THE AVIAN AND MAMMALIAN REMAINS
FROM NIGHTFIRE ISLAND

by

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1969 *The Western Cascades Archaeological Survey: 1969.* Manuscript on file at the Museum of Natural History, University of Oregon.

1969 *The Tigalda Site: An Eastern Aleutian Midden.* Master's Thesis, Department of Anthropology, University of Oregon.

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INTRODUCTION

Excavated in 1967, the Nightfire Island site yielded large amounts of artifactual, floral, and faunal data. This report presents the analysis of the bird and mammal segments of this large collection. While a fragmentary part of the archaeological record provided by Nightfire Island, these remains suggest a number of hypotheses, some of wide import, which may be tested by other categories of data from the site.

My approach to these materials is, I hope, straightforward. After a brief review of the Nightfire Island site, I discuss the area in which the site is located, since it is this area which supported the avian and mammalian resources which are the subject of the report. Next, a detailed summary of the modern avian and mammalian faunas of the Lower Klamath Basin is presented, a summary which provides essential background material for interpreting the use made of these animals by the prehistoric Nightfire Islanders. Also essential background is the discussion of the methodology of faunal analysis provided in Chapter 3, since an explicit discussion of methods employed is felt essential to an adequate understanding of the analysis itself. Finally, the actual analysis of the avian and mammalian remains from Nightfire

Island is presented and, in a concluding chapter, the hypotheses which these data suggest are discussed.

It is a pleasure to acknowledge the assistance of those who made the completion of this project possible. To Dr. J. Arnold Shotwell I owe special thanks for helping me make the shift from my knowledge of human osteology to that of other mammals, as well as for many discussions of the methodology of both paleontological and archaeological faunal analysis. To my doctoral committee--Drs. Don E. Dumond, C. Melvin Aikens, L.R. Kittleman, and Philip D. Young--I also owe thanks for their careful reading of earlier versions of this dissertation. Finally, Dr. C. Garth Sampson provided much data essential to the completion of this project. To Drs. Shotwell and Sampson both I am deeply indebted.

Further afield, Mr. Robert Watson, Refuges Manager, and Mr. Edward O'Neill, Refuges Biologist, of the Klamath Basin National Wildlife Refuges, kindly allowed me access to the Refuges' files and thus allowed the detailed summary of the modern Klamath Basin avian and mammalian faunas presented in Chapter 2. It would be hard to overemphasize the help which these two men provided.

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CHAPTER 1

THE NIGHTFIRE ISLAND SITE AND THE LOWER KLAMATH BASIN

The Nightfire Island site (4SK4), a low mound some 70 meters in diameter and 1 1/2 meters high, is located on the dry margin of what was once the southwestern shore of Lower Klamath Lake in Siskyou County, California, about two miles south of the Oregon border (see Figure 1). The site, excavated in 1967 by the University of Oregon, yielded a large collection of primarily stone artifacts, large numbers of bird, mammal, fish, and fewer amphibian and reptile, remains, as well as sizeable samples of identifiable pollen. Much progress has been made toward understanding the geological history of the site, but the analysis of the Nightfire Island artifacts has only recently begun. Of all the categories of data obtained from 4SK4, only the mammalian and avian remains, the subject of the report, have to date been fully studied.

Although much work remains to be done on the 4SK4 material, it is nonetheless possible to divide the history of the site into five archaeological phases, defined by artifact typology and dated primarily on the basis of 20 radiocarbon determinations (Sampson, personal communication; see also Table 1): phase 1 (4000 B.C.-3000 B.C.), defined by the presence of Cascade and large side-notched projectile points and rare bonework; phase 2 (3000 B.C.-2200 B.C.), characterized by corner- and side-notched projectile points, cylindrical mullers, and antler wedges; phase 3 (2200 B.C.-A.D. 0), marked by an increase in relative frequency of corner- over side-notched projectile points; phase 4 (A.D. 0-A.D. 1000), defined by the presence of small stemmed and small corner-notched projectile points; and, phase 5 (A.D. 1000-circa 1400), defined by the appearance of "winged" or Gunther Barbed projectile points.

