A LATE QUATERNARY MAMMAL FAUNA

FROM THE TAR SEEPS OF McKITTRICK, CALIFORNIA

Thesis by

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SUMMARY

Forty-three species of mammals are known at present from the McKittrick tar seeps, in addition to a larger number of bird species and a smaller number of plant types. In the McKittrick fossil assemblage Recent or still living forms are more abundant than extinct types. Since at Rancho La Brea the reverse is generally true, it appears that McKittrick is a somewhat later accumulation. The interval does not appear to be greater, however, than that separating a glacial and interglacial epoch. Many lines of evidence indicate that Rancho La Brea dates from the late rather than early Pleistocene, and there seems to be good reason for believing that this deposit is of Sangamon age. The McKittrick assemblage thus appears to be referable to the Wisconsin, or last glacial epoch.

Of the 49 mammalian species known at Rancho La Brea only 21 are found also at McKittrick. In view of the rather marked specific differences still existing between the faunas of the Los Angeles Basin and San Joaquin Valley, it seems reasonable to assume that a large part of the difference between the two faunas is due to ecology rather than to a time factor. In addition, environmental conditions surrounding the tar seeps at the two localities do not seem to have been exactly alike and some of the faunal differences may be due to this cause.

Judging from evidence of the rodents and plants, the late Pleistocene climate of the San Joaquin Valley was not greatly different from conditions still prevailing in the area. A possible explanation is that the Coast Ranges then as now prevented free passage of moisture-laden winds over the area.

INTRODUCTION

Because of their many unusual features the tar pit vertebrate fossil occurrences of California have aroused much interest. Rancho La Brea is perhaps the most widely known fossil locality in the world, while the work of Chaney and Mason (1933), L. H. Miller and A. H. Miller (1931, 1932), and Wilson (1933) has established for Carpinteria a well deserved place in the literature of palaeobotany and palaeontology. Although numerous short papers dealing with various aspects of the fauna of McKittrick have appeared in times past, the mammalian assemblage as a whole has not been described, and this is the primary purpose of the present report. While major emphasis is placed upon the mammals, opportunity is taken to supplement the record of this group with a brief review of the avian and floral assemblages. The combined evidence is discussed in relation to that of Rancho La Brea and Carpinteria, and an effort is made to determine the time sequence of these three asphalt deposits.

In a region so topographically and climatically varied as California, distribution of fossil forms in both time and space must be known before satisfactory correlations can be made. Rancho La Brea furnishes an unparalleled record of late Pleistocene life of the Los Angeles Basin, while Carpinteria is noteworthy for its record of the plants of this period. The caves in the mountainous northern and middle parts of the state have furnished large and varied faunas, but their time relations to the tar pit assemblages are difficult to determine.

Due to its geographic position, the McKittrick fauna is of considerable importance, and for the first time an adequate record of late Pleistocene life of the San Joaquin Valley is available. The information now at hand seems to indicate that no very significant time difference exists between the three asphalt faunas, but a correlation of these assemblages with those of the California caves still remains as an important problem requiring solution. Of greater importance is the correlation with faunas from other parts of North America and with those of the Old World. When such studies are completed, the tar pit assemblages will be found to possess fundamental significance.

So unlike the existing fauna of California are the tar pit assemblages that it is not difficult to understand why early workers were inclined to regard the latter as dating from the early Pleistocene. While abundance of extinct forms doubtlessly indicates considerable antiquity measured in terms of years, it now appears that this criterion alone does not necessarily point to an age more remote than the latter part of the Glacial Period. Gradually is it becoming evident that the changes which have brought about so great an impoverishment in mammalian life are of relatively recent date in the geological sense. Hardly less true for vertebrate palaeontology than for geology are Gilbert's words: "When the work of the geologist is finished and his final comprehensive report written, the longest and most important chapter will be upon the latest and shortest of the geologic periods."

ACKNOWLEDGMENTS

The writer has been fortunate to carry out this work under the supervision of Dr. Chester Stock, who not only aided in every possible way, but by his unfailing interest furnished a constant source of encouragement. R. W. Wilson gave generously of his time and knowledge in the determination of the rodents and lagomorphs in the McKittrick collection. E. L. Furlong, to whom has fallen the task of preparing much of the material, furnished many valuable suggestions which are deeply appreciated. Those portions of the present report dealing with the avifauna have been read by Dr. Hildegarde Howard, and whatever merit they may possess is largely due to Dr. Howard's careful and critical notations.

The Los Angeles Museum kindly permitted access to the Rancho La Brea collection; while the staff in charge of the Dickey collection of Recent mammals loaned important comparative material. The staff of the Museum of Palaeontology, University of California, placed the McKittrick collection of that institution at the writer's disposal, and thus made possible a complete study of the fauna. I am particularly indebted for many courtesies to R. A. Stirton, V. L. Vander Hoof and C. J. Hesse. Dr. Joseph Grinnell of the Museum of Vertebrate Zoology, University of California, permitted access to the collections of Recent mammals. Dr. W. S. W. Kew of the Standard Oil Company of California made available a geological map of the McKittrick area, while V. L. Vander Hoof furnished a detailed topographic and geologic map of the same area. Dr. Vander Hoof also loaned many maps and photographs of the brea deposits, and furnished detailed information based upon his own studies of the McKittrick tar seeps.

John L. Ridgway prepared the illustrations and retouched the photographs. Further acknowledgments of assistance are made in the text.

HISTORICAL REVIEW

A summary of the results of previous workers is necessary in order to place the present study in proper perspective.

The first mention of vertebrate remains from the McKittrick region seems to have been made by Joseph Leidy (1865, p. 94), who described two horse teeth from the vicinity of Buena Vista Lake and referred them to Equus occidentalis. Additional horse material from this locality was described and figured by Leidy in 1873 (pp. 242-244, pl. 33, fig. 1). Whitney (1880, p. 256) stated that Leidy's specimens were obtained from Santa Maria Oil Springs, a locality approximately two miles to the southwest of McKittrick.

Although Watts (1894, pp. 46-50) treated the asphaltum from an economic point of view, for a period of nearly twenty-five years, no further interest seems to have been manifested in the palaeontology of the locality.

In 1903 J. C. Merriam (pp. 288-289, pl. 30, fig. 2), then at the University of California, described a fragmentary lower jaw of Canis indianensis from a locality given as Oil Springs in Tulare County. Doubt was expressed as to the occurrence of this find in Tulare County, for the Asphalto area, a short distance north of McKittrick, was at that time known as Oil Cañon. In the same paper Hyaenognathus pachyodon was described by Merriam. The type of this genus came from Asphalto and from beds of either late Pliocene or early Quaternary age.

Two years later the same author (Merriam, 1905) described from the Asphalto beds a feline form now known as Ischyrosmilus ischyrus. The Asphalto fauna served to revive interest in the locality, but the assemblage is not closely related to that of McKittrick.

In 1908 F. M. Anderson (pp. 32-35) described a series of upraised Pleistocene terraces in the McKittrick area. Mention was also made of extensive beds of asphalt in which were found remains of elephants, horses, and an extinct species of wolf. The fauna was thought to belong to the latter part of the Pleistocene period.

Approximately seven years later Merriam invited Neil Cornwall, a student at the University of California, to reinvestigate the Asphalto and McKittrick areas. Although a part of the summer was spent in this work, the information obtained at that time was never published.

In 1921 construction of the Taft-McKittrick paved highway brought to light a fossiliferous bed of asphalt on the southern outskirts of McKittrick. The occurrence was reported by Merriam and Stock (1921), and eleven mammalian forms were listed: Aenocyon dirus, Canis near ochropus, Felis atrox, Felis near daggetti, Arctotherium near simum, Mylodon sp., Equus occidentalis, Antilocapra? sp., Bison sp., a slender-limbed camel, and Mastodon sp. The birds were studied by L. H. Miller, who found ten species in all, six of which are aquatic or semi-aquatic in habit. Shore-birds, which are rare at Rancho La Brea, appeared to be very abundant at McKittrick. At this time Merriam and Stock were inclined to attribute the dissimilarities between the Rancho La Brea and McKittrick assemblages to environmental factors, although an age difference between the two deposits was considered a possible contingency.

In the following year Miller (1922) published a preliminary report on the McKittrick birds. At that time the collection numbered approximately three hundred and twenty-five specimens. Two years later the same author (Miller, 1924) noted the absence of gulls at McKittrick and their rarity at Rancho La Brea. It was concluded that these birds were late-comers on the California coast.

Charles H. Sternberg began collecting at McKittrick in 1925 and continued his excavations until 1927. During this time most of the material now in the collections of the California Institute of Technology was obtained. An interesting account of his work is to be found in the book "Hunting Dinosaurs" (Sternberg, 1932, pp. 242-252).

In 1925 L. H. Miller (pp. 307-326) published another important paper on the McKittrick birds. This report was based on a study of approximately one thousand specimens, representing thirty-four species. Of these eighteen were assigned to living species, while four were referred tentatively to forms still extant. Seven types were not specifically determined. Three species were thought to be extinct, while two were found to live no longer in the region. Remains of water birds were stated to outnumber those of land forms approximately two to one. Ducks and shore birds predominated. Migratory species were thought to form a larger percentage of the fauna than at Rancho La Brea. No evidence was found of gulls, divers, steganopods, night herons, condors, and small vultures. The golden eagle appeared to be the most abundant species. As a whole the bird assemblage was regarded as indicative of a marshy country with water only in small and shallow bodies, but not in true lakes. Miller suggested that the avifauna might indicate a somewhat later age than the Rancho La Brea and Fossil Lake assemblages.

During the same year Stock (1925, pp. 202-203) published a monograph on the gravigrade edentates. In this work the 1921 mammalian faunal list was expanded by addition of _Taxidea_ sp. The proboscidean formerly described as _Mastodon_ sp. was listed as _Mammut_ near _americanum_. Considerable emphasis was placed upon the then existing absence of _Smilodon_ from the McKittrick locality, and absence of the slender-limbed camel at Rancho La Brea. The camel was thought to be generically distinct, and closely related to _Lama_. It was concluded from evidence furnished by the birds and mammals that the conditions of life during the Pleistocene were different at Rancho La Brea and McKittrick. Possibility of an age difference between the two faunas, however, was not considered as out of the question.

In a paper by Merriam and Stock (1925), the faunal list was enlarged by the addition of _Camelops_ sp. In the same publication (Merriam and Stock, 1925A) the slender-limbed camel was described as _Lama stevensi_.

Two years later Stock and Furlong (1927) announced the discovery in the McKittrick tar seeps of a musk-ox-like animal, which they tentatively referred to _Preptoceras sinclairi_. At this time these authors were inclined to believe that faunal differences between Rancho La Brea and McKittrick could not wholly be accounted for by geographic separation. Consequently, the two asphalt occurrences could hardly be contemporaneous.

During the same year Hay's (1927, pp. 197-199) comprehensive work on the Pleistocene vertebrates appeared. The 1925 mammalian and avian faunal lists were reprinted, and the combined evidence summarized. Hay concluded that any differences between Rancho La Brea and McKittrick must be due to environmental factors, for in the opinion of that author, both are of Aftonian age.

In 1928 Stock (pp. 25-27) described some fragmentary peccary remains from the McKittrick asphalt, and referred them to Platygonus near compressus. In the same publication (Stock, 1928A) Lama stevensi was designated the type of a new genus, Tanupolama. Camelus americanus from the Pleistocene of Hay Springs, Nebraska, was found to be referable to the new genus.

The faunal list was still further extended in 1930, when Furlong (pp. 49-53) described Capromeryx minor from McKittrick.

Two years later Merriam and Stock (1932, pp. 225-226) made important additions to the McKittrick Felidae. Smilodon californicus was recorded from the locality for the first time; while mention was made of a wildcat, but without specific designation. The McKittrick puma was compared with Felis bituminosa and Felis daggetti, and the conclusion reached that it is more closely related to the latter. It was observed, moreover, that the larger cats in the McKittrick collections do not dominate in numbers the puma and wildcat to the extent seen at Rancho La Brea. The suggestion was made that in the McKittrick fauna, Felis atrox may have outnumbered Smilodon.

In 1934 V. L. Vander Hoof (p. 332) published a brief account of the geology of the McKittrick fossil occurrence. It was pointed out that the tar seeps have their origin in fissures which cut the underlying oil sands. Alternate banding of tar and alluvium was interpreted as due to seasonal changes in temperature. It was thought that in summer the tar becomes fluid enough to spread over relatively large areas; while the winter rains were considered sufficient to wash in large quantities of alluvium. A sequence of one hundred and eighty bands was counted and plotted. A correlation with the tree ring and varve chronologies has been attempted, but this part of the study has not as yet been published.

One year later another paper by L. H. Miller appeared (1935). In this important contribution to the McKittrick avifauna a collection of three thousand specimens was described. This assemblage was obtained from a locality on the south side of the Taft-McKittrick highway, and approximately one hundred feet from the original excavations on the opposite side of the road. The avifauna from the new locality was found to present some marked contrasts with assemblages described in earlier papers. In the assemblage from the south side of the highway, aquatic and semiaquatic flesh-eating birds were found to predominate. In Miller's opinion the difference between the two McKittrick avifaunas is not to be attributed to a time factor, but to difference in environment. The locality on the north side of the road was thought to mark the shore of a large lake; while the occurrence one hundred feet to the south was conjectured to have been mainly dry land. The striking similarity of the avifauna from the south side of the highway to that of Rancho La Brea was noted.

During the same year Ross (1935) proposed the name, <u>Anabernicula</u>, for a new genus of pigmy goose from the McKittrick asphalt. One of the two "pigmy geese" from Rancho La Brea cited as Branta? sp., and two specimens from McKittrick formerly referred to Chen hyperborea were assigned to the new genus. Branta minuscula from the late Pliocene or early Pleistocene of Arizona was found to be very close to Anabernicula.

Howard (1936, pp. 34-35) has since demonstrated that Ross's species and Branta minuscula are the same. However, this author is also of the opinion that the Arizona material represents a new genus. Anabernicula gracilente Ross thus becomes a synonym of A. minuscula (Wetmore).

By 1935 seventeen species of mammals from the McKittrick asphalt had either been listed or described, in addition to a larger number of birds. The general similarity of the fauna to that of Rancho La Brea was recognized, and outstanding dissimilarities were attributed to either environmental factors, or to a time difference between the two assemblages.

The present study deals mainly with the mammals. Every effort has been made to complete the study of this group in so far as it is represented in collections now available at the California Institute of Technology and the University of California, but the rodents in the latter collection have not been carefully examined. This part of the fauna is being studied by J. W. Paxton, who plans to publish a report in the near future. Continued collecting in future may bring new forms to light, so that no claim to finality is made in this report on the fossil mammals. A considerable number of bird bones still awaits study, as does also a small assemblage of insects. Some fragmentary plant material is likewise available. The present paper is in many respects a synthesis, but in addition to the new species that is described many forms are listed from the area for the first time.

GEOGRAPHIC SITUATION AND EXISTING PHYSICAL CONDITIONS IN THE McKITTRICK AREA CONTRASTED WITH THOSE AT RANCHO LA BREA

As is shown in plate 1, McKittrick is located approximately one hundred and twenty miles north and slightly west of Los Angeles. The fossil deposit is situated in the foothills of the southern California Coast Ranges near the southwestern border of the San Joaquin Valley, an almost featureless plain which occupies the entire central portion of the state. To the south the Tehachapi and San Gabriel Mountains effectively isolate the region from the Los Angeles Basin and the Rancho La Brea area; while to the east the Sierra raise a formidable barrier between the San Joaquin Valley and Great Basin.

Rancho La Brea is located in the northwestern part of Los Angeles, and nearly three miles from the steep southern front of the Santa Monica Range. The Los Angeles Plain, in which this deposit is situated, is an area almost as featureless as the San Joaquin Valley. Since during the period of fossil accumulation configuration of major relief features was probably similar to that of the present day, it seems reasonable to infer that at that time climatic and life zones were also similarly demarcated.

The Temblor Range which rises just to the west of McKittrick, is a broad belt of rugged upland country very similar in general appearance to the Santa Monica Mountains in the vicinity of Rancho La Brea. In summer these heights are somewhat cooler than the surrounding lowlands, while in winter the summits are often snow-covered. It is worthy of note, however, that snow is more frequent and somewhat more abundant on the Temblor than on the Santa Monica Range.

By virtue of its geographic position, the Rancho La Brea area enjoys an almost mediterranean climate. The rainfall is light, and is almost completely confined to the winter months. Fog is common on the slopes of the Santa Monicas, and in the Los Angeles Basin.

The climate of the McKittrick area, on the other hand, is somewhat more of a continental type, for while this area is likewise semi-arid, the summers are hotter and the winters colder than is usual in the Los Angeles district. It is difficult to estimate the effect a period of glaciation might have upon the climates of the two areas, and while fuller discussion must be left to a later page, it seems reasonable to assume that the McKittrick area was more noticeably affected by such a change than the Los Angeles region. Could this inference be proved, it might be possible to state with greater definiteness than is now possible, the time relations of the three asphalt faunas.

EXISTING LIFE OF THE McKITTRICK AND RANCHO LA BREA AREAS

In uncultivated areas both the San Joaquin Valley and Los Angeles Basin support a sparse growth of vegetation of a semi-arid type. The Santa Monica Mountains, however, are covered by a substantial growth of brushy plants. On the crest and southern slopes chaparral is so dense as to be almost impenetrable. Some areas are covered with grass, sage, black walnut, and oak. The bottoms of the deeper canons are heavily wooded with oak and a variety of shrub-like undergrowth. Occasional sycamores are present. The Temblor Range, on the other hand, supports only a sparse vegetation of brush and occasional stunted trees. This observation is of interest in that, as will be seen in later pages, there is evidence that during the period of fossil accumulation the Temblor Range was covered by a somewhat heavier growth of vegetation.

The Atriplex belt of the San Joaquin Valley does not at present extend into the region of McKittrick. This plant, however, is found at slightly lower altitudes and within a few miles of the fossil deposit. Since distribution of Atriplex seems to exercise an important influence upon distribution of passerine birds and rodents, this fact is of considerable significance.

Although Man's occupancy of both areas has disturbed considerably the native animal life, information is not lacking as to at least some of the original faunal features of these regions. The wildcat still lingers in less frequented spots of the Santa Monica Mountains, while the Mexican jaguar has been reported by Indians as having been seen in the Temblor Range. The fauna of the San Joaquin Valley is essentially that of a semi-arid plain and is characterized by an abundance of kangaroo rats of the genus Dipodomys. Despite the relative dryness of the region, the marshes of Buena Vista Lake are still a favorite retreat for ducks and other water birds. As will be seen in later pages, similar conditions may have existed in the McKittrick area during late Pleistocene time.

TABLE 1- Recent mammalian fauna of the McKittrick area

Temblor Range	San Joaquin Valley
TALPIDAE	
Scapanus latimus occultus Grinnell & Swarth (Southern Calif. Mole)	Scapanus latimus occultus Grinnell & Swarth
SORICIDAE	
Sorex ornatus ornatus C. H. Merriam (Adorned Shrew)	Sorex ornatus ornatus C. H. Merriam
	Sorex ornatus relictus Grinnell (Buena Vista Lake Shrew)
VESPERTILIONIDAE	
Myotis yumanensis sociabilis H. W. Grinnell (Tejon Yuma Bat)	
Myotis subulatus melanorhinus (C. H. Merriam) (Black-nosed Bat)	Myotis subulatus melanorhinus (C. H. Merriam)
Eptesicus luscus (Peale & Beauvois) (Large Brown Bat)	Eptesicus luscus (Peale & Beauvois)
	Nycteris borealis teliotis (H. Allen) (Western Red Bat)
Nycteris cinerea (Peale & Beauvois) (Hoary Bat)	Nycteris cinerea (Peale & Beauvois)
Corynorhinus rafinesquii intermedius H. W. Grinnell (Intermediate Lump-nosed Bat)	Corynorhinus rafinesquii intermedius H. W. Grinnell
Antrozous pallidus pacificus C. H. Merriam (Pacific Pallid Bat)	Antrozous pallidus pacificus C. H. Merriam
MOLOSSIDAE	
Tadarida mexicana (Saussure) (Mexican Free-tailed Bat)	Tadarida mexicana (Saussure)
	Eumops perotis californicus (C. H. Merriam) (Calif. Mastiff Bat)

TABLE 1- Continued

URSIDAE	
Ursus tularensis C. H. Merriam (Tejon Grizzly)	
	?Ursus colusus C. H. Merriam (Sacramento Grizzly)
PROCYONIDAE	
Procyon lotar psora Gray (Calif. Coon)	Procyon lotar psora Gray
MUSTELIDAE	
	Mustela xanthogenys xanthogenys Gray (Calif. Weasel)
Lutra canadensis brevipilosus Grinnell (Calif. River Otter)	Lutra canadensis brevipilosus Grinnell
Spilogale gracilis phenax C. H. Merriam (Calif. Spotted Skunk)	Spilogale gracilis phenax C. H. Merriam
Mephitis mephitis holzneri Mearns (Southern Calif. Striped Skunk)	Mephitis mephitis holzneri Mearns
Taxidea taxus neglecta Mearns (California Badger)	Taxidea taxus neglecta Mearns
CANIDAE	
	Vulpes macrotis mutica C. H. Merriam (San Joaquin Valley Kit Fox)
Urocyon cinereoargenteus californicus Mearns (Calif. Gray Fox)	Urocyon cinereoargenteus californicus Mearns
Canis latrans ochropus Eschscholtz (California Valley Coyote)	Canis latrans ochropus Eschscholtz
FELIDAE	
Felis concolor californica May (Calif. Mountain Lion)	
?Felis onca hernandesii (Gray) (Mexican Jaguar)	
Lynx rufus californicus Mearns (California Wildcat)	

TABLE 1- Continued

SCIURIDAE	
Citellus beecheyi beecheyi (Richardson) (Beechey Ground Squirrel)	Citellus beecheyi beecheyi (Richardson)
Citellus beecheyi fisheri (C. H. Merriam) (Fisher Ground Squirrel)	Citellus beecheyi fisheri (C. H. Merriam)
Ammospermophilis nelsoni nelsoni (C. H. Merriam) (Nelson Antelope Ground Squirrel)	Ammospermophilis nelsoni nelsoni (C. H. Merriam)
Eutamias merriami merriami (Allen) (Merriam Chipmunk)	Eutamias merriami merriami (Allen)
GEOMYIDAE	
Thomomys bottae pascalis C. H. Merriam (Fresno Pocket Gopher)	Thomomys bottae pascalis C. H. Merriam
	Thomomys bottae ingens Grinnell (Buena Vista Lake Pocket Gopher)
Thomomys bottae diaboli Grinnell (Diablo Pocket Gopher)	
HETEROMYIDAE	
Perognathus longimembris longimembris (Coues) (Tejon Pocket Mouse)	?Perognathus longimembris longimembris (Coues)
?Perognathus inornatus neglectus Taylor (McKittrick Pocket Mouse)	Perognathus inornatus neglectus Taylor
Perognathus inornatus inornatus C. H. Merriam (San Joaquin Pocket Mouse)	Perognathus inornatus inornatus C. H. Merriam
Perognathus californicus ochrus Osgood (Kern Calif. Pocket Mouse)	Perognathus californicus ochrus Osgood
Dipodomys heermanni swarthi (Grinnel) (Carrizo Plain Kangaroo Rat)	Dipodomys heermanni swarthi (Grinnell)
Dipodomys heermanni tularensis (C. H. Merriam) (Tulare Kangaroo Rat)	Dipodomys heermanni tularensis (C. H. Merriam)
Dipodomys ingens (C. H. Merriam) (Giant Kangaroo Rat)	Dipodomys ingens (C. H. Merriam)

TABLE 1- Continued

	Dipodomys nitratoides nitratoides C. H. Merriam (Tipton Kangaroo Rat)
	Dipodomys nitratoides brevinasus Grinnell (Short-nosed Kangaroo Rat)
CASTORIDAE	
	Castor canadensis subauratus Taylor (Golden Beaver)
CRICETIDAE	
Onychomys torridus tularensis C. H. Merriam (Tulare Grasshopper Mouse)	Onychomys torridus tularensis C. H. Merriam
Reithrodontomys megalotis longicaudus (Baird) (Long-tailed Harvest Mouse)	Reithrodontomys megalotis longicaudus (Baird)
Peromyscus californicus californicus (Gambel) (Parasitic White-footed Mouse)	Peromyscus californicus californicus (Gambel)
Peromyscus maniculatus gambelii (Baird) (Gambel White-footed Mouse)	Peromyscus maniculatus gambelii (Baird)
Peromyscus boyleii rowleyi (Allen) (Rowley White-footed Mouse)	Peromyscus boyleii rowleyi (Allen)
Neotoma lepida gilva Rhoades (Banning Wood Rat)	Neotoma lepida gilva Rhoades
Neotoma fuscipes simplex True (Tejon Wood Rat)	Neotoma fuscipes simplex True
	Microtus californicus aestuarinus R. Kellogg (Tule Meadow Mouse)
Microtus californicus kernensis R. Kellogg (Kern River Meadow Mouse)	Microtus californicus kernensis R. Kellogg
LEPORIDAE	
Lepus californicus californicus Gray (Calif. Jack Rabbit)	Lepus californicus californicus Gray
Lepus californicus richardsoni Bachman (San Joaquin Jack Rabbit)	Lepus californicus richardsoni Bachman

TABLE 1- Continued

Sylvilagus auduboni vallicola Nelson (San Joaquin Cottontail)	Sylvilagus auduboni vallicola Nelson
Sylvilagus bachmani bachmani (Waterhouse) (Calif. Brush Rabbit)	Sylvilagus bachmani bachmani (Waterhouse)
CERVIDAE	
Cervus nannodes C. H. Merriam (Dwarf Elk)	Cervus nannodes C. H. Merriam
Odocoileus hemionus californicus (Caton) (Calif. Mule Deer)	Odocoileus hemionus californicus (Caton)
ANTILOCAPRIDAE	
Antilocapra americana americana (Ord) (Prong-horn Antelope)	Antilocapra americana americana (Ord)
BOVIDAE	
Ovis canadensis nelsoni C. H. Merriam (Desert Bighorn)	

Faunal list from Grinnell (1933).

GEOLOGIC RELATIONS OF THE McKITTRICK BREA DEPOSITS

The geology of the McKittrick area has been discussed by Arnold and Johnson (1910, pp. 110-114, pl. 1), Pack (1920, pp. 20-61), and at a later time by Cunningham and Kleinpell (1934, p. 799, fig. 4). As is generally true for the southern California Coast Ranges, both the stratigraphy and structure are complex. Indeed, the structure of the McKittrick-Sunset oilfield is so involved that it is difficult to find two geologists familiar with the area who are agreed as to details. In not a few instances even points of major importance are still under debate. In the present discussion only the broader features of the geology are treated for the purpose of determining the principal physical events of late Cenozoic and early Quaternary time.

The McKittrick formation since its description by Arnold and Johnson has been subdivided into the Etchegoin and Tulare formations (Pack, 1920, pp. 44-52). The upper Etchegoin may be early Pleistocene in age, but the consensus of opinion seems to be that these beds belong in the late Pliocene (Merriam, 1915A, pp. 40-53). The lower part of the Tulare is likewise regarded as late Pliocene by many geologists, but the upper part of this formation is usually considered as early Quaternary.

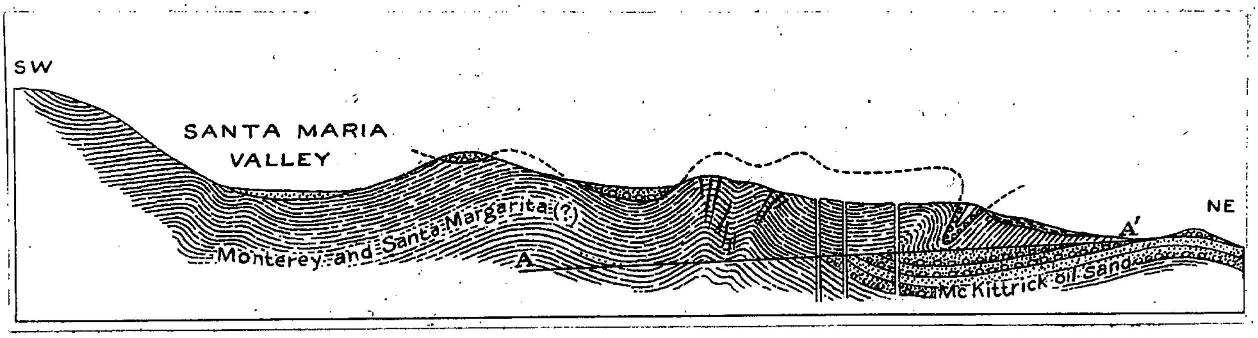

Figure 1 -- Generalized structure section of the McKittrick-Sunset oilfield in the vicinity of the fossil occurrence. Horizontal scale approximately 2 inches = 1 mile. The fossil vertebrates were found in the alluvium indicated near A'. After Gester.

Folding movements have affected the Tulare, and this diastrophism would thus appear to be an early to middle Pleistocene event. The flat-lying thrust shown in figure 1 has often been disputed by geologists, but all seem to be agreed that an important line of dislocation crosses the area. Many have postulated an almost vertical thrust. In any event, this fracture is still active as is evidenced by frequently recurring offsets of the Taft-McKittrick highway where it crosses this zone.

Anderson (1908, pp. 32-35) described a series of upraised Pleistocene terraces in the McKittrick region. These benches extend along much of the southwestern border of the San Joaquin Valley. Their elevation varies from twelve hundred to fifteen hundred feet above sea-level, or approximately eight hundred to one thousand feet above the floor of the valley. Their age is difficult to determine precisely, but since at least one of them cuts the Tulare, the period of base-leveling must have extended into the early or middle Pleistocene.

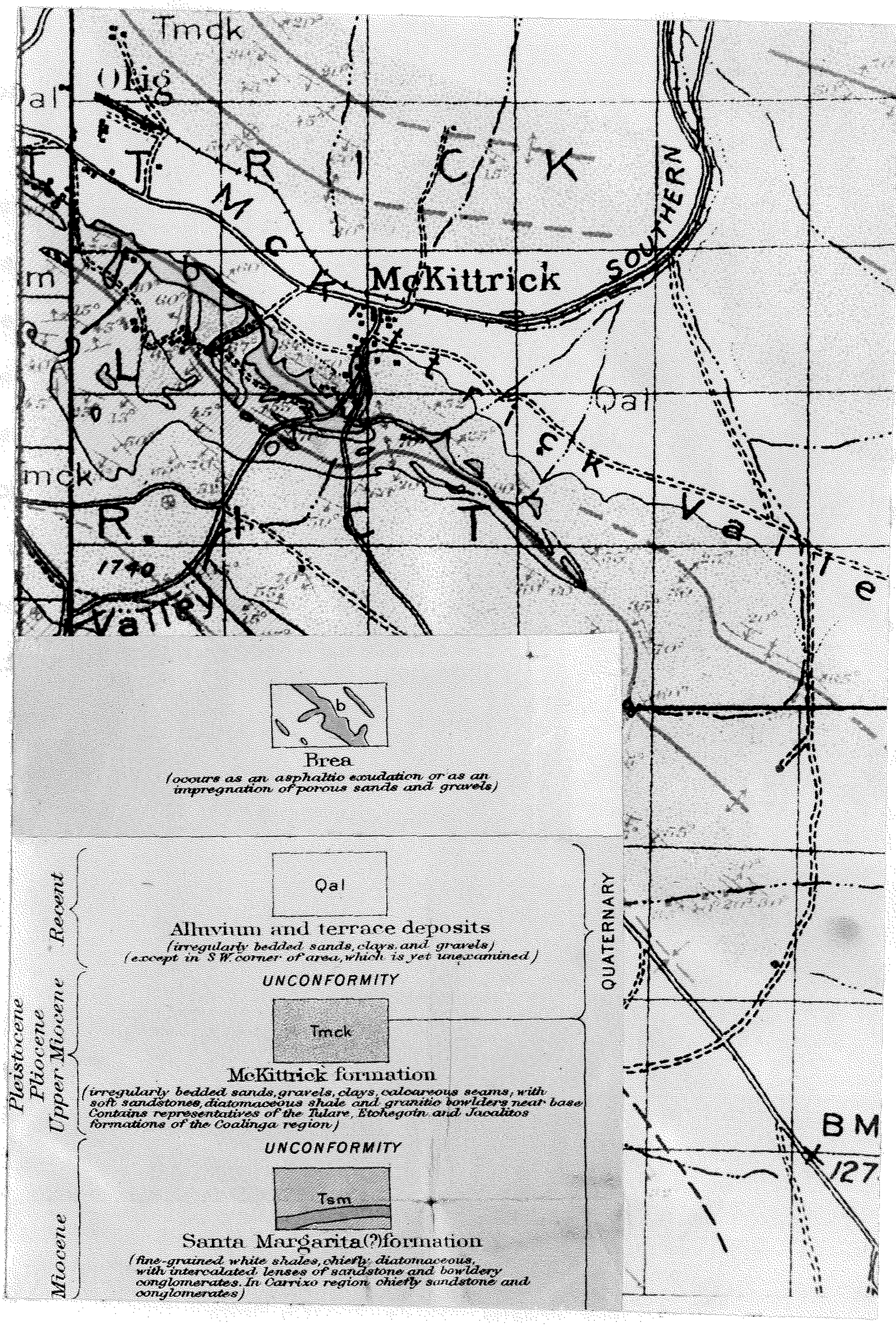

Figure 2 -- Geologic map of the area surrounding the fossil occurrence. Scale approximately 1 inch = 1 mile. The red dot just south of McKittrick marks the fossil quarries. After Arnold and Johnson (1910).

Some of the terraces may be older, however.

The fossiliferous brea rests upon one of these terraces with a pronounced unconformity between it and the older beds. The history thus recorded seems to imply an early to middle Quaternary period of folding followed by erosion that resulted in formation of terraces. This was followed by outpouring of tar and renewed uplift. Which of these events occurred first is difficult to determine, and it is possible that they were concomitant. During this period the McKittrick Pleistocene vertebrates were entombed. Consequently, from the geology of the region it would appear that the fauna cannot be older than middle Pleistocene, and it is probable that it is somewhat younger.

OCCURRENCE OF THE McKITTRICK FAUNA

Oil seeps in various stages of oxidation are not uncommon in the petroleum-producing belt of the southern San Joaquin Valley, and are mentioned or illustrated in nearly all reports on the area. Although vertebrate remains have been reported from the McKittrick area since the time of the Civil War, there is no reliable evidence that any of the earlier finds came from the same horizon as the fauna which forms the basis of this paper.

The seeps in question occupy a narrow zone of some five miles in length just southwest of the village of McKittrick. As is shown by figure 2 , the brea belt actually consists of a more or less continuous zone of local seeps, which in their general northwest trend are parallel to the axis of a major anticline, and it seems quite certain that the oil has found access to the surface along tension cracks in the axis of this fold. This conclusion is substantiated by exposures in certain of the gullies cut through the surface layer of hardened petroleum. In these excavations dikes of asphalt, which form the feeders of the surface flows, are exposed.

