mesic conditions. The early post-pluvial intrusion by Quercus chrysolepis and Quercus dunnii of the pluvial occurrence of pinyon-juniper is indicative of a climatic amelioration. Altitudinal depressions of 300 meters for pinyon and 800 meters for Quercus chrysolepis are suggested by direct comparison with present elevational distribution of these species in the Newberry Mountains. However, the mesic microhabitats of Quercus chrysolepis may not be directly comparable to the present open slope conditions of pinyon.

This study indicates that significant data, providing an insight into past vegetational patterns, can be derived from the more easily identifiable plant remains recoverable from fossil woodrat middens. The shifting spatial distributions of certain vegetation associations are indicative of the relationship between vegetation and climate and the environmental history of the Southwestern deserts.

REFERENCES CITED

Findley, R. B., 1958, The woodrats of Colorado; Univ. Kans. Publ. Museum Nat. Hist., vol. 10, p. 514-523.

Laudermilk, J. D. and P. A. Munz, 1938, Plants in the dung of Nothrotherium from Rampart and Mauv Caves, Arizona: Washington, Carnegie Inst., Pub. 487, p. 273-281.

Longwell, C. R., E. H. Pampeyan, B. Bowyer and R. J. Roberts, 1965, Geology and Mineral deposits of Clark County, Nevada: Nevada Bureau of Mines Bulletin 62, Reno, Mackay School of Mines, 198 p.

Martin, P. S., B. E. Sabels and D. Shutler, 1961, Rampart Cave coprolite and ecology of the Shasta ground sloth; American Journal of Science, vol. 259, p. 102-127.

Mehringer, P. J., 1967a, Pollen analysis of the Tule Springs Area, Nevada; Nevada State Museum, Anthropological Papers, No. 13, p. 130-200.

_____, 1967b, Pollen analysis and the alluvial chronology; The Kiva, Journal of the Arizona Archeological and Historical Society, vol. 32, no. 3, p. 96-101.

Pons, Armand and Pierre Quezel, 1958, Premieres remarques sur l'etude palynologique d'un guano fossile du Hoggar, Compte rendus, 246, p. 2290-2292.

Stidd, Charles K., 1967, The use of eigenvectors for climatic estimates: Journal of Applied Meteorology, vol. 6, p. 255-264.

Tucker, John M. and Horace C. Haskell, 1960, Quercus dunnii and Quercus chrysolepis in Arizona, Brittonia, vol. 12, no. 3, July 1960, p. 196-216.

U. S. Weather Bureau, 1969, Climatological Data - Nevada, vol. 82-83, 161 p.

_____, 1960, Climates of the States, no. 60 - 26, Nevada, Washington, U. S. Government Printing Office, 16 p.

Vasek, Frank C., 1966, The distribution and taxonomy of three western junipers, Brittonia, vol. 18, Oct.-Dec. 1966, p. 350-372.

Wells, P. V., 1966, Late Pleistocene vegetation and degree of pluvial climatic change in the Chihuahuan Desert: Science, vol. 153, p. 970-975.

_____ and C. D. Jorgensen, 1964, Pleistocene woodrat middens and climatic change in Mohave Desert: a record of juniper woodlands; Science, vol. 143, p. 1171-1174.

_____ and Rainer Berger, 1967, Pleistocene history of coniferous woodland in the Mohave Desert; Science, vol. 155, p. 1640-1647.