Each of these phases has been subdivided into smaller units, or levels, which consist of groups of roughly coeval strata whose contemporaneity was determined by radiocarbon, and in some instances obsidian-hydration, dates, stratigraphic and geomorphologic considerations, and on the basis of detailed similarities in artifact content. A total of 16 such levels were defined for the site in this fashion: levels 1 and 2 in phase 5; 3 through 6 in phase 4; 7 through 10 in phase 3; 11 and 12 in phase 2; and 13 through 16 in phase 1. These smaller units form the basis for analysis of the 4SK4 avian and mammalian remains.

Lower Klamath Basin, in which Nightfire Island is located, occupies a valley some 25 miles long and 5 miles wide that trends southeast from its border with the Tule

Lake drainage system and northwest to its opening into the Klamath Valley (Sweet and McBeth 1910). In the late nineteenth century, Lower Klamath Lake filled much of this basin with approximately 55,000 acres of bulrush (Scirpus spp.) and cattail (Typha latifolia) marsh, and 30,000 acres of shallow lake. The marshes were only seasonally submerged: extensive sections of marsh were used by whites at times of low water in the late nineteenth and early twentieth centuries for livestock pasture (Sweet and McBeth 1910). Of the 30,000 acres of lake, 26,000 formed part of Lower Klamath Lake, most of the remainder being divided between Miller and White lakes in the southern end of the valley. Lower Klamath Lake occupied the central part of the Lower Klamath Basin and, with the exception of the southern end of the lake, was almost entirely surrounded by bulrush-cattail marshes. Where present, these marshes, and not the lake, abutted the ridges which form the perimeter of the Basin on three sides. Lower Klamath lake was so shallow in the late nineteenth century that currents would frequently form ridges in bottom sediments which interfered with navigation (Sweet and McBeth 1910).

Before modern modification of the region began, the only important source of inflow into Lower Klamath Lake besides precipitation was the Klamath River, which entered the Lower Klamath Basin through the Straits, a wide channel at the northern end of the valley. During high stages of the river, or low stages of Lower Klamath Lake, the Klamath flowed south into the Lower Klamath Basin, but this pattern was reversed during high lake or low river levels. Lower Klamath Lake was also fed by a few small streams entering the lake from the west and southwest, the most important of which were Willow, Cottonwood, and Sheepy creeks (Sweet and McBeth 1910; USDI n.d.a).

The distribution and abundance of water supplies in the Lower Klamath area has had a torturous history since the entry of whites into the region. Although Europeans first entered the Klamath Basin as early as 1826 (Stern 1966), European influence here was not great during the next few decades. By the middle 1800's, white settlement of the area had begun in earnest, and by the 1880's white settlers had already begun to modify the natural drainage patterns of the area. Early modification was relatively minor. The first irrigation ditch in the Klamath Basin was apparently built in 1882 and enlarged in 1886, carrying water from White and Lower Klamath lakes north and east to the area of Merrill. By 1903, some 20,000 acres of the Klamath Basin were being irrigated (USDI 1957, 1958). Although Lower Klamath Lake does not seem to have been greatly affected by these early projects, significant alteration of the lake had begun by 1909, when the Southern Pacific Railroad placed the roadbed for its "Natron Cutoff" across the Klamath Straits, cutting Lower Klamath Lake off from its water supply. The Straits were entirely closed by 1912, control gates at the railroad dike apparently being added in 1914 (USDI 1957). As a result, with the exception of a few spring-fed areas which supported small patches of marsh (Walker n.d.), the lake became dry within a few years. In many places, the now-dry lake bottom peat caught fire, sometimes burning to a depth of six feet or more, "leaving nothing but a vast, alkaline, ashy desert, from which clouds of choking dust arose, often obscuring the sun" (Jewett 1943:6). Not only did subsequent attempts to farm the exposed lake bottom prove unsuccessful, but the lowered water table which accompanied blockage of the Klamath River also adversely affected ranching ventures bordering the lake (Jewett 1943).

Attempts to rejuvenate Lower Klamath Lake began in 1935, when excess irrigation water began to be pumped into its basin. After the completion of a tunnel and pumping station between Tule and Lower Klamath lakes in 1942, water began to be pumped back into Lower Klamath Lake. As a result of these and associated projects, about 23,000 acres of lake and marsh had been restored to Lower Klamath Lake by 1958 (USDI 1958).