Most geologists who have studied the area are of the opinion that the original source of the oil is the diatomaceous Maricopa (Monterey) shale, and that at a later time the hydrocarbons migrated into the porous overlying sandstones of the Etchegoin and Tulare formations. In the McKittrick producing district it is generally agreed that the Upper Etchegoin is the principal reservoir rock. Since the anticline which forms the structural trap seems to be in the main post-Tulare in age, the history of the flows may be outlined as follows.

Either contemporaneously or slightly later than the folding which arched the Tertiary and early Quaternary sediments, oil migrated from the underlying shale into the porous overlying sediments. Contemporaneously with the folding tension cracks formed along the crest of the anticline, and it was along these fissures that the oil reached the surface. From the existing distribution of the seeps, it seems probable that none of the fissures are very extensive laterally, and that the almost continuous belt of brea is actually due to coalescence of numerous individual seeps of slightly different ages rather than to one large flow. V. L. Vander Hoof has informed the writer that during his many visits to the area, he has observed that old seeps often become active after an unknown period of quiescence. It seems reasonable to assume that such was also the case from the earliest inception of the fissures, so that the brea belt rather than constituting one definite horizon actually may represent a complicated sequence of events extending from middle to late Pleistocene time down into the present.

During late Pleistocene time sedimentation was active in the area, and as the oil reached the surface and spread out in sheets of a fraction of an inch or so in thickness it became intercalated with clay, sand, gravel, and wind-blown material. The resulting product is a rudely stratified material consisting of fine and coarse sediments more or less uniformly saturated with petroleum. The upper layers which contain a Recent vertebrate fauna seem to be somewhat better stratified than the lower levels which contain the Pleistocene vertebrates. Vander Hoof (1934, p. 332) has interpreted stratification of the brea deposit as a form of varves. As is mentioned on page 10 of this paper, this author contends that it was mainly during the summer months that the oil became fluid enough to spread over large areas; while the winter rains carried in most of the clastic material. This conclusion may well be correct, although correlation with other areas, or even between isolated exposures within the same area, seems to be a difficult matter.

From the above it will be seen that while McKittrick is often spoken of as a tar pit fauna, conditions of accumulation must have been quite different from those at Rancho La Brea. At the Los Angeles locality deep pools of liquid oil seem to have existed at the surface (Stoner, 1913, p. 392), and these were not only responsible for preservation of fossil remains, but for entrapment of the creatures as well. At the McKittrick locality it seems improbable that the seeps could have had much effectiveness as traps; the principal function of the oil seems to have been as a preservative. As will be seen on a later page, this inference is fully substantiated by the constituency of the fossil fauna.

Vertebrate remains are found at several localities in the McKittrick oil seeps, although all but one, which is located on either side of the Taft-McKittrick highway, seem to be Recent or sub-Recent accumulations. The Pleistocene deposit is situated in the N.E. 1/4, N.E. 1/4 of section 29, T. 30 S., R. 22 E. measured from the Mount Diablo base line and meridian. The locality on the northeast side of the road is known as the University of California locality 4096; while that to the southwest is University of California locality 7139. Locality 138 of the California Institute of Technology comprises essentially the same area as U. C. locality 7139.

At this locality the seeps range upward of ten feet in thickness and rest upon the Santa Margarita and McKittrick formations. Approximately one mile to the northwest an extension of the same flows overlie the alluvium of McKittrick valley. As is shown by plate 2 the upper surface is quite irregular, but there seems to be very little evidence of erosion of the petroliferous material since it was laid down. The lower surface is likewise quite irregular, and numerous shallow pipes or depressions which are filled with brea were found to extend down into the underlying sediments. One of the larger of these pipes is shown by plate 2 , and in all cases as this illustration demonstrates, the pockets narrow toward the bottom. The diameter varies from a few inches to several feet. Sternberg (1932, pp. 244-245) records a depth of seventeen feet for one of these peculiar features. In these pockets numerous rodent remains were found, and occasionally larger animals as well. The origin of these pockets is a matter of doubt, but it seems reasonable that some of the smaller pipes may be tar-filled rodent burrows; while the larger openings may represent ancient pot holes subsequently filled with asphalt. This conjecture is substantiated by other features of the occurrence, for from the greater than average thickness of the tar bands at this locality and the uncommon thickness of the brea itself, it appears that the fossil locality may have been the site of a rather broad and shallow stream valley. At any event, the pipes seen in the McKittrick brea bear only a superficial resemblance to the pits of Rancho La Brea. In case of the former the pockets definitely terminate in a clay layer, while in the latter instance, the bottom has never been reached by quarrying operations. At McKittrick the oil seems to have seeped down into the pockets, while at Rancho La Brea the pipes represent the fissures along which the petroleum seems to have risen to the surface.

On the upper surface of the brea, dense accumulations of Recent animals formed a layer a few inches to a few feet in thickness. Below this layer the Pleistocene fauna was found in considerable abundance. Carnivores and herbivores were mixed indiscriminately throughout the mass, and while most of the skeletons were dismembered, articulated remains and a few almost complete skeletons were found. This is in contrast with Rancho La Brea, where differential motion of the matrix disjointed much of the skeletal material.

The brea does not photograph well, and plate 2 gives only a vague impression of the enclosing material. From the generalized sketch, however, (figure 3) it is possible to form some idea of its inner complexity. It is difficult to interpret such intricate sedimentary structures as those shown in this illustration, but only two explanations seem plausible. As mentioned above, the locality may mark the site of an old stream valley, in which case interfingering of clay, coarse clastics and asphalt is due to cut and fill of the stream, which may have operated in conjunction with intermittent outpouring of petroleum. On the other hand, the fossil avian fauna indicates that the locality was also near the shore of a body of standing water. Repeated advance and recession of the shore line might also produce the effects observed.

A combination of both is not inconceivable.

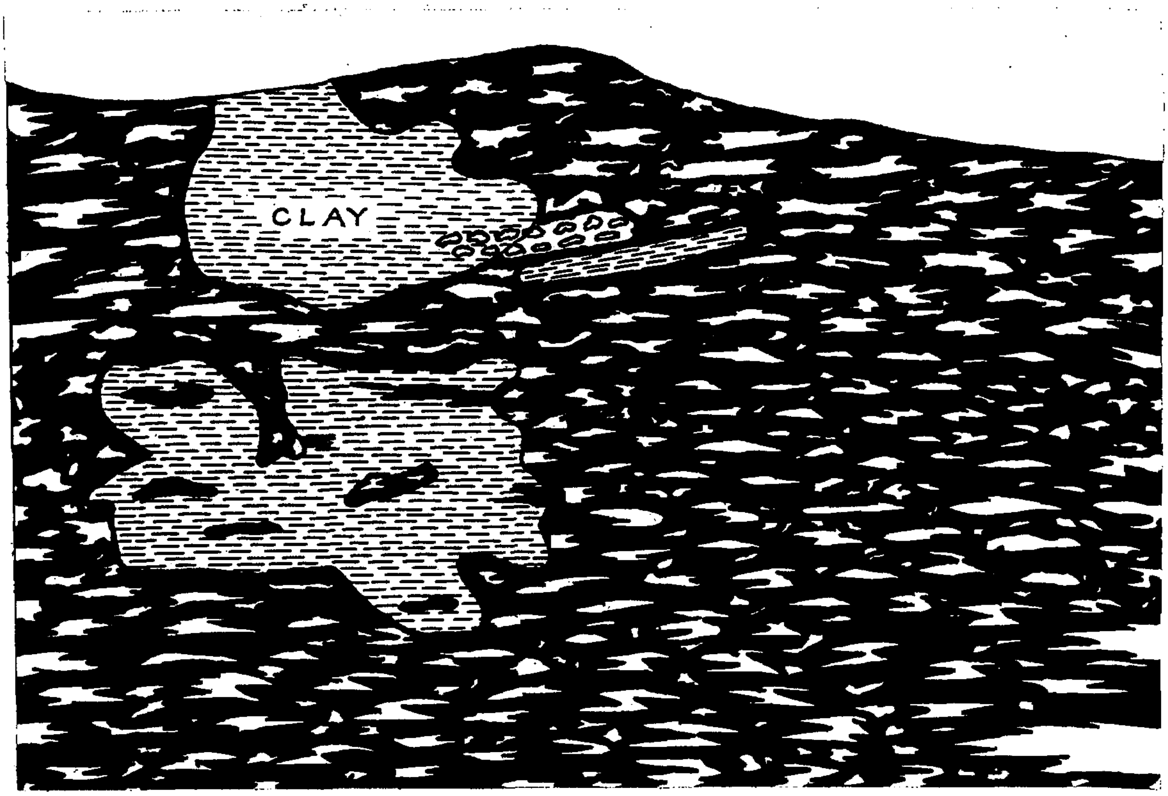

Figure 3 -- Generalized sketch of southwest wall of excavation. Nodules indicated are chert. Black and white areas rudely stratified asphalt and clastics. Mammal and bird remains were found in all types of sediment, but were particularly abundant in the area on the upper left. From a sketch by Chester Stock.

During excavation care was taken to separate the obviously Recent material found in the upper layers from the underlying fossil material. It might also have been possible to zone the fossils according to stratigraphic level. This, however, was not attempted, and it cannot be said with assurance that all of the Recent and sub-Recent material was separated from the Pleistocene accumulation. This is especially true for the smaller mammals. However, there seems to be no good reason for assuming that the collections now at hand represent more than a fraction of Pleistocene time, although it is probable that the time span represented by them is somewhat longer than a single glacial or interglacial epoch.

At present the fossil locality is approximately one thousand feet above sea-level, or nearly seven hundred feet above the level of Buena Vista Lake. Furthermore, if the existing topography corresponds even roughly to that of the late Pleistocene, it would not be possible for heavier rainfall alone to have brought into existence a lake at this elevation. Such a body of water would flood most of the San Joaquin Valley, and there is no evidence of a lake of these dimensions. According to Blake (1856, p. 193) "the greater part of Tulare Valley was formerly submerged by a broad lake." This water body could hardly have extended into the McKittrick area, and there is no reason for assuming that it was a remnant of a Pleistocene lake. Consequently, it seems necessary to conclude that the ancient lake at McKittrick had some physiographic or structural cause. Since it is known that the region is still tectonically active, it does not seem unreasonable to infer that uplift and erosion subsequent to fossil accumulation brought about extinction of the lake. This inference has an important bearing upon interpretation of the fossil assemblage, and will be developed more fully on a later page.

In review then, the McKittrick brea forms a definitely stratified layer which rests with unconformity upon folded Tertiary and early Pleistocene sediments. No continuously-baited traps such as those which existed at Rancho La Brea seem to have been present at McKittrick, and this appears to have been an important factor in bringing about some of the faunal features in which the latter occurrence contrasts with the former.

PRESERVATION OF FOSSIL REMAINS

As in the case of Rancho La Brea, the McKittrick fossils are thoroughly saturated with bitumen, which has penetrated into sinuses of skulls and the marrow cavities of the long bones. Aside from the dark-brown to black color imparted by the bitumen, the osseous material has remained unchanged. All skull openings are filled with sand and tar, which has carried into these cavities the remains of rodents and other small mammals. Surface markings which show the courses of nerves and blood vessels, although occasionally preserved, are not so common as in the Rancho La Brea material. Pit wear (Stock, 1930, p. 27) and tooth marks of rodents (Stock, 1929) so often seen on bones from Rancho La Brea, are rarely encountered on specimens from McKittrick. Absence of pit wear is perhaps explained by the surficial nature of the McKittrick tar seeps, which may have prevented differential motion of the matrix; while presence of large bodies of standing water may have prevented incursion of rodents.

An interesting difference in state of preservation of the McKittrick and Rancho La Brea bones has been brought to the writer's attention by V. L. Vander Hoof. In bones from Rancho La Brea nearly all lacunae are completely filled with tar; while in osseous material from McKittrick these canals often are either entirely free from hydrocarbons or only partially saturated by this substance. Whether less thorough saturation of the McKittrick bones is to be attributed to their more recent burial, or to some unknown difference in character of the oils, remains an open question.

Two types of staining are observed: one of an intensely black color and almost vitreous lustre, the other of a light to dark-brown shade and wax-like appearance. Nearly all rodents and lagomorphs from McKittrick show the first type of preservation; while the second type is usually exhibited by remains of larger mammals. Since the rodents and lagomorphs were in the main collected from somewhat higher levels than the larger forms, it suggests that the first type of preservation indicates a relatively recent age for the small mammals. As indicated on pages **30-31** , there are other reasons for believing that a part of the McKittrick rodent and lagomorph assemblages is Recent or sub-Recent in age.

Compared with Rancho La Brea nearly all mammalian material from McKittrick is poorly preserved. Perfect skulls are rare, and articulated elements are seldom found. This is to be attributed perhaps to the character of the McKittrick seeps. Apparently only in rare instances were animals actually engulfed by the tar. In a majority of cases preservation may have depended upon chance contact of petroleum with osseous material. Consequently, considerable decay may have occurred prior to their saturation by the hydrocarbons.

The relatively poor state of preservation of mammalian remains is in marked contrast with the very perfect preservation of the avifauna. According to Miller (1925, p. 308) the McKittrick birds are better preserved than those of Rancho La Brea. To quote from this author:-

"The matrix and immediate entombment are not seen to differ in any degree from these same factors at Rancho La Brea. ..... Furthermore, the factor of weathering was largely eliminated, so that specimens not broken by differential motion in the matrix have the most minute characters of the bone beautifully preserved. For some reason not clearly evident, the specimens are more fragile than those from Rancho La Brea. A difference in composition of the oil is presumed to be the factor responsible, since the matrix appears more friable and of lighter brown color than the darker, more tenacious asphalt of Rancho La Brea."

Why bird remains from McKittrick should be better preserved than those of the mammals is not clearly evident. Perhaps relatively small forms as birds were completely covered by the limited amount of asphalt available at any one time, while with larger forms this was scarcely possible.

The percentage of old, young, and diseased animals in the McKittrick fauna does not appear to be higher than normal. This is in marked contrast with Rancho La Brea, where an exceptionally high proportion of such types is found (Merriam, 1911, pp. 209-210). Here again the supposition that the McKittrick seeps did not function as traps to so great an extent as those of Rancho La Brea seems to be borne out.

MAMMALIAN AND AVIAN FOSSIL FAUNAS OF McKITTRICK AND RANCHO LA BREA

Table 2 lists the mammals now known from McKittrick and Rancho La Brea, while table 3 lists the birds. No tabulation of the faunas from the Carpinteria and Palos Verdes beds is made, but of the twenty-seven species of mammals known from the former locality nearly all of the genera and many of the species occur also at Rancho La Brea. The fifteen mammalian forms found in the Upper San Pedro, or Palos Verdes beds, are all found at Rancho La Brea, and as Stock (1925, pp. 118-119) has indicated furnish some basis for correlation of the two deposits.

TABLE 2- Fossil mammalian faunas of McKittrick and Rancho La Brea

McKittrick	Rancho La Brea
FELIDAE	
Smilodon californicus Bovard	Smilodon californicus Bovard
	Smilodon californicus brevipes Merriam and Stock
Felis atrox Leidy	Felis** atrox Leidy*
	Felis bituminosa Merriam and Stock
	Felis concolor Linnaeus
Felis daggetti Merriam	Felis daggetti Merriam
Lynx rufa cf. fischeri Merriam	Lynx* rufa fischeri Merriam
CANIDAE	
Canis latrans orcutti Merriam	Canis* latrans orcutti Merriam
	Canis andersoni Merriam
	Canis occidentalis furlongi Merriam

TABLE 2- Continued

Aenocyon dirus (Leidy)	Aenocyon** dirus (Leidy)*
Aenocyon near milleri (Merriam)	Aenocyon milleri (Merriam)
	Urocyon* californicus (Mearns)
Vulpes macrotis cf. mutica C. H. Merriam	
MUSTELIDAE	
Mustela frenata nigriauris Hall	Mustela frenata latirostra Hall*
Mephitis mephitis holzneri Mearns	Mephitis mephitis holzneri Mearns*
Spilogale phenax phenax C. H. Merriam	Spilogale phenax microrhina Hall*
Taxidea taxus cf. neglecta Mearns	Taxidea taxus cf. neglecta Mearns*
URSIDAE	
Tremarctotherium simum (Cope)	Tremarctotherium simum (Cope)
Ursus optimus New Species	Ursus optimus New Species
MEGATHERIIDAE	
Megalonyx? sp.	Megalonyx** jeffersoni californicus Stock
MYLODONTIDAE	
Paramylodon harlani (Owen)	Paramylodon harlani (Owen)
	Paramylodon harlani tenuiceps (Stock)
	Nothrotherium shastense Sinclair
CAMELIDAE	
Camelops hesternus (Leidy)	Camelops hesternus (Leidy)* **
Tanupolama stevensi (Merriam and Stock)	

TABLE 2- Continued

EQUIDAE	
Equus occidentalis Leidy	Equus occidentalis Leidy
BOVIDAE	
Preptoceras? cf. sinclairi Furlong	
Bison antiquus Leidy	Bison* ** antiquus Leidy
CERVIDAE	
Cervus sp.	
Odocoileus sp.	Odocoileus sp. indet.* **
ANTILOCAPRIDAE	
Capromeryx minor Taylor	Capromeryx minor Taylor**
Antilocapra americana (Ord)	Antilocapra americana (Ord)
ELEPHANTIDAE	
Parelephas columbi (Falconer)	Parelephas columbi (Falconer)
	Archidiskodon imperator (Leidy)*
MASTODONTIDAE	
Mastodon raki Frick	Mastodon americanus (Kerr)
TAYASSUIDAE	
Platygonus near compressus Le Conte	Platygonus sp.
TAPIRIDAE	
	Tapirus? sp.
SCIURIDAE	
Otospermophilis cf. grammurus C. H. Merriam	Otospermophilis grammurus C. H. Merriam
Ammospermophilis cf. nelsoni (C. H. Merriam)	

TABLE 2- Continued

GEOMYIDAE	
Thomomys bottae bottae (Eydoux and Gervais)	Thomomys bottae* ** occipitalis Dice
HETEROMYIDAE	
Dipodomys near ingens (C. H. Merriam)	Dipodomys* agilis Gambel
Perognathus cf. inornatus C. H. Merriam	Perognathus* californicus C. H. Merriam
CRICETIDAE	
Onychomys? sp.	Onychomys* torridus ramona Rhoades
Reithrodontomys? sp.	Reithrodontomys megalotis longicauda (Baird)
Peromyscus cf. californicus (Gambel)	Peromyscus* imperfectus Dice
Neotoma lepida gilva Rhoades	Neotoma* ** sp. indet.
Microtus californicus aestuarinus R. Kellogg	Microtus californicus neglectus L. Kellogg
	Microtus californicus (Peale)* **
LEPORIDAE	
Lepus californicus Gray	Lepus* californicus Gray
Sylvilagus bachmani (Waterhouse)	Sylvilagus bachmani cinerascens (Allen)
Sylvilagus auduboni (Baird)	Sylvilagus* ** auduboni pix Dice
SORICIDAE	
Sorex cf. ornatus (C. H. Merriam)	Sorex cf. ornatus (C. H. Merriam)*
	Notiosorex crawfordi Coues
VESPERTILIONIDAE	
Antrozous pallidus pacificus C. H. Merriam	

* indicates that the form is found at Carpinteria

** indicates that the form is found in the Upper San Pedro (Palos Verdes beds)

TABLE 3- Fossil avian faunas of McKittrick and Rancho La Brea

McKittrick	Rancho La Brea
COLYMBIDAE- Grebes	
	Colymbus sp. indet. (Grebe)
Podilymbus podiceps (Linnaeus)	Podilymbus podiceps (Linnaeus) (Pied-billed Grebe)
ARDEIDAE- Herons and Bitterns	
Ardea herodias Linnaeus	Ardea herodias Linnaeus (Great Blue Heron)
	Casmerodius albus (Gmelin) (American Egret)
	Egretta thula? (Molina) (Snowy Egret)
	Florida caerulea? (Linnaeus) (Little Blue Heron)
	Butorides virescens (Linnaeus) (Green Heron)
Nycticorax nycticorax (Linnaeus)	Nycticorax nycticorax (Linnaeus) (Night Heron)
	Botaurus lentiginosus (Montagu) (American Bittern)
CICONIIDAE- Storks and Wood Ibises	
	Mycteria americana Linnaeus (Wood Ibis)
	†Mycteria wetmorei Howard (La Brea Wood Ibis)
†Ciconia maltha Miller	†Ciconia maltha Miller* (Brea Stork)
THRESKIORNITHIDAE- Ibises and Spoonbills	
	Plegadis guarauna (Linnaeus) (White-faced Glossy Ibis)
Ajaia ajaja (Linnaeus)	Ajaia ajaja (Linnaeus)? (Roseate Spoonbill)

TABLE 3- Continued

ANATIDAE- Swans, Geese, and Ducks

Cygnus columbianus (Ord)	Cygnus columbianus (Ord) (Whistling Swan)
Branta canadensis (Linnaeus)	Branta canadensis (Linnaeus)** (Canada Goose)
†Branta dickeyi Miller (Giant Goose)	Branta sp. indet.
	Anser albifrons (Scopoli)** (White-fronted Goose)
	Chen hyperborea (Pallas) (Lesser Snow Goose)
	Chen rossi? (Cassin) (Ross's Goose)
††Anabernicula minuscula (Wetmore)	††Anabernicula minuscula (Wetmore) (Pigmy Goose)
Anas platyrhynchos Linnaeus	Anas platyrhynchos Linnaeus* ** (Common Mallard)
Chaulelasmus streperus (Linnaeus) (	Chaulelasmus streperus (Linnaeus) (Gadwall)
Mareca americana (Gmelin) (Baldpate)	
Dafila acuta? (Linnaeus) (Pintail Duck)	
Nettion carolinense (Gmelin)	Nettion carolinense (Gmelin)** (Green-winged Teal)
Querquedula cyanoptera (Vieillot)** (Cinnamon Teal)	Querquedula sp. indet.
Spatula clypeata (Linnaeus)	Spatula clypeata? (Linnaeus) (Shoveller Duck)
Nyroca affinis? (Eyton) (Lesser Scaup Duck)	Nyroca valisineria? (Wilson) (Canvas-back Duck)
Nyroca americana (Eyton) (Red-head Duck)	

TABLE 3- Continued

Charitonetta albeola (Linnaeus) (Buffle-head Duck)	
Erismatura jamaicensis (Gmelin) (Ruddy Duck)	
CATHARTIDAE- American Vultures	
Cathartes aura (Linnaeus)	Cathartes aura (Linnaeus)* ** (Turkey Vulture)
†Coragyps occidentalis (Miller)	† Coragyps occidentalis (Miller)* (Black Vulture)
	Gymnogyps californianus (Shaw)* (California Condor)
	† Vultur clarki (Miller) (Vulture)
	††Cathartornis gracilis Miller (Vulture)
TERATORNITHIDAE- Teratornithes	
††Teratornis merriami Miller	††Teratornis merriami Miller* (Teratornithe)
ACCIPITRIIDAE- Kites, Hawks, and Allies	
	Elanus leucurus (Vieillot) (White-tailed Kite)
	Astur atricapillus (Wilson)* (Goshawk)
	Accipiter velox (Wilson)* (Sharp-shinned Hawk)
Accipiter cooperi (Bonaparte)	Accipiter cooperi (Bonaparte) (Cooper's Hawk)
	Buteo sp. indet.*
Buteo borealis (Gmelin)	Buteo borealis (Gmelin)* (Red-tailed Hawk)
Buteo swainsoni Bonaparte	Buteo swainsoni Bonaparte (Swainson's Hawk)
	Buteo lagopus (Gmelin) (American Rough-legged Hawk)

TABLE 3- Continued

Buteo regalis (Gray)	Buteo regalis (Gray) (Ferruginous Rough-leg)
†Urubitinga fragilis (Miller)	†Urubitinga fragilis (Miller)* (Fragile Eagle)
Aquila chrysaetos (Linnaeus)	Aquila chrysaetos (Linnaeus)* (Golden Eagle)
Haliaeetus leucocephalus Linnaeus	Haliaeetus leucocephalus Linnaeus (Bald Eagle)
††Neogyps errans Miller	††Neogyps errans Miller* (Errant Eagle)
††Neophrontops amerianus Miller	††Neophrontops americanus Miller (American Neophron)
	† Morphnus woodwardi Miller (Woodward Eagle)
	††Wetmoregyps daggetti (Miller) (Daggett Eagle)
	† Spizaetus grinnelli (Miller)* (Grinnell Eagle)
Circus hudsonius (Linnaeus)	Circus hudsonius (Linnaeus)* (Marsh Hawk)
FALCONIDAE- Caracaras and Falcons	
Polyborus cheriway (Jacquin)	Polyborus cheriway (Jacquin)* (Audubon's Caracara)
Falco mexicanus Schlegel	Falco mexicanus Schlegel (Prairie Falcon)
Falco peregrinus Tunstall	Falco peregrinus Tunstall (Peregrine Falcon)
Falco columbarius Linnaeus	Falco columbarius Linnaeus (Pigeon Hawk)
Falco sparverius Linnaeus	Falco sparverius Linnaeus* (Sparrow Hawk)
†Falco swarthi Miller (Giant Falcon)	
Falco sp. indet.	Falco sp. indet.

TABLE 3- Continued

PERDICIDAE- Partridges and Quails	
Lophortyx californica (Shaw)	Lophortyx californica? (Shaw)* ** (California Quail)
MELEAGRIDIDAE- Turkeys	
	††Parapavo californicus Miller* (California Turkey)
GRUIDAE- Cranes	
Grus canadensis (Linnaeus)	Grus canadensis (Linnaeus) (Little Brown Crane)
	Grus americana? (Linnaeus) (Whooping Crane)
RALLIDAE- Rails, Gallinules, and Coots	
Rallus limicola Vieillot (Virginia Rail)	
	Fulica americana Gmelin (American Coot)
CHARADRIIDAE- Plovers, Turnstones, and Surf-Birds	
Eupoda montana (Townsend) (Mountain Plover)	
Oxyechus vociferous (Linnaeus)	Oxyechus vociferous (Linnaeus) (Killdeer)
	Squatarola squatarola (Linnaeus) (Black-bellied Plover)
SCOLOPACIDAE- Woodcock, Snipe, and Sandpipers	
	Capella delicata (Ord) (Wilson's Snipe)
Numenius americanus Beckstein	Numenius americanus Beckstein (Long-billed Curlew)
	Phaeopus hudsonicus (Latham) (Hudsonian Curlew)
Totanus melanoleucus (Gmelin)	Totanus melanoleucus (Gmelin) (Greater Yellow-legs)

TABLE 3- Continued

Pelidna alpina (Linnaeus) (Dunlin)	
Limnodromus griseus (Gmelin)	Limnodromus griseus (Gmelin) (Dowitcher)
	Limosa fedoa? (Linnaeus) (Marbled Godwit)
RECURVIROSTRIDAE- Avocets and Stilts	
Recurvirostra americana Gmelin	Recurvirostra americana Gmelin (Avocet)
LARIDAE- Gulls and Terns	
	Larus brachyrhynchus? Richardson (Short-billed Gull)
	Rissa tridactyla? (Linnaeus) (Kittiwake)
COLUMBIDAE- Pigeons and Doves	
	Columba fasciata Say* (Band-tailed Pigeon)
Zenaidura macroura (Linnaeus)	Zenaidura macroura carolinensis (Linnaeus) (Mourning Dove)
	Ectopistes migratorius (Linnaeus) (Passenger Pigeon)
CUCULIDAE- Cuckoos, Roadrunners, and Anis	
Geococcyx californianus (Lesson)	Geococcyx californianus* (Lesson) (Road-runner)
TYTONIDAE- Barn Owls	
	Tyto alba (Scopoli)* (Barn Owl)
STRIGIDAE- Typical Owls	
	Otus asia (Linnaeus)* (Screech Owl)
Bubo virgianianus (Gmelin)	Bubo virgianianus (Gmelin)* (Great Horned Owl)

TABLE 3- Continued

	Glaucidium gnoma Wagler (Pigmy Owl)
Speotyto cunicularia (Molina)	Speotyto cunicularia (Molina) (Burrowing Owl)
	† Strix brea Howard (La Brea Owl)
Asio wilsonianus (Lesson)	Asio wilsonianus (Lesson)* (Long-eared Owl)
	Asio flammeus (Pontoppidian) (Short-eared Owl)
	Cryptolglaux acadica (Gmelin) (Saw-whet Owl)
PICIDAE- Woodpeckers	
Colaptes cafer (Gmelin)	Colaptes cafer (Gmelin)* (Flicker)
	Asyndesmus lewis Gray (Lewis's Woodpecker)
TYRANNIDAE- Tyrant Flycatchers	
	Tyrannus sp. (Kingbird)
ALAUDIDAE- Larks	
	Otocoris alpestris (Linnaeus) (Horned Lark)
HIRUNDINIDAE- Swallows	
Petrochelidon albifrons (Rafinesque) (Cliff Swallow)	
CORVIDAE- Jays, Magpies, and Crows	
	Aphelocoma* sp. (Jay)
	Pica nutalli (Audubon)* (Yellow-billed Magpie)
Corvus corax Linnaeus	Corvus corax Linnaeus* (Raven)

TABLE 3- Continued

	Corvus brachyrhynchos Brehm (Crow)
	Corvus caurinus Baird* (Northwest Crow)
PARIDAE- Titmice, Verdins, and Bush-Tits	
	Penthestes sp.* (Chickadee)
MIMIDAE- Mockingbirds and Thrashers	
	Toxostoma cf. redivivum (Gambel) (California Thrasher)
BOMBYCILLIDAE- Waxwings	
	Bombycilla cedrorum Vieillot* (Cedar Waxwing)
LANIIDAE- Shrikes	
	Lanius ludovicianus Linnaeus (Loggerhead Shrike)
ICTERIDAE- Meadowlarks, Blackbirds, and Troupials	
	Sturnella neglecta? Audubon* ** (Western Meadowlark)
	Xanthocephalus? sp. (Yellow-headed (Blackbird)
	Icterus sp. (Oriole)
	†Euphagus magnirostris A. H. Miller (La Brea Blackbird)
	Agelaius phoeniceus californicus Nelson (Bicolored Red-wing)
GRINGILLIDAE- Grosbeaks, Finches, Sparrows, and Buntings	
	Pipilo* sp. indet. (Towhee)

* indicates the form is also present at Carpinteria.
** indicates the form is also present in the Palos Verdes (Upper San Pedro beds).
†† indicates the genus is extinct.
† indicates the species is extinct.

Comparison of tables 1 and 2 reveals that many of the forms found fossil in the McKittrick tar seeps are still living in the area, as is especially true in case of the rodents, and that in the fossil assemblage plains-dwellers apparently greatly outnumber mountain-living forms. Indeed, the rodent fauna is so similar to that still living in the area as to suggest that it may be in part post-Pleistocene in age.

In case of extinct forms, the habitat cannot be determined definitely, but it would appear that at McKittrick mountain-dwellers are somewhat more abundant relatively than at Rancho La Brea. Due to closer proximity of the former locality to uplands, this is perhaps not surprising. It would seem, therefore, that the McKittrick fossil assemblage affords a valuable transitional stage between the predominately plains assemblage of Rancho La Brea and the upland faunas of the northern California caves.

Forms which occur as fossils at either Rancho La Brea or McKittrick, and which may have been mountain-dwellers are: Lynx rufa fischeri, Felis daggetti, Mustela frenata nigriauris, Tremarctotherium simum, Ursus optimus, Tanupolama stevensi, and Preptoceras sinclairi.

Among the larger mammals only four species, Vulpes macrotis, Antilocapra americana, Odocoileus, and Cervus which inhabit the McKittrick area at the present time are found in the tar pits. Specific identification of the deer and elk is very uncertain, but there seems to be little difference between the fossil and living forms. Most of the remaining large mammals found in the fossil assemblage are definitely extinct and seem to have left no descendants in the region, although Ursus optimus and Canis latrans orcutti may be ancestral to living forms.

Examination of table 2 serves to point out the very striking similarity in mammalian faunas of McKittrick and Rancho La Brea. Some noteworthy differences are likewise apparent. Of the latter, perhaps the most striking is the absence of Preptoceras? and Tanupolama at Rancho La Brea. In view of the unusual number of individuals known from this locality, it seems very probable that these forms did not live in the Los Angeles area at a time when the fossil assemblage was accumulating. This problem is discussed more fully below.

Of the forty-three species of mammals occurring at McKittrick twenty are no longer extant, while of the forty-nine species found at Rancho La Brea twenty-nine are extinct. It would appear, furthermore, that extinction at Rancho La Brea has been confined largely to larger forms, for only one rodent species, Peromyscus imperfectus, and three of the subspecies seem to be extinct. In the McKittrick rodent assemblage, apparently, all of the species are still living, although one, Thomomys bottae bottae, seems to live no longer in the region. While the McKittrick rodents may be partly Recent in age, it seems probable that members of this order have not been affected by extinction to so great an extent as the larger mammalian forms. This inference has considerable bearing upon accuracy of the percentage method of correlation. Most Pleistocene faunas are relatively poor in representation of the rodents; consequently, indiscriminant methods of calculation which do not take into consideration differences in life spans of the smaller and larger mammals can hardly be convincing.

Of the 103 species of fossil birds now known from Rancho La Brea, sixteen are extinct. Fifty-seven species of birds are known from McKittrick. Of these nine are known to be no longer living. The percentage of extinct forms would thus appear to be approximately fifteen and one-half in both instances. As Miller (1925, p. 311) has noted, migratory species are relatively somewhat more abundant at McKittrick, and since such forms may be expected to have a better chance of survival, no definite statement of relative age of the two deposits can be made on the basis of avifaunas alone. The percentage of extinct mammals at McKittrick is approximately forty-six as compared with fifty-nine at Rancho La Brea. On this basis it might appear that McKittrick is somewhat younger than Rancho La Brea. The writer must confess, however, that whenever doubt has arisen as to whether a given mammalian form is to be referred to an extinct or living species, he has always favored the latter interpretation. In view of the relatively small percentage differences between the two faunas, not much reliance is to be placed upon these figures as indicators of relative age. As shown on pages 73-74, however, there are other and better reasons for believing McKittrick to be a little younger than Rancho La Brea.

The only birds found at Carpinteria which do not also occur at McKittrick or Rancho La Brea are: Buteo lineatus (Gmelin) (Red-bellied Hawk), Dryobates sp. (Woodpecker), Sayornis sp. (Phoebe-Flycatcher), Empidonax sp. (Small Flycatcher), Cyanocitta stelleri (Gmelin) (Steller Jay), Sitta canadensis Linnaeus (Red-breasted Nutthatch), Chamaea fasciata (Gambel) (Wren-tit), Turdus migratorius Linnaeus (Robin), Hylocichla? sp. (Thrush), Spinus pinus (Wilson) (Pine Siskin), Loxia curvirostra Linnaeus (Red Crossbill), and Passerella iliaca (Merrem) (Fox Sparrow). All are still living. Many of the above are woodland forms, and their absence at McKittrick and Rancho La Brea is readily explained by lack of adequate forest cover in the vicinity of the latter tar pits.