Some effects which these changes in the distribution and abundance of water in the Lower Klamath Basin might have had on the area's avian and mammalian faunas will be discussed below. Unfortunately, however, since there are neither early nor modern floral surveys available for the Lower Klamath Basin, the changes which occurred in the flora of the region during the early twentieth century are difficult to assess. As noted, the dominant vegetation forming the marshes of Lower Klamath Lake now consists of bulrush and cattail, both extremely important in providing nesting places and refuge for waterbirds. Similarly abundant are pondweeds (*Potamogeton* spp.), an important food source for all waterfowl, but especially for the divers, and numbers of other aquatic plants (O'Neill, personal communication; USDI n.d.b; Jewett 1943). The vegetation surrounding Lower Klamath Lake and its marshes is dominated by sagebrush (*Artemisia tridentata*), although other shrubs, including rabbitbrush (*Chrysothmnus* spp.) and gooseberry (*Ribes velutinum*), are common. Cottonwood and quaking aspen (*Populus* spp.) are scattered along the lake shore, while juniper (*Juniperus occidentalis*) is scattered on the hills above the lake, but trees in general are quite scarce (O'Neill, personal communication).

The few available descriptions of Lower Klamath and nearby Tule lakes which predate major European modification indicate a pattern of vegetation similar to that seen today (Bailey 1902; Finley 1907, n.d.; Sweet and McBeth 1910; Wheeler-Voegelin 1957). That is, although the distribution of these plants must have been altered by the shrinking of Lower Klamath Lake, the kinds of plants present do not seem to have been greatly affected. Thus, it would probably be correct to describe Lower Klamath Lake at the time of European entry as having been characterized by vast, shallow marshy lakes with abundant bulrush, cattail, and pondweeds, with large expanses of sagebrush-dominated flatlands and hills back from the water. Stands of cottonwood and aspen were probably scattered around the lake, while tributary streams may also have supported fringing stands of these trees. The mammalian and avian faunas which this region supports today, and presumably supported in the past, form the subject for the next chapter.

CHAPTER 2

MODERN AVIAN AND MAMMALIAN FAUNAS OF LOWER KLAMATH BASIN

Since 1908, Lower Klamath Lake has been part of the Lower Klamath National Wildlife Refuge, one of five National Wildlife Refuges in the Klamath Basin (Jewett 1943). As a result, the Lower Klamath region has been the subject of fairly intensive wildlife studies conducted by the Refuge staff. Detailed, quantitative data regarding abundance are available for the waterfowl (ducks, geese, and swans) and coots (see Appendix for technical and common names), and to a lesser extent for most other waterbirds and many land birds. Although there are no comparable data for the mammals, there are excellent qualitative distributional data for these forms. With certain reservations, such information provides an acceptable background for examining the prehistoric use of the Lower Klamath avian and mammalian faunas.

Birds

Perhaps the most striking aspect of the Lower Klamath region today is its large and varied avifauna. Some 250 species of birds have been recorded in the Klamath Basin, of which almost 180 nest in the area (see Table 2). Since it would be unrealistic to attempt to discuss each of these forms, my discussion of the modern Lower Klamath avifauna will focus on those species important to the former residents of Nightfire Island.

It would be difficult to overemphasize the abundance of migratory waterfowl (birds of the family Anatidae) in the Klamath Basin. The Pacific flyway involves migratory birds whose breeding grounds include Alaska, central and northwestern Canada, and the contiguous northern United States, and which summer in California, western Mexico and adjacent areas; migratory routes pass through Washington, Oregon, California, Idaho, western Montana and Nevada (USDI 1955). Eighty percent of all the waterfowl using the Pacific flyway utilize the Klamath Basin during one or another part of their yearly cycle, and most of this use involves Tule or Lower Klamath lakes (USDI 1955, 1958). A population of 5,000,000 or more ducks alone may be found in the Klamath Basin during the height of fall migration: "There is no other place on earth where waterfowl congregate in such large numbers on such small areas" (USDI 1958:4). It would not be surprising to find that waterfowl provided an important source of subsistence for the prehistoric occupants of this area.

Discussion of the birds of the Lower Klamath area is greatly simplified by the use of the Klamath Basin

National Wildlife Refuges' Narrative Reports, which present yearly accounts of the mammalian and avian faunas of the five Klamath Basin Refuges. Exacting detail in the form of weekly censuses, by species, are presented for all waterfowl as well as for the American coot. Less exacting, but still valuable, data are also available for other birds.

Table 3 presents quantitative data for all recorded waterfowl of the Lower Klamath Refuge. While this table gives an adequate account of the abundance and diversity of the waterfowl of Lower Klamath Lake, some comments concerning this information seem necessary.

First, the waterfowl will be of little help in inferring seasonality from the Nightfire Island material. Although the frequency of utilization of Lower Klamath Lake by any species of waterfowl may change greatly from season to season, in almost every instance the presence of substantial numbers of any given taxon in any month diminishes the possibilities of inferring seasonality from the waterfowl component of the Nightfire Island avifauna. Indeed, as shall be seen, only two waterfowl species identified from 4SK4 allow any statements as to the seasons when that site was occupied--goldeneyes and, less certainly, whistling swans.

Secondly, particular patterns of utilization of Lower Klamath Lake by waterfowl may be defined. Specifically, non-diving waterfowl, those which do not habitually dive for food or to escape from danger (Anserini, Anatini, and Cairinini), greatly outnumber diving waterfowl (Aythyini, Mergini, and Oxyurini) throughout the year (see Table 4). At the minimum, non-diving Anatidae are more than twice as plentiful as their diving relatives; this ratio increases as the number of Anatidae in the Lower Klamath region increases, to the point where, at the height of the fall migration, non-divers are some fifty times as plentiful as divers. On the yearly average, non-diving Anatidae outnumber their diving relatives by about 20 to 1. This information provides a key to understanding the pattern of waterfowl and other waterbird utilization through the occupation of Nightfire Island.

Although waterfowl account for much of the Lower Klamath avifauna, a wide range of other water and shore birds is also present. While the same kind of exacting information presented for waterfowl is available only for coots, there are nonetheless good data on seasonal abundance for the most common of these other birds. Data for these forms are presented in Table 5, except for the more detailed information for coots presented in Table 3. Again, the year-round presence of these birds will allow little in the way of inferences from the 4SK4 avifaunal material concerning the seasons during which Nightfire

Island was occupied. Although there are large numbers of non-diving waterbirds other than waterfowl (gulls, terns, and pelicans) present throughout the year, diving waterbirds other than waterfowl (grebes, cormorants, and coots) heavily outnumber non-divers, primarily because of the abundance of coots, reversing the situation seen for the waterfowl.

Information about the other birds present at Nightfire Island and in the modern Lower Klamath area is scarce, though some statements may be made concerning these forms. Horned grebes at times nest on Upper Klamath Lake, are occasionally found as spring migrants, and in earlier times may have been found through August on Lower Klamath Lake (O'Neill, personal communication; USDI 1969). Present year-round, and common to abundant though numbers fluctuate seasonally, are American bitterns, black-crowned night herons, bald eagles, golden eagles, ravens, short-eared owls, great horned owls, and great blue herons (USDI 1960, 1965, 1970). Also year-round residents but rare are common loons, hooded mergansers, and sage grouse (O'Neill, personal communication; USDI 1969). Red-breasted mergansers are present in the spring only, and even then are not common (USDI 1969). Finally, herring gulls are occasional fall and winter visitors (USDI 1969).

The only avian species identified from Nightfire

Island which has not been recorded in the modern Klamath Basin is the snowy owl. This large owl breeds on the tundra of the far north, its abundance in that area apparently depending upon the abundance of the small mammals upon which it feeds. During the winter months many of these birds migrate south, this winter movement rarely taking them as far south as Oregon and California; the southwesternmost record of which I am aware comes from San Diego County, California (Bent 1938). Although there are some hearsay records of snowy owls in the Klamath Basin, no definite sightings of this bird have been made in the area (O'Neill, personal communication). Nonetheless, while their appearance in the archaeological record will allow inferences as to occupational seasonality, their presence at Nightfire Island certainly does not imply a climatic regime any different from that of today.

Mammals

The Klamath Basin supports a diverse mammalian fauna. Table 6, compiled from Hall and Kelson (1959) and checked against Jewett (1943), Lava Beds National Monument (n.d.), and the Narrative Reports, lists the 61 species of mammals which have been reported for the Klamath Basin in modern times, with the exception of such recently introduced forms as muskrats and Old World rats. Approximately one-third of these mammalian species were utilized during the occupation of Nightfire Island. The current distribution and abundance of each of these utilized forms will be discussed in turn.

Lagomorphs

Both animals of the open sagebrush, black-tailed jackrabbits and Nuttall's cottontails are currently very common in the Klamath Basin. For instance, an estimated 300 black-tails were reported for the area surrounding Lower Klamath Lake in 1965, while cottontails are frequently reported in numbers equal to or exceeding those noted for the black-tails (USDI 1960, 1965, 1970).