Birds found in the Palos Verdes beds, but which have not yet been encountered in asphalt deposits are: Gavia near immer (Bruennich) (Loon), Synthliboramphus antiquus (Gmelin) (Ancient Murrelet), Diomedea near nigripes Audubon (Black-footed Albatross), Puffinus opisthomelas Coues (Black-vented Shearwater), Fulmarus glacialis (Linnaeus) (Fulmar), Phalacrocorax penicillatus (Brandt) (Cormorant), and Oidemia perspicillata (Linnaeus) (Surf Scoter). All these species are still in existence. In this instance it seems reasonable to attribute dissimilarities of the avifauna with those of the tar pits to proximity of the ocean and lack of woods at the San Pedro locality.

Examination of table 3 reveals that twelve species of birds found at McKittrick do not occur at Rancho La Brea. Of these, seven are aquatic or semi-aquatic in habit. Thus the major differences may be accounted for by absence of large bodies of standing water at the Los Angeles locality. Fifty-seven species of birds occurring at Rancho La Brea are not found at McKittrick. Reasons for absence of some of these forms from the San Joaquin Valley locality will be discussed on a later page. In this connection it should be kept in mind that the McKittrick passerines have not yet been thoroughly studied.

Since birds are perhaps somewhat longer lived than mammalian species, it is not surprising that insofar as avian faunas are concerned, there seems to be little reason for regarding the McKittrick and Rancho La Brea, Carpinteria, and Palos Verdes assemblages as other than closely related in time.

FOSSIL FLORAS OF McKITTRICK, RANCHO LA BREA AND CARPINTERIA

In order to complete the extraordinary picture of late Pleistocene life afforded by the asphalt assemblages, it seems desirable to list the floras. The plant assemblage of Carpinteria is particularly well known. In case of McKittrick and Rancho La Brea it seems reasonably certain that in the immediate vicinity of the tar seeps no woods were present, but it is probable that during the period of fossil accumulation both the Temblor and Santa Monica Ranges were forest-covered.

TABLE 4- Fossil floras of McKittrick, Rancho La Brea and Carpinteria

McKittrick	Carpinteria	Rancho La Brea
	Cupressus goveniana (Mountain Cypress)	Cupressus macrocarpa (Monterey Cypress)
Juniperus utahensis	Juniperus californica (Juniper)	Juniperus californica*
Pinus monophylla	Pinus muricata (Pine)	Pinus muricata**
	Pinus radiata (Monterey Pine)	
	Pinus remorata (Santa Cruz Pine)	
	Pinus sabiniana (Digger Pine)	
	Pseudotsuga taxifolia (Douglas Fir)	
	Quercus agrifolia (Live Oak)	Quercus agrifolia
	Sequoia sempervirens (Redwood)	

TABLE 4- Continued

	Umbellularia californica (Spice Wood)	
Arctostaphylos glauca	Arctostaphylos glauca (Big-berried Manzanita)	
Prunus ilicifolia (California Wild Plum)	Arctostaphylos sp.	
Atriplex sp. (Salty Sage)	Eriodictyon californicum (Yerba Santa)	
	Ceanothus thyrsiflorus (Blue Blossom Lilac)	
	Garrya elliptica (Quinine Bush)	
	Pyrus hoffmanni (Extinct Pear)	
	Rhus diversiloba (Poison Oak)	Celtis mississippiensis reticulata (Western Hackberry)
	Sambucus glauca (Blue Elderberry)	Sambucus glauca
	Arceuthobium campylopodum (Mistletoe)	
		Undetermined Compositae?
	Chorizanthe pungens (Turkish Rugging)	
	Corethrogyne sp.	
	Cymopterus littoralis	
	Pteris aquilina (Common Brake)	
	Xanthium calvum (Cocklebur)	

* J.c. breaensis of Frost ** P. tuberculata of Frost

The Carpinteria floral list has been compiled from Chaney and Mason (1933, p. 52). According to these authors, only one species found at this locality, *Pyrus hoffmanni*, is new. The remainder belong to the living flora of California, and in a majority of cases are also known from other Pleistocene deposits in the state. The ecologic relations are those of the Monterey pine forest, which at present occurs typically on the Monterey Peninsula, although scattered groves are found as far south as Morro Rock in San Luis Obispo County. Consequently, a northward retreat of the forest seems to have been the only important change in the plant world since the deposit was laid down. Chaney and Mason (1933, pp. 75-76) are of the opinion that the southward extension of the pine forest was brought about by glaciation.

Frost (1927, pp. 85-87) who is the authority for the Rancho La Brea floral list points out that all of the species found at this locality with the exception of *Celtis mississippiensis reticulata*, live today in Monterey County. All are elements of the mesophytic forest except *Sambucus glauca*, which is hygrophytic. Present distribution of *C. m. reticulata* is largely confined to mountain ranges bordering deserts, and Frost considers occurrence of this plant at Rancho La Brea as inconsistent with character of the remainder of the flora. He suggests that the seeds of this plant, which constitute its entire record at Rancho La Brea, may well have been carried into the area by birds. The conclusion reached by Frost is that a comparison of the existing climates of the Monterey and Los Angeles areas should serve as an indicator of the climatic change which has occurred since Rancho La Brea time. According to this view, there would appear to be a marked similarity between the floras of Rancho La Brea and Carpinteria.

At a later time Mason (Compton, 1937, p. 88) offered a quite different interpretation of the Rancho La Brea flora. This author points out that the taxonomic aspect of the pine is in doubt; while the cypress could as well be similar to _Cupressus nevadensis_ as to _C. goveniana_ or to _C. macrocarpa_. When reasonable allowance for these doubtful elements is made, it is seen that the Rancho La Brea flora suggests arid interior conditions similar to those now existing well up on the south slopes of the Tehachapi mountains.

For the floral list of McKittrick I am indebted to Dr. Mason, who states in conversation that this assemblage is likewise of a dry interior aspect. _Juniperus utahensis_ and _Atriplex_ are somewhat out of their present range, although the latter occurs abundantly on the low-lands a few miles from the fossil deposit. It is hoped that Mason's report on the McKittrick flora will appear before publication of this paper.

CENSUS OF THE McKITTRICK FOSSIL MAMMALS

The method employed in estimating relative abundance is essentially the same as that used by Stock (1929A, p. 282) for a census of the Rancho La Brea mammals. However, Stock considered only adult animals, while in

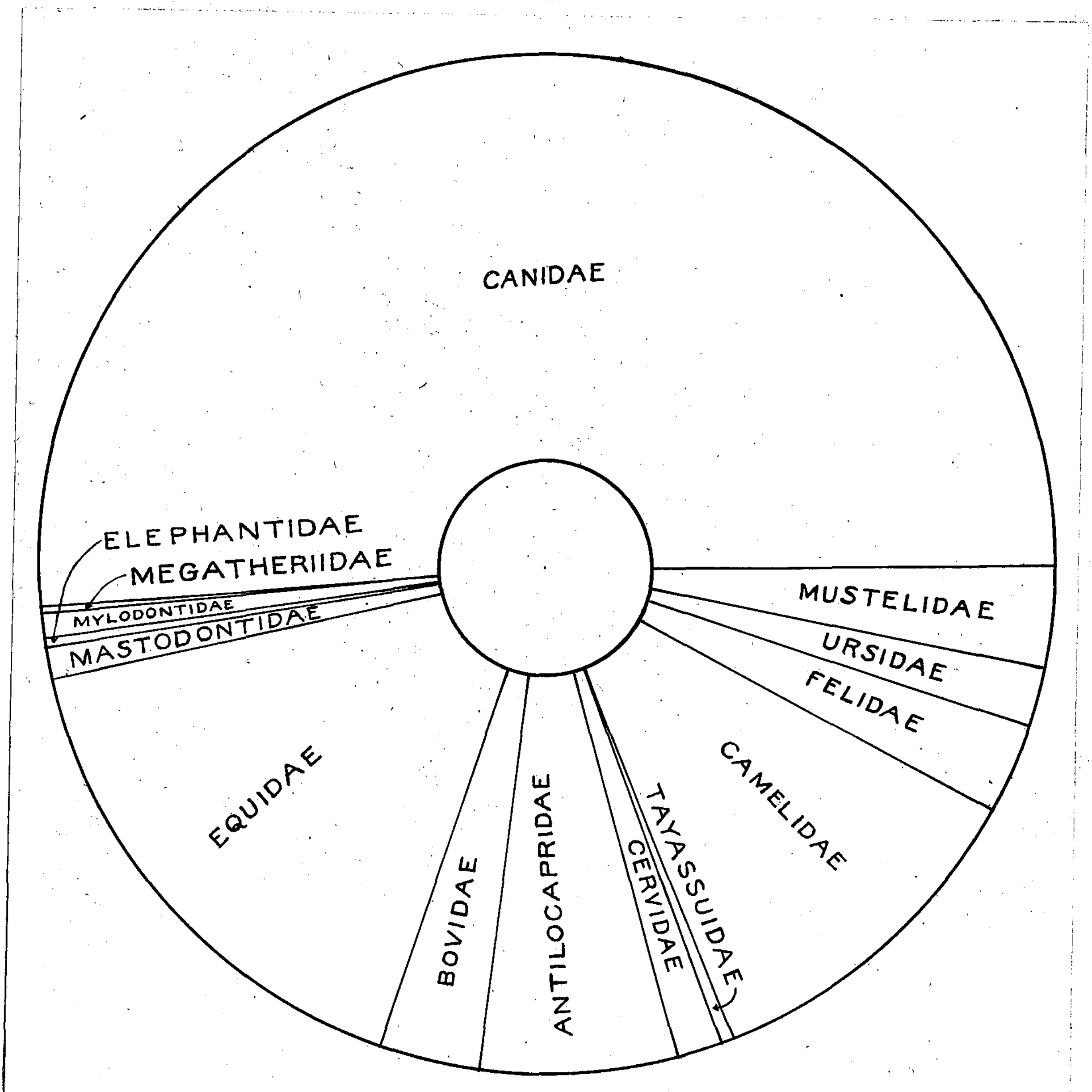

Figure 4 -- Diagram showing relative number of individuals in the mammalian families (except rodents, lagomorphs, insectivores and bats) occurring in the McKittrick Pleistocene fauna.

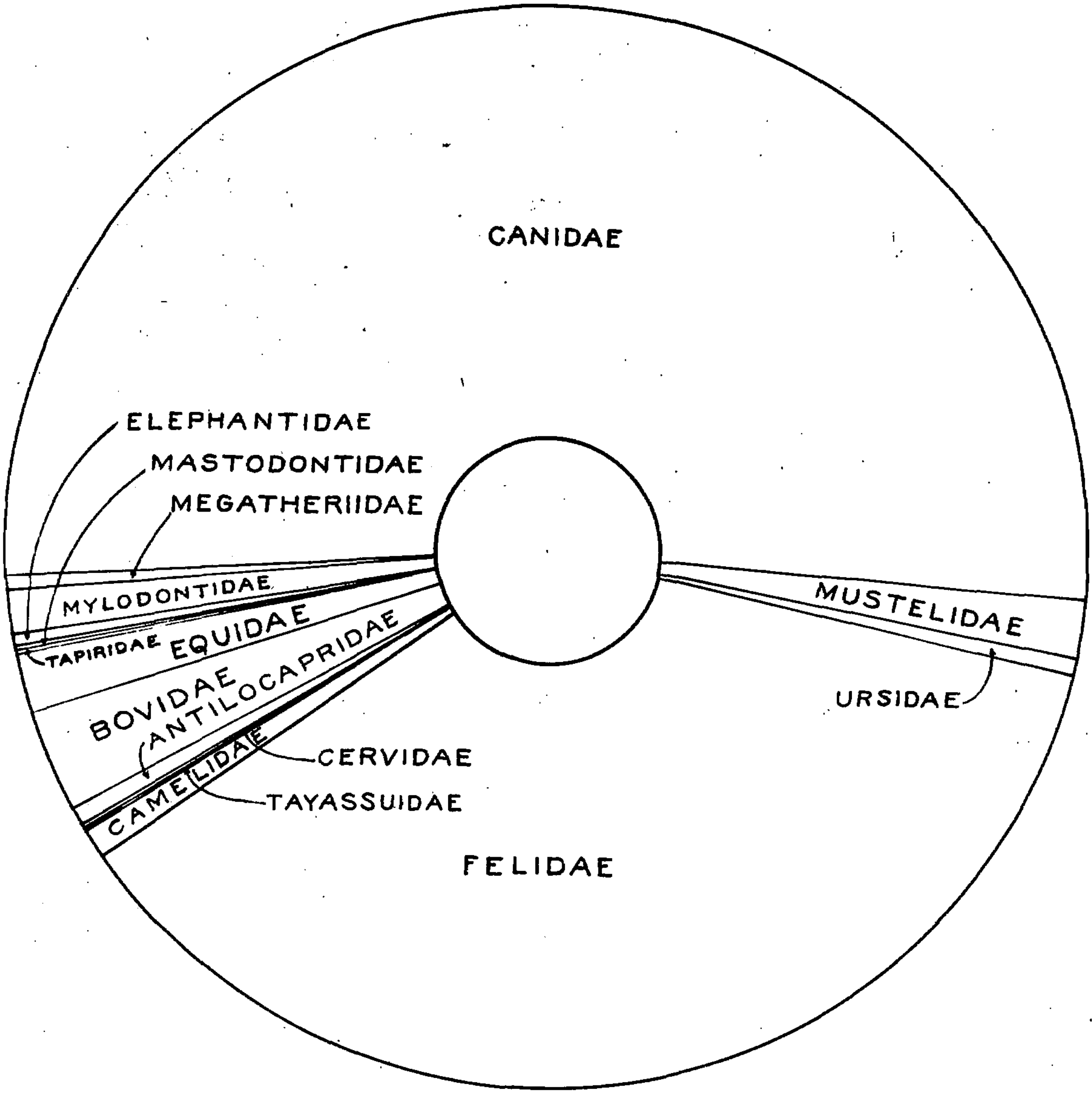

Figure 5 -- Diagram showing relative number of individuals in the mammalian families (except rodents, lagomorphs, insectivores and bats) occurring in the Rancho La Brea Pleistocene fauna. After Merriam and Stock (1932).

this case individuals in all stages of growth are considered. In both cases, however, the count seems to represent some basis for comparison of the two mammalian faunas.

Figures 4 and 5 illustrate relative abundance of individuals of various mammalian orders at McKittrick and Rancho La Brea, while figure 6 contrasts the relative abundance of individuals of various species at the

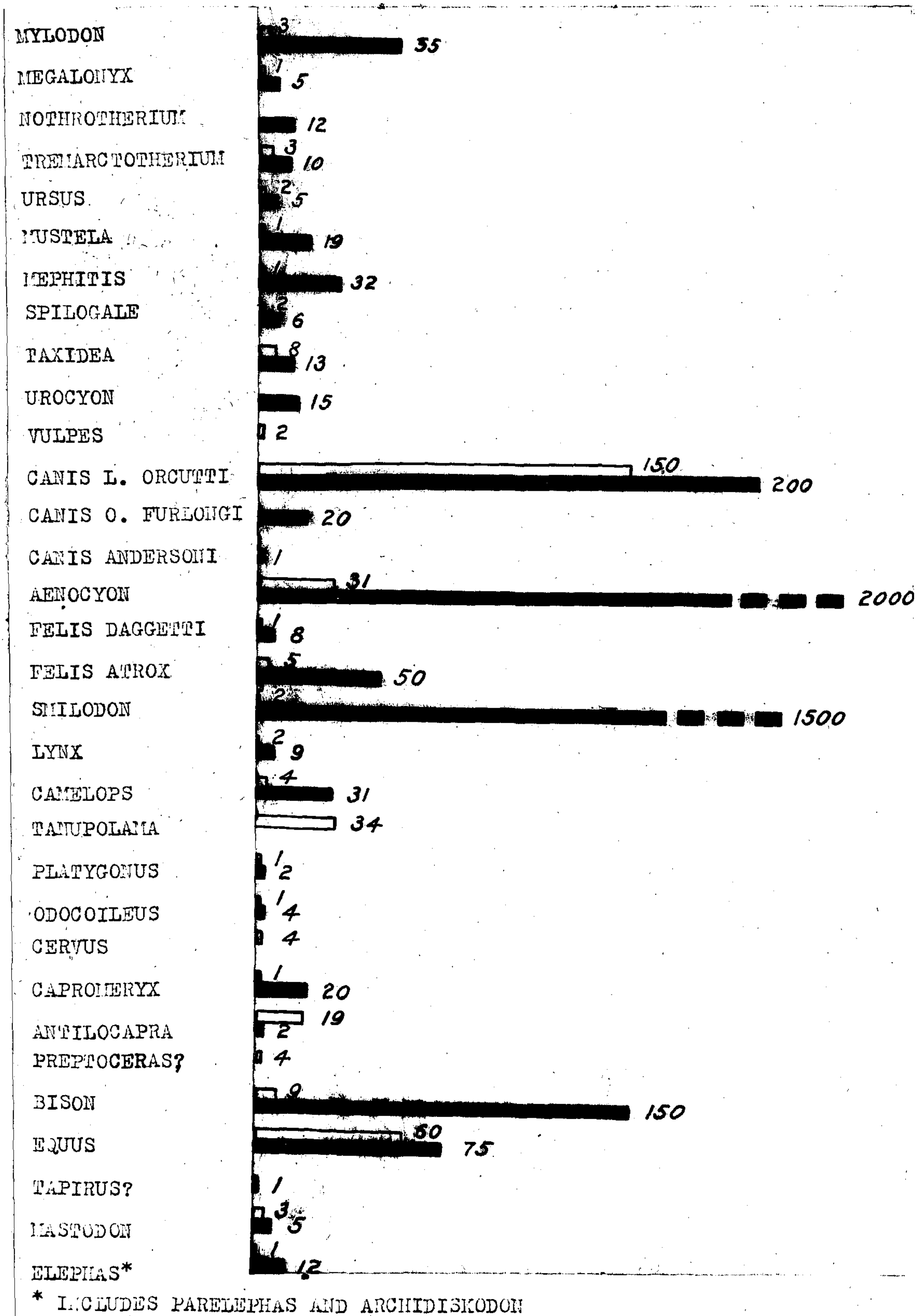

Figure 6 -- Diagram showing number of individuals recorded for genera and species of mammals in the Pleistocene faunas of McKittrick (white bar) and Rancho La Brea (black bar). Rancho La Brea census after Stock (1929A).

two localities. In all cases rodents, insectivores and bats have been omitted.

Although the McKittrick collection comprises only 355 individuals as compared with 4264 in the Rancho La Brea collection of the Los Angeles Museum, there seems to be a fair basis for comparison of the two faunas. Perhaps the most important difference in constituency is the comparatively meagre representation of carnivores at McKittrick. As is shown by figure 6, the carnivora of McKittrick are predominantly modernized forms such as the coyote, while at Rancho La Brea types like Aenocyon and Smilodon comprise the greater part of the carnivore population.

Since statistical studies of the smaller mammals of Rancho La Brea have not been made, there seems to be no necessity of illustrating their relative abundance at McKittrick. With regard to the lagomorphs, the cotton-tail, Sylvilagus auduboni, seems to be the most abundant at McKittrick and is represented by no less than fifty-four individuals. The jack-rabbit, Lepus californicus, is next in order of abundance with forty-one individuals, while the brush-rabbit, Sylvilagus bachmani, numbers approximately twenty-eight. Following Wilson's determinations (1933, pp. 63-65), it would appear that representation of the lagomorphs is approximately similar to that at Rancho La Brea, but at Carpinteria Sylvilagus bachmani is relatively common while Lepus is rare.

At McKittrick representation of the rodents is as follows: Dipodomys, two hundred and fifty-five; Peromyscus, one hundred, Microtus, thirty-five; Thomomys, sixteen; Ammospermophilis, nine; Perognathus, eight; and Otospermophilis and Onychomys with one individual each. According to Wilson, at Rancho La Brea Thomomys is the most abundant rodent; while at

Carpinteria Peromyscus is the most abundant form. As this author points out, these facts may have no special significance insofar as environmental conditions are concerned, but the great abundance of Dipodomys in the McKittrick fauna suggests an arid to semi-arid climate, for the kangaroo-rats characteristically inhabit regions of low rainfall. The evidence of the rodent fauna is apparently in disagreement with the evidence of the birds, and perhaps also with that of the larger mammals, which seem to indicate more humid conditions. In this connection it should be noted how very similar is the fossil rodent fauna to that still inhabiting the area, for only one variety, Thomomys bottae bottae, seems to live no longer in the region.

Insectivores and bats are not at all abundant at McKittrick, and are represented by not more than one or two individuals each.

A CENSUS OF THE McKITTRICK FOSSIL AVIFAUNA

Present knowledge of the McKittrick birds is due almost entirely to the work of L. H. Miller. The collections now reported consist of approximately 4000 specimens. This number although large in comparison to that from other fossil localities, is insignificant when compared to the 86,242 bird bones in the Rancho La Brea collections of the Los Angeles Museum. The passerines of McKittrick have not yet been reported upon in a formal statement, and it is hoped that A. H. Miller's paper on this division of the McKittrick avifauna will precede in print the present report. Most of the reports on the McKittrick birds list the total number of remains of each species as a basis for estimating relative abundance; while Howard (1930, p. 81) has estimated the constituency of the Rancho La Brea avifauna by a method essentially comparable to that employed by Stock in his census of the mammalian assemblage. Furthermore, studies of the Rancho La Brea and McKittrick avifaunas are still being carried on so actively that it is futile to attempt at this time more than a general statement as to the constituencies of the two assemblages.

As has been noted already, the McKittrick avifauna is not an ecologic unit. Fauna number 1, which consists of nearly 1000 specimens comprises thirty-three percent anserines; twenty percent limicolines; fourteen percent herons, storks, and cranes; the golden eagle twenty-eight percent; and all other land birds five percent. As Miller (1925, p. 310) has noted, this assemblage suggests a widespread marshy area similar to conditions inferred at Fossil Lake. It should be noted that McKittrick avifauna number 1 comprises relatively more water birds than does Rancho La Brea (Miller, 1925, p. 310).

McKittrick avifauna number 2, on the other hand, is predominantly a land assemblage, and is quite similar to that of Rancho La Brea. Both the Rancho La Brea assemblage and the second McKittrick avifauna are characterized by relatively large representation of vultures and other raptoral types. In this connection it is interesting to note that the bird assemblage from the southern California Academy of Sciences pit at Rancho La Brea (Howard 1936, pp. 32-34) resembles McKittrick avifauna number 1, in that this excavation contains a relatively large percentage of water-dwelling types.

Combination of McKittrick avifaunas 1 and 2 shows that far less difference exists between the McKittrick and Rancho La Brea assemblages than when either McKittrick assemblage is considered alone. It is true, however, that aquatic types are slightly more abundant, relatively, at McKittrick, but this does not seem to have any age significance. Galliformes and owls are somewhat less abundant at McKittrick, but this discrepancy is probably due to the less forested condition which prevailed in vicinity of the McKittrick tar seeps. Since McKittrick avifauna localities 1 and 2 are separated by only one hundred feet, Miller's explanation that accumulation occurred near the shore of a lake and that avifauna number 2 is predominantly a land assemblage, is entirely acceptable to the writer.

Perhaps the most important difference in the avifaunas of McKittrick and Rancho La Brea lies in the relative abundance of the black vulture

(*Coragyps*) and the American turkey vulture (*Cathartes*). At McKittrick *Cathartes* outnumbers *Coragyps* in a ratio of slightly more than five to one (Miller, 1935, p. 76); while at Rancho La Brea the extinct black vulture outnumbers *Cathartes* in a ratio of twenty to one (Howard, 1930, p. 84). As will be mentioned on a following page, the relative proportions of these raptors may have considerable age significance.

FACTORS GOVERNING GROUP REPRESENTATION

The factors governing the presentation of animals in brea deposits are classifiable into three major categories, the first of which is capable of subdivision. They are: (1) environment, (2) time, and (3) chance and probability.

Since it is difficult, when dealing with tar pit assemblages, to separate environment and ecology, and still more difficult to distinguish between regional environment and the conditions which prevailed in the immediate vicinity of the pits, these factors are discussed to best advantage with climatic evidence in following sections.

The factor of time is so intimately associated with the problem of correlation, which in turn is related to environment and ecology, that a separate section has been set aside for its discussion. For the present it is sufficient to note that time seems to be of relatively little importance insofar as group representation is concerned. With regard to relative abundance of various groups, however, time seems to be the deciding factor, and on this basis it would appear that since modernized forms show greater abundance relative to extinct types at McKittrick, this occurrence is somewhat younger than Rancho La Brea.

With regard to the third factor, it is scarcely necessary to point out that since the Rancho La Brea mammalian assemblage in the collections of the Los Angeles Museum contains approximately twelve times as many individuals as that of McKittrick, absence of a specific type from the Los Angeles locality probably means that it did not inhabit the area during the period of fossil accumulation. However, in case of absence of a form from McKittrick, known to occur at Rancho La Brea, it is far less certain that it was absent from the area at a time when the tar seeps were active.

In view of rather scanty representation of the Felidae at McKittrick, it is not surprising that certain forms such as Smilodon californicus brevipes, Felis bituminosa, and Felis concolor seem to be absent from the fauna, for these types are rare even at Rancho La Brea. Since the latter form still lives in the McKittrick area, it seems almost certain that chance alone is responsible for its absence in the fossil assemblage.

The McKittrick Canidae, on the other hand, are a relatively abundant group. Why certain of the Rancho La Brea forms, Canis andersoni, and Canis occidentalis furlongi, should be absent from the former locality is difficult to explain. Both of these forms are rare at Rancho La Brea and never seem to have been present in the California area in great numbers. Consequently, their absence in the McKittrick tar pits may be due to chance. On the other hand, isolated and fragmentary specimens of both the above forms are not readily determinable, but it is certain that no skull material is available. Since foxes are not abundant at either Rancho La Brea or McKittrick, absence of Urocyon at the latter locality may well be due to chance. As Stock (1929A, p. 289) has indicated, it may be that absence of Vulpes at the Los Angeles locality is to be attributed to more humid conditions than those now prevailing in the area.

While the habits of Nothrotherium are not sufficiently well known to permit a reasonable inference as to the environmental conditions permitting its presence, the sparse representation of ground sloths at McKittrick indicates that absence of this form from the San Joaquin valley locality is likewise the result of chance.

The Elephantidae are not well represented at McKittrick, and absence of <u>Archidiskodon imperator</u> from the collections seems reasonably attributed to the same factor presumed to be responsible for the non-occurrence of <u>Nothrotherium</u>.

In view of their scarcity at Rancho La Brea, absence of representatives of the Tapiridae at McKittrick seems reasonably attributed to accident.

While it is probably true that a large proportion of the McKittrick rodents are Recent in age, time alone does not seem sufficient reason for their relative scarcity at Rancho La Brea. Possibly sufficient care was not taken in collecting these types at Rancho La Brea. In view of the great numbers of very small bones of passerine birds obtained at this locality, however, this explanation is not very plausible. Some unknown factor in local environment seems to be the only possible explanation of the rarity of rodents at Rancho La Brea.

As at Rancho La Brea, a conspicuous absence of all members of the Procyonidae is noted in the McKittrick fauna. As Stock (1929A, pp. 288-289) has suggested, the extreme wariness of these animals may be responsible for their absence in the tar pits.

Factors governing representation of the birds have already been touched upon in pages 50-51 . There remain, however, some outstanding exceptions which deserve mention.

Miller (1935, pp. 74-75) noted the absence of <u>Parapavo</u> at McKittrick, and concluded that there was too little cover in the area for so large and conspicuous a galliform as the wild turkey. The same author (1935, p. 75) suggested that the factor of latitude may account for the apparent limitation of Morphnus woodwardi to the deposits of Rancho La Brea. The same factor was suggested by Miller (1935, p. 76) as an explanation for the apparent rarity of Coragyps at McKittrick. However, as this author pointed out, its near relative, Coragyps shastensis, is found in the Pleistocene caves several hundred miles to the north. No explanation was offered by Miller for rarity of Cathartes aura at Rancho La Brea.

Howard and Miller (1933, p. 17) demonstrated that at Conkling Cave, New Mexico, Coragyps predominates over Cathartes, while at Shelter Cave in the same state Coragyps is absent and Cathartes is abundant. These authors suggested that since in most Pleistocene deposits Coragyps predominates over Cathartes, Shelter Cave may be younger than Conkling Cave. Wetmore (1931, p. 25) also noted the abundance of Coragyps in the Pleistocene of Florida. As is stated on page 62, at McKittrick Cathartes is much more abundant than Coragyps; while at Rancho La Brea (Howard, 1930, p. 84) the reverse is true. Following Howard and Miller's suggestion, it would appear that on this basis McKittrick is younger than Rancho La Brea.

Miller (1935, p. 76) held the entire absence of the California Condor, Gymnogyps californicus, from the McKittrick tar seeps to be inexplicable. This species was found in great numbers at Rancho La Brea, and still lives within sight of the McKittrick locality.

With regard to other raptors, Miller (1935, p. 77) pointed out that in McKittrick avifauna number 2, of the three genera Aquila comprised sixty-five percent, Urubitinga twenty-nine percent, and Neogyps five percent. At Carpinteria _Neogyps_ outnumbered Aquila by two to one, while _Urubitinga_ was more abundant in one exposure and less in the other. Miller stated that McKittrick thus comes to resemble Rancho La Brea, and is in sharp contrast to Carpinteria. The explanation offered by this author is that at the time of fossil accumulation Carpinteria was a wooded area.

A. H. Miller has informed the writer that the northwest crow, _Corvus caurinus_, is definitely absent at McKittrick. In Miller's opinion this form was then as now a coast-living bird. Consequently, absence of this form has no climatic significance.

ECOLOGICAL AND ENVIRONMENTAL FACTORS AT McKITTRICK AND RANCHO LA BREA

In preceding sections all seemingly pertinent data relating to the McKittrick fossil assemblage have been presented with a minimum of interpretation. It is now necessary to re-examine the evidence with a view to sorting out the following factors: regional environment and ecology as contrasted with local ecology and environment; climate as distinguished from environment; and chronology. Since the second proves to be the most highly inferential, it has been left to the last. In this section only the first factor will be considered.

The combined evidence of the mammals, birds, and plants indicates that during the period of fossil accumulation the regional environment at Rancho La Brea and McKittrick was much the same as that of today. In both instances the physical environment consisted of broad, and perhaps rather arid plains, which bordered directly upon rugged mountain ranges. Since the McKittrick fossil deposit is located nearer to the uplands, it is possible that absence of certain mammals at Rancho La Brea is to be attributed to greater distance of this locality from the Santa Monica Range. Tanupolama and Preptoceras? are cases in point. In any event, it seems reasonably certain that neither of these forms ranged into the Los Angeles area during the period of fossil accumulation. Contrasted with these dissimilarities are those which may be due to fundamental differences in mode of accumulation at McKittrick and Rancho La Brea. The factors involved in the latter may be designated as local environment as distinguished from regional environmental conditions.

Nothing is more apparent than that the Rancho La Brea assemblage is an abnormal and ecologically impossible one. This is shown by the extraordinarily high percentage of carnivores: over ninety percent in case of the mammals, and approximately sixty-seven percent in case of the birds. It is almost equally apparent that the McKittrick assemblage is a more normal one from an ecological standpoint, for only fifty-nine percent of the mammals and a slightly higher percentage of the birds are carnivorous. Reasons for this discrepancy are to be sought perhaps in differences in the two types of traps involved. The seeps at Rancho La Brea seem to have been very efficient traps, in which a considerable number of animals were more or less continuously snared. The surface flows at McKittrick may have congealed periodically, and thus were not so often an active death-dealing agent in entrapping creatures. In addition, presence of large bodies of water may have served to conceal victims of the tar from flesh-eaters. Under these conditions it is conceivable that carnivorous types were not attracted to the McKittrick seeps in numbers comparable to those that must have haunted the borders of the Rancho La Brea tar pools. Although some time difference may exist between the two asphalt assemblages, it would appear that this factor plays only a subordinate part insofar as relative abundance of carnivorous and non-carnivorous types in areas not immediately adjacent to the tar seeps is concerned. There likewise appears to be no ecologic reason why raptoral forms should have been overly abundant in the region of Rancho La Brea, and it seems necessary to conclude that environmental conditions in the vicinity of the tar seeps are responsible for the poorer representation of flesh-eaters at McKittrick. Since the relative abundance of carnivores at the latter locality is considerably higher than normal, it would appear that trapped herbivores offered some bait for such types.

Two closely related problems are the relative abundance of saber tooth and true cats, and the proportion of dire wolves to other representatives of the dog family. At Rancho La Brea _Aenocyon_ far outnumbers all other canids; while _Smilodon_ outnumbers _Felis atrox_ in a ratio of approximately thirty to one. It should be noted, however, that in some of the pits: numbers 67, 61, 60, 13, and 4 of the Los Angeles occurrence _Felis atrox_ actually outnumbers _Smilodon_. This may be due to nothing more than chance, but it may indicate an age difference between these and other pits. As Merriam (1912, pp. 255-256) has shown, the dire wolves appear to have been persistent predators of the tar seeps; while the coyotes, which depend upon smaller animals and birds for their prey, do not appear to have frequented the traps to so great an extent as their larger relatives. A similar relation seems to have existed in case of the saber tooth and true cats. As has been indicated by Merriam and Stock (1932, p. 21), _Felis atrox_ apparently did not visit the tar pools as often as did _Smilodon_. The conclusion seems justified that even at Rancho La Brea, _Felis atrox_ and the smaller dogs may have actually outnumbered _Smilodon_ and _Aenocyon_ in areas away from the tar pits. If this is true, the greater normality of the McKittrick assemblage is again emphasized.

Since there appear to be fewer large herbivores such as ground sloths and mastodons at McKittrick than at Rancho La Brea, it may be that large carnivores, _Smilodon_ for example, were not attracted to the area. This assumption will not explain the dominance of _Felis atrox_, however.

It is also possible to construe these data as indicating a time difference between the two faunas. If it is assumed that McKittrick is older than Rancho La Brea, it is conceivable that Smilodon and Aenocyon had not yet been forced by racial senility to seek an easier prey as represented by trapped animals in tar pools. An alternative view is that McKittrick is younger than the Los Angeles occurrence, and that only the last survivors of these gradually disappearing races are found there. Of the two possibilities, the latter seems preferable, but none appears as probable as the alternative first offered.

The relative scarcity of rodents at Rancho La Brea has already been mentioned. No explanation other than some unknown difference in local environment seems possible at the present time.

With regard to birds, as has been mentioned on pages 50-51 , nearly all major discrepancies between the avifaunas of McKittrick, Rancho La Brea, and Carpinteria can be accounted for on the assumption that Carpinteria was a well wooded area, Rancho La Brea less so, and McKittrick was one practically devoid of trees. The somewhat better representation of water birds at McKittrick leads to the conclusion that during the period of fossil accumulation, the tar seeps were near the shore of a lake or marshy area. Singularly enough, this feature of the local environment seems to have left no recognizable impression upon the mammalian fauna.

As to ecology very little can be said with conviction, except that when suitable allowance is made for peculiar environmental conditions in the immediate vicinity of the tar pits, nearly all factors with the following important exception seem to have been much like those of the present. With the decline of large herbivores the larger carnivores could also be expected to die out, and this seems to be true in case of McKittrick. Since this process was presumably a gradual one, a purely ecologic factor takes on considerable chronological significance.