Rodents

Yellow-bellied marmots are common in the Klamath Basin. In 1970, an estimated 300 utilized the rocky grasslands in the Lower Klamath area, while similar habitats adjacent to Tule Lake sported approximately 700 (USDI 1970). Marmots are abundant in the rocky grasslands and brush of the Lava Beds National Monument southeast of Lower Klamath Lake where they make their first appearance above ground in February or March and return to dormancy between mid-July and August (Lahr 1960; Brainerd 1939-1940; Forsell 1961). Even if accurately located, the marmots' rocky winter retreats are essentially impenetrable, and any animals caught prehistorically must represent active animals of the spring and summer.

Belding's ground squirrel colonies are most commonly found in grassy openings in yellow pine or juniper forests; rarely, however, they will follow water sources into the valleys beneath these trees, nesting in the grass in these open areas (Bailey 1936; Ingles 1965). Although little information is available concerning their distribution near Nightfire Island, they are found along the northern boundary of the Lava Beds National Monument southeast of the Lower Klamath area (Forsell 1961), and their presence at 4SK4--probably as occupants of the site with or after its human occupants--does not necessarily imply climate different from that of today.

Beaver, which prefer bodies of water with adjacent stands of willow, cottonwood, alder, aspen, or birch, have been scarce in the Lower Klamath basin in recent years. In 1970, for instance, none were reported for Lower Klamath and Tule lakes, while Clear Lake supported only two and the marshy borders of Upper Klamath Lake, 10 (USDI 1970). These small numbers, however, seem to be a recent phenomenon. Maillaird (1927), for instance, noted 25 beaver on Willow Creek near Steele Meadows and Clear Lake in 1922, while Bailey (1936) noted that J.K. Lord described

Lower Klamath Lake in 1860 as supporting a large population of these animals. In earlier times, then, beaver seem to have been common in the Lower Klamath Basin, and their current low numbers are probably to be attributed to the modifications of Lower Klamath Lake detailed in Chapter 1.

The montane vole is found in sagebrush and sagebrush-juniper associations, most abundantly in the area of streams and marshes (Maser and Storm 1970). Active year-round, these voles are abundant in the Lower Klamath region today, where close watch is kept on their numbers because of the potential damage to agricultural crops which they represent (Forsell 1961; O'Neill, personal communication; Wunner 1964).

Finally, porcupines, which usually occupy areas of open timber, are relatively common today in the sagebrush-juniper around Lower Klamath and Tule lakes, as well as in the willows along the shores of Tule lakes, where the aquatic and semi-aquatic plants of the lake provide them with food (Forsell 1961; Lahr 1960; USDI 1970).

Carnivores

Coytes are very common in the Klamath Basin, holding their own against programs designed to eliminate them. Although their numbers seem to fluctuate from year to year, these animals are year-round residents of the Lower Klamath region. In the 1930's, for instance, some 500 to 700 were thought to be in the Lava Beds National Monument southeast of Lower Klamath Lake (Fisher n.d.), while all Narrative Reports note coyotes along the shores and adjacent uplands of Lower Klamath and Tule lakes. Indeed, in 1942, coyotes had even been sighted in the small islands in Tule Lake, islands which can be reached only by traveling through water (USDI 1942). Even though coyotes are year-round residents of the Lower Klamath area, their numbers reach two seasonal peaks: in August, when new young have become abundant, and in late fall and winter when the resident population is bolstered by arrivals of coyotes following migratory deer into the area (Forsell 1961).

Wolves at one time also ranged the sagebrush hills and plains east of the Cascades and Sierras. Unfortunately, however, these animals were exterminated over much of their Oregon and California range before reliable data on their distribution had been collected. Bailey (1936) felt that their presence in eastern Oregon was correlated with the presence of bison, a view which Seton (1909) held for the northern Plains, both pointing out that the disappearance of the bison was apparently accompanied by a similar disappearance of the wolf. In the area of Nightfire Island, no wolves have been sighted in recent years, although suitable habitat--open sagebrush hills--is certainly abundant. To the north, however, a wolf was killed in Sycan Marsh in 1927 (Bailey 1936), while Mailliard (1927) stated that four wolves had been sighted near Straw, southeast of Tule Lake. Earlier, in 1899, Bailey (cited in LBNM n.d.) had noted that "a few" had been seen south of Tule Lake. Thus, although wolves are no longer found in the Lower Klamath basin, there is little reason to believe that they were not present before their recent extermination by whites--a view with which Grinnell (1933) agrees.