A few mammalian species, Thomomys bottae bottae and Mustela frenata migriauris, found at McKittrick are slightly out of their present range, but this does not necessarily indicate an important change in environment or climate.

AGE AND CORRELATION OF THE McKITTRICK FAUNA

The preceding section points out that insofar as mammalian and avian faunas are concerned, there seems to be scant reason for considering McKittrick and Rancho La Brea as other than closely related in time. Outstanding discrepancies can be attributed to either environmental or ecological factors. However, the method used so far can not be expected to give precise results. It remains to examine the faunas more carefully in order to determine, if possible, the age relations of the asphalt faunas, and the part of Pleistocene time they represent.

Stock (1929A, pp. 286-287) has suggested that should another large tar pit fauna be found, its time relations with Rancho La Brea might be determined by a comparison of relative abundance of extinct and living forms. This method assumes that extinction was a gradual rather than a sudden process and, furthermore, that environmental conditions around the separate tar pits were identical. The first supposition seems very probable, but the second encounters difficulties when applied to McKittrick and Rancho La Brea. As indicated on page 69 , it seems probable that conditions of entombment at McKittrick were such as to bring about a relatively poor representation of extinct carnivores. Since members of this order furnish the most convenient basis for comparison, it is impossible to conclude from this evidence alone whether relatively greater abundance of modernized carnivores at McKittrick indicates that this deposit is actually younger than Rancho La Brea, or that in areas away from the tar pits _Smilodon_ and _Aenocyon_ were not nearly so abundant as a census of the Rancho La Brea fauna seemingly indicates. As shown by figure 6, however, the relatively small number of McKittrick carnivores includes almost as many modernized forms as does the entire Los Angeles Museum collection from Rancho La Brea. Unless an unduly large proportion of the McKittrick canids are post-Pleistocene in age, it would appear that if there is an age difference between the two localities, McKittrick is a somewhat younger stage.

In this connection it should be recalled how several sources of evidence suggest that the above conclusion is correct. At McKittrick _Cathartes_ is relatively more abundant than _Coragyps_ and among mammals _Antilocapra_ dominates over _Capromeryx_. At Rancho La Brea the reverse is true. Furthermore, in both percentage of extinct species and their relative abundance Rancho La Brea exceeds McKittrick. Therefore, it seems necessary to conclude that McKittrick is somewhat younger than Rancho La Brea, but in view of the relatively slight differences as measured by ordinary standards, the age difference does not appear to be greater than a single glacial or interglacial epoch. In this connection it seems desirable to determine, if possible, to what epoch of the Pleistocene Rancho La Brea belongs.

In his comprehensive review of the geology of the Rancho La Brea occurrence Merriam (1911, pp. 206-208) pointed out that the alluvial deposits which contain the Rancho La Brea fauna may interfinger with marine beds of Upper San Pedro age, and I have been informed by petroleum geologists that later drilling has actually proved this to be the case. It was stated, furthermore, that the fossil-bearing continental deposits had their origin from detritus carried down by streams since the last uplift of the Santa Monica Mountains. The only subsequent event has been formation of a series of stream terraces, which has caused some erosion of the fossil-bearing alluvium. Although the epoch of Pleistocene time represented by the Rancho La Brea fossil assemblage was not stated specifically, by implication it would appear to be the early part of that period, for the Upper San Pedro beds were then regarded as belonging in the Aftonian, or first interglacial epoch. Consequently, the Rancho La Brea fauna likewise appears to be Aftonian in age.

For various reasons Hay (1927, pp. 189, 199, 216) considered both Rancho La Brea and McKittrick to belong to the Aftonian. The relation of the alluvial deposits of Rancho La Brea to the Upper San Pedro marine beds was stressed by this writer to a far greater extent than by Merriam, but no incontrovertible proof of Aftonian age was offered. However, at that time it was still the opinion of many workers that the Upper San Pedro beds belonged to the first interglacial epoch.

In a discussion of the geology of the Santa Monica Mountains Hoots (1930, pp. 126-130) considered that the last uplift of the range occurred in late Pleistocene time. The evidence cited for this conclusion is mainly physiographic, however. The trend toward a later date for uplift of the California Coast Ranges is noteworthy, and has continued to gain support in subsequent years.

During recent years, a strong tendency to refer the Upper San Pedro, or Palos Verdes beds as they are now called, to the late Pleistocene has developed. It is unfortunate that evidence for these conclusions has not yet been fully published, but Woodring (1932, p. 36) has suggested that the Palos Verdes should be referred to the Sangamon, or last interglacial epoch. Since this conclusion seems likely to be substantiated, it is important to inquire if there is any aspect of the vertebrate faunas of Rancho La Brea and McKittrick which cannot be harmonized with so relatively late a date.

The writer (1937, pp.) has stated his objections to Hay's correlations in a previous article, and it is only necessary to point out that all of the forms which Hay considered to be characteristically Aftonian have been found in beds of late Pleistocene age (Romer, p. 75). Consequently, insofar as ranges of vertebrates are concerned, there seems to be no reason why the Rancho La Brea Pleistocene assemblage should be regarded as any older than the Sangamon, or last interglacial epoch. Since there is some evidence that McKittrick is younger than the Los Angeles occurrence, it would follow that this assemblage is Wisconsin in age. The fauna of Carpinteria seems more closely related to McKittrick than to Rancho La Brea, and may even range into the sub-Recent.

Consequences of the above correlations and age determinations are worthy of note. Perhaps most striking of all is the inference that if these so-called early Pleistocene assemblages are actually late Pleistocene in age, it appears that early Quaternary vertebrate faunas are as yet practically unknown in western United States. This problem was discussed in some detail in an earlier paper by the writer (1937, pp. and it was suggested that some of the so-called late Pliocene faunas may be referred more properly to the early part of the Pleistocene.

A small collection of fossil vertebrates from Astor Pass, near

Pyramid Lake, Nevada, was described by Merriam (1915) and compared with the Rancho La Brea fauna. Since, as Merriam indicated, this assemblage is very similar to that of the Los Angeles occurrence, and since the Astor Pass fauna can be correlated with one of the stages of Lake Lahontan, it is now possible to reconcile the vertebrate evidence with the opinion of Antevs (1925, pp. 76-77) and perhaps even with that of Jones (1925, p. 47) as to the relatively recent age of the lake.

A striking feature of both the McKittrick and Rancho La Brea assemblages is that they contain certain forms whose descendants now live in more southernly regions. As has been shown by Merriam and Stock (1932, pp. 180-199), the great cat, Felis atrox, may have been the ancestor of the lion and tiger of the Old World, and may have been closely related to the jaguar of North and South America. Numerous instances of a more southerly distribution at the present time of forms found fossil in the tar pits might be cited. Among these are the camel, the llama, and short-faced bear. If the above interpretation of age of the tar pit assemblages is correct, the time required for these changes may not have been very great.

The relatively late date for uplift of the California Coast Ranges necessitated by this view is in accord with nearly all recent work excepting that of Davis (1933). This investigator has sought to correlate marine terraces on the southern flanks of the Santa Monica Mountains in the vicinity of Santa Monica Bay with changes of sea-level incident to glacial and interglacial climatic changes. Such an interpretation would necessarily place uplift of the range in early or middle Pleistocene time. However, in a tectonically active region such as southern California it would be surprising if this interpretation should eventually prove correct, for in the Palos Verdes Hills a short distance to the south, a series of marine terraces occur which cannot be correlated with those of Santa Monica Bay. Consequently, it would appear reasonable to ascribe the terraces in the latter region to diastrophism, for in the Palos Verdes Hills there are too many terraces to be accounted for by changes of sea-level. That the Santa Monica terraces may be of rather late Pleistocene age is suggested by Woodring's work (1935) in the Palos Verdes Hills. This author finds that fossils from terraces west of the city of San Pedro are essentially the same forms as those inhabiting the Pacific Ocean today. A late-middle to early-late Pleistocene age is suggested for the lowest terrace.

Finally it can be said that if the above views are substantiated by future studies, a somewhat new conception of sequence of Pleistocene vertebrate faunas seems necessary. In this connection, the work of Hall (pp. 44-46) is a valuable contribution.

CLIMATIC CONDITIONS DURING THE PLEISTOCENE ACCUMULATION AT McKITTRICK AND RANCHO LA BREA

The ideal correlation of the tar pit faunas is to establish their position in the glacial-interglacial sequence established in the glaciated areas. This can scarcely be done without some knowledge of climate of the times, and any attempt to arrive at a defensible interpretation of the Pleistocene climate of an area situated in the latitude of California encounters many difficulties. It is a desire to point out some of these complications rather than a hope to reach a final conclusion that has led to a formulation of the following statement.

Perhaps the most serious obstacle is that climatologists are not yet agreed as to the influence exerted on climates of unglaciated areas by the glacial and interglacial conditions in northern latitudes. Brooks (1925, p. 30) supports the view that glacial epochs in northern latitudes are accompanied by pluvial periods in tropical and sub-tropical areas. Milankovitch (1930, p. A137), on the other hand, contends that during epochs of glaciation arid to semi-arid conditions prevailed. The present discussion does not aim to reconcile these conflicting views, or to indicate a preference. It is merely intended to demonstrate that many of the apparent discrepancies in the climatic evidence furnished by the tar pit faunas are not necessarily inconsistent with the correlations proposed in this paper.

McKittrick is at present in the rain-shadow belt which extends along the lee side of the Coast Ranges, and this must have been true ever since the mountains reached a sufficient elevation to disturb passage of moisture-laden winds coming from the Pacific Ocean. Rancho La Brea, on the other hand, is situated on the seaward slope of the Coast Ranges, and it is possible that changed meteorological conditions of the Pleistocene may have been in this instance quite effective on climate of the area. Just what this effect on the Rancho La Brea area was, is at present difficult to evaluate, but it seems reasonable to suppose that even during a glacial epoch, the climate of McKittrick was relatively dry.

Turning now to the fossil evidence, the climate of Rancho La Brea has been a subject of some disagreement among palaeontologists. L. H. Miller (1912, pp. 103-105) suggested that the climate of Rancho La Brea may have been somewhat warmer and more humid than at present. The inconclusive nature of the evidence was fully recognized by this author. Frost (1927, pp. 85-87) concluded from evidence of the plants, that the climate was somewhat cooler and with a rainfall of approximately fifteen inches. Merriam and Stock (1932, p. 26) likened conditions to those prevailing in the South African veldt at the present time, although a slightly more humid climate was considered probable. Compton (1937, pp. 88-89) who based his inferences upon evidence of shrews, concluded that the climate of Rancho La Brea was warmer and dryer than at present, and supported this view with a note by Mason concerning the plants. The latter author states that preponderance of _Juniperus_ of a type now found in the Tehachapi mountains and absent on the coast should be conclusive. From the above it appears that the tendency is to regard the Rancho La Brea assemblage as indicating an arid to semi-arid climate characterized by relatively high temperature. This inference agrees quite well with the evidence of the

Upper San Pedro marine assemblage, which is of a warm water aspect. Whether this conclusion can be cited as evidence that the Rancho La Brea fauna lived during an interglacial stage remains an open question, but there seems to be some evidence opposed to this view.

A. H. Miller (1929, p. 19) has pointed out that presence of the northwest crow, Corvus caurinus, at Rancho La Brea seemingly indicates cold conditions. Although this interpretation may eventually be modified, if it is assumed to be correct, it is still possible to reconcile this evidence with the general climatic picture, if it is assumed that at Rancho La Brea deposition extended into an epoch of glaciation. From the character of the seeps this contingency is not only possible, but even probable. The timber wolf, Canis occidentalis furlongi, may also indicate a rather cold climate, but in this instance it is probable that the wolf is more closely related to forms still inhabiting western United States than those of the plains of Canada.

As stated on a preceding page, the evidence for considering the climate of Carpinteria as relatively humid, and perhaps somewhat cooler than at present, is particularly well established. It also seems plausible to correlate the southward extension of the Monterey Pine Forest with an epoch of glaciation. Since Carpinteria is apparently of same age as McKittrick, it might be concluded that similar climatic conditions prevailed at the San Joaquin Valley locality. This, however, does not seem to be true.

As has been mentioned already, the McKittrick rodent fauna indicates a climate comparable to that of the present day. A. H. Miller and H. L. Mason have stated in conversation that this is also true for the passerine birds as well as for the plants. Abundance of anserines at McKittrick, seemingly indicates humid conditions, but as demonstrated on page 31 it seems reasonable to assume that Lake McKittrick came into existence through physiographic causes, and its disappearance is perhaps also attributable to similar causes. Consequently, it would appear that the abundance of water-fowl at this locality is somewhat misleading insofar as climatic inferences are concerned. Therefore, one may reasonably conclude that the area was then as now in the rain-shadow belt, and it is not inconsistent to correlate the humid coast forest of Carpinteria with the dry interior plant assemblage of McKittrick. Furthermore, there is no important climatic reason why both should not be referred to the Wisconsin glacial epoch.

When it is recalled that a traverse of the Coast Ranges of Oregon from the Pacific Ocean to the central part of the state shows a similar condition to exist in this area at the present time, the above conclusion does not seem improbable. It is perhaps noteworthy that today the climate of Carpinteria is somewhat more humid than that of the McKittrick area.

Several facts tend to argue against the above interpretation of the climate of the McKittrick area. First of all, the northwest crow, which might reasonably be expected in the fauna, is as I am told by A. H. Miller, definitely absent. However, this same authority believes that this crow was then as now a coast species, which never ranged into the dry interior belt of McKittrick. Absence of the timber wolf is so inconclusive that this alone does not seem sufficient evidence to overthrow the major conclusion, for its absence is compensated by presence of Preptoceras?. This form shows musk-ox affinities, and would thus tend to indicate relatively low temperatures. However, there is a strong probability that at McKittrick, as at Rancho La Brea, deposition extended into both a glacial and interglacial stage.

SYSTEMATIC DESCRIPTION

Since most of the forms found in the McKittrick asphalt have already been adequately described from other localities, only new or controversial species are treated in detail. In all cases, however, an attempt has been made to indicate the principal reasons for specific reference of the form in question.

The McKittrick occurrence is entered in the field records of the division of palaeontology, California Institute of Technology, as locality 138; while in the records of the Museum of Palaeontology, University of California, this locality is entered as number 7139. No further reference to locality numbers will be made.

For purposes of reference the California Institute of Technology is cited as C. I. T., while the University of California is shortened to U. C. Specimens listed by number alone, or preceded by the letters C. I. T., are from the collections of the California Institute. The letters M. V. Z. refer to the Museum of Vertebrate Zoology, University of California. All numbers preceded by the letters D. C. refer to specimens in the Dickey Collection of Recent Mammals, California Institute of Technology.

References to J. C. Merriam are usually cited by surname only; while allusions to C. Hart Merriam are always accompanied by initials. A similar plan is followed in references to L. H. and A. H. Miller; the surname without initials always refers to the former.

FELIDAE

In contrast to Rancho La Brea, McKittrick has relatively few representatives of the cat family. Three of the Rancho La Brea forms: *Smilodon californicus brevipes*, *Felis bituminosa*, and *Felis concolor* are not found at McKittrick, and the remainder are far less abundant relatively than at the Los Angeles locality. Reasons for this discrepancy are discussed on pages 69-71 , and it is of interest to find, as is noted on page 70 , that at McKittrick *Felis atrox* apparently outnumbers *Smilodon*.

Smilodon californicus Bovard

The skull and mandible of a mature individual, Calif. Inst. Tech. No. 650, with the teeth badly broken, associated skeletal parts and a few additional cranial elements tentatively referred to the sabre-tooth cat are the only indications of this form. As noted by Merriam and Stock (1932, p. 225), the skull almost equals in size the largest individuals from Rancho La Brea, and even exceeds the latter in certain dimensions. Among these measurements (see table 5) width of skull and thickness of ramus seem to be the most important. There appears to be little doubt, however, as to the specific identity of the Rancho La Brea and McKittrick machaerodonts.

TABLE 5- Measurements (in millimeters) of skull and mandible of Smilodon californicus

	McKittrick	Rancho La Brea	
Skull	650	200124	2001230
Length from anterior end of premaxillary to posterior end of condyles	330ap	344.1	343.9
Basal length from anterior end of premaxillary to inferior notch between condyles	314ap	324.9	329.4
Length from anterior end of premaxillary to posterior end of inion	335ap	377.9	364
Length from anterior end of premaxillary to anterior end of posterior nasal opening	170ap	174.9	172
Length of palate from anterior end of premaxillary to a line tangent to posterior surfaces of maxillary parapets	146ap	158.3	151.6
Length from posterior end of glenoid cavity to posterior end of condyles	104	109	117.8
Anterior diameter of nasals	85ap	85.9	95.1
Width of anterior nares	49	63.4ap	59
Greatest width across muzzle at canines	102	114.5	111.1
Least width between superior borders of orbits	102.5	101	100.9
Width across postorbital processes	130ap	124.8	127ap
Least width of postorbital constriction	68	63.9	65.5
Greatest width across zygomatic arches	221ap	232.4	
Anterior palatal width between superior canines	60	63	62.3
Posterior palatal width between inner roots of superior carnassials	106	106.5	108.6
Greatest transverse diameter across auditory bulla, measured from foramen lacerum posterius to external auditory meatus	56	56.9	63.3
Greatest width across mastoid process	145ap	154.3	151.7
Greatest diameter across condyles	69.7	70.4	69
Height of anterior zygomatic pedicle	66	70.2	60.7ap

TABLE 5- Continued

Mandible	650	200272	2002324
Length from anterior end of symphysis to posterior end of condyle	225	230	225.3
Length from anterior end of outer flange to posterior end of condyle	211	218.8	213.3
Length of symphysis measured along anterior border	71	72.7	73.8
Least depth of ramus below diastema	36.8	38.7	39.4
Depth of ramus below posterior end of M1	47.5	45.6	39.8
Transverse width of condyle	50	51.4	55.9
Greatest depth of condyle	19.3	18.9	17.1
Greatest width of mandible measured across symphysis and between outer walls of alveoli for lower canines	61	56.5	60.5
Greatest width of mandible measured across outer flanges	53ap	58.6	53.8

ap Indicates approximate measurement
After Merriam and Stock (1932)

Felis atrox Leidy

The great lion-like cat is represented in the California Institute collections by two fairly complete skulls and mandibles, in addition to various other skeletal elements. Both skulls represent mature individuals, for the sutures are closed and the teeth rather worn. No. 648 lacks only the incisors and M1, while No. 649 is practically complete. The former is remarkable for its large size, for it approaches the larger individuals from Rancho La Brea in nearly all measurements, and equals even the largest in width across the zygomatic arches. No. 649 is much smaller than No. 648, and is below the average of the Rancho La Brea forms in size. However, it compares closely in measurements with No. 2900-18 from that locality, as is shown by table 6 . It seems probable that the size difference between the two McKittrick individuals represents a variation due to sex, in which case the larger form would appear to represent a male. Similar size differences between the sexes has been noted by Merriam and Stock (1932, p. 166) in specimens from Rancho La Brea. In this connection it is interesting to note that overhang of the inion is more marked in the smaller form, a difference which may also be sexual in nature.

Other skeletal elements comprise numerous vertebra, a right humerus, three tibia, two radii, a fibula, an ulna, a large right femur, as well as various carpal and tarsal elements.

TABLE 6- Measurements (in millimeters) of skull and mandible of Felis atrox

	McKittrick		Rancho La Brea		
Skull	648	649	29003	29009	290016
Length from anterior end of premaxillary to posterior end of condyles	380ap	324	410	380.8	328
Basal length from anterior end of premaxillary to inferior notch between condyles	352ap	306	388	359.4	306.8
Length from anterior end of premaxillary to posterior end of inion	410ap	354	458	429.5	368.9
Length from anterior end of premaxillary to anterior end of posterior nasal opening	202ap	167	212	194.4	156.9
Length of palate from anterior end of premaxillary to line tangent to posterior surfaces of maxillary parapets	132ap	130ap	134.4	148	138.2
Length from posterior end of glenoid cavity to posterior end of condyles	105	86	112.5	108.5	87.8
Anteroposterior diameter of nasals		54ap		101.6	92.4
Width of anterior nares	69	60	73	67	53.7

TABLE 6- Continued

Mandible	648	649	29013	290115	290125
Greatest width across muzzle at canines	122	104.5	141.5	122.8	104.3
Least width between superior borders of orbits	94.5	80		98.3	74.6
Width across postorbital processes	109ap	109ap		132ap	101.4
Least width of postorbital constriction	83	72		85	71
Greatest width across zygomatic arches	296		294	296.5	
Anterior palatal width between superior canines	64.5	53.8	71.4	66.2	55.5
Posterior palatal width between inner roots of superior carnassials	100	82	107.8	97.6	81.4
Width across palate between posterior alveoli of superior carnassials	134	113	147.8	140.8	113.3ap
Greatest transverse diameter across auditory bullae, measured from foramen lacerum posterius to external auditory meatus	31	25	29.6	29.2	21.1
Greatest width across mastoid processes	165	136	173.6		132.2
Greatest diameter across condyles	68	68.3	76.8	74.1	62.4
Height of anterior zygomatic pedicle	82	70	78.8	84.4	65.2
Length of anterior zygomatic pedicle	52	39	52.5	44.7	43.2
Length from anterior end of symphysis to posterior end of condyle immediately behind coronoid process		238	309.5	276.8	237.8
Length of symphysis measured along anterior border		74ap	94	79.5	76
Depth of ramus below anterior end of P4	58.5	49	60.7	55.6	49.3
Depth of ramus below posterior end of M1	58	53	63.4	57.4	50.4
Thickness of ramus below posterior end of M1	28	24	29.2	27.3	23.8
Height from inferior border of angle to summit of condyle		47	66.4	52.2	44
Height from inferior border of angle to summit of coronoid process	140ap	110	150	132.6	111.8
Transverse width of condyle		54.8	74.9	70.2	58.3
Greatest depth of condyle		18	26.7	25.7	20.8

ap Indicates approximate measurement
After Merriam and Stock (1932)

TABLE 7- Measurements (in millimeters) of dentition of Felis atrox

Superior Dentition	McKittrick		Rancho La Brea		
	648	649	29003	29009	290016
Length from anterior end of canine alveolus to posterior end of P4	129	117.3	139.4	120.4	111.7
Length from anterior end of alveolus for P2 to posterior end of alveolus for P4		79	91.6	77.7	77.5
I1, greatest transverse diameter		7	6.3	5.9	5.7
I2, greatest transverse diameter		8.6			
I3, greatest transverse diameter		13	12.8	11	9.4
C, anteroposterior diameter at base of enamel	32	31	36.8	29.3	25.2
C, transverse diameter	22	24	25.7ap	20.4	18
P2, anteroposterior diameter of alveolus		8	11.4	10.2	7.6
P3, anteroposterior diameter	25.5	26	30.4	26.2	25.9
P3, greatest transverse diameter	12.6	13	16.2	14.4	12.3
P4, anteroposterior diameter	40	38	45	39.5	38.3
P4, greatest transverse diameter across protocone	18	19.5	19ap	20.9	19.3
P4, anteroposterior diameter of base of paracone	15	14	17	14.7	14
P4, anteroposterior diameter of parastyle	6.7	6	8.1	7.7	7.4
P4, length of metacone blade	14.3	14	17	14.7	14
M1, anteroposterior diameter		5.6			
M1, transverse diameter		11			

Inferior Dentition	648	649	29013	290115	290116
Length from anterior end of C to posterior end of M1	151	130	156.7	142.7	127.4
I1, greatest transverse diameter		6		4.3	4
I2, greatest transverse diameter		7.3		5.9	5.4

TABLE 7- Continued

Inferior Dentition	648	649	29013	290115	290116
I$\overline{3}$, greatest transverse diameter		8		8	6.7
C, anteroposterior diameter at base of enamel	28	30	30.4	27.3	25.8
C, transverse diameter	20	23	21.6	19.3	16.4
P$\overline{3}$, anteroposterior diameter	18	18.2	21	20.2	18.2
P$\overline{3}$, greatest transverse diameter	10.5	10.5	13.2	12.5	9.4
P$\overline{4}$, anteroposterior diameter	28	28	32.3	30.5	26.4
P$\overline{4}$, greatest transverse diameter	14	14.5	16.8	14.4	12.6
P$\overline{4}$, basal length of principal cusp	13.3	12.5	14.5	13.6	12.4
M$\overline{1}$, anteroposterior diameter	32	29	33.7	30	28.3
M$\overline{1}$, greatest transverse diameter	15	15	17.5	15.5	13
M$\overline{1}$, length of protoconid blade	13.5	13	16	16	14.8

ap Indicates approximate measurement
After Merriam and Stock (1932)

Felis daggetti Merriam

An incomplete and somewhat distorted skull in the collections of the University of California, No. 29524, is the only representative of this species. As indicated by Merriam and Stock (1932, pp. 225-226), the dentition is exceptionally heavy, nearly all tooth dimensions being in excess of those of the type of *Felis bituminosa*. In P3 the postero-external corner of the crown is prominently developed. Merriam and Stock conclude that No. 29524 may represent a large male individual of the *Felis bituminosa* group or it may be more nearly related to *Felis daggetti*.

The specimen was provisionally referred to the latter species. The measurements given in table 8 have been copied from the memoir cited above.

TABLE 8- Measurements (in millimeters) of Felis daggetti and F. bituminosa

Superior Dentition	McKittrick F. daggetti U.C. 29524	Rancho La Brea F. bituminosa Type X8629
Length from anterior end of canine alveolus to posterior end of P4	68	63.5
Length from anterior end of alveolus for P2 to posterior end of alveolus for P4	49.2	45
I1, greatest transverse diameter	3.5	
I2, greatest transverse diameter	4.2	
I3, greatest transverse diameter	6.3	
Transverse width of entire upper incisor series	29ap	
C, anteroposterior diameter at base of enamel	15	
C, transverse diameter	12.2	
P2, anteroposterior diameter	6.4	
P3, anteroposterior diameter	17.4	16.4
P3, greatest transverse diameter	9.8	9.7
P4, anteroposterior diameter	26.4	24.4
P4, anteroposterior diameter at base of paracone	10.4	10.1
P4, greatest transverse diameter across protocone	12.6	11.8
P4, anteroposterior diameter of parastyle	4.6	
M1, anteroposterior diameter		

ap Indicates approximate measurement
Measurements after Merriam and Stock (1932)

Lynx rufa cf. fischeri Merriam

Part of a right mandibular ramus in the collections of the California Institute of Technology, No. 2040, which lacks the anterior lower premolar is referred to this subspecies. The condyle is also lacking. Consequently, the most important characters which distinguish Lynx rufa fischeri from Lynx canadensis have been lost. The specimen is referred to the former variety largely because of close agreement in nearly all measurements between it and the type. In this connection see table 9 below.

TABLE 9- Measurements (in millimeters) of Lynx rufa cf. fischeri

Mandible	McKittrick 2040	Type* U.C. 11287
Length from posterior side of canine alveolus to posterior side of M1	36	33.9
P4, anteroposterior diameter	8.9	
M1, anteroposterior diameter	11.5	11.2
Height of mandible below protoconid of M1	15.9	12.2
Thickness of mandible below protoconid of M1	6.8	7.5

* Rancho La Brea collection measurements after Merriam and Stock (1932)

A left mandibular ramus, in the collections of the University of California, approximates the type even more closely in nearly all measurements than the California Institute material.

U.C. No. 33113 consisting of an immature mandible with milk-teeth corresponds very closely with two immature specimens of the Recent Lynx rufa californicus in the collections of the Museum of Vertebrate Zoology, University of California. It is possible that the McKittrick lynx represents the living rather than the extinct variety, but it seems improbable that any difference may exist in milk-dentitions of _Lynx rufa fischeri_ and _Lynx rufa californicus_.

CANIDAE

Since Merriam's early work on the Canidae of Rancho La Brea considerable information regarding modern forms of the California area has accumulated. In addition, the dogs of Rancho La Brea have been the occasion of comment by various authors, and already a confusing amount of synonymy has resulted. In order to clarify the issue, it is necessary to review the status of the Rancho La Brea forms.

Notes on the Status of the Genus Aenocyon:- This genus was founded by Merriam, who listed the following characters:-

"The generic characters of _Aenocyon_ are found in the massiveness of skull and dentition, extreme overhang of the inion, shortness of the basicranial region posterior to the glenoid fossae, massiveness of the upper and lower carnassials, reduction of the hypocone of M1, and probably in characters of the skeleton not as yet available from other material than that obtained at Rancho La Brea."

To this genus Merriam referred the following species:- _Aenocyon dirus_ (Leidy), _A. ayersi_ (Sellards), and _A. milleri_ (Merriam).

Although his objections to _Aenocyon_ as a genus do not appear to have ever been stated definitely, W. D. Matthew continued to refer these forms to Canis. The McKittrick material offers little evidence of value as to the status of the genus. However, the occurrence of both Aenocyon dirus and Aenocyon milleri at the San Joaquin Valley locality rather tends to confirm the existence of two distinct species of dire wolves in the Pleistocene of western North America. Since one of the principal reasons for Merriam's reluctance to establish a new genus for A. dirus was the apparent lack of specific differentiation in the group, this objection does not appear valid. From the writer's point of view, although Aenocyon may not be of equivalent rank with other canid genera and may eventually be reduced to a subgenus, it furnishes a convenient grouping for the large Pleistocene wolves.

Notes on the Status of Canis occidentalis furlongi:- Merriam (1912, p. 251) separated this form from the living Canis occidentalis on the basis of relatively narrower muzzle, heavier superior carnassial, and relatively narrower anteroposterior diameter of M2 seen in the Rancho La Brea form.

Hay (1927, p. 184) expressed a desire to elevate this form to specific rank. To quote from Hay:

"The dog designated as Canis occidentalis furlongi by Dr. John C. Merriam appears to the present writer as better given specific rank. The name C. occidentalis has been restricted by Gerrit S. Miller (Smiths. Misc. Coll., vol. 59, 1912, No. 15, p. 4) to the wolf inhabiting the plains of Canada from Saskatchewan to the Arctic coast. It is improbable that it or a subspecies of it was present at La Brea during the warm early Pleistocene. I find no other large Canis which has, so far as we know, inhabited that region. I see no good reason why C. furlongi should not for the present be regarded as a distinct species."

Although the McKittrick fauna does not bear directly upon this question, in light of present knowledge Hay's arguments do not appear very convincing. In view of the amount of individual variation known to occur in Recent species, it would appear that Merriam showed correct judgement in regarding the Rancho La Brea form as only a distinct subspecies. The question here involved, relates particularly to whether or not Canis occidentalis furlongi is at all distinct from the living form. For the present it seems desirable to regard the Rancho La Brea wolf as a distinct subspecies.

Notes on the Status of Canis ochropus orcutti:- This form was originally described as Canis orcutti (Merriam, 1910, p. 391). At a later date Merriam (1912, pp. 255-258) changed the designation to Canis ochropus orcutti. The subspecific characters were listed as follows:-

"The skulls of C. o. orcutti average somewhat larger than in the living C. ochropus, and are noticeably broader across the palate and zygomatic arches. The mandible is considerably higher, particularly below the molars, and is also thicker transversely than in the living form in this region........."

In 1927 Hay (p. 184) listed this form under the original title of Canis orcutti. No comment was given. In view of the above statements concerning the status of Canis occidentalis furlongi it would appear that this revision is likewise unwarranted.

Grinnell (1933, pp. 112-114) now recognizes only four races of the genus Canis in the California area. Canis ochropus Eschscholtz is now a synonym of Canis latrans ochropus, the coyote inhabiting most of the state west of the Sierra Nevada. Intergradation with other races is very common, as is variation of subspecific characters. Grinnell states that variation is especially marked in characters of skull and teeth.

Until the extent of individual and secondary sex variation among Recent coyotes is determined by mammalogists it appears almost futile to attempt to establish the status of Canis ochropus orcutti (=C. latrans orcutti). After a somewhat cursory examination of approximately two hundred skulls of Canis latrans ochropus in the Museum of Vertebrate Zoology, University of California, the writer was unable to recognize definitely any constant secondary sex variation in either skull or tooth characters. Variation in size and pattern of the teeth, however, is extremely common, and of so marked a nature that on these characters alone a palaeontologist might establish several distinct species. There appears to be little doubt, however, that the Rancho La Brea coyotes are correctly referred to the species C. latrans, although subspecific reference is still a matter of doubt. With the exception of very old male individuals, few modern specimens of Canis latrans ochropus equal the Rancho La Brea form in width of muzzle and massiveness of the lower jaw. In addition, the dentition of the latter is also somewhat heavier than that of the modern form. Consequently, pending a fuller report on the coyotes, it seems advisable to retain Canis latrans orcutti as a distinct subspecies.

In both the Rancho La Brea and McKittrick collections are coyotes which cannot be distinguished from Recent C. latrans ochropus on the basis of available material and this fact was fully appreciated by Merriam (1912, p. 258), in his study of the Rancho La Brea specimens.

He therefore concluded that the designation Canis latrans orcutti suited the entire series better than recognition of the presence of two subspecies at Rancho La Brea. Although the period of fossil accumulation at both Rancho La Brea and McKittrick may have been long enough to permit evolution of one subspecies into another, this interpretation does not seem so plausible as does the inference that during late Pleistocene time the range of individual variation within a subspecies was somewhat greater than now. Since there is at present no data of value for choosing between these alternatives, it seems to the writer less confusing to future workers to proceed on the basis of the second hypothesis, and to refer all of the McKittrick coyote material to the subspecies Canis latrans orcutti. In order to place the evidence before the reader, the McKittrick coyotes are described in some detail, in the hope that future studies may lead to a satisfactory clarification of this group.

Canis latrans orcutti Merriam

Of the twenty-three nearly complete skulls in the collections of the California Institute of Technology five, Nos. 2041-2045, are characterized by somewhat more massive dentition, larger size, and broader muzzle than is the case for average skulls of the existing Canis latrans ochropus. The remaining eighteen, Nos. 2046-2063, fall within range of variation of the living species.

Three mandibular rami, Nos. 2064-2066, are characterized by massive dentition, noticeable thickness below $\overline{M1}$, and prominent convexity in the region of the first lower molar. These features agree closely with those of the Rancho La Brea form. On the other hand, eight mandibular rami show, Nos. 2067-2074, no characters wherein they can be distinguished from the living form.

Except for character of size, the lower teeth seem to show relatively little individual or subspecific variation. The upper teeth, however, exhibit such a striking variation of characters that were it not true that a similar range can be seen in a large series of the modern species, several distinct species or subspecies might be founded upon the McKittrick material.

One mature skull, No. 2046, in the McKittrick collection is characterized by a massive dentition and a peculiar M1. In this specimen the first molar shows an extraordinarily large hypocone, which continues without interruption around the antero-internal margin of the tooth where it is connected with the cingulum. Thus, a tooth pattern is developed which is more characteristic of *Canis occidentalis furlongi* than of *Canis latrans*. This specimen was at first thought to represent a distinct species until it was discovered that it corresponds in all respects, except that of size, to a mature male specimen of *C. l. ochropus*, M. V. Z. No. 12687, from West Riverside, California.

Individuals from Rancho La Brea comparable to the above are L. A. Mus. specimens Nos. 3200-46 and 3200-5.

In all remaining specimens there is, as is shown by tables 10-11, considerable variation in size. The most striking variation, however, is seen in the pattern of M1. This is most marked in shape of the internal lobe, and in size and shape of the hypocone. It is worthy of note that in both the *orcutti* and *ochropus*-like individuals approximately the same degree of divergence from the normal is exhibited. In a majority of cases the internal lobe is relatively narrow anteroposteriorly, while the hypocone is quite small, and does not extend forward to the anterior margin of the tooth. Although size and shape of the remaining tooth cusps also show minor variations, divergences of these cusps from the normal are insignificant compared with variation seen in the hypocone. It is true that there are in the McKittrick collection scarcely any intermediate forms between those having the type of M_1 shown by No. 2046 and those possessing a first molar of normal character. However, the collection is small as compared with the two hundred odd skulls in the Museum of Vertebrate Zoology, and this apparent absence of intermediate types does not seem a valid criterion for subspecific or specific differentiation.

With regard to skull characters, the most marked variation other than size and width of muzzle is seen in the occipital region. In some specimens, as for example No. 2049, a well-marked inion is present; while in others, No. 2046 for example, a noticeable overhang of the occipital crest is not shown. The outlines of the zygomatic arches are also subject to considerable variation, and the angle subtended by a line connecting the postorbital processes of the frontals and the superior border of the jugal varies within an arc of from ten to fifteen degrees.

Also referred to *Canis latrans orcutti*, at least tentatively, are two very small although mature mandibular rami, Nos. 2075, 2076. In shortness of tooth-row these elements closely approximate *Canis andersoni*, but the roughened condition of the bone seems to indicate that the specimens are abnormal.

TABLE 10- Measurements (in millimeters) of skull, mandible, and dentition of *Canis latrans orcutti*

Skull	McKittrick 2041	McKittrick 2042	McKittrick 2043	Rancho La Brea U.C. No. 10842 (small sp.)
Length from anterior end of premaxillary to posterior end of condyles	194ap	186ap	198	188.5
Length from posterior side of C to posterior side of M2	78	78.5	82.6	80.5
Length from anterior side of P4 to posterior side of M2	40ap	41	40.8	37.3
Least width of muzzle between C and P4	36.8	35	36.8	
Width across zygomatic arches	112ap			108
Width between outer sides of tritocones of P4	67	69	65	65
Least width between superior borders of orbits	36ap	38.5	39.2	38
Width between postorbital processes of frontals	48ap	52ap	53.2	55
P3, anteroposterior diameter	13.1	14	14	13.3
P4, anteroposterior diameter	22.1	22.8	24ap	21.2
P4, thickness across protocone	8.5	8	8.8ap	8.5
M1, anteroposterior diameter	13	13.8	13.3	13.3
M1, greatest transverse diameter	17.2	17.8	18.2	16
M2, anteroposterior diameter	7.7	7.5	6.2	7.3
M2, greatest transverse diameter	12	12.7	12	10.5
Mandible	2064	1683	1682	11278
Length, anterior end of ramus to middle of posterior side of condyles	150ap	159ap	143ap	145.5
Height of mandible below posterior side of P2	18	19	19.2	17
Height of mandible below posterior side of M1	25	23.9	22.8	22.5
Thickness of mandible below protoconid of M1	11	10.8	11.7	11.8
Length from posterior side of C to posterior side of M2	88	90	82	85

TABLE 10- Continued

Mandible	2064	1683	1682	11278
$P\overline{3}$, anteroposterior diameter	12.5		12	11.7
$P\overline{3}$, greatest transverse diameter	5.2		4.8	4.8
$M\overline{1}$, anteroposterior diameter	24.2	23	23.5	22.9
$M\overline{1}$, greatest transverse diameter of trigonid	9		9	9.5
$M\overline{2}$, anteroposterior diameter	10	10	10	9.8

ap Indicates approximate measurement

TABLE 11- Measurements (in millimeters) of skull, mandible, and dentition of Canis latrans orcutti (Canis latrans ochropus-like type)

	McKittrick				Recent	
Skull	2047	2048	2049	2050	651[a]	0-20[b]
Length from anterior end of premaxillary to posterior end of condyles	188	185	186	192ap	192	181
Length from posterior side of $\underline{C}$ to posterior side of $M\underline{2}$	78	75.5	74	82	80	72
Length from anterior side of $P\underline{4}$ to posterior side of $M\underline{2}$	38		39	39	38.7	35.2
Least width of muzzle between $\underline{C}$ and $P\underline{4}$	29	30	32.6	32.2		28.5
Width across zygomatic arches	102		98ap		104	91
Width between outer sides of tritocones of $P\underline{4}$	59.5	61	59.2	63	57	55
Least width between superior borders of orbits	33.8	38.5	39.5	38	35.4	32
Width between postorbital processes of frontals	54ap	54ap	55	54.7	53.5	45
$P\underline{3}$, anteroposterior diameter	11.2	13	12.5	13.2	13.2	
$P\underline{4}$, anteroposterior diameter	20.2	22	21.8	22	20.8	
$P\underline{4}$, thickness across protocone	7.5	8	8	8.2	7.5	

TABLE 11- Continued

	2047	2048	2049	2050	651[a]	0-20[b]
$\underline{M1}$, anteroposterior diameter	13	13	13	13	12.8	
$\underline{M1}$, greatest transverse diameter	16	16.8	17	17.8	16	
$\underline{M2}$, anteroposterior diameter	8		7	7	8	
$\underline{M2}$, greatest transverse diameter	11.5		10.9	12	11.3	

Mandible	2068	2069	2067	651[a]	
Length, anterior end of ramus to middle of posterior margin of condyles	143	146ap	153ap	149	
Height of mandible below posterior side of $\overline{P2}$	17.2	18.2	18	16.3	
Height of mandible below posterior side of $\overline{M1}$	24	22	24	19.4	
Thickness of mandible below protoconid of $\overline{M1}$	10	9.2	11.4	10	
Length from posterior side of $\overline{C}$ to posterior side of $\overline{M2}$	82	82	84	85	
$\overline{P3}$, anteroposterior diameter		11	12	11.5	
$\overline{P3}$, greatest transverse diameter		5	4.8	4.5	
$\overline{M1}$, anteroposterior diameter	23	22.5	23.3	22.2	
$\overline{M1}$, greatest transverse diameter of trigonid	9	8.8	9	8.1	
$\overline{M2}$, anteroposterior diameter	11	10	10	9.8	

ap Indicates approximate measurement.
a Large specimen of Canis l. ochropus, M. V. Z., Univ. Calif.
b Small specimen Canis l. ochropus, Calif. Inst. Tech.

Aenocyon dirus (Leidy)

The common species of Pleistocene dire or grim wolf is represented in the collections of the California Institute of Technology by four nearly complete skulls, Nos. 2077-2080, numerous mandibular elements, and by various skeletal parts. The structural characters of *A. dirus* are well known, due particularly to the work of J. C. Merriam, so that it is not deemed necessary to make extended descriptions. As is shown by tables 12-13, some individuals equal the larger specimens from Rancho La Brea in nearly all skull measurements, and may actually exceed them in size of the crushing teeth. In all details the McKittrick specimens agree very closely with those from Rancho La Brea.

TABLE 12 - Measurements (in millimeters) of skull and mandible of *Aenocyon dirus*

	McKittrick*			Rancho La Brea**	
Skull	2077	2078	2079	10856	10834
Length from anterior end of premaxillary to posterior end of occipital condyles	282	272	260	282	267
Length from anterior end of premaxillary to anterior end of posterior nasal opening	151	146	141	155	141
Width across rostrum measured tween outer sides of bases of canines	57	59	58	67.3	58.5
Width measured between outer sides of superior sectorials	98	94	99	107.5	96.2
Width across zygomatic arches	169	166.5	164	175ap	164.5
Least diameter between superior borders of orbits	60	57.3	63	64.9	54.1
Width between postorbital processes of frontals	78	79	90ap	93.9	77
Length from a line drawn between posterior borders of glenoid fossae to posterior end of occipital condyles	60	58	55	54	57

TABLE 12 - Continued

Mandible	2077	2078	2079	10856	10834
Length from anterior end of left ramus to middle of condyle	224	217		230ap	210.5
Height measured between summit of coronoid process and inferior side of angle	90ap			91.3	87
Height of ramus below hypoconid of M1	38	37ap	38.5	39.7	35.3
Height of ramus below protoconid of P3	36	32.5	35	36.9	32.5
Thickness of ramus below protoconid of M1	17.5	18ap	19	20.3	19.3

ap Indicates approximate measurement
* Selected from a series of 7 individuals
** After Merriam (1912)

TABLE 13- Measurements (in millimeters) of dentition of Aenocyon dirus

	McKittrick*			Rancho La Brea**	
Upper Dentition	2077	2078	2079	10856	10834
I3, greatest anteroposterior diameter	11.5		10		
C, greatest anteroposterior diameter at upper edge of enamel	14	15.5	14.6	17	
P1, greatest anteroposterior diameter				10.2	9.4
P2, greatest anteroposterior diameter	15.9	16		16	16.2
P3, greatest anteroposterior diameter	18		17.1	19	18.1
P3, greatest transverse diameter	7.2		7.5		7.9
P4, greatest anteroposterior diameter	32	31	31	32	30.7
P4, greatest transverse diameter across deuterocone	15.5	16	14	16.2	15
P4, greatest transverse diameter across protocone	12.5	12.4	12	13	13
M1, greatest anteroposterior diameter	18.5	19.8	18.6	20	18.7
M1, greatest transverse diameter	24.2	24.8	23	24	23
M1, transverse diameter of protocone	12.6	12.1	12.1	13.6	
M2, greatest anteroposterior diameter	10		7.8	10	9.2
M2, greatest transverse diameter	15.2		13	15.4	14.4

TABLE 13- Continued

Lower Dentition	2077	2078	2079	10856	10834
$\overline{C}$, greatest anteroposterior diameter at lower edge of enamel	15	15.2	20	17.5	
$\overline{P1}$, greatest anteroposterior diameter				7.7	7.4
$\overline{P2}$, greatest anteroposterior diameter	16.5	14.5	16.2	15.4	15.3
$\overline{P3}$, greatest anteroposterior diameter	17.5		17.2	16.7	15.8
$\overline{P4}$, greatest anteroposterior diameter	20.1	19.2	21	20	19.5
$\overline{M1}$, greatest anteroposterior diameter	37	37.3	35.2	35.7	34.5
$\overline{M1}$, greatest transverse diameter of heel	13	13	13	13.5	13
$\overline{M1}$, greatest anteroposterior diameter of heel on outer side	9	8.5	9	9.2	8.8
$\overline{M1}$, greatest transverse diameter of trigonid	14.2	13.5	14.2	14.3	13.6
$\overline{M2}$, greatest anteroposterior diameter	14.2		13	12.8	13.3
$\overline{M2}$, greatest transverse diameter	10.5		10	10	9.3
$\overline{M3}$, greatest anteroposterior diameter			7	6.5	7.3

* Selected from a series of 8 individuals
** After Merriam (1912)

Aenocyon near milleri (Merriam)

This species was based largely on skull characters. The only diagnostic features of the teeth are that in $\underline{M1}$ the hypocone is unusually large and extends around the antero-internal region of the protocone, where it is connected with the cingulum (Merriam, 1912, p. 247). In *Aenocyon dirus* this tooth is somewhat larger than in *milleri*. In addition the hypocone is greatly reduced and does not extend so far anteriorly. *Canis occidentalis furlongi* resembles *Aenocyon milleri* insofar as the general characters of this tooth are concerned (Merriam, 1912, pp. 251-254), but differs in the somewhat smaller size, and, if Merriam's figures are reliable, in shape of the para- and metacones as well. In Canis o. furlongi these cusps are quite round, while in A. milleri they appear to be divided into four sub-equal quadrants by two almost mutually perpendicular cross ridges. The metaconule also appears to be less well developed in Aenocyon milleri.

In the collections of the California Institute of Technology are a right and a left M1, Nos. 2082, 2083, which according to the above analysis appear to belong to Aenocyon milleri rather than to A. dirus or to the timber wolf. Since A. milleri is rare also at Rancho La Brea, its very scanty representation at McKittrick is not surprising. For measurements of these teeth see table 14.

TABLE 14 - Measurements (in millimeters) of dentition of Aenocyon milleri

	McKittrick	Rancho La Brea		
Upper Dentition	2082	U.C. 11257a	U.C. 11283b	U.C.19792c
M1, greatest anteroposterior diameter	17.5	16.4	16	17.2
M1, greatest transverse diameter	22	20.7	19.3	21.5
M1, transverse diameter of protocone	12	12.7		

a Type of Aenocyon milleri
b Canis occidentalis furlongi
c Canis occidentalis furlongi
Measurements a-c after Merriam (1912)

Vulpes macrotis cf. mutica C. H. Merriam

This species of fox is represented in the collections of the California Institute of Technology by an incomplete skull, No. 2084, a fragment of right maxillary, No. 2085, in addition to several mandibular rami.

The skull is somewhat crushed, and lacks the zygomatic arches and a large part of the premaxillaries and occipital condyles. The only teeth present are P4 and the molars on the right side. There is no trace of a lyrate temporal crest. This character in conjunction with lack of a pronounced inflection on the postero-inferior border of the horizontal rami definitely excludes the form from the genus Urocyon. Other characters of the skull are:- (1) muzzle long and slender, (2) bullae deep with very large external auditory meatus, (3) brain case sharply bulged above external auditory meatus, (4) palate very narrow, (5) post-orbital process sharply pointed, recurved, and with but little concavity above, (6) anterior palatal foramina do not extend to rear of canines, and (7) basocranial region between bullae relatively narrow. These characters, especially the first and fifth, seem to exclude the McKittrick form from the gray foxes. On the other hand the first, second, and fourth characters seem to place No. 2084 quite definitely in the group of Vulpes macrotis, or kit foxes.

As is shown by table 15, the specimen is considerably larger than the subspecies, Vulpes macrotis arsipus. While specimens are not available, C. Hart Merriam (1902, p. 74) states that Vulpes macrotis mutica is large in size and it seems reasonable to refer the McKittrick form to this race, which still inhabits the San Joaquin Valley.

TABLE 15- Measurements (in millimeters) of *Vulpes macrotis* cf. *mutica*

	McKittrick		Recent*
Skull	2080		HX 27
Length from occipital crest to posterior end of canine	100ap		96
Width across postorbital processes of frontals	29.7		25.5
Greatest width of parietals	42ap		42.8
Mandible	2129	2128	
Length from condyles to back of lower canine	76.5		73
Depth below $\overline{M1}$	10.8	10.2	8
Thickness below $\overline{M1}$	4.5	4.9	4.3
Upper Dentition	2084	2085	
$\underline{P4}$, greatest anteroposterior diameter	11.2		10.8
$\underline{M1}$, greatest anteroposterior diameter	7	6.4	6.2
$\underline{M1}$, greatest transverse diameter	10	9.7	9.4
$\underline{M2}$, greatest anteroposterior diameter	4.5	3.7	3.5
$\underline{M2}$, greatest transverse diameter	7.4	6.2	6.2
Lower Dentition		2128	
$\overline{M1}$, greatest anteroposterior diameter		11.5	11
$\overline{M2}$, greatest anteroposterior diameter		5.1	5

ap Indicates approximate measurement
* A female specimen of *Vulpes macrotis arsipus* from Riverside County, California, in the Dickey collection.

MUSTELIDAE

The McKittrick mustelids have been studied by E. Raymond Hall of the Museum of Vertebrate Zoology. All the types found in the asphalt belong to living species and subspecies although Mustela frenata nigriauris no longer inhabits the area. For convenience, Hall's remarks concerning the McKittrick mustelids are given below.

The same author has revised the Rancho La Brea and Carpinteria mustelids (1936, pp. 41-119), and his lists are followed in this paper. Hall's studies of the California tar pit mustelid faunas is of interest in that it emphasizes their essential similarity and relatively Recent age.

Mustela frenata nigriauris Hall

Hall (p. 113) offers the following remarks regarding the McKittrick weasel:-

The collection of vertebrate fossils at the California Institute of Technology contains a nearly complete skull and lower jaw possibly of the same individual, from one of the excavations made in the asphalt deposits at McKittrick. The subspecies of Mustela frenata found in the region of McKittrick today is Mustela frenata pulchra. Its skull differs from that of the two coastal subspecies, M. f. nigriauris and M. f. latirostra in a way which permits satisfactory subspecific identification of the skulls alone.

The skull from McKittrick, allowing for differences due to its lesser age, is a duplicate of the skull of a Recent adult male, No. 46723, Mus. Vert. Zool., of the coastal subspecies, from five miles southeast of

Santa Margarita, San Luis Obispo County. This Recent skull, others from places in the coastal district to the southeast of McKittrick, and the fossil one from McKittrick, are intermediate in structural features between *M. f. latirostra* to the south and *M. f. nigriauris* to the north, though decidedly nearer the latter.

The skull from McKittrick, then, is of the subspecies *nigriauris* which does not occur in that region today but instead farther to the westward in the more humid coastal area.

Mephitis mephitis holzneri Mearns

In regard to the striped skunk Hall states:-

On October 20, 1932, I found, among material being prepared for study at the California Museum of Palaeontology, and not at the time given catalogue numbers, the lower jaw bearing $\overline{M1}$ and $\overline{P4}$ of a young *Mephitis mephitis* taken from the asphalt deposits at McKittrick. The specimen is not identifiable as to subspecies and is here referred to *holzneri* on geographic grounds.

Spilogale phenax phenax C. H. Merriam

Hall comments on the spotted skunk as follows:-

Two lower jaws of the right side and one of the left, in the collection of vertebrate fossils at the California Institute of Technology from locality 138, an excavation in the asphalt deposits at McKittrick are to me indistinguishable from *S. p. phenax*, the Recent form found also in that region.

Taxidea taxus cf. neglecta Mearns

The following remarks concerning the McKittrick badger are made by Hall:-

The writer has examined specimens from the McKittrick asphalt deposits, which are at present being prepared for study and are not yet provided with catalogue numbers. This material, in the University of California Museum of Palaeontology, comprises three skulls, six lower jaws and the larger part of the body skeleton of one individual. In the collection of vertebrate fossils at the California Institute of Technology there are available parts of three skulls and four lower jaws. Comparisons fail to reveal any structural features distinguishing the fossil specimens from ones of the Recent animal found in Kern County.

URSIDAE

This family is represented in the McKittrick fauna by a species of Tremarctotherium, and by a form closely related to the existing black bear. These species are not particularly abundant either at Rancho La Brea or at McKittrick. In its massive size and very heavy molar dentition, the black bear appears to be distinct from any species previously described, and has been designated Ursus optimus.[1]

In view of the present state of the literature, no one can venture to describe a new species of ursid without misgivings, for from the palaeontological point of view many characters used in separating living forms are of little value. In dealing with fossil types, it appears expedient to accept the distinctions between grizzly and other

[1] Dr. Stock has suggested that judging from its distinctive characters, this form may have lived under very nearly ideal, or optimum conditions, hence the specific name.

forms as constant, although these are known to vary in existing species (C. H. Merriam, 1918, p. 13). Moreover, criteria for determining the living forms have not been critically examined except for the recent work of Stovall and Johnston (1935, pp. 212-213) who find many of them to be unreliable. Relative proportions of skulls and teeth furnish perhaps a sound distinction, and a series of thirteen skulls representing three subspecies of existing black bears has been studied, in order to determine what the expectable range of variation within a species may be. The results indicate that the McKittrick form, although closely related to existing California black bears, is a species now extinct.

The short-faced bears of Rancho La Brea and McKittrick were referred to the genus _Arctotherium_ by Merriam and Stock (1925, pp. 7-9). Kraglievich (1926, pp. 14-16) has since demonstrated that the North American species: _yukonense_, _simum_, and _californicum_ are generically distinct from _Arctotherium latidens_, a South American form which is the genotype. For the North American species this author proposed the new genus _Tremarctotherium_. Matthew (1929, p. 474) arrived independently at the conclusion that _T. simum_ is generically distinct from _A. bonaerense_, and after seeing Kraglievich's article tentatively concurred that the former is separable as _Tremarctotherium_.

T. californicum as defined by Merriam (1911A, p. 165) differs from _T. simum_ principally in its larger size. At a later time Merriam and Stock (1925, p. 9) concluded that the two are at least subspecifically distinct, and until the time relation of Potter Creek Cave to Rancho La Brea is known definitely, the arctotheres from these localities might be regarded as distinct species.

While it is true that most of the McKittrick arctothere material agrees closely in size with T. simum from Potter Creek Cave, there is in the collections of the University of California a left $\overline{M2}$, No. 33112, which equals in size the average of T. californicum from Rancho La Brea, and exceeds even the largest second lower molar of that species in antero-posterior diameter (see table 19). On the other hand, the University of California collections contain a metatarsal 1, No. 12768, from Rancho La Brea which is of nearly the same size as the corresponding element in T. simum. In addition, a $\overline{M1}$, No. 2088, in the collections of the California Institute of Technology bridges the gap between T. simum and T. californicum (see table 19). Therefore, unless both T. simum and T. californicum are to be recognized as occurring at Rancho La Brea and McKittrick, it seems necessary to conclude that the latter is synonymous with Cope's species.

It is possible that T. californicum is a subspecies of T. simum, but since subspecies are based on lateral rather than vertical distribution, this does not seem to be probable. However, during the Pleistocene there may have been considerable shifting of ranges of subspecies, but in the present instance this must still be demonstrated.

Tremarctotherium simum (Cope)

The McKittrick collections of the University of California contain a nearly complete skull, No. 33111, and mandible, No. 33111, of this species. These specimens probably belong to the same individual, for the teeth appear to be in the same stage of wear in both the upper and lower jaws. The skull is that of an old individual, for the sutures are closed and the teeth rather deeply worn.

As is shown by table 16, the skull is slightly smaller in nearly all measurements than *T. simum* from Potter Creek Cave. The teeth, on the other hand, usually equal, and often exceed, the dimensions of comparable teeth in the cave material (see table 17). In all details, the tooth pattern closely approximates that in the cave material. Due probably to injury, the posterior portion of the frontal region is deeply indented, and this may be responsible for the more pronounced bulge in the contour of the skull above the orbits of the McKittrick specimen than is seen in *T. simum* from the northern California cave. The central, posterior incisive foramen is almost as large as either of the anterior two, and is much larger than the corresponding opening in U. C. No. 3001 from Potter Creek. Two infraorbital foramina are present on each side of the skull.

The mandible is similar to that of *T. simum* from Potter Creek, but in the McKittrick specimen, the space between the third and fourth lower premolars is somewhat greater than in a specimen from the former locality, U. C. No. 3004.

A single left lower molar two, No. 33112, in the collections of the University of California is remarkable for its large size. As is shown by table 19, this tooth exceeds even the largest comparable tooth from Rancho La Brea in antero-posterior diameter.

The matérial in the collections of the California Institute of Technology consists of a canine tooth, No. 2087, an $\overline{M1}$ from the right side, No. 2088, and numerous more or less complete appendicular and axial skeletal elements.

All are nearer in size to the Potter Creek Cave material than to specimens from Rancho La Brea. Certain elements, ulna No. 2089 for example, are even smaller than corresponding parts of the Potter Creek form. On the other hand, $\overline{M1}$ equals the larger individuals from Rancho La Brea in anteroposterior diameter, but in the transverse measurement more nearly approximates the cave material.

TABLE 16- Measurements (in millimeters) of skull of *Tremarctotherium simum*

	McKittrick U.C. 33111	Potter Cr. Cave U.C. 3001
Length, anterior end of premaxillary to inion	377	391
Length, anterior end of premaxillary to posterior end of condyle	352	
Length, anterior end of premaxillary to inferior notch between condyles	331.5	
Length, anterior end of premaxillary to anterior border of posterior nasal opening	196.5	
Length, from posterior end of glenoid cavity to posterior end of condyle	111.9	
Length, anterior side of premaxillary to posterior side of auditory meatus	296	300
Length, from postorbital process of frontal to inion	226.5	220
Length, from anterior border of orbit to posterior side of auditory meatus	195.8	192
Length, from anterior border of premaxillary to anterior side of orbit		110
Greatest width across muzzle from outer walls of canine alveoli	96.7	101.5
Width across frontal at narrowest point between orbits	116.3	112
Greatest width across postorbital processes	152ap	150ap
Least width of postorbital constriction	100ap	
Greatest width across zygomatic arches		
Greatest width across mastoid processes		167ap
Greatest diameter across condyles	73.3	
Palate, width between middle internal borders of M1	73	80

TABLE 16- Continued

Width of nasals anteriorly		47
Length of nasals	85.2	81
Width of anterior nares	74.4	77
Height of anterior nares	70	63
Height of orbit	56	50
Height, inferior border of maxillary to top of frontal between postorbital processes of frontal	136	121
Height of inion above superior border of auditory meatus	96	94
Height of inion above base of occipital condyles	116	

ap Indicates approximate measurement.
Measurements of Potter Creek Cave material after Merriam and Stock (1925).

TABLE 17- Measurements (in millimeters) of upper dentition of *Tremarctotherium simum*

	McKittrick	Potter Creek Cave	
	U.C. 33111	U.C.3001	U.C.3005
Greatest transverse diameter of incisor series, measured at cingulum of I3		57.2	
Length from anterior side of C to posterior side of M2	140.03	136.8	
Length from anterior side of P4 to posterior side of M2	77.6	76	
I1, greatest transverse diameter		7.9	
I2, greatest transverse diameter	10.1	9	
I3, greatest transverse diameter	10.6	10.8	
C, antero-posterior diameter at base of enamel	28.5	27.9	
P1, greatest anteroposterior diameter		10.4	
P2, greatest anteroposterior diameter			
P3, greatest anteroposterior diameter	8.3	8.5	

TABLE 17- Continued

	U.C. 33111	U.C.3001	U.C. 3005
P3, greatest transverse diameter	5	5	
P4, greatest anteroposterior diameter	21	20.5	20.4
P4, transverse diameter across protocone	15	15	15.3
M1, greatest anteroposterior diameter	23.5	24	23.8
M1, greatest transverse diameter	22.5	23	22.1
M2, greatest anteroposterior diameter	33.9	35	33
M2, greatest transverse diameter	22.2	22	21.4

Measurements of Potter Creek Cave material after Merriam and Stock (1925).

TABLE 18- Measurements (in millimeters) of mandible of *Tremarctotherium simum*

	McKittrick	Potter Creek Cave
	U.C. 33111	U.C. 3001*
Length from posterior side of condyle to anterior alveolar border	252	262
Height at anterior end of $\overline{M1}$	51	58.5
Height at anterior end of $\overline{M3}$	65.5	75.4
Thickness below posterior end of $\overline{M1}$	24.2	25.5

* After Merriam and Stock (1925)

TABLE 19- Measurements (in millimeters) of lower dentition of *Tremarctotherium simum*

	McKittrick		Potter Creek Cave	
	U.C.33111		U.C.3004	
C, greatest anteroposterior diameter at base of enamel	24.3			
$\overline{P4}$, greatest anteroposterior diameter	11.6			
$\overline{P4}$, greatest transverse diameter	7			
$\overline{M1}$, greatest anteroposterior diameter	29.7	34*	30.5	35**
$\overline{M1}$, transverse diameter across protoconid	14.5	14.3*	14.4	16.6**
$\overline{M1}$, width of heel	16.8	17*		18**
$\overline{M2}$, greatest anteroposterior diameter	25.5	33.3***	27.2	31.7**
$\overline{M2}$, transverse diameter across protoconid	18.7	21.8***	19.8	22.4**
$\overline{M3}$, greatest anteroposterior diameter	18.8		19.7	
$\overline{M3}$, transverse diameter across protoconid	14.9		16	

* C.I.T. No. 2088 from McKittrick
** L.A.Mus. No. Z6 from Rancho La Brea
*** U.C. No. 33112 from McKittrick

TABLE 20- Measurements (in millimeters) of appendicular skeleton of *Tremarctotherium simum*

	McKittrick	Potter Creek Cave
Metacarpal IV	2096	U.C. 3040
Greatest length	119.5	106.2
Anteroposterior diameter of proximal end	27.5	31
Least width of shaft	15	15.8
Greatest width of distal end	23.5	25.7
Metacarpal V	2097	
Greatest length	98	104
Anteroposterior diameter of proximal end	28	32.3

TABLE 20- Continued

Least width of shaft	14	16.1
Greatest width of distal end	23	25.5
Metatarsal III	2098	
Greatest length	108	
Anteroposterior diameter of proximal end	33	
Least width of shaft	15.7	
Greatest width of distal end	24.4	
Metatarsal IV	2099	
Greatest length	122	
Anteroposterior diameter of proximal end	31.5	
Least width of shaft	15.8	
Greatest width of distal end	25.5	
Calcaneum	2100	L.A.M. 10214
Greatest length (a-axis)*	103.5	110
Greatest width measured obliquely across sustentaculum (b-axis)*	72	77.8
Width of cuboid facet (c-axis)*	38.5	39.4
Unciform	2130	U. C. 24067
Proximo-distal diameter (a-axis)*	43.7	47.6
Anteroposterior diameter of distal articulating surface (b-axis)*	28	34.7
Transverse diameter of distal end (c-axis)*	27	36.5

* For explanation of system of axes see Merriam and Stock (op. cit., pp. 26, 31, 1925)
Measurements of Potter Creek Cave material after Merriam and Stock (1925)

Ursus optimus New Species

Type Specimen:- Skull No. 2090 in the collections of the California Institute of Technology. This specimen presumably represents a rather old male, and is complete except for the incisor and premolar teeth, the occipital condyles, and the outer portions of the zygomatic arches.

Cotype:- A mandible No. 2091 in the collections of the California Institute. This specimen lacks only the incisors, the first two premolars, and the coronoid process on the right side.

Referred Material:- A right and a left $M\overline{2}$, Nos. 2093, 2094; part of a palate with molar teeth, No. 2092; a left and a right femur, a left and a right humerus, a tibia, an ulna, an ilium, in addition to various metapodials and rib and vertebral elements. All specimens are in the collections of the California Institute.

Specific Characters:- Skull very wide in relation to its length. Mandible heavy, the horizontal rami being very thick and deep below the diastema and lower cheek-teeth. Upper and lower molars very large, premolars relatively reduced in size.

Description

Skull and Mandible:- Although the occipital crest and condyles have been somewhat damaged, it is apparent that overhang of the inion is less pronounced in the Pleistocene species than in the living black bear. Other than this there is little difference between the skull profiles of the two. In both instances the anterior half of the nasals projects nearly straight forward. The frontals are arched, and the apex is located slightly in front of the fronto-parietal suture. Ursus optimus is relatively broader in nearly all skull proportions than the living species, Ursus americanus, and this is especially true for the muzzle. The one exception is the posterior nares, which are relatively narrower than in the latter. In the fossil skull the postpalatine and sphenopalatine foramina are located in an elongated depression, or sulcus, a feature not seen in any of the Recent skulls examined. In all other respects the McKittrick species is very similar to the living black bear.

Except for its massive appearance and greater depth, the mandible offers little to distinguish it from Ursus americanus. The symphyseal region is relatively wider, however, and the horizontal rami are somewhat deeper below the diastema and lower cheek-teeth. The condyles are also a little heavier and wider than are commonly seen in the living form. As in the latter, the coronoid flange is long and only moderately produced posteriorly, while the masseteric fossa is wide and very deep. The inferior border of the horizontal ramus is very straight in both the living and fossil forms.

Dentition:- The dental formula is $\frac{3}{3}\frac{1}{1}\frac{3}{3}\frac{2}{3}$ in which Ursus optimus apparently differs from the living bear, for in Ursus americanus the third lower premolar is occasionally lacking. It is probable, however, that a similar tooth reduction may be found in individuals of the Pleistocene species, for in the latter $P\overline{3}$ is very small. Spacing of individual teeth is very similar to that of the modern species, except that the diastema between the third and fourth lower premolars appears to be somewhat longer in the fossil form.

Alveoli for the upper incisors indicate that the first two teeth were sub-equal in size, while the third must have been very much larger than either of the two inner incisors. The upper canines are very large, and curved as in the modern form. The second upper premolar is somewhat larger than P$\underline{3}$, but neither tooth is more than a mere peg. P$\underline{4}$ is broken off at the roots, and all that can be said is that this tooth was probably triangular in shape, as is the case with the living black bears. The first upper molar is similar to the corresponding tooth in *Ursus americanus* but is larger. This is true for the last upper molar as well.

The lower incisor alveoli indicate the same relative proportions for these teeth as has been noted for the upper incisors. P$\overline{2}$ and P$\overline{3}$ are both very small, and the third premolar is practically rudimentary. P$\overline{4}$ although small is nearly of same size as the comparable tooth in the modern black bear, and possesses the same conical shape. All three lower molars are very similar to those of *Ursus americanus*, but are much larger. This discrepancy in size between the molar and premolar series as contrasted with the living form furnishes, perhaps, the most important distinction between the two species. In this connection see table 22.

Skeleton:- The elements at hand furnish little information other than that the body was also large in size. Femur No. 2095 measures three hundred and ninety millimeters from the head to rotular groove. As in *Ursus floridanus* and a fossil specimen from the Conard Fissure referred to *Ursus americanus* (Brown, 1908, p. 184), the deltoid ridge extends far down the shaft of the humerus. Similarly to *U. americanus*, the ulna shows a very large articular surface for the radius. Metacarpals 3 and 4 measure 72 and 83 millimeters respectively in their longest dimension.

The material in the collections of the University of California, which consists of a skull, No. 8851, and a mandible, No. 1009, from Samwell cave, also seems referable to the new species. The material from Rancho La Brea in the Los Angeles Museum consisting of an immature skull and mandible of a single individual, No. 5500-1, is also referred to U. optimus.

Comparisons:- A number of fossil bears have been described from the Pleistocene, but usually without specific designation. It is possible that some of these forms are identical with the McKittrick species.

Ursus vitabilis Gidley (1913, p. 96) from a cave deposit near Cumberland, Maryland, differs from Ursus optimus in the smaller size of the referred upper molars. The type mandible figured, indicates that in the Maryland form the first three lower premolars have been lost. Otherwise there is little to distinguish the two, except that the molars, $\overline{M1}$ especially, are considerably smaller in the Maryland type.

Ursus procerus Hay (1911, p. 772) differs from the McKittrick species in its more slender skull proportions and in narrowness across the zygomatic arches. Other differences are: the less highly arched frontals, and the more slender canines exhibited by Hay's species.

Ursus amplidens Leidy (1853, p. 303) from Natchez, Mississippi is based on two lower molar teeth. Although the teeth are large, the jaw fragment containing them is considerably lighter than in Ursus optimus.

Ursus horribilis oklahomaensis Stovall and Johnston (1935, pp. 208-213) from the Oklahoma Pleistocene agrees somewhat closely with the California specimen in tooth measurements, but differs decidedly in the much more pronounced inion. Furthermore, the Oklahoma specimen is described as belonging to the grizzly type, from which the McKittrick form is distinguished by its more massive skull and conical shape of $\overline{P4}$.