In Oregon and California grizzly bears preferred flat to rolling areas interspersed with dense stands of trees. While in any area grizzlies may or may not be active during the winter, even hibernating grizzlies would be available to hunters, and their archaeological presence does not support inferences as to occupational seasonality (Storer and Tevis 1955; Bailey 1936; Seton 1929). Grizzlies have been exterminated in the Klamath Basin, although several records for areas peripheral to Lower Klamath Lake are available. These bears were known to occur on Goose Nest Mountain north of Mt. Shasta (Storer and Tevis 1955) while a single grizzly was killed in December, 1874 in the Swan Lake Valley east of Upper Klamath Lake (Bailey 1936). Newberry (1857, in Bailey

1936) further reported seeing grizzlies while traveling from the Pit River to the Klamath Basin. And, Storer and Tevis (1955) have pointed out that although there are no records for grizzly in the area, the lava beds of northeastern California would have provided both adequate shelter and ample food for this bear. Thus, the occupants of Nightfire Island would definitely have had access to grizzlies in the more forested regions to the northeast, north, and west of Lower Klamath Lake, while they may have had a second source in the lava beds to the south and southeast.

In the Lower Klamath basin, raccoons are commonly found along the permanent cattail-bulrush marshes of Tule and Lower Klamath lakes; they are similarly found in Hank's Marsh and Upper Klamath Lake, where they range into nearby pine forests. Raccoons were at one time more common along Tule Lake; as this lake was drained, the animals declined in number, a decline which has only recently been reversed (Bloch 1963; Brainerd 1941). Except for the areas immediately adjacent to Tule Lake, the Lava Beds National Monument contains neither suitable raccoon habitat nor raccoons.

Mink are rare in the Klamath Basin--none were seen along Lower Klamath and Tule lakes in 1970, for instance, although the cattail-bulrush marshes of Upper Klamath Lake and Hank's Marsh supported a sizeable population (some 75) in the same year (USDI 1970). In earlier years, however, mink were common along the Lower Klamath marshes (Grinnell et. al. 1937), and their reduction in numbers seems linked with subsequent disruption of their habitat. Indeed, Henshaw (1917) reported that large numbers of mink were killed during the Lower Klamath peat fires of the early 1900's.

Badgers, animals of dry, open country, are currently uncommon in the Klamath Basin. Recent surveys have not recorded these animals in the vicinity of Lower and Upper Klamath lakes, although the uplands surrounding Clear Lake supported about 30 in 1970 (USDI 1960, 1965, 1970). In the Lava Beds National Monument, badgers are found in the same general area as marmots, upon which they prey. Here, they make their first appearance in April and are last seen in mid-October (Forsell 1961); again like marmots, badgers are inaccessible during the winter in the Klamath Basin, and any animals found archaeologically in this area must represent individuals caught between spring and early fall.

Striped skunks are very common along Lower Klamath and Tule lakes, living in and utilizing the sage, grasslands, and marsh adjacent to these lakes (USDI 1970). Further south, they become rare, undoubtedly because of the lack of permanent ground water in the area, and the Lava Beds National Monument supports these animals primarily along its northern boundary with Tule Lake (Fisher n.d.; Forsell 1961). As might be expected, the well-watered zones north of Lower Klamath Lake-- for instance, the marshes of Upper Klamath Lake--also support sizeable striped skunk populations (USDI 1970).

River otters, once common in northern California, are now only rarely seen there (Grinnell 1933). Currently, they survive to the north of Lower Klamath Lake, living in the cattail-bulrush marshes of Upper Klamath Lake and Hank's Marsh. They are present but scarce in Lower Klamath Lake, and, apparently, absent in Tule Lake (USDI 1965, 1970). As with mink, there is little reason to doubt that otters were more abundant in the undisturbed marshes of Lower Klamath and Tule lakes in the past, since they are more common in similar habitat to the north.

Even though consistently persecuted, bobcats are relatively numerous in the Klamath Basin. In 1970, for instance, they were noted in the sagebrush, grasslands, and marshy areas surrounding Lower Klamath and Tule lakes, as well as near Upper Klamath Lake and in the adjacent pine forests (USDI 1970). South of Lower Klamath Lake, bobcats are common year-round residents in the Lava Beds National Monument, where, protected from hunters, they play an important role in regulating the Monument's rodents and lagomorphs (Forsell 1961).