TABLE 21- Measurements (in millimeters) of skull and mandible of *Ursus optimus*

Skull	McKittrick: 2090	M. V. Z., 20746♂?a	Univ. of Calif. 16375♂?b	Univ. of Calif. 4678♂?c
Length from anterior end of premaxillary to posterior end of condyles	330ap	309	291	274
Length from anterior end of premaxillary to posterior end of inion	336ap	324	313	298
Length of palate from anterior end of premaxillary to a line tangent to posterior surfaces of maxillary parapets	142	138	132	127
Length from posterior end of glenoid cavity to posterior end of condyles	111ap	96	93	90
Length from anterior end of premaxillary to anterior end of posterior nasal opening	158	163	145	149
Anteroposterior diameter of nasals	88ap	92	85	77
Width of anterior nares	42	41.6	32.5	34.4
Breadth of rostrum immediately posterior to roots of upper canines	84.2	71	65	60
Least width between superior borders of orbits	90	79	80.5	73
Width across postorbital processes	122ap	113	114	104
Least width of postorbital constriction	78	70	72.5	71
Greatest width across zygomatic arches	213ap	201	200	180
Anterior palatal width between superior canines	51	40.2	40	37.5
Posterior palatal width between posterior borders of M2	51.2	51	48.8	42.5

TABLE 21- Continued

Mandible				
Length from anterior end of symphysis to posterior end of condyle	226		222	193.5
Length of symphysis measured along anterior border	73ap		64.2	61.5
Least depth of ramus below diastema	41		35	34
Depth of ramus below posterior end of M1	44.8		37.5	37
Thickness of ramus below M1	21.2		18	15.1
Height from inferior border of angle to summit of coronoid process	104.3		91.5	81
Transverse width of condyle	53		47	41.3
Greatest depth of condyle	18		15.2	14
Greatest width of mandible measured across symphysis and between outer walls of alveoli for lower canines	46.2		40	40

ap Indicates approximate measurement
Recent specimens selected in order to show extremes in variation of a series of thirteen individuals.
a *Ursus americanus altifrontalis*, Trinity Co., California
b *Ursus americanus californiensis*, Tulare Co., California
c *Ursus americanus altifrontalis*, Eugene City, Oregon

TABLE 22- Measurements (in millimeters) of dentition of *Ursus optimus*

Upper Dentition*	McKittrick: 2090	M. V. Z., 16375 a	29803b	Univ. of Calif. 4678c	20746d
Length of upper tooth row from anterior margin of C to back of M2	124.3	108.2	101.5	104	104
C, greatest anteroposterior diameter	24.8	19.8	21.2	20.6	22.7
C, greatest transverse diameter	15.7	13	12.3	13	15.1
M1, greatest anteroposterior diameter	20.2	17	16.8	17	18
M1, greatest transverse diameter	15	13	12.3	13	13
M2, greatest anteroposterior diameter	33.1	26.7	26.5	26	28.2
M2, greatest transverse diameter	17	15	15	14	15.8

TABLE 22- Continued

Lower Dentition	2091	16375 a	29803b	4678c
Length of lower tooth row from anterior margin of C to back of M3	139	125	118	118.5
C, greatest anteroposterior diameter	23.2	19.8	18	19.8
C, greatest transverse diameter	15	13	12	11.6
P4, greatest anteroposterior diameter	10	10	9.2	10
P4, greatest transverse diameter	6	5.3	5.1	5.1
M1, greatest anteroposterior diameter	21.2	17.4	17	17.4
M1, greatest transverse diameter	11	9	8	9
M2, greatest anteroposterior diameter	22.5	20	19	18.5
M2, greatest transverse diameter	13.8	11.5	11.2	11
M3, greatest anteroposterior diameter	17.2	15.2	14.2	14.5
M3, greatest transverse diameter	14.5	12.8	12	11.8

a Ursus americanus, south fork of Kern River, Tulare Co., California
b Ursus americanus, Tuolumne Co., California
c Ursus americanus, Eugene City, Oregon
d Ursus americanus altifrontalis, California
* Grinnell found that out of thirteen specimens of Calif. black bears, M2 varies in anteroposterior diameter from a minimum of 23.7mm to a maximum of 29.1mm, while M1 varies in the same measurement from a minimum of 14.5mm to a maximum of 18.2 mm.

MEGATHERIIDAE

Ground sloths of this family are not abundant in the McKittrick collection, and are represented by only one individual of the genus Megalonyx. Absence of Nothrotherium may be due to accidents of collecting, but this is an open question.

Megalonyx? sp. indet.

A single phalanx II, No. 2101, in the collections of the California Institute of Technology, is referred to this genus. This element corresponds closely in measurements and general shape to the similar phalanx of *Mylodon*, but the groove between the distal condyles seems to be too deep for that genus. The phalanx is clearly not that of *Nothrotherium*, for both in size and shape there is little correspondence between the two. In *Nothrotherium* the proximal end is subquadrate in outline; while in the McKittrick specimen the proximal end is nearly triangular in shape. Since No. 2101 does not correspond to either of the better known genera of ground sloths found at Rancho La Brea, it is referred to *Megalonyx*, the form to which it bears closest resemblance.

MYLODONTIDAE

Since Stock's (1925) work on the ground sloths of Rancho La Brea, Kraglievich (1928) has demonstrated that *Mylodon darwini* Owen is the type of the genus *Mylodon*, and not as is usually accepted, *Mylodon harlani* Owen. Kraglievich's illustrations show the former to be characterized by a beak-like premaxillary region, and it would seem that this form cannot belong to the same genus as the Rancho La Brea mylodonts. Kraglievich applies the generic name *Paramylodon* Brown to the tar pit forms. Although this genus was described on invalid grounds, in consequence of Kraglievich's redefinition *Paramylodon* becomes a valid name.

Paramylodon harlani (Owen)

Material in the collections of the University of California consists of several detached teeth, Nos. 33104-33109, a fragment of right maxillary of an immature individual; No. 33110, a left mandibular ramus, No. 33103, also of an immature individual; an ungual phalanx, digit III, of the left manus, No. 33121, and numerous skeletal elements in addition to a large number of dermal ossicles. The material in the collections of the California Institute of Technology consists of dermal ossicles, and a few isolated teeth.

All of the teeth show marked resemblance to the Rancho La Brea material. As in the latter (Stock, 1925, p. 128), the external surface of the hard dentine layer is marked by transverse undulating lines, while the external surface of the cement is marked by longitudinal striations. The outlines of the enamel patterns fall within the range of variation of corresponding teeth from Rancho La Brea.

The fragment of immature right maxillary, U. C. No. 33110, contains the last four superior teeth. Although this specimen is considerably smaller than No. 1717-35 from Rancho La Brea (Stock, 1925, fig. 61), the McKittrick specimen is remarkably similar in all other respects to the Rancho La Brea material.

The immature left mandibular ramus, U. C. No. 33103, is of some interest in that it seems to be one of the few young specimens of its kind on record. Judging from Stock's (1925, pp. 127-128) summary of the characters of Paramylodon harlani, very little change apparently takes place in this element during growth. In both mature and the young specimen the horizontal ramus is thick. The depth of the ramus decreases slightly from the base of the coronoid process to the anterior side of the first lower tooth.

In mandible, No. 33103, two mental foramina are present, the lower one of which is the larger. This is also the case with mature specimens, although occasionally more than two openings may be present in this region.

The postero-external opening of the dental canal is situated opposite the posterior lobe of the last lower tooth. Similarly as in mature specimens, the coronoid process slopes slightly backward, and the posterior end of the process extends to a point vertically above the anterior portion of the condyle.

Phalanx, U.C. No. 33121, has lost most of the bony sheath which incases the claw process, but in all other respects resembles the terminal phalanx of digit III of the left manus of Paramylodon harlani from Rancho La Brea.

TABLE 23- Measurements (in millimeters) of Paramylodon harlani

	Rancho La Brea	McKittrick
Mandible*		U.C. 33103
Length from anterior end of symphysis to posterior end of condyle		153
Greatest length of symphysis		41.5ap
Greatest pre-dental width		57ap
Depth of ramus between third and fourth inferior teeth, measured normal to inferior margin		34.9
Maxillary*	1717-35	U.C. 33110
Greatest length of upper tooth row	73	57
Dentition	U.C. 21158	U.C. 33110
2, anteroposterior diameter	28.8	26
2, transverse diameter	20.7	14

TABLE 23- Continued

	L.A. M. 1717-6	U.C. 33110
4, anteroposterior diameter	25.5	25.5
4, transverse diameter	27.8	21.6
	L.A.M. 1717-2	U.C. 33110
5, anteroposterior diameter	23	23.2
6, transverse diameter	19.3	18

* Immature specimen
ap Indicates approximate measurement
All measurements of Rancho La Brea material after Stock (1925, table 64)

CAMELIDAE

A monograph of the Rancho La Brea camels by Dr. Stock is in course of preparation, and as one of the McKittrick forms is apparently specifically identical with Camelops hesternus from the former locality, it is to be expected that any revision of the Rancho La Brea forms will involve a change in status of the forms from McKittrick. In addition to Camelops, the McKittrick assemblage contains the type of Tanupolama stevensi. Absence of this genus from Rancho La Brea raises a puzzling problem, which is treated on page 68 .

Tanupolama stevensi (Merriam and Stock)

Rather fragmentary remains of this form were first described as Lama stevensi by Merriam and Stock (1925, pp. 39-42). Further study of more complete material convinced the latter author that the form is generically distinct, although closely related to the South American llamas (1928, pp. 29-37). The type specimen is a fragmentary mandible in the collections of the University of California, U. C. No. 24260.

The generic characters are as follows:-

Size of average specimens larger than living llama, but smaller than *Camelops*.

Orbits smaller, brain-case larger and somewhat flatter dorsally than in *Lama*.

Posterior portion of mastoid region and paroccipital process situated closer to basioccipital and occipital condyles than in living genus. Deep narrow groove on postero-external side of mastoid behind stylo-hyal pit. Paroccipital process bluntly pointed and not projecting inward in its downward course.

Lower canine present or absent. Lower molars with inner enamel surfaces flatter and median longitudinal groove of inner side not as deep as in *Lama*. Antero-external style not as well developed as in living genus. Posterior lobe of $M\overline{3}$ wider transversely and less prominently constricted from second lobe.

Limb elements much more slender than those of *Camelops*. Radius-ulna and cannon bones greatly elongated. Metapodials in some individuals approaching those of *Camelops hesternus* in length.

Notes on the Milk-Dentition of Tanupolama stevensi

Since Stock's original description, an excellent series illustrating the milk-dentition of this form has become available at the University of California. This institution also possesses a representative collection of milk-teeth of *Procamelus* and *Pliauchenia*. Opportunity is taken, therefore, to supplement knowledge of the slender-limbed Pleistocene camel by a comparison of milk-dentitions of this and the Pliocene forms.

In the lower jaw of *Tanupolama* two milk-teeth are present, $Dm\overline{3}$ and $Dm\overline{4}$. The former is small, and possesses two lobes. $Dm\overline{4}$ is larger, and shows three well defined lobes. In some specimens, U. C. No. 33114, for example, the outer valleys between the lobes carry well defined pillars; while in others, U. C. No. 33114a, no trace of pillars can be seen. A fragment of left maxillary, U. C. No. 33114b, contains $Dm\underline{2}$ and $Dm\underline{3}$, but four deciduous upper molars are present in C. I. T. No. 31.

In the *Procamelus* material of the University of California from Burge and Gordon Creek, Nebraska $Dm\overline{2}$ is always present. In addition, $Dm\overline{3}$ is somewhat larger than the corresponding tooth of *Tanupolama*, and shows definite indications of three lobes. $Dm\overline{3}$ is much alike in both genera, except that in *Procamelus* the external buttresses seem to be invariably absent.

In the upper deciduous dentitions there seems to be little difference between the Pleistocene and Pliocene genera except that in *Tanupolama* $Dm\underline{2}$ is greatly reduced in size as compared with the same tooth in *Procamelus*. In the latter genus this tooth is long and narrow and possesses three lobes; while in *Tanupolama* $Dm\underline{2}$ is very small and shows no tendency to development of lobes. In addition, the long axis of this tooth describes an angle of approximately forty-five degrees with the rest of the tooth-row, while in Procamelus $Dm\underline{2}$ is parallel in its long dimension with the tooth-row.

The collection of milk-dentitions of *Pliauchenia* from Hemphill, Texas, now in the collections of the University of California offers good comparative material. The milk-teeth of this form are distinguished from corresponding teeth of Tanupolama by the following characters:-

In Pliauchenia $\overline{Dm2}$ is always present, but while in some instances as for example in U. C. No. 30886 this tooth is closely appressed to $\overline{Dm3}$, in other cases, U. C. No. 30888 for example, an interval of approximately one centimeter separates $\overline{Dm2}$ from $\overline{Dm3}$. This may indicate that in Pliauchenia the second lower milk molar was in the process of suppression. As in Procamelus, $\overline{Dm3}$ of Pliauchenia is a three-lobed tooth, but the first lobe is often quite obscure. Similarly, as in Procamelus and in contrast to Tanupolama, $\overline{Dm4}$ of Pliauchenia, although three-lobed, never shows the presence of pillars on the external valleys between the lobes.

In the upper-milk molars of Pliauchenia $\underline{Dm2}$ is more reduced in size than in Procamelus, but somewhat less so than in Tanupolama. In contrast to the latter and as in Procamelus, the long axis of this tooth is parallel with the tooth-row instead of describing an angle to that plane. For complete measurements of this form the work of Stock (1928A) should be consulted.

Camelops hesternus (Leidy)

Remains of this camel from the McKittrick deposits include various cranial, axial and appendicular elements.

Skull and Permanent Dentition:- The single mature cranial element available, Calif. Inst. No. 2102, consists of the maxillaries and a complete cheek-tooth dentition. As shown by table 24, the skull is approximately intermediate in size between Nos. 20028 and 20040 in the University of California collections from Rancho La Brea.

The teeth are moderately worn, and although they depart somewhat from the dimensions of the Rancho La Brea specimens, they closely resemble them in shape and outline of the enamel pattern. In both instances P$\underline{3}$ has a narrow and rather blade-like crown, while P$\underline{4}$ is nearly quadrate in cross-section. In M$\underline{2}$ the anterior lobe is noticeably wider than the posterior lobe; while in M$\underline{3}$, as in U. C. No. 20028 from Rancho La Brea, the metastyle is drawn out posteriorly into a wing-like projection.

A single permanent lower molar, C. I. T. No. 2103, because of its relatively narrow transverse diameter is thought to correspond to M$\overline{3}$. However, the one diagnostic feature of M$\overline{3}$ cannot be seen, for the posterior lobe is lacking. All that can be said definitely is that there is no evidence of an antero-external buttress, while the inner ribs are very poorly developed.

Upper and Lower Milk-Teeth:- A rather large number of these teeth are available. Two deciduous premolars appear to have been present in both the upper and lower jaws. Dp$\underline{3}$ tapers markedly toward the anterior margin, while the enamel pattern of this tooth appears to be quite simple. Dp$\underline{4}$ is quadrangular in shape, and appears to possess a very simple enamel pattern.

Dp$\overline{3}$ is a triangularly-shaped tooth, the apex of which is directed forward. The fourth deciduous premolar is three-lobed. The valleys between the lobes, in marked contrast to those of the same tooth in *Preptoceras?*, do not show the development of subsidiary tubercles. For measurements of these teeth see table 25.

<u>Skeletal Elements</u>:- These consist of numerous vertebra, limb, and foot elements. All are of large size. The metapodials in particular are very heavy, and are readily distinguishable on this character from corresponding elements of *Tanupolama*.

TABLE 24- Measurements (in millimeters) of permanent dentition of *Camelops hesternus*

Upper Dentition	McKittrick: 2102	Rancho La Brea: U.C.20028	Rancho La Brea: U.C.20040
Greatest width of palate between outer borders of superior cheek-tooth series measured between outer borders of third molars	129ap	141.9	148
Least transverse diameter of palate between superior cheek-teeth measured between outer borders of P4	53	66	56
Length, anterior side of P4 to posterior side of M3	144	142.7	156.4
Length anterior side of M1 to posterior side of M3	124	124	132
C, anteroposterior diameter	13	13.9	13.2
P3, anteroposterior diameter	16		18.8
P3, greatest transverse diameter	11.5		11
P4, anteroposterior diameter	26	23.5	28
P4, greatest transverse diameter	23	25	22.5
M1, anteroposterior diameter	31.8	24.4	42
M1, greatest transverse diameter	29	31	33.6
M2, anteroposterior diameter	40.4	42.1	52
M2, greatest transverse diameter across protocone	30	31.6	32.8
M3, anteroposterior diameter	46.5	49.5	45.8
M3, greatest transverse diameter	28	31.4	27.2

ap Indicates approximate measurement
Measurements of Rancho La Brea material after Merriam (1913)

TABLE 25- Measurements (in millimeters) of milk dentition of *Camelops hesternus*

Upper Dentition	McKittrick 2104
Dp1, anteroposterior diameter	19.5
Dp1, greatest transverse diameter	14.5
Dp2, anteroposterior diameter	21
Dp2, greatest transverse diameter	16.8
Lower Dentition	**2105**
Dp1, anteroposterior diameter	9.5
Dp1, greatest transverse diameter	5.6
Dp2, anteroposterior diameter	27
Dp2, greatest transverse diameter	11

BOVIDAE

In addition to *Bison antiquus*, which is common to both Rancho La Brea and McKittrick, the latter locality has furnished remains of a musk ox-like animal as yet unknown from the Los Angeles occurrence. This form has been tentatively referred to *Preptoceras* by Stock and Furlong (1927, pp. 409-434), but it was recognized that in many ways the McKittrick form approximates *Euceratherium*, while in some characters it resembles neither. The present study has brought to light some additional material representing this interesting form, but not enough to fix its generic reference with any greater degree of certainty.

Preptoceras? cf. sinclairi Furlong

The material described by Stock and Furlong consists of a fairly complete skull and mandible, in addition to various limb and foot elements. The following resumé of characters was given by these authors:-

Characters like those of Preptoceras:- Size and shape and presumably curvature of horn-core; extent to which horn core extends outward and backward from the base before curving forward; width across frontals between outer lower borders of horn-cores; indentation of palatine on each side of posterior notch; absence of median ridge on occiput above foramen magnum and general appearance of occiput; parietals form dorsoposterior roof of skull.

Characters like those of Euceratherium:- Backward and upward extent of horn cores; some resemblance possibly in curvature; width of palate; absence of accessory style in upper molars.

Characters common to Preptoceras and Euceratherium:- Width of frontals between orbital rims; presence of a lachrymal depression; shape of elements and position of foramina in basicranial region of skull; position and size of occipital condyle; number and structure of teeth; structure of feet.

Characters distinguishing the McKittrick form from both Preptoceras and Euceratherium:- Width measured between inner nasal borders of horn cores; elevation of frontals in their extent from the fronto-nasal suture to horn cores; depth of lachrymal depression; abrupt downward descent of posterior border of alisphenoid; angle (139 degrees) in vertical plane made by plane of dorsal surface of the cranial roof with plane of the occiput.

It was concluded that of the characters exhibited by the McKittrick form, those allying it with both *Preptoceras* and *Euceratherium* are of greater significance than those which relate it to either of the two genera. It would thus appear that *Preptoceras* and *Euceratherium* are generically identical. If so, the name *Euceratherium* would take precedence over *Preptoceras*. Stock and Furlong suggested that the type of *Preptoceras* may possibly represent a young male and the type of *Euceratherium* an older female.

New material available consists of a very imperfect skull of an immature individual, C. I. T. No. 2106, a very fragmentary left mandibular ramus, C. I. T. No. 2107, also of an immature individual, a right and left third metacarpal, C. I. T. Nos. 2108, 2109, the first and second phalanges IV, C. I. T. Nos. 2110, 2111, and in addition numerous upper and lower milk-teeth.

The milk dentition consists of three upper and lower premolars. The second lower milk-premolar is poorly preserved, but appears to taper toward the front. $Dp\overline{4}$, No. 2113, is likewise very imperfect. There are indications, however, that this tooth was tri-lobed. In addition, it shows two subsidiary cuspules; one on the posterior margin of the valley between the first and second lobes, the other on the anterior border of the posterior valley. The upper milk-teeth show few features of interest. $Dp\underline{2}$ is not present in any of the maxillaries, but from the size and shape of the alveolus, it is inferred that this tooth was very small and quadrate in cross-section. For measurements of the milk dentition see table 27.

The skull, No. 2106, contains only the molar teeth on the right side. As can be seen from table 26, these correspond very closely to the measurements of No. 27118 in the University of California collection from McKittrick. In all other respects the skull and teeth agree very well with that specimen.

Since only elements of the pes were available at the time of the original description of the McKittrick material, the elements of the fore-limbs now at hand are of some importance. The two third metacarpals, Nos. 2108, 2109, although nearly the same length as corresponding elements of the pes, are considerably broader. This is also true for the proximal and middle phalanges. For measurements of these elements see table 28.

TABLE 26- Measurements (in millimeters) of permanent dentition of *Preptoceras? cf. sinclairi*

Upper Dentition	No. 2106	U.C. 27118
M$\underline{1}$, anteroposterior diameter	28	26.9
M$\underline{1}$, transverse diameter	18.2	19.2
M$\underline{2}$, anteroposterior diameter	30.5	30.2
M$\underline{2}$, transverse diameter	17	17.2
M$\underline{3}$, anteroposterior diameter	30	29.1
M$\underline{3}$, transverse diameter	13.8ap	16.1
Lower Dentition		
M$\overline{1}$, greatest anteroposterior diameter		25.9
M$\overline{1}$, greatest transverse diameter		13.1
M$\overline{2}$, greatest anteroposterior diameter		30
M$\overline{2}$, greatest transverse diameter		13
M$\overline{3}$, greatest anteroposterior diameter		38.2
M$\overline{3}$, greatest transverse diameter		13.2

ap Indicates approximate measurement
After Stock and Furlong (1927)

TABLE 27- Measurements (in millimeters) of deciduous dentition of *Preptoceras? cf. sinclairi*

Upper Dentition	No. 2115
$Dp\underline{2}$, greatest anteroposterior diameter of crown	21
$Dp\underline{3}$, greatest transverse diameter	13.7
	No. 2116
$Dp\underline{4}$, greatest anteroposterior diameter	24.4
$Dp\underline{4}$, greatest transverse diameter	15
Lower Dentition	**No. 2107**
$Dp\overline{2}$, greatest anteroposterior diameter	10ap
$Dp\overline{2}$, greatest transverse diameter	7
$Dp\overline{3}$, greatest anteroposterior diameter	14
$Dp\overline{3}$, greatest transverse diameter	9
$Dp\overline{4}$, greatest anteroposterior diameter	23.7
$Dp\overline{4}$, greatest transverse diameter	13.3

ap Indicates approximate measurement

TABLE 28- Measurements (in millimeters) of manus of *Preptoceras? cf. sinclairi*

Left Metacarpal III	No. 2109
Greatest length over all	188
Width of proximal end	57
Greatest anteroposterior diameter of proximal end	36
Width of shaft at middle	37
Anteroposterior diameter of shaft at middle	24
Greatest width across distal condyles	64
Greatest anteroposterior diameter of distal condyles	34
Phalanx I	**No. 2110**
Greatest length	64
Greatest width of proximal end	30
Greatest depth of proximal end	30
Greatest width of distal end	27
Greatest depth of distal end	22

TABLE 28- Continued

Phalanx II	No. 2111
Length from base of proximal articulating surface to middle of distal articulating surface	39
Greatest width of proximal end	28
Greatest depth of proximal end	25.5
Greatest width of distal end	23

Bison antiquus Leidy

This species is well represented in the collections of the University of California and California Institute of Technology. Most of the material, however, consists of limb and other extra-cranial elements. A well preserved skull in the collections of the California Institute, No. 2124 , is complete except for the tips of the horn-cores, and although the teeth are in a fragmentary condition, furnishes an adequate basis for reference of the McKittrick bison to _B. antiquus_.

This specimen apparently represents an old male, for the horn cores are quite robust and the neck of the horn cores, i.e., the portion between the forehead and the rugose horn-covered portion, is of smaller caliber than the base of the horn core itself. According to Chandler (1916A, pp. 126-127), these are distinguishing marks of the male of _Bison antiquus_. As is shown by Table 29 , the McKittrick skull is considerably larger than most specimens of _Bison antiquus_ from Rancho La Brea, but the proportions are so similar as to leave little doubt that No. 2124 is correctly referred to that species.

As in the specimen figured by Chandler (1916A, p. 127, figs. 1a,1b), the horn-cores curve upward and slightly forward. The angle between the median plane of the skull and horn-cores approximates ninety degrees, and according to Chandler (op. cit. p. 130) this distinguishes character of B. antiquus from B. bison. In the latter species this angle varies from 110° to 125°.

The naso-frontal suture is obscured by tar, but as in B. antiquus the nasal bones seem to be relatively short and broad, only moderately arched, and taper gradually toward the tip. The teeth are too fragmentary to furnish any evidence of systematic value.

Several fragmentary lower jaws are available. All seem to closely approximate in outline the similar element of B. antiquus. The teeth also show no points of major difference from those in the latter species.

TABLE 29- Measurements (in millimeters) of skull of Bison antiquus

	McKittrick	Rancho La Brea	
	No. 2124	No. 21154*	No. 21185*
Length from lower border of foramen magnum to rear of nasals	280	285	290
Length from occipital crest to fronto-nasal suture measured along median line	255	272	226
Length from rear of condyles to tip of premaxillaries	660		582ap
Length from rear of orbits to tip of premaxillaries	440		440ap
Length from lower border of foramen magnum to rear of hard palate			214
Length from rear of hard palate to tip of premaxillaries			325
Width of forehead between bases of horn-cores	370	417	290
Width at narrowest point between horn-cores and eye-sockets	352	309	256
Width between outer sides of M3 at base of crown			157

TABLE 29- Continued

Width between anterior inner corners of P2	106		112
Anteroposterior diameter of orbits		70ap	72
Length of nasal bones			227
Width of nasal bones	115		115
Width of nasal bones with curvature	133ap		135
Distance between tips of horn-cores	1000ap	826	660
Length of horn-cores along upper curvature	385ap	275	235
Circumference of horn cores at base	330ap	310	212
Dorso-ventral diameter of horn-cores	94	102	68
Anteroposterior diameter of horn-cores	114ap	104	67

ap Indicates approximate measurement
* After Chandler 1916A
Specimens from U.C. collections from Rancho La Brea

CERVIDAE

During excavation of the fossil material a considerable number of deer and elk bones were encountered, but principally in the upper and presumably sub-Recent levels of the asphalt. Closer inspection of the material, however, indicates that while most of the cervid remains show the glossy black appearance characteristic of Recent material, a number of elements approximate in their state of preservation the Pleistocene remains. It is inferred, therefore, that members of this family formed a part of the Pleistocene fauna of the area.

Cervus sp.

Two fragmentary metapodials, several astragali, a left unciform, and two right cuneiforms constitute the evidence of this form. All of these elements approximate the Tulare elk, _Cervus nannodes_, in size, but Dr. Stock found minor discrepancies in size and shape of the various facets between the fossil and Recent material. Although it seems probable that the tar pit material is specifically identical with the Tulare elk, it seems unwise to attempt specific identification on such fragmentary evidence.

Odocoileus sp.

Remains of this form consist mainly of astragali and fragmentary metapodials. These correspond very closely in size with _Odocoileus hemionus californicus_, the Recent California mule deer. There does not seem to be sufficient material, however, to permit positive identification of this form.

ANTILOCAPRIDAE

Both Capromeryx and Antilocapra are found at McKittrick. As shown on page 57a, however, the relative abundance of the two types at McKittrick is the reverse of their occurrence at Rancho La Brea. At the Los Angeles locality Capromeryx outnumbers the prong-horn; while at McKittrick the reverse is true.

Capromeryx minor Taylor

The material in the collections of the California Institute consists of two lower molars, and a calcaneum, No. 15. According to Furlong (1930, pp. 49-53) the specimens are to be referred to a single individual. There seem to be no apparent differences between the McKittrick material and Capromeryx minor from Rancho La Brea.

Antilocapra americana (Ord)

The collections of the California Institute include the following: an immature right mandibular ramus, No. 2118, a mature mandibular ramus also from the right side, No. 2119, a fragment of skull with the right horn-core, No. 2120, and a horn-core, No. 2121.

Specimen No. 2118 contains the milk-teeth and the first two permanent lower molars. As indicated by Chandler (1916, pp. 116, 117), $Dm\overline{4}$ is three-lobed, and the vertical ramus does not make so close an approach to a right angle with the horizontal ramus as is the case in Capromeryx.

The mature mandibular specimen, No. 2119, agrees in all particulars with that of Antilocapra americana. As shown by table 31, both the teeth and ramus are relatively larger than in Capromeryx. The diastema is fully equal in length to the combined measurements of the lower cheek-teeth. As noted by Chandler (1916, p. 117), the anterior mental foramen is quite near the end of the symphysis; while in *Capromeryx* this opening is approximately one-half way between $\overline{P3}$ and the symphysis.

The horn-core as noted by Furlong (1931, p. 34) has some resemblances to the corresponding element of *Sphenophalus*. It is relatively broader at the base than a Recent specimen of *Antilocapra*. Compared with the Recent form, the horn is relatively slender, and the anterior appressed prong is more distally placed. If as Furlong has indicated, *Antilocapra* is a descendant of *Sphenophalus*, the McKittrick specimens would seem to be somewhat closer to the ancestral type than the average of the Recent forms. However, the tar pit material seems reasonably referred to the living species, *A. americana*.

Phalanges II and III, Nos. 2122, 2123, are available. As shown by table 32 , all are of relatively large size, and exceed corresponding elements of *Capromeryx* in nearly all measurements.

The material in the University of California comprises numerous teeth and two horn-cores, U. C. No. 33102. The shape of these elements corresponds much more closely to that of Recent *Antilocapra americana* than C.I.T. No. 2120.

TABLE 30- Measurements (in millimeters) of lower jaw and milk dentition of Antilocapra americana

	Antilocapra	Capromeryx
	2118	U.C.12523*
Length, from posterior margin of anterior dental foramen to angle	131	47ap
Depth of ramus below Dm2 measured from the outside	16	7.5
Depth of ramus below Dm4 measured from the outside	18.2	11
Thickness of mandible across middle of Dm4	9.3	5.9
Length of diastema from posterior margin of anterior dental foramen to Dm2	37.5	5
Dm2, greatest anteroposterior diameter	5.4	
Dm2, greatest transverse diameter	3	
Dm3, greatest anteroposterior diameter	7	5.4
Dm3, greatest transverse diameter	4.1	3ap
Dm4, greatest anteroposterior diameter	15	9
Dm4, greatest transverse diameter	5.6	3.7

* Type of *C. minor* from Rancho La Brea
ap Indicates approximate measurement

TABLE 31- Measurements (in millimeters) of lower jaw and permanent dentition of Antilocapra americana

	Antilocapra	Capromeryx*
	2119	U.C. 20036
Length, from posterior margin of anterior dental foramen to back of M3	128	
Depth of ramus below P3 measured from the outside	25	
Depth of ramus below middle of M3 measured from outside	29	22
Thickness of ramus below M3	13	
Length of diastema measured from posterior margin of anterior dental foramen to front of P3	56	
P3, greatest anteroposterior diameter	8.3	4.4

TABLE 31- Continued

$\overline{P3}$, greatest transverse diameter	4.7	2.4
$\overline{P4}$, greatest anteroposterior diameter	8.5	5
$\overline{P4}$, greatest transverse diameter	5	3
$\overline{M1}$, greatest anteroposterior diameter	12.5	7
$\overline{M1}$, greatest transverse diameter	6	4
$\overline{M2}$, greatest anteroposterior diameter	14	9
$\overline{M2}$, greatest transverse diameter	7	2.8
$\overline{M3}$, greatest anteroposterior diameter	24	15ap
$\overline{M3}$, greatest transverse diameter	7	

* Rancho La Brea collection
ap Indicates approximate measurement

TABLE 32- Measurements (in millimeters) of horn-core and phalanges of *Antilocapra americana*

Horn-core		2120
Greatest length		115ap
Greatest anteroposterior diameter		45ap
Greatest transverse diameter		20
Phalanx II	**2121**	
Greatest length	41	
Greatest width of distal articulating surface	19.5	
Greatest anteroposterior diameter of proximal articulating surface	18.5	
Greatest transverse diameter of proximal articulating surface	22.5	
Phalanx III	**2123**	**U.C.12521***
Greatest length	24ap	17
Greatest dorso-ventral diameter	19.5	11
Greatest transverse diameter	14	

* Rancho La Brea collection
ap Indicates approximate measurement

TAYASSUIDAE

In view of the rare occurrence of members of this family in the Pleistocene of California, it is not surprising that at McKittrick only a few fragments of a form near Platygonus compressus have been found. Peccary material from Rancho La Brea is still too fragmentary for close determination, but may represent a species different from the McKittrick form.

Platygonus near compressus Le Conte

Remains of this form consist of a lower jaw fragment, No. 1, Calif. Inst. Coll. Vert. Pale.; and metacarpal III of the left manus, No. 2, Calif. Inst. Coll. Vert. Pale. This material was described by Stock (1928, pp. 23-27), and judged to be near Platygonus compressus.

The metacarpal was compared with a similar element, No. 26004 L. A. Mus. Coll. from Rancho La Brea, and was found to be much larger than the latter. When viewed from the outer side, the shaft of the McKittrick specimen is relatively narrower than in the one from Rancho La Brea.

Measurements and illustrations of the McKittrick peccary are to be found in Stock's paper cited above.

EQUIDAE

Merriam's study of the horses of Rancho La Brea (1913) gives an adequate account of Equus occidentalis, the only species of the family found at that locality. It has been found necessary to treat the McKittrick horses in some detail, however, in order to bring out some interesting relationships.

Equus occidentalis Leidy

Horse material from McKittrick is very abundant, and includes almost all parts of the skeleton. Isolated teeth are especially abundant. No attempt to give a complete account of the osteology of this form is made. Characters of the skull and mandible have been carefully compared with the Rancho La Brea material, and except for differences which are noted in the detailed description, the horses from the tar pit occurrences appear to be specifically identical.

Skull and Mandible:- In only one instance, C.I.T. No. 1855, were skull and mandible found in association. This specimen represents a young adult, for all of the teeth are well worn excepting the last upper molar. The skull has been somewhat distorted, but is practically complete, for it lacks only the first upper incisors and the paroccipital process on the left side.

The large size and peculiar profile of the skull is very conspicuous. Posterior to the frontals, which are arched both longitudinally and transversely, the occiput slopes upward and backward, and terminates in an overhanging crest, or inion. Anteriorly the nasals project nearly straight forward, except for a slight concavity near their midpoint, until they end with a gentle downward slope. This type of profile also characterizes the majority of the Rancho La Brea horses. As in the former, the skull is wide in relation to its length. It would appear, moreover, that arching of the frontals, although marked in the McKittrick specimen, is not so conspicuous as is usually the case in the Rancho La Brea forms. Since the former is slightly distorted, it is difficult to decide to what extent this apparent discrepancy is due to individual variation.

In contrast to the material described from Rancho La Brea the notch between the nasals and premaxillaries is relatively acute, for the angle is approximately the same as in the living species. The nasal bones are relatively wide, and extend forward to a point within two centimeters of the superior canines. It is inferred that the muzzle was likewise relatively wide.

The occiput is high and narrow. As in the Rancho La Brea species, but unlike the modern horse, the occipital condyles are narrow transversely. As in the former, the maxillary ridges do not extend forward beyond the posterior border of the infraorbital foramen. The latter is located above the middle of $\underline{P4}$, a position somewhat farther back than is commonly seen in Rancho La Brea specimens in which this opening is situated above $\underline{P3}$.

Just below the naso-maxillary suture and a little above and to the rear of the infraorbital foramen is a long and very shallow groove, or lachrymal fossa. This feature is here scarcely so well developed as in *Equus caballus*. The position of the anterior palatine foramen is similar to that in the Rancho La Brea specimens and is much the same as in the modern horse. The posterior foramen is situated near the anterior half of $\underline{M2}$, a position somewhat farther forward than is usual in the Rancho La Brea material in which this opening is situated opposite the posterior half of $\underline{M2}$. The palatine notch of the posterior nares is in line with the middle of the second upper molars, and is quite narrow. As noted by Merriam, the orbits are relatively large.

It is unfortunate that the sutures have been obscured by tar, but the naso-frontal contact and boundaries of the lachrymal bone can be readily distinguished. The forward projection of the former along the middle of the nasals is a broadly open U in shape. This is in sharp contrast to the outline seen in Equus caballus, where the extension forms a rather well marked V. As in the modern form, the lachrymal bone is roughly quadrangular in outline.

Mandible:- This element is heavy, and in C. I. T. No. 1855 the horizontal ramus is very deep below the anterior cheek-teeth and the first lower molar. This relatively young individual from McKittrick surpasses even old specimens from Rancho La Brea in extent of the latter measurement. The great depth of mandible below $\overline{M1}$ is to be accounted for by presence of a distinct convexity of the inferior border of the ramus. The mental foramen is approximately opposite the posterior end of the symphysis, a feature along with the relatively great width of the symphysis in which the McKittrick and Rancho La Brea horses are much alike.

Additional Skull Material:- Skull No. 1856 C.I.T. is of an individual slightly older than the one previously described. In No. 1856 all the teeth are well worn, but the inner enamel ring of $I\underline{1}$ is still present. The specimen lacks both bullae and paroccipital processes, as well as the left zygomatic arch. The frontal region has been somewhat crushed, but not sufficiently to obliterate any important characters.

In profile this skull resembles No. 1855 rather closely. The nasals, however, show no trace of concavity, and the overhang of the inion is a trifle less pronounced. In these respects No. 1856 resembles the typical Rancho La Brea horse more closely than does the specimen first described. In contrast to the latter, No. 1856 is much longer and relatively narrow. Reference to table 34 shows that while the two differ in length by forty millimeters, the greater part of the difference is confined to the facial region, for there is a difference of thirty-three millimeters in the distance from the anterior end of the pre-maxillaries to a line connecting the posterior borders of the orbits. This leaves only seven millimeters for difference in occipital lengths. Reference to Merriam's paper shows that No. 1855 corresponds in a general way in its measurements to that of a young adult from Rancho La Brea; while No. 1856 surpasses all specimens in distance from the anterior borders of the orbits to the anterior margin of the premaxillaries. This would appear to be merely an individual variation, for in all other characters No. 1856 closely resembles the more usual type of skull from Rancho La Brea. It should be noted, however, that the longer-faced form exhibits a more nearly V-shaped projection of the naso-frontal suture than the skull first described.

Specimen No. 1859 C. I. T. is of a young individual. The first upper molar on the right side is in use, but the corresponding tooth on the left side is just emerging, as are the canines and last upper molars. This specimen is quite incomplete, for the posterior portion of the skull is broken off at the orbits.

The most interesting feature of this skull is that it shows to a greater degree than any other from McKittrick the arching of the frontal region which is so characteristic of the species. The naso-frontal suture ends anteriorly in a rather well marked V-shaped projection. As in young individuals from Rancho La Brea, the posterior palatine foramen is located near the anterior half of M2. The anterior margin of the posterior nares is situated opposite the middle of M1.

Two incomplete skulls of very young individuals are available: one, No. 1860 C. I. T., possesses the milk-teeth in an early stage of wear with M1 just emerging from the left side of the palate; the other, No. 1858 C. I. T., represents a somewhat younger stage, for the milk-teeth are scarcely worn. The former has had to be restored in the occipital region, and lacks most of the rostrum; while the latter wants both the rostrum and condyles, as well as the left zygomatic arch.

Both skulls show an overhanging inion. In addition, No. 1860 shows the profile characteristic of older individuals. The infraorbital foramen is located above the anterior half of Dp3; while the anterior borders of the postpalatine foramina and posterior nares are situated on a line connecting the centers of the last upper milk-teeth. The naso-frontal suture is well shown in No. 1858, and possesses a well marked V-shaped projection.

Summary of Skull Characters:- A survey of the material described above indicates that while the various specimens probably belong to the same species there is, nevertheless, considerable individual variation. This is most marked in the degree of arching of the frontals, overhang of the inion, and in outline of the forward extension of the naso-frontal suture which varies from a broadly open U to a V in shape. Variations in size are shown by table 34. Changes during growth do not appear to be very important, and are manifest mainly in a backward shifting of the postpalatine foramen and a lengthening of the facial region with advancing age.

Dentition:- All of the cheek-teeth are very long, moderately curved, and are well cemented. The anterior margins of the first two upper incisors fall into a vertical plane when the skull is laid top down upon a horizontal surface. Both upper and lower incisors are wide, and there is no evidence of a cup in I3, although an inner enamel fold is always present in the third upper incisor. Compared to Equus caballus the canines are of moderate size, and are laterally compressed in young individuals. The first upper premolar is never present in the McKittrick material, but a small P1 is found in some of the Rancho La Brea specimens.

Permanent Upper Cheek-teeth:- In No. 1855, the skull and mandible which have already been described, both para- and mesostyles are moderately heavy. The parastyle is flattened on its outer margin in all teeth excepting M3 and P2, where it is smaller and somewhat rounded in outline. The mesostyle is smaller than the parastyle in all cases excepting P2, in which it is much larger and nearly flat on its outer margin. The metastyle is very small, and is practically wanting in M1.

In its broader outlines the enamel pattern is very similar to that of Equus caballus. The fossettes, however, are quite small and possess relatively simple borders. In the premolars the anterior lake shows two well marked plications: one near the antero-internal margin, the other at the postero-internal angle. The antero-internal fold appears to be lacking in the molars. In the postfossette there is a single well defined plication at approximately the middle of its anterior margin, and a similar fold on the posterior border. The latter fold appears to be wanting in the molar teeth.

The protocone is long and markedly indented in the last two premolars, but only slightly so in P2. In the molars this cusp is longer, and is only very slightly indented on its inner margin. In both molar and premolar teeth the protocone projects far ahead of the isthmus, which is quite narrow.

The postprotoconal valley is rather narrow, and extends to within a few millimeters of the prefossette. This groove ends anteriorly in an oblique truncation, the face of which is directed forward and outward. There are no very definite indications of a pli caballin, although a few minor wrinkles of the enamel are to be seen along the truncation face. In the molars and second upper premolar, the long axis of the postprotoconal valley points toward the middle of the anterior margin of the tooth, while in the last two premolars this valley is directed toward the parastyle. Merriam has applied the terms "depressed" and "erect" to these respective positions, and points out that the position is to be correlated with form of the protocone. It appears that in the McKittrick material the erect type is always associated with markedly indented protocones; while the depressed position invariably occurs in teeth with nearly smooth inner pillars.

In consequence of a deeply incised posthypoconal valley, the hypocone is distinct in all teeth, excepting of course the last upper molar.

Permanent Lower Cheek-Teeth.- In mandible No. 1855 C.I.T. the lower teeth can hardly be distinguished from those of *Equus caballus*.

They are, however, somewhat narrower transversely. Both proto- and hypoconid present markedly flattened outer walls in the anterior cheek-teeth, but in the molars these pillars are a trifle rounded. The external valley is somewhat deeper in the molars, and possesses one subsidiary fold on its posterior margin in all teeth excepting $P\overline{2}$ and $M\overline{3}$, in which it appears to be completely lacking. In all teeth excepting $P\overline{2}$, the gutter is a broadly open V-shaped incision, the apex of which is rounded. In $P\overline{2}$ the internal groove can hardly be seen.

In the premolars the entoconid is large and nearly round. In the molars, on the other hand, this cusp is much smaller, but has the same shape. The hypoconulid is small, and shows only an internal transverse projection, or prong.

The enamel pattern is otherwise remarkably simple, and shows only a few minor crenulations.

<u>Deciduous Upper Cheek-Teeth</u>;- C. I. T. No. 1862 shows the enamel pattern in a section which corresponds to an early stage of wear. Both para- and mesostyle are remarkably heavy. The latter style is almost as broad as the parastyle in all cases excepting $Dp\underline{2}$, where in consequence of the unusually small size of the parastyle, it is much the larger of the two. The fossettes are much larger than in the permanent teeth, but show the same principal folds, and in addition some tiny plications not seen in the latter. Pre- and postfossettes are united in the second and fourth upper milk-premolars, but in deeply worn teeth the lakes are separate and much smaller in size.

The protocone is long, relatively narrow, and shows nearly smooth inner borders in the second and third milk-premolars. It is noteworthy that in both of these teeth the inner pillar does not project forward beyond the isthmus. In Dp4, however, this cusp is longer and somewhat indented, and in addition the anterior margin projects forward to a degree as great as any seen in the permanent teeth. In all cases the isthmus is very narrow. The postprotoconal valley, on the other hand, is very wide, and is marked by a well defined pli caballin on its anterior margin. The hypocone is distinct, and scroll-like in outline.

Deciduous Lower Cheek-Teeth:- The enamel pattern of these teeth does not differ greatly from that of their permanent correlatives. The most significant departure, perhaps, is presence in the milk-teeth of an outward folding of the enamel (protostylid) on the antero-external margin of the protoconid. However, this cuspule is not well developed in all of the lower milk-teeth series.

It is perhaps not unduly speculative to remark that the pattern shown by both upper and lower milk-teeth is in many respects that which would have to be postulated, if it is assumed that *Equus* has been derived from *Pliohippus* through the intermediate genus, *Plesippus*.

Changes in the Enamel Pattern with Wear:- Separation of the anterior and posterior enamel lakes in the second and fourth upper milk-premolars with advancing wear has already been noted. Other alterations in the enamel pattern of the milk-teeth brought about by increased wear are: narrowing of both pre- and postfossettes and loss of minor folds along their margins; obliteration of the posthypoconal valley resulting in loss of a distinct hypocone; smoothing of the inner wall of the protocone, as well as great reduction in the degree of anterior projection of this cusp beyond the level of the isthmus; and finally a narrowing of the isthmus itself. In the lower milk-teeth there seem to occur no changes worthy of note, excepting a gradual decrease in size and final obliteration of the protostylid.

In the permanent upper teeth much the same changes are noted as in their milk predecessors. Nearly all minor folds disappear in the permanent lower teeth after they have been worn down approximately two-thirds of their original length. There appears to be a tendency for the proto- and hypoconid to assume a more rounded outline at this stage of wear.

Individual Variation:- As noted by Merriam, the protocone of the permanent upper dentition varies greatly in size, and is also subject to minor variations in shape. The proto- and hypoconid may vary from a concave to a convex shape in individual instances, and this is especially true for the molar teeth. In the premolars the outer walls of these cusps are almost always flat or indented. Table 35 shows the differences in size, and it will be noted that in nearly all instances the measurements correspond closely with those of comparable individuals from Rancho La Brea.

Limb and Foot Elements:- There appears to be little difference between *Equus occidentalis* and the Recent horse insofar as the limb and foot elements are concerned. The ungual phalanges are considerably smaller in *E. occidentalis*, however, and this is only one character among many in which the Pleistocene horse compares very closely with *Equus asinus*. As contrasted with *Plesippus shoshonensis*, *Equus occiden-*

talis is distinguished by its somewhat more robust limb proportions and slightly shorter splints. It should be borne in mind, however, that these are merely average differences, which are not always to be found in individual instances.

Relationships

Only two relationships need be discussed: one concerns the connection between Equus occidentalis and Plesippus; the other relates to the many characters which E. occidentalis possesses in common with the asses.

Relation of Equus occidentalis to Plesippus:- On a former occasion the writer (1936) attempted to show that the Pleistocene genus, Equus, has been descended from the upper Miocene-Pliocene genus, Pliohippus, through the intermediate forms which are included in the late Pliocene genus, Plesippus. In this connection it is interesting to note that Matthew (1929A) considered Equus occidentalis to be intermediate between Plesippus and Equus. Since the evidence for this conclusion was not stated by Matthew, it seems desirable to compare Plesippus and Equus occidentalis.

Characters common to Plesippus and Equus occidentalis are: (1) overhanging occiput, (2) heavy mandible with a distinct convexity of the inferior border below $\overline{M1}$, (3) presence of a protostylid in the lower milk-teeth, and (4) relatively small feet and slender limb elements. It should be noted, furthermore, that the relatively simple fossette borders seen in Equus occidentalis are more characteristic of Plesippus than of Equus.

There appear, however, to be some important differences between the two genera. When the skull profile of Equus occidentalis is superimposed upon that of Plesippus shoshonensis it is readily seen that overhang of the inion is more marked in the latter. In addition, the frontals appear to be somewhat more arched in Equus occidentalis. Another and no less striking departure is apparent lack of a pli caballin in the molar teeth of the Pleistocene form. Perhaps most significant of all is the presence of a well marked lachrymal fossa in Plesippus shoshonensis and and its almost total absence in the McKittrick species. In short, differences between Equus occidentalis and Plesippus, although marked, are only those that might be expected if Plesippus is intermediate between Pliohippus and Equus. In this connection the rather primitive characters of the milk-teeth of Equus occidentalis should be recalled. In view of the late Pleistocene age of the McKittrick species, it is remarkable that it should retain so many characteristics of the horses of the late Pliocene.

The writer's views as to the ancestry of Equus are at variance with those expressed by Stirton (1934, pp. 382-383). This author places Plesippus in the rank of a subgenus of Equus, and regards Calippus, a middle Pliocene form, as the ancestor of the living genus. Evidence for these conclusions rests upon isolated teeth, which are long crowned, only moderately curved, and show an Equus-like enamel pattern. The first is most significant, for on the basis of enamel pattern alone it would appear that Neohipparion princeps (Matthew, 1924, p. 166), Calippus, and Plesippus are all ancestors of Equus. When it is recalled that Equus has been described from the late Pliocene of Europe, there would appear to be good reason to derive the living genus from middle Pliocene or even earlier ancestors. On the other hand, the late Pliocene form from Europe, _Equus stenonis_, possesses many characters which might lead one to regard it as a species of _Plesippus_. The genus _Equus_ would thus be limited to the Pleistocene and Recent.

From the well marked _Equus_-like enamel pattern of _Calippus_ it appears necessary to assume that it diverged from the parent stock as far back as perhaps the late Miocene. On this assumption it is difficult to account for the many rather primitive characters shown by _Equus occidentalis_. Abnormalities usually thought to be atavistic in nature are sometimes encountered in living horses (Lydekker, 1912, pp. 59-60), but in the McKittrick form such relatively primitive characters as simple bordered fossettes, and unindented protocone in the molar teeth might almost be said to characterize the species. Rounded proto- and hypoconids are, moreover, by no means rare. In other words, as we go back in time the characters of _Equus_ converge quite rapidly toward _Pliohippus_, and by the late Pliocene have almost merged with the latter. For this reason it appears plausible to regard _Calippus_ as a rather precocious offshoot of the _Protohippus_ group, but not in the direct line to _Equus_. In other words, _Calippus_ appears to be too advanced at too early a date to be the ancestor of _Equus_, for the earliest species of the latter genus are more primitive in tooth structure than _Calippus_, the supposed middle Pliocene ancestor.

Relation of Equus occidentalis to the Asses:- The many characters which distinguish the living forms, _Equus caballus_ and _Equus asinus_, have been evaluated and compiled by Osborn (1912, pp. 88-92), and table 33 is based on the work of this author.

TABLE 33- Major distinctions between Equus caballus and Equus asinus

	Equus caballus	Equus asinus
Orbits	Longitudinal diameter greater than vertical	Both diameters nearly alike, vertical may be greater than horizontal
Mandible	Inferior border of horizontal ramus smooth and straight: seldom convex	Inferior border furnished with prominences, thicker than in horse, convex
Forehead	Nearly straight	Convex
Occipital Crest	Continues curve of occiput	Prominent
Line drawn from anterior end of maxillary ridge to a point just above external auditory meatus (Line of Lesbre)	Passes below occipital crest	Passes through occipital crest
Height of skull at occiput, mandible included	Relatively low	Relatively high
Occiput vertex angle	More nearly perpendicular	More nearly retrocumbent
Enamel pattern of upper cheek-teeth	Pli caballin distinct	Pli caballin lacking in molars
Nasal-frontal suture	V-shaped	A nearly straight line
Nasal-lachrymal suture	Nearly a straight line parallel to long axis of skull	Concave (Not characteristic of Asiatic asses)
Postorbital process	Three sided	Oval and compressed

In addition to the distinctions tabulated above, two others have been cited by Lydekker (pp. 42-44). According to this author Equus asinus is characterized by smaller and narrower ungual phalanges, with a deeper and broader frog than is to be seen in the horse. Lydekker comments that the type of frog found in E. asinus is probably an adaptation fitting the animal to a more rocky terrain than is frequented by horses. However that may be, it will be noted that the ungual phalanges of Equus occidentalis are relatively small and narrow with a broad and deep cavity in their lower surface.

Referring to the above table it is seen that out of the eleven distinctions listed, Equus occidentalis approximates Equus asinus in the first eight. In the remaining three the McKittrick form resembles the horses, but it should be noted that shape of the naso-frontal suture in Equus occidentalis is subject to considerable individual variation, and is in some respects intermediate between that of the horses and asses. That certain North American Pleistocene horses resemble Equus asinus has been known for a long time, and it would appear that despite its relatively large size Equus occidentalis is to be included in this group. It is interesting to recall that Boule (1910, p. 20) has noted the presence of asses in the European Pleistocene, and remarks that by this time the horses were already highly diversified.

As has been noted in the section concerning the relation of Equus occidentalis to Plesippus, certain characters of the asses are also to be seen in the late Pliocene genus. It would appear, therefore, that Plesippus represents the parent stock from which may have descended the three major divisions of the modern horses. According to this postulate, the ass and zebra have undergone less modification than the horse, and that cleavage of the various lines began sometime in the late Pliocene or early Pleistocene.

Note on a Large Variant of *Equus occidentalis* and the Status of *Equus pacificus*

In the collections of the University of California are several isolated permanent and deciduous upper cheek-teeth, noteworthy because of their large size. No less than four individuals are represented in this collection, and from it a composite right cheek-tooth series has been assembled. In addition to their large size (see table 36), these teeth are remarkable in that the enamel pattern of the fossettes is somewhat more complicated than is usual by the case in *Equus occidentalis*. Two cheek-tooth series from Rancho La Brea, L. A. M. Nos. 3500-22 and 3500-R-5, agree very closely in size and outline of enamel pattern with the teeth in question. As is shown by table 36 , although the anteroposterior diameters of the McKittrick specimens usually exceed those from Rancho La Brea, the transverse measurements of teeth from the two localities are approximately equal. Comparison of tables 35 and 36 indicates that in the latter dimension the teeth in question exceed the average of *Equus occidentalis* by more than three millimeters. As has been pointed out by Gidley (1901, pp. 105-106) this measurement seems to be quite constant in living horses of the same species, and according to the views of this author (op. cit. pp. 102-103) the large teeth in both the Rancho La Brea and McKittrick collections should be referred to distinct species. However, in the writer's opinion there is less justification for this view than for the assumption that they merely represent large end members of the *Equus occidentalis* group.

A cast of the type of Equus pacificus, a P3, in the collections of the California Institute measures 34 mm. in anteroposterior diameter and 32 mm. in transverse. As will be seen from table 36 , this tooth exactly corresponds in size with large specimens of Equus occidentalis. While Equus pacificus is usually thought of as possessing a somewhat more complicated enamel pattern, it must be noted that the type does not substantiate this view. Therefore, it seems advisable to consider Equus pacificus as a synonym of Equus occidentalis. As a matter of fact this was actually done by Leidy (1873, p. 332) but at a later time Gidley (1901, pp. 116-118) re-instated E. pacificus, largely upon characters of referred material from Fossil Lake. The large teeth with complicated enamel pattern from this locality referred by Gidley to Equus pacificus possess few characters other than size to substantiate the reference. Since the large teeth from the tar pits equal the latter in size, but in enamel pattern are very similar to E. occidentalis, from the writer's point of view it seems best to regard E. pacificus as invalid, and to regard the status of the Fossil Lake materials as an open question. It may be that the latter are also referable to E. occidentalis, but are more probably to be referred to a new or some previously described species, other than Equus occidentalis (E. pacificus).

TABLE 34- Measurements (in millimeters) of skull and mandible of Equus occidentalis

Skull	1856a	1861b	1859c	1857d	1855e
Length from anterior end of premaxillaries to posterior end of condyles	575	580			535ap
Length from anterior end of premaxillaries to inferior margin of foramen magnum	546	556			507ap

TABLE 34- Continued

Skull	1856a	1861b	1859c	1857d	1855e
Length from anterior end of premaxillaries to a line connecting anterior border of second upper premolars	151	148	153		134ap
Length from anterior end of premaxillaries to a line connecting posterior border of last upper molars	335	340	330ap		327ap
Length from anterior end of premaxillaries to a line connecting anterior border of orbits	369	336ap	334		325ap
Length from anterior end of premaxillaries to a line connecting posterior borders of orbits	426				393ap
Least width across rostrum	68	68			
Width of skull on maxillary ridge at maxillo-malar suture	190		183	201	180
Greatest width across posterior border of orbits	224				
Width between outer sides of second upper premolars	108	107	109	116	105ap
Width between outer sides of last upper molars	134ap	122ap	116	132	114ap
Greatest anteroposterior diameter of orbits	60	71			65
Height of occiput above base of occipital condyles	115				127ap
Least width of occiput below superior crest	66				62ap
Mandible					
Greatest anteroposterior diameter measured along one ramus					427
Anteroposterior diameter of symphysis					80ap
Least width of symphyseal region					46
Height measured below anterior end of P2 measured normal to inferior border					65
Height below anterior end of M1 measured normal to upper border					100

ap Indicates approximate measurement
a Young adult, M3 in function; inner enamel ring of I1 still present
b Individual of about the same age as above
c Young individual, M3 just emerging
d Old individual, all teeth well worn
e Young adult, M3 just coming into use

All specimens in the collections of the California Institute of Technology

TABLE 35- Measurements (in millimeters) of permanent dentition of *Equus occidentalis*

Upper Dentition	1857a	1856b	1861c	1855d	1859e
Length of upper molar-premolar series	192	180	184	190	192
Length of upper premolar series without P1	102	100	100	102	104
Length of upper molar series	89	80	83	87	88
P2, anteroposterior diameter	39	37.3	40	39	39.6
P2, transverse diameter	27.5	27	28	27.8	26.5
P2, length of protocone	8.5	9.7	11.9	11.4	10.8
P3, anteroposterior diameter	31.7	32.6	29.6	32	33
P3, transverse diameter	31.2	30	30	29.6	28
P3, length of protocone	13	13.8	14	14	14
P4, anteroposterior diameter	30	30	29.5	32	29.7
P4, transverse diameter	30.2	27.8	28.5	28	26
P4, length of protocone	13.1	14.5	17.2	15	10.5
M1, anteroposterior diameter	28.1	25.2	26	27	29
M1, transverse diameter	30.7	28.2	27.8	27	29
M1, length of protocone	12.8	13	14	14.8	15
M2, anteroposterior diameter	27.8	27.5	27.2	29	30
M2, transverse diameter	27	27.8	26	27	27
M2, length of protocone	12.8	15	15.8	15	15
M3, anteroposterior diameter	30	26.8	26	27	
M3, transverse diameter	23.2	20.2	19.6	22	
M3, length of protocone	14	14	13	15	
Lower Dentition					
Length of lower molar series				83	
Length of lower premolar series				99	
P2, anteroposterior diameter				34.2	
P2, transverse diameter				16.2	
P3, anteroposterior diameter				31	
P3, transverse diameter				17.8	
P4, anteroposterior diameter				33	
P4, transverse diameter				15.8	
M1, anteroposterior diameter				28.2	
M1, transverse diameter				16.2	
M2, anteroposterior diameter				28.5	
M2, transverse diameter				15.5	
M3, anteroposterior diameter				25	
M3, transverse diameter				11.2	

For system of measurements see Merriam (op. cit., p. 409, 1913).

a Old individual, all teeth well worn
b Young adult, M3 in function; inner enamel ring of I1 still present
c Individual approximately of the same age as b
d Young adult, M3 just coming into use
e Young individual, M3 just emerging

All specimens in the collections of the California Institute of Technology

TABLE 36- Measurements (in millimeters) of large variation of *Equus occidentalis*

Permanent Dentition	McKittrick 33101	33101	Rancho La Brea 3500-22*	3500-R-5*
P2, anteroposterior diameter	41			40
P2, transverse diameter	30			30
P3, anteroposterior diameter	34	34	29	32
P3, transverse diameter	33.4	33	32.5	29.8
P4, anteroposterior diameter	32.5		31.2	31
P4, transverse diameter	32.8		32.8	31.8
M1, anteroposterior diameter	34.5		26.5	29
M1, transverse diameter	29.8		29	28.3
M2, anteroposterior diameter	36.4		28	28
M2, transverse diameter	31		30.5	27
M3, anteroposterior diameter	32		31.5	28
M3, transverse diameter	26		27	20.5
Milk Dentition	33101		3500-27*	3500-32*
Dp2, anteroposterior diameter			47	47.4
Dp2, transverse diameter			26	26
Dp3, anteroposterior diameter	35.5		32.5	32.5
Dp3, transverse diameter	28.5		26	27
Dp4, anteroposterior diameter	38.6		36	36
Dp4, transverse diameter	29.5		26	25.5

* Los Angeles Museum Collection

TABLE 37- Measurements (in millimeters) of milk dentition of *Equus occidentalis*

Upper Dentition	McKittrick 1860a	1858b	Rancho La Brea U.C.20099c	19834d
Dm2, anteroposterior diameter	45.5		50	48
Dm2, transverse diameter	22.8	20.5	24.6	24.8
Dm3, anteroposterior diameter	36.4	34.8	34	33
Dm3, transverse diameter	23.7	21.5	26	26.5
Dm4, anteroposterior diameter	37	36.5	38	36.2
Dm4, transverse diameter	21.4	21.5	24.5	26.2

TABLE 37- Continued

Lower Dentition	e	f	U.C.21072g	19835h
Dm$\overline{2}$, anteroposterior diameter	38.6	39.2	40	39.8
Dm$\overline{2}$, transverse diameter	14	14	14.2	14.8
Dm$\overline{3}$, anteroposterior diameter	36.2	35.5	34	34.9
Dm$\overline{3}$, transverse diameter	14	13.8	14.5	16.2
Dm$\overline{4}$, anteroposterior diameter	42	39.8	37.2	34.6
Dm$\overline{4}$, transverse diameter	13.2	12	12.9	15.9

a M$\underline{1}$ just emerging
b M$\underline{1}$ not yet emerging
c M$\underline{1}$ just emerging
d M$\underline{1}$ erupting
e All molars very slightly worn
f Approximately in same stage of wear as e
g M$\underline{1}$ showing first traces of wear
h M$\overline{1}$ in function, M$\overline{2}$ erupting

ELEPHANTIDAE

Representatives of this family are rare at McKittrick and consist of only fragmentary remains, which apparently are to be referred to Parelephas columbi. There is no evidence that the species Archidiskodon imperator existed in the McKittrick area during the period of fossil accumulation. Whether absence of this form is to be attributed to chances of preservation and collecting, or to environmental factors, remains an open question.

Parelephas columbi (Falconer)

This species is represented in the collections of the California Institute of Technology by a single last upper molar, No. 2125. There are on the average seven enamel plates in a one hundred millimeter line.

This appears to be too many for *Archidiskodon imperator*, and is of the right order of magnitude for *Parelephas columbi.* The maximum length of this tooth is approximately 240 mm.; the greatest width is 78 mm.

MASTODONTIDAE

As at Rancho La Brea, only one species, *Mastodon raki* is recorded from the McKittrick tar seeps.

Mastodon raki Frick

This species seems to be represented in the collections of the University of California by a fragment of upper tusk, No. 33118; a right mandibular ramus containing M$\overline{1}$ and M$\overline{2}$, No. 33117; a fragment of left mandibular ramus containing M$\overline{1}$ and M$\overline{2}$, No. 33116; a left M$\overline{3}$, No. 33115; a deeply worn M$\underline{1}$, No. 33119; a fragment of mandibular ramus containing Dp$\overline{2}$, Dp$\overline{3}$ and Dp$\overline{4}$, No. 22120; and a few isolated foot elements in addition to an almost complete foot.

The upper tusk is too fragmentary to furnish much information other than that this element must have been large, and seems to have possessed a gentle upward curvature.

Ramus No. 33117 is broken at the symphyseal end, and it is impossible to discover whether lower tusks were present or not. The symphyseal trough is likewise imperfectly preserved, but this feature seems to have been much the same as in *M. americanus* and *M. raki*.

M$\overline{1}$ shows a well developed cingulum around the entire tooth, except for the internal border, where the enamel is too broken to leave any reliable indications. This tooth is three-lophed, and there are indications of trefoils on the outer cusps.

M2 is also three-lophed, and shows the presence of a well developed cingulum on all sides except the internal one. The posterior cingulum is especially well developed. The outer cusps show trefoils on both their posterior and anterior margins. Each of the principal cusps carries a median conelet. The conelets of the inner cusps, however, are larger than those on the outer ones. The sulcus between the lophs is quite acute. The lophs are very high (see table 38).

M3 possesses four fully developed transverse crests, with the fifth partially formed, and a small heel. This tooth shows the presence of only the anterior cingulum. The outer cusps show trefoils on both their anterior and posterior margins. As in M2, the second and third lophs show median conelets on both the inner and outer cusps. The sulcus between the lophs is quite acute, and is shaped much as in Mastodon acutidens (Osborn, 1936, pp. 696-697). However, the McKittrick specimen does not possess the knife-like grinding surface of Osborn's species. There appears to be a deposit of cement in the valleys, which is especially thick in the first two anterior depressions. This tooth is relatively long and narrow (see table 38), for the index is only 43 as compared with 54 for the American mastodon (Osborn, 1936, pp. 175-176). In characters of M3 the McKittrick specimen agrees very well with Mastodon raki (Frick, 1933, p. 630). Since the index of this tooth and presence of cement in the valleys are the two principal characters of Mastodon raki, it seems necessary to refer the McKittrick material to Frick's species.

M1 is too deeply worn to show much more than that this tooth was three-lophed, and possessed the same shape as the corresponding tooth of *M. americanus*.

The ridge formula of the deciduous teeth agrees with that of the American mastodon as determined by Osborn (1936, p. 142). $Dp\overline{2}$ is small with two ridge crests and is bilophodont. $Dp\overline{3}$ is larger than $Dp\overline{2}$, is bilophodont, and each loph carries two crests. In addition, this tooth possesses a large talon. $Dp\overline{4}$ is not well preserved, but as in *M. americanus* this tooth is larger than $Dp\overline{3}$, and is trilophodont.

In summary, it can be said that although the McKittrick mastodon in some respects agrees closely with *M. acutidens* and *M. americanus*, there does not seem to be sufficient reason for referring the material to any species other than *M. raki*. Since Frick's species was obtained from deposits of Hot Springs, New Mexico, which are presumably of late Pleistocene age, very little chronological significance is to be attached to the specific reference of the McKittrick mastodon.

TABLE 38- Measurements (in millimeters) of dentition of *Mastodon raki*

	U.C. 33120
$Dp\overline{2}$, anteroposterior diameter	29.4
$Dp\overline{2}$, transverse diameter	23
$Dp\overline{3}$, anteroposterior diameter	48.7
$Dp\overline{3}$, transverse diameter	36
$Dp\overline{4}$, anteroposterior diameter	60ap
	U.C. 33116
$M\overline{1}$, anteroposterior diameter	93.2
$M\overline{1}$, transverse diameter	70
$M\overline{2}$, anteroposterior diameter	117
$M\overline{2}$, transverse diameter	76
$M\overline{2}$, height of middle loph	44.2
	U.C. 33115
$M\overline{3}$, anteroposterior diameter	163
$M\overline{3}$, transverse diameter at third loph	74.2
$M\overline{3}$, height of second loph (exclusive of cement	47.5

ap Indicates approximate measurement

RODENTIA

As mentioned on page 65 , representatives of this order are relatively more abundant at McKittrick than at Rancho La Brea. Furthermore, the latter assemblage is reputed to include extinct species, but the McKittrick collection seems to consist entirely of living forms. The difference may indicate that the McKittrick rodent fauna is largely post-Pleistocene in age, and this conclusion seems to be substantiated by the tentative determination that the rodent assemblage indicates arid conditions. As noted on page 34 , however, material in all conditions of preservation is included in the rodent assemblage, and it seems very improbable that all specimens of this order are of Recent age.

In contrast to the relatively large proportion of extinct species and subspecies listed from Rancho La Brea, the McKittrick rodent assemblage appears to be considerably later in time. While, as mentioned on page 74, a slight time difference may exist between the two localities, the discrepancies in the rodent faunas are too great to be attributed entirely to this cause. A revision of the Rancho La Brea rodents is beyond the scope of this work, but it is the writer's opinion that many of the extinct types listed from the Los Angeles locality are founded on inadequate material.

SCIURIDAE

McKittrick is somewhat richer than Rancho La Brea in representatives of this family, for in addition to Otospermophilis grammurus which is common to both localities, the San Joaquin Valley occurrence includes a species of antelope ground squirrel Ammospermophilis cf. nelsoni, not yet recorded from the Los Angeles locality. None of the Sciuridae is particularly abundant at McKittrick, however.

Otospermophilis cf. grammurus (Say)

A right and a left mandibular ramus in the collections of the California Institute of Technology are referred to this species. The former lacks all teeth excepting the first two lower molars; the latter contains only the lower premolar, which by its sub-triangular form serves to mark the genus, Otospermophilis. The size and tooth pattern of both specimens is very close to that of Otospermophilis grammurus grammurus, but the fragmentary nature of the remains advises a comparison rather than an identification with that form.