Artiodactyls

Reports of elk in the Klamath Basin are rare, even though the Basin does contain suitable elk browse. Bailey (1936), for instance, notes that although there are ample records of elk along the western slope of the Oregon Cascades, there are no such reports for the east slope. In California, however, Murie (1951:22) reported elk "in the vicinity of Mt. Shasta," while Miller (1874)--whose reports may or may not be trustworthy--described a winter elk hunt in the same area. Reports of elk closer to Nightfire Island are even scarcer. In 1944, these animals were reported to be in the forests just north of Klamath Falls, while in December of that year a solitary bull was seen just north of Lower Klamath Lake (USDI 1944). Thus, it seems that although elk are rare in the Klamath Basin, they are not entirely absent, and it seems possible that severe winters might bring--or might have brought--groups or scattered individuals into the Basin. As elsewhere, increasing human occupation would have made the Klamath region decreasingly attractive for these animals.

Mule deer are environmentally tolerant animals, the several Californian subspecies ranging from the deserts of

Owens Valley to the dense, humid forests of the Coast Range. The large majority of northeastern California mule deer are Rocky Mountain mule deer (<u>Odocoileus</u> <u>hemionus</u> <u>hemionus</u>)--animals of the open sagebrush plains, open pine forests, and lava beds. This habitat corresponds to that in which mountain sheep used to live, and it will be argued below that the extermination of the bighorn in this area brought with it an increase in the mule deer population. The herd closest to Lower Klamath Lake--the Mt. Dome deer herd--usually summers in the Highlands some 15 to 20 miles south of the lake, moving down towards Lower Klamath Lake in the winter, augmenting the small resident population there. Although the numbers of animals utilizing the Lower Klamath region vary from year to year, some 50 to 100 animals seem to be present in all seasons. The mule deer population to the southeast is much greater: while the Mt. Dome herd numbers 800, three herds to the southeast and east--the Glass Mountain, Bryant Mountain, and Devil's Garden herds--consist of some 32,000 animals (Stutz and Ward 1966; Stutz, Ward, and Brough 1967; USDA 1964). Although many of these animals live far south and east of Tule Lake, the Lava Beds Monument, which supports a small resident herd of some 50 animals, is part of the main winter range for the Glass Mountain herd, and during these months some 500 to 4000 mule deer may be found on the monument (Bloch 1962; Cahalane 1951; Starr 1934). These impressive numbers are probably not accurate indicators of original mule deer densities in the area. Not only do mule deer seem to have benefited both from the extermination of mountain sheep and from the logging of forested areas, but many of their natural predators--coyotes and bobcats, for instance--have been reduced in number. Thus, the original mule deer population must have been smaller in size than that of today. Indeed, "According to reports of some early residents of the Modoc region...in the early days, fifty or so years ago, mule deer were not at all plentiful in the area...one could ride for a day without seeing a deer in regions where similar excursions today would reveal many of these animals" (Moffitt 1934:53).

It should be noted that while the deer herds mentioned above consist primarily of Rocky Mountain mule deer, there are a few Columbian black-tails (*O. hemionus columbianus*) in these groups. Black-tails are primarily animals of the dense forest and chapparal, but, with the changes brought about by their differing environmental adaptations, are similar to Rocky Mountain mule deer in general habits. I did not attempt to distinguish between subspecies of mule deer in the Nightfire Island collection, although such a distinction might be tenuously possible with the proper cranial elements (Dasmann and Taber 1956;

Hall 1927; Starr 1934; Stutz and Ward 1966; Stutz, Ward, and Brough 1967).

At one time, there were some 30,000,000 antelope in North America. There are now some 365,000, of which approximately 3000 are in northeastern California (Thayer 1970; Yoakum 1968). Although these few thousand must be a pale reflection of the original abundance of antelope in the area, the animals are nonetheless relatively common in the Lower Klamath region. There are currently two separate herds found in this area: the Dorris herd, numbering some 50 animals, located to the west of Lower Klamath Lake, and the Mt. Dome herd of some 200 or more animals, whose summer and winter range is just south of Lower Klamath Lake (O'Neill, personal communication; Starr 1934). Mt. Dome animals are frequently seen in the sagebrush just south of Lower Klamath Lake in both summer and winter months, often coming up to the southern edge of the lake for water or forage (USDI 1944, 1954, 1960, 1965, 1970). Antelope are rarely seen on the Lava Beds Monument. Occasionally during dry years, an individual will move east from the Mt. Dome herd down Gillem's Bluff, but such instances are uncommon (Starr 1934).