Ammospermophilis cf. nelsoni (C. H. Merriam)

No satisfactory criteria for differentiating Ammospermophilis from Callospermophilis are to be found in the literature. An examination of skulls and mandibles of living forms indicates that Callospermophilis possesses a larger P3 and somewhat higher cusped teeth than does Ammospermophilis; while in the lower jaw P4 of the latter is more nearly triangular in outline, and the trigonids of all teeth appear to be lower. In addition the angle appears to be somewhat more nearly horizontal in Callospermophilis than in Ammospermophilis. It must be admitted that the above criteria were not tested by examination of all known species of the two genera, but they appear to hold insofar as forms which still live in or near the McKittrick area are concerned. It is interesting to note that if these criteria are correct, Callospermophilis is closer to the ground squirrel, Citellus, than is Ammospermophilis. The latter resembles the tree squirrel, Sciurus, much more closely than its habits might lead one to suspect.

The material in the collections of the California Institute of Technology, which consists of nine right and nine left mandibular rami, is evidently to be referred to Ammospermophilis, and insofar as size and tooth-pattern is concerned appears to be quite close to the species A. nelsoni which still lives in the McKittrick area. A fragmentary left maxillary containing P4 and the first two upper molars is also referred to this species.

GEOMYIDAE

As at Rancho La Brea only one species of gopher is recognized at McKittrick. The McKittrick material has been studied by Joseph Grinnell of the Museum of Vertebrate Zoology at the University of California. No detailed descriptions of the material are available.

Thomomys bottae bottae (Eydoux and Gervais)

The material in the California Institute collections consists of two fairly complete and eight fragmentary skulls in addition to thirty-one more or less complete mandibles, which represent not less than sixteen individuals. Although there is considerable size variation in this series it is usually possible to correlate this with stage of growth, and there thus appears to be little reason for considering more than one species to be represented in the collection.

HETEROMYIDAE

Only two species of this family occur at McKittrick: Dipodomys near ingens and Perognathus cf. inornatus. The great abundance of representatives of Dipodomys points to environmental conditions similar to those prevailing in the area today, but there seems to be some reason for considering most of the heteromyids from the tar seeps as Recent in age.

Dipodomys near ingens (C. H. Merriam)

The collections of the California Institute of Technology contain no less than 255 individuals of this species, for they include this number of left mandibular rami, an almost equal number of the corresponding element from the right side, and 51 more or less complete skulls.

According to Wood (1935, pp. 148-155) Dipodomys is distinguished from Microdipodops by a less pronounced inflation of the bullae than in the latter. In addition, in Dipodomys the bullae do not extend below the level of the cheek-teeth, while in Microdipodops they extend somewhat below this level. The single rather perfect skull, although considerably smaller than in most individuals of the Dipodomys ingens group, agrees in these characters with the genus Dipodomys. No other characters can be found which separate the McKittrick material from this genus, for the variation in size can usually be correlated with stage of individual growth. In all characters the average of the specimens is close to Dipodomys ingens, but since few specific characters are exhibited by the material it is not possible to identify positively the McKittrick kangaroo rat with the above species.

Since variation in size is quite marked in the McKittrick specimens, it is impossible to give in a limited space a table which would adequately express the average proportions. In all measurements, however, the material averages close to those of Dipodomys ingens.

Perognathus cf. inornatus C. H. Merriam

This genus has been identified by the wing-like outward inflection of the descending process of the ramus. The material in the collections of the California Institute of Technology consists of nine rather imperfect mandibular rami, none of which possesses the full compliment of teeth. Few, if any, specific characters are shown by this material, but in size all the specimens are close to Perognathus inornatus, a form which still inhabits the McKittrick area.

CRICETIDAE

Separation of genera of this group is a difficult task. Much of the McKittrick cricetid material has lost all diagnostic characters, and must remain indeterminate. It seems reasonably certain, however, that all five of the Rancho La Brea cricetine genera: Onychomys, Reithrodontomys, Peromyscus, Neotoma, and Microtus are present in the McKittrick collection.

Onychomys? sp.

According to Wilson (p. 71) this genus is distinguished from Peromyscus by the following characters: in the mandible the coronoid process is better developed in Onychomys, while in the grasshopper-mouse the ascending ramus makes a somewhat greater angle with the alveolar portion of the jaw than in Peromyscus.

Following the same author, Onychomys is distinguished from Reithrodontomys by character of the descending process of the ramus. In Reithrodontomys this portion of the ramus is bent into a more nearly horizontal position than in Onychomys, and the extreme edge is twisted upward, leaving a depression. Furthermore, in Onychomys the coronoid process is less strongly developed than in the grasshopper-mouse.

It would appear, therefore, that the only Onychomys-like specimen in the collections of the California Institute of Technology, which has the descending ramus completely preserved is to be referred to the grasshopper-mouse. This specimen is approximately the same size as a mandibular ramus from Carpinteria tentatively referred to the grasshopper-mouse. As noted by Wilson (p. 72), the Carpinteria material is of relatively large size, but is within the range of variation of Onychomys torridus and O. torridus ramona. Some of the mandibular rami which lack the descending ramus, and are tentatively referred to Peromyscus, may actually represent the genus Onychomys.

Reithrodontomys? sp.

Characters separating this genus from Onychomys have been listed in the preceding section. With regard to the mandible Wilson (p. 73) quotes from Howell:

"Descending process of mandible a broad flattened plate, strongly inflected inward, the lower portion twisted into a nearly horizontal position and the inner margin raised, leaving a distinct depression in the ramus...."

Wilson also states that the upper incisors of Reithrodontomys are grooved.

There are in the collections of the California Institute four imperfect mandibular rami, one of which contains $\overline{P4}$. All lack the descending process of the ramus, but by their very small size they seem referable to the harvest-mouse. While the specimens may be merely immature forms of Peromyscus, the presence of numerous, very small grooved upper incisors in the collection of detached teeth seems to verify the presence of Reithrodontomys in the McKittrick rodent collection. Some of the small specimens tentatively referred to Peromyscus may actually belong to this group.

Peromyscus cf. californicus (Gambel)

The material in the California Institute collections consists of approximately 100 left mandibular rami and nearly 90 corresponding elements of the right side. Apparently all stages of growth are represented by these individuals. As has been noted in preceding sections, however, it is possible that some of the smaller specimens are to be referred to either Reithrodontomys or Onychomys. In size and in characters of the teeth, the average of this material is quite close to Peromyscus californicus californicus, but since few specific and subspecific characters are present, it is impossible to state definitely whether or not the two additional varieties of deer-mice, P. maniculatus gambelii and P. boyleyii rowleyi, which also inhabit the McKittrick area, are present in the fossil assemblage. It seems probable that they do occur in the collection.

Neotoma lepida gilva Rhoades

The wood rat is represented in the collections of the California Institute by two right and one left mandibular rami. This material has been identified by Emmet Hooper of the Museum of Vertebrate Zoology, University of California, who finds no difference between the tar pit material and the form still inhabiting the McKittrick area.

Microtus californicus cf. aestuarinus R. Kellogg

According to Kellogg (pp. 15-18) this variety is distinguished by its large size; long, angular skull with ridges strongly converging in the interorbital region, but always with a definite sulcus between them. The dorsal profile of the skull is convex with the exception of the interorbital region, where it is somewhat depressed. The upper teeth preserve the typical M. californicus pattern, but the anterior loop of M1 is crescentic. An internal lobe is usually present on the posterior triangle of M2. The long terminal loop of M3 is variable in outline, and is usually crescentic, but sometimes is strongly indented by a notch. Internally the loop is notched by a deep reentrant angle.

The mandible is robust, and heavier than in M. californicus.

The lower molars are similar in pattern to those in other members of the genus, excepting that the posterior transverse loops are proportionally wider.

The material referred to this subspecies in the collections of the California Institute consists of 35 left mandibular rami, an almost equal number of the corresponding element from the right side, two nearly complete skulls, and several fragmentary skulls. The mandibles are often noteworthy for their size, for they occasionally exceed the average of M. c. aestuarinus in this respect.

According to Kellogg (p. 1) this race of meadow mouse is semi-aquatic, and is limited in range to the San Joaquin Valley.

LEPORIDAE

As at Rancho La Brea the McKittrick lagomorph assemblage is made up of the jack rabbit, Lepus californicus, the cotton-tail, Sylvilagus auduboni, and the brush-rabbit, Sylvilagus bachmani. According to Dice (1925, pp. 126-129) the cotton-tail and jack rabbit from Rancho La Brea are to be referred to extinct subspecies. The subspecies of the McKittrick lagomorphs still inhabit the San Joaquin Valley.

The leporids present many difficulties to the palaeontologist, and many questions which concern the McKittrick forms have not been entirely settled. Dice (op. cit., pp. 128-129, 1925) states that Sylvilagus bachmani can usually be distinguished from Sylvilagus auduboni by relative size of skull, and complication of the enamel pattern of the cheek-teeth. The latter is stated to be larger in size than the brush-rabbit, and is supposed to possess a more complicated enamel pattern. Due to difficulty in fixing the age of an individual, these criteria are not very useful when dealing with a relatively small series. In addition, the McKittrick collection contains several specimens, which while apparently adult and of approximately the same size as the brush-rabbit possess a rather complicated enamel pattern; while a number of adult specimens of a size common to *Sylvilagus audubonі* show a very simple enamel pattern. Consequently, it is very difficult to make a satisfactory specific determination of each and every individual. It would appear, however, that the jack rabbit, the cotton-tail, and brush-rabbit are all represented in the McKittrick fauna.

As in the case of the rodents, it appears that a large proportion of the McKittrick lagomorph material is of rather Recent age, for the semi-arid climate indicated by them is not in harmony with conditions indicated by the birds and larger mammals. The peculiar mode of occurrence of much of the McKittrick rabbit material (see page 28) makes this supposition even more plausible than in the first instance.

Lepus californicus Gray

No less than 41 individuals are represented by a series of left mandibular rami in the collections of the California Institute. In addition the collection contains more or less complete skulls, right mandibular rami, and numerous other skeletal elements.

In general the material cannot be distinguished from *Lepus californicus richardsoni*, which inhabits the San Joaquin Valley at the present time. A few of the mandibles show a rather straight horizontal ramus and relatively long diastema. In this respect the above correspond to *Lepus californicus orthognathus* from Rancho La Brea, and it is possible that two races of jack rabbit are present in the McKittrick fauna. On the other hand, when it is remembered that Dice's subspecies (1925, pp. 126-127) is based on a single mandible, its validity seems doubtful. In any event, retention of Dice's variety serves no useful purpose insofar as correlation and description of the two faunas are concerned, and in this paper *Lepus californicus orthognathus* is considered as identical with at least the straight-jawed McKittrick jack rabbits referred to *Lepus californicus.* In view of geographic separation, however, it seems probable that the McKittrick and Rancho La Brea forms belong to distinct subspecies, but until osteological differences between living varieties have been demonstrated no satisfactory separation can be made.

In view of the difficulty in distinguishing young individuals of this species from the *Sylvilagus* group no table of measurements of the McKittrick leporids is given.

Sylvilagus bachmani (Waterhouse)

At least 28 individuals are represented by left mandibular rami, in the collections of the California Institute. The collection also contains several left mandibular rami and four rather imperfect skulls. All the adult material falls within the size range of the brush-rabbit as contrasted with the cotton-tail, but the enamel pattern of the cheek-teeth is not always as complicated as is supposed to be the case with *Sylvilagus bachmani*. While the procedure is admittedly questionable, it has been thought best to refer all specimens which fall within the proper size range to *Sylvilagus bachmani* regardless of the degree of complication shown by the enamel pattern.

Sylvilagus auduboni (Baird)

The cotton-tail is apparently twice as abundant in the collections of the California Institute as is the brush-rabbit. 54 left mandibular rami are referred to this form; in addition to a large number of the corresponding element from the right side; and several more or less complete skulls. While there is considerable variation in complication of the enamel pattern of the cheek-teeth, both size and proportions of this material indicate a form not far removed from *Sylvilagus auduboni*.

SORICIDAE

The McKittrick fauna contains a species of shrew very close to *Sorex ornatus*, a form which also occurs at Rancho La Brea and Carpinteria. It is possible that the McKittrick material is of Recent age, but since species of this family are unusually long-lived, the supposition is difficult to prove.

Sorex cf. ornatus (C. H. Merriam)

This form is represented in the collections of the California Institute by a left mandibular ramus, No. 2126, which apparently represents a rather young individual. This specimen lacks only P$\overline{4}$ and M$\overline{3}$. No. 2126 compares closely in size with No. C152, a juvenile female in the Dickey collection of Recent mammals. The only noteworthy differences between the McKittrick material and the Recent specimen are that in the former the horizontal ramus is somewhat lighter, while the teeth are a trifle larger. Since size is supposed to be a very constant character among these insectivores, it seems possible that the asphalt form represents a new subspecies.

The McKittrick form differs from *Notiosorex* in the farther forward position of the premolars and in the position of the molars, M$\overline{3}$ especially, which are not so close to the median plane of the jaw and therefore do not permit the presence of a shelf along the outer border of the horizontal ramus.

The type from the asphalt differs from *Sorex obscurus obscurus* in greater length of lower middle incisors and in trifle shorter condyles.

In *Sorex trowbridgii trowbridgii* the lower middle incisors are somewhat shorter and project nearly straight forward, while in the McKittrick specimen these teeth are longer, and possess a distinct upward curvature along their anterior extremities.

Sorex montereyensis montereyensis differs, among other characters from the McKittrick form, in its larger size.

Sorex californicus californicus is smaller than either of the McKittrick specimens; while *Sorex trowbridgii humboltensis* is much larger.

VESPERTILIONIDAE

The McKittrick collection contains a single specimen of bat, which as in the case of the shrew, may be Recent in age. Here again the supposition is impossible of proof.

Antrozous pallidus pacificus C. H. Merriam

A single right mandibular ramus, No. 2127, in the collections of the California Institute is the only specimen available. Although the horizontal ramus is slightly deeper below the cheek-teeth than is usual in the living species, there seem to be few, if any, other important differences. $P\overline{3}$ is missing, but the alveolus and notch on the postero-internal border of the canine indicate that this tooth was of approximately the same size and shape as in the Recent form. $P\overline{4}$ has a slightly smaller heel and more nearly vertically directed principal cusp than a male specimen, No. C26, of the Dickey collection. These characters seem to be somewhat variable in the Recent material, however, for No. 15582, a female from the same collection, corresponds almost exactly to the McKittrick specimen in characters of the last lower premolar. Since no other differences between the fossil and living form could be found, the McKittrick specimen has been referred to _Antrozous pallidus pacificus_, a race which still inhabits the mountains bordering the San Joaquin Valley.

REFERENCES

No attempt to cover the extensive literature dealing with the southern California tar pit faunas has been made. References to McKittrick are reasonably complete, but for a more comprehensive bibliography of Rancho La Brea the work of Stock (1930) should be consulted.

ANDERSON, F. M.

1908. A further stratigraphic study in the Mount Diablo Range of California. Proc. Calif. Acad. Sci., Series 4, vol. 3, pp. 1-40.

ANTEVS, ERNST

1925. On the Pleistocene history of the Great Basin. Carnegie Inst. Wash. Publ. No. 352, Art. 2, pp. 53-114.

ARNOLD, RALPH and HARRY R. JOHNSON

1910. Preliminary report on the McKittrick-Sunset oil region of Kern and San Luis Obispo counties, California. U. S. Geol. Surv. Bull. 406, pp. 1-225.

BLAKE, W. P.

1856. Report of explorations in California for railroad routes to connect with the routes near the 35th and 32d parallels of north latitude. Part 2, vol. 5, p. 193.

BOULE, MARCELLIN

1910. Les chevaux fossiles des grottes de Grimaldi et observations generals sur les chevaux quaternaries. Annales de Paleontologie, Tome 5, pp. 113-135.

BROOKS, C. E. P.

1925. The evolution of climate. London, 173 pages.

BROWN, BARNUM

1908. The Conard fissure, a Pleistocene bone deposit in northern Arkansas. Mems. Amer. Mus. Nat. Hist., vol. 9, Pt. 4, pp. 157-208.

CHANDLER, A. C.

1916. Notes on Capromeryx material from the Pleistocene of Rancho La Brea. Univ. Calif. Publ., Bull. Dept. Geol., vol. 9, No. 10, pp.111-120.

1916A. A study of the skull and dentition of Bison antiquus Leidy, with special reference to material from the Pacific coast. Univ. Calif. Publ., Bull. Dept. Geol., vol. 9, No. 11, pp. 121-135.

CHANEY, RALPH and HERBERT L. MASON

1933. A Pleistocene flora from the asphalt deposits at Carpinteria, California. Carnegie Inst. Wash. Publ. No. 415, Art. 3, pp. 45-79.

COMPTON, L. V.

1937. Shrews from the Pleistocene of the Rancho La Brea asphalt. Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 24, No. 5, pp. 85-90.

CUNNINGHAM, G. M. and W. D. KLEINPELL

1934. Importance of unconformities to oil production in the San Joaquin Valley, California. Problems of Amer. Pet. Geol., Published by Amer. Assoc. Pet. Geol., pp. 785-805.

DAVIS, W. M.

1933. Glacial epochs of the Santa Monica Mountains, California. Bull. Geol. Soc. Amer., vol. 44, pp. 1041-1133.

DICE, LEE RAYMOND

1925. Rodents and lagomorphs of the Rancho La Brea deposits. Carnegie Inst. Wash. Publ. No. 349, Art. 7, pp. 121-130.

FRICK, CHILDS

1933. New remains of Trilophodont-Tetrabelodont Mastodons. Bull. Amer. Mus. Nat. Hist., vol. 59, Art. 9, pp. 505-652.

FROST, FREDERICK H.

1927. The Pleistocene flora of Rancho La Brea. Univ. Calif. Publ. in Botany, vol. 14, No. 3, pp. 73-98.

FURLONG, E. L.

1930. _Capromeryx minor_ Taylor from the McKittrick Pleistocene, California. Carnegie Inst. Wash. Publ. No. 404, Art. 5, pp. 49-53.

1931. Distribution and description of skull remains of the Pliocene antelope _Sphenophalus_ from the northern Great Basin province. Carnegie Inst. Wash. Publ. No. 418, Art. 2, pp. 27-36.

GIDLEY, J. W.

1901. Tooth characters and revision of the North American species of the genus _Equus_. Bull. Amer. Mus. Nat. Hist., vol. 14, Art. 9, pp. 91-141.

1913. Preliminary report on a recently discovered Pleistocene cave deposit near Cumberland, Maryland. Proc. U. S. Nat. Mus., vol. 46, No. 2014, pp. 93-102.

GRINNELL, JOSEPH

1929. The two races of black bear in California. Univ. Calif. Publ. in Zoology, vol. 32, No. 3, pp. 395-408.

1933. Review of the recent mammal fauna of California. Univ. Calif. Publ. in Zoology, vol. 40, No. 2, pp. 71-234.

HALL, E. RAYMOND

1936. Mustelid mammals from the Pleistocene of North America. Carnegie Inst. Wash. Publ. No. 473, Art. 4, pp. 41-119.

HAY, O. P.

1911. The Pleistocene period and its vertebrates. 13th. Ann. Rept. Indiana Geol. Surv., p. 772.

1927. The Pleistocene of the western region of North America and its vertebrated animals. Carnegie Inst. Wash. Publ. No. 332B, pp. 1-346.

HOOTS, H. W.

1930. Geology of the eastern part of the Santa Monica Mountains, Los Angeles county, California. U. S. Geol. Surv. Prof. Paper 165-C, pp. 83-134.

HOWARD, HILDEGARDE

1930. A census of the Pleistocene birds of Rancho La Brea from the collections of the Los Angeles Museum. The Condor, vol. 31, pp. 251-252.

1932. Eagles and eagle-like vultures of the Pleistocene of Rancho La Brea. Carnegie Inst. Wash. Publ. No. 429, pp. 1-82.

1933. A new species of owl from the Pleistocene of Rancho La Brea, California. The Condor, vol. 35, pp. 66-69.

1935. The Rancho La Brea wood ibis. The Condor, vol. 37, pp. 251-253.

1936. Further studies upon the birds of the Pleistocene of Rancho La Brea. The Condor, vol. 38, pp. 32-36.

1937. A Pleistocene record of the passenger pigeon in California. The Condor, vol. 39, pp. 12-14.

HOWARD, HILDEGARDE and A. H. MILLER

1933. Bird remains from cave deposits in New Mexico. The Condor, vol. 35, pp. 15-18.

JONES, J. CLAUDE

1925. Geologic history of Lake Lahontan. Carnegie Inst. Wash. Publ. No. 352, Art. 1, pp. 1-50.

KELLOGG, REMINGTON

1918. A revision of the Microtus californicus group of meadow mice. Univ. Calif. Publ. in Zoology, vol. 21, No. 1, pp. 1-42.

KRAGLIEVICH, LUCAS

1926. Los arctoterios Norteamericanos en relación con los de Sud América. Anales del Museo Nacional de Historia Natural, Tomo 34, pp. 1-16.

1928. Mylodon darwini Owen es la especie genotipo de Mylodon Owen, rectificación de la nomenclatura generica de los milodontes. Revista de la Sociedad Argentina de Ciencias Naturales, Tomo 9, pp. 169-185.

LEIDY, JOSEPH

1853. Fossil fragments found in association with remains of Megalonyx, in the neighborhood of Natchez, Mississippi. Proc. Acad. Nat. Sci. Phila., vol. 6, No. 8, p. 303.

1865. On fossil horses from California and Oregon. Proc. Acad. Nat. Sci. Phila., p. 94.

1873. Contributions to the extinct vertebrate fauna of the western territories. Rept. U. S. Geol. Surv. Terr., Pt. 1, pp. 1-358.

LYDEKKER, R.

1912. The horse and its relatives. London, 286 pages.

MATTHEW, W. D.

1924. Third contribution to the Snake Creek fauna. Bull. Amer. Mus. Nat. Hist., vol. 50, Art. 2, pp. 59-210.

1929. Critical observations upon Siwalik mammals. Bull. Amer. Mus. Nat. Hist., vol. 56, Art. 7, pp. 437-560.

1929A. Article on fossil horses. Encyclopaedia Britannica, 14th Ed., vol. 11, p. 757.

MERRIAM, C. HART

1902.
Proc. Biol. Soc. Wash., vol. 15, p. 24.

1918. Review of the grizzly and big brown bears of North America. North American Fauna, U. S. Dept. Agri., Bur. Biol. Surv., No. 41, pp. 1-136.

MERRIAM, J. C.

1903. The Pliocene and Quaternary Canidae of the Great Valley of California. Univ. Calif. Publ., Bull. Dept. Geol., vol. 3, No. 14, pp. 277-290.

1905. A new sabre-tooth from California. Univ. Calif. Publ., Bull. Dept. Geol., vol. 4, No. 9, pp. 171-175.

1910. New mammalia from Rancho La Brea. Univ. Calif. Publ., Bull. Dept. Geol., vol. 5, No. 25, pp. 391-395.

1911. The fauna of Rancho La Brea. Part 1, Occurrence. Mems. Univ. Calif., vol. 1, No. 2, pp. 199-213.

1911A. Note on a gigantic bear from the Pleistocene of Rancho La Brea. Univ. Calif. Publ., Bull. Dept. Geol., vol. 6, No. 6, pp. 163-166.

1912. The fauna of Rancho La Brea. Part 2, Canidae. Mems. Univ. Calif., vol. 1, No. 2, pp. 217-262.

1913. The skull and dentition of a camel from the Pleistocene of Rancho La Brea. Univ. Calif. Publ., Bull. Dept. Geol., vol. 7, No. 14, pp. 305-323.

MERRIAM, J. C. (Continued)

1913A. Preliminary report on the horses of Rancho La Brea. Univ. Calif. Publ., Bull. Dept. Geol., vol. 7, No. 21, pp. 397-418.

1915. An occurrence of mammalian remains in a Pleistocene lake deposit at Astor Pass, near Pyramid Lake, Nevada. Univ. Calif. Publ., Bull. Dept. Geol., vol. 8, No. 21, pp. 377-384.

1915A. Tertiary vertebrate faunas of the north Coalinga region of California. Trans. Amer. Philos. Soc., n. s., vol. 22, pp. 1-44.

1918. Note on the systematic position of the wolves of the Canis dirus group. Univ. Calif. Publ., Bull. Dept. Geol., vol. 10, No. 27. pp. 531-533.

MERRIAM, J. C., and CHESTER STOCK

1921. Occurrence of Pleistocene vertebrates in an asphalt deposit near McKittrick, California. Science, n. s., vol. 54, No. 1406, pp. 566-567.

1925. Relationships and structure of the short-faced bear, Arctotherium, from the Pleistocene of California. Carnegie Inst. Wash. Publ. No. 347, Art. 1, pp. 1-35.

1925A. A llama from the Pleistocene of McKittrick, California. Carnegie Inst. Wash. Publ. No. 347, Art. 2, pp. 39-42.

1932. The Felidae of Rancho La Brea. Carnegie Inst. Wash. Publ. No. 422, pp. 1-231.

MILANKOVITCH, M.

1930. Mathematische klimalehre und astronomische theorie der klimaschwankungen. Handbuch der Klimatologie, Band 1, Teil A, pp. 1-176.

MILLER, A. H.

1929. The passerine remains from Rancho La Brea in the paleontological collections of the University of California. Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 19, No. 1, pp. 1-22.

1932. The fossil passerine birds from the Pleistocene of Carpinteria, California. Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 21, No. 7, pp. 169-194.

MILLER, L. H.

1912. Contributions to avian palaeontology from the Pacific coast of North America. Univ. Calif. Publ., Bull. Dept. Geol., vol. 7, No. 5, pp. 61-115.

1922. Fossil birds from the Pleistocene of McKittrick, California. The Condor, vol. 24, No. 4, pp. 122-125.

1924. Anomalies in the distribution of fossil gulls. The Condor, vol. 26, No. 5, pp. 173-174.

1924A. Branta dickeyi from the McKittrick Pleistocene. The Condor, vol. 26, pp. 178-180.

1925. Avifauna of the McKittrick Pleistocene. Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 15, No. 9, pp. 307-326.

1927. The Falcons of the McKittrick Pleistocene. The Condor, vol. 29, pp. 150-152.

1931. Pleistocene birds from the Carpinteria asphalt of California. Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 20, No. 10, pp. 361-374.

1935. A second avifauna from the McKittrick Pleistocene. The Condor, vol. 37, pp. 72-79.

OSBORN, H. F.

1912. Craniometry of the Equidae. Mems. Amer. Mus. Nat. Hist., n. s., vol. 1, Pt. 3, pp. 57-100.

1936. Proboscidea, a monograph of the discovery, evolution, migration and extinction of the mastodonts and elephants of the world. Vol. 1. Published by the Amer. Mus. Nat. Hist., pp. 1-802.

PACK, R. W.

1920. The Sunset-Midway oil field, California, Part 1, geology and oil resources. U. S. Geol. Surv. Prof. Paper 116, pl. 2, pp. 43-51.

ROMER, A. S.

1933. Pleistocene vertebrates and their bearing on the problem of human antiquity in North America. Art. 2 in The American Aborigines, Univ. Toronto Press, pp. 49-83.

ROSS, R. C.

1935. A new genus and species of pigmy goose from the McKittrick Pleistocene. Trans. San Diego Soc. Nat. Hist., vol. 8, No. 15, pp. 107-114.

SCHULTZ, JOHN R.

1936. Plesippus francescana (Frick) from the late Pliocene, Coso Mountains, California. Carnegie Inst. Wash. Publ. No. 473, Art. 1, pp. 1-13.

1937. A late Cenozoic vertebrate fauna from the Coso Mountains, Inyo county, California. Carnegie Inst. Wash. Publ. No. 487, Art. 3, pp. 75-109.

STERNBERG, CHARLES H.

1932. Hunting dinosaurs on Red Deer River, Alberta, Canada. Published by the author, San Diego, Calif., 261 pages.

STIRTON, R. A.

1934. Phylogeny of North American Miocene and Pliocene Equidae. Proc. Geol. Soc. Amer., pp. 382-383.

STOCK, CHESTER

1925. Cenozoic gravigrade edentates of western North America with special reference to the Pleistocene Megalonychinae and Mylodontidae of Rancho La Brea. Carnegie Inst. Wash. Publ. No. 331, pp. 1-206.

1928. A peccary from the McKittrick Pleistocene, California. Carnegie Inst. Wash. Publ. No. 393, Art. 3, pp. 23-27.

1928A. Tanupolama, a new genus of llama from the Pleistocene of California. Carnegie Inst. Wash. Publ. No. 393, Art. 4, pp. 29-37.

1929. Significance of abraded and weathered mammalian remains from Rancho La Brea. Bull. South. Calif. Acad. Sci., vol. 28, Pt. 1, pp. 1-5.

STOCK, CHESTER (Continued)

1929A. A census of the Pleistocene mammals of Rancho La Brea, based on collections of the Los Angeles Museum. Jour. Mammalogy, vol. 10, No. 4, pp. 281-289.

1930. Rancho La Brea a record of Pleistocene life in California. Los Angeles Museum Publ. No. 1, Paleontology No. 1, pp. 1-84.

STOCK, CHESTER and E. L. FURLONG

1927. Skull and skeletal remains of a ruminant of the Preptoceras-Euceratherium group from the McKittrick Pleistocene, California. Univ. Calif. Publ., Bull. Dept. Geol. Sci., vol. 16, No. 10, pp. 409-434.

STONER, REGINALD C.

1913. Recent observations on the mode of accumulation of the Pleistocene bone deposits of Rancho La Brea. Univ. Calif. Publ., Bull. Dept. Geol., vol. 7, No. 20, pp. 387-396.

STOVALL, J. W., and C. S. JOHNSTON

1935. Two fossil grizzly bears from the Pleistocene of Oklahoma. Jour. Geol., vol. 43, No. 2, pp. 208-213.

VANDER HOOF, V. L.

1934. Seasonal banding in an asphalt deposit at McKittrick. Proc. Geol. Soc. Amer., p. 332.

WATTS, W. L.

1894. The gas and petroleum yielding formations of the central valley of California. Calif. State Mining Bureau, Bull. No. 3, pp. 1-100.

WETMORE, ALEXANDER

1931. The avifauna of the Pleistocene in Florida. Smiths. Misc. Coll., vol. 85, No. 2, pp. 1-41.

WHITNEY, J. D.

1880. The auriferous gravels of the Sierra Nevada of California. Mems. Mus. Comp. Zool. Harvard College, Mem. 6, No. 1, 659 pages.

WILSON, ROBERT W.

1933. Pleistocene mammalian fauna from the Carpinteria asphalt. Carnegie Inst. Wash. Publ. No. 440, Art. 6, pp. 59-76.

WOOD, A. E.

1935. Evolution and relationships of the heteromyid rodents with new forms from the Tertiary of western North America. Annals of the Carnegie Museum, vol. 24, pp. 73-262.

WOODRING, W. P.

1933. The San Pedro Hills. Guidebook 15, XVI International Geol. Congress, pp. 34-40.

1935. Fossils from the marine Pleistocene terraces of the San Pedro Hills, California. Amer. Jour. Sci., Series 5, vol. 29, No. 171, pp. 292-305.

PLATE 1

Relief map of California showing the principal physiographic barriers between the better-known Pleistocene vertebrate localities in the state.

1 - McKittrick

2 - Rancho La Brea

3 - Palos Verdes (Upper San Pedro beds)

4 - Carpinteria

5 - Hawver Cave

6 - Potter Creek Cave

7 - Samwel Cave

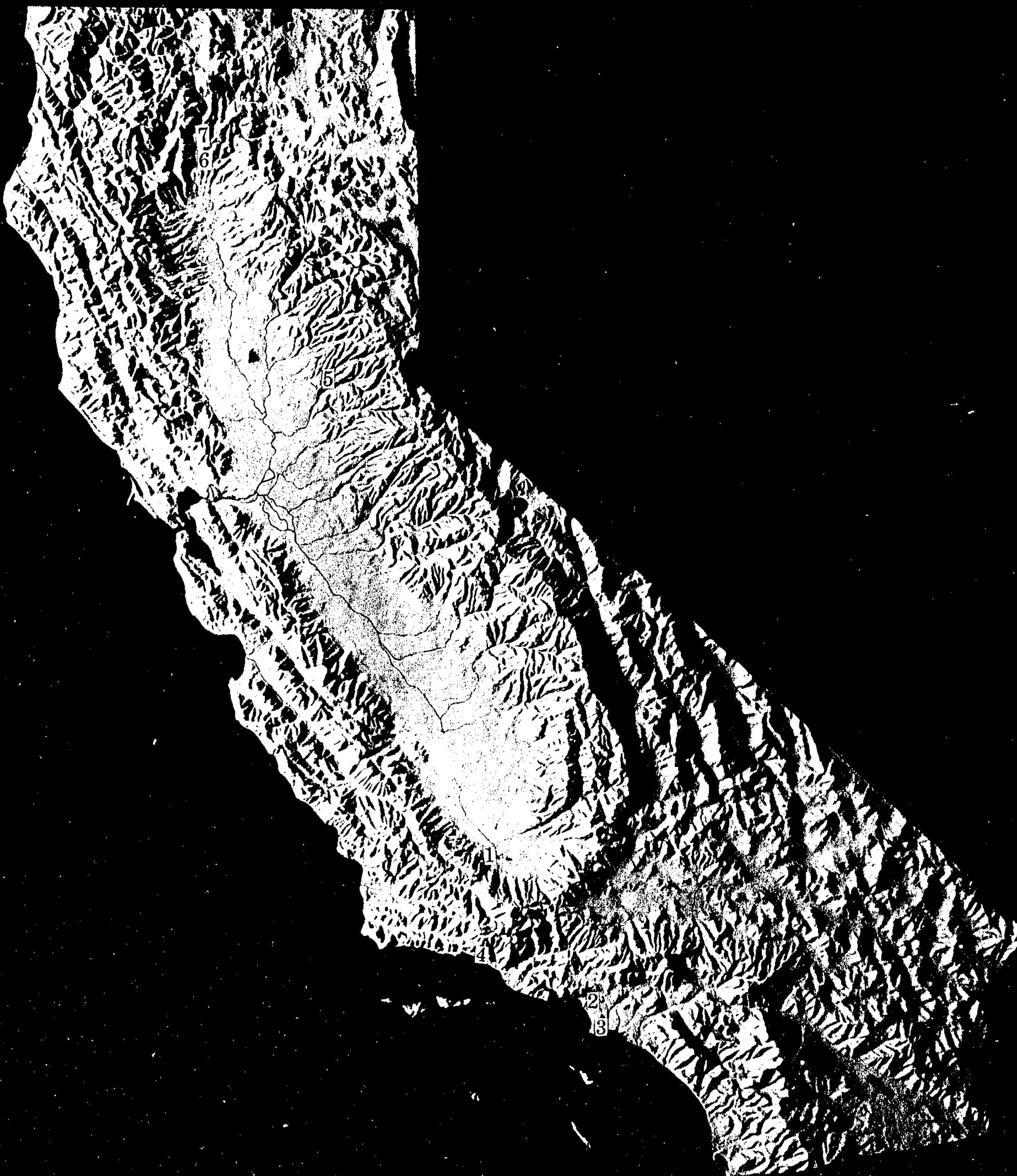
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PLATE 2

Views of the McKittrick fossil quarry.

Figure 1 - View of the fossil quarry at McKittrick during an early stage of excavation.

Figure 2 - View of the fossil quarry at a later stage of excavation showing one of the larger asphalt-filled pipes.