Mountain sheep were at one time spread throughout the western United States, living almost any place with available rough, broken, or craggy land and foraging both in these areas as well as in the more open plains, their habitat thus having much in common with that of mule deer (Bailey 1936; Grinnell 1928; McCann 1965; Ober 1931). The lava beds southeast of Lower Klamath Lake supported an apparently sizeable population of bighorn until the late 1800's, but a combination of factors--overhunting, competition with domestic sheep for food, and decimation by diseases caught from domestic competitors--led to the extermination of mountain sheep in all of northeastern California. In the Lower Klamath area, mountain sheep had become very rare by the late nineteenth century, the last known animal dying on the Lava Beds National Monument:

> It is not generally known but the last mountain sheep died on what is now the Monument in the winter of 1913. They summered on Mt. Dome and watered at Willow Creek on the Von Brimmer ranch under the west side of the mountain. Normally they wintered in the south half of T46N, R3E where the antelope now run. A severe winter would have put them down onto the "Little Lavas." Domestic sheep cleared out the Little Lavas (Monument) ahead of them in 1913, and too deep snow covered there [sic] normal range (T45N, R3E) so the last remnant starved to death (Starr 1934).

This quotation also summarizes much of what is known of the distribution of Mountain sheep in the Klamath Basin. The animals were apparently common near Mt. Shasta and inhabited all rocky areas to the east (Grinnell 1933; Merriam 1921), and, as noted, there are reports of mountain sheep summering in the vicinity of Mt. Dome, moving east to the Lava Beds during the winter. In this area, Tule Lake was used as a water source, as were the lava tube caves of the area, in which drinking water accumulated. In fact, Fisher (n.d.) reported that he had been told by "The Indians" that Indians (presumably Modoc) would wait by these caves, killing the animals with bow and arrow as they left them. Like other mountain sheep, these animals probably wandered some distance from rough ground, and it would be of interest to know how close and how often mountain sheep came to the area of Nightfire Island. Judging from their habits elsewhere, it is reasonable to assume that the sheep did make the short trip from the Lava Beds, or the closer Mt. Dome, along the ridges which led north to and beyond the western edge of Lower Klamath Lake--there is, for instance, a single record of mountain sheep being found north of Lower Klamath Lake (Jones 1950). It is, thus, possible that the inhabitants of Nightfire Island had mountain sheep wandering literally in their backyard. But immediately available or not, it is obvious that a short trip to the Mt. Dome area would have put the inhabitants of 4SK4 into an area which supports, or recently supported, sizeable herds of mountain sheep, as well as those of antelope and deer. Finally, it might be added that an effort to reintroduce mountain sheep to the

Lava Beds Monument was made in 1971, and has apparently been successful (Watson, personal communication).

Nightfire Island provided only one mammal which has never been recorded for the Klamath Basin--the bison. Although previously unrecorded for the area either archaeologically or historically, however, there are scattered reports of bison to the immediate east of the Klamath area. Thus, Bailey (1923) noted records of bison from the Malheur and Harney Lake area, while Merriam (1926) stated that his Achomawi and Atsugewi informants gave him what he felt to be reliable records for many of the arid valleys of Modoc and Lassen counties: Surprise, Alturas, Hot Springs, Horse Lake, Eagle Lake, Pine Creek, and Honey Lake valleys, and Madeline Plains. Bailey (1936) extended the Oregon finds to Warner Lake, and argued that the animals Merriam noted probably came from the Warner and Goose Lake Valleys. Finally, Riddell (1952) added ethnographic support to Merriam's contentions that there had been bison in the northeastern Californian valleys, and suggested that the western limit of bison range be extended at least in Lassen County to the crest of the Sierras. Thus, there are fairly numerous reports of bison to the immediate east of the Klamath Basin--indeed, if Bailey (1936) is correct in extending bison from Warner Lake through Goose Lake to the rest of northeastern California, this would put bison in historic Modoc territory. At any rate, this historic distribution implies that archaeological finds of bison in the Klamath Basin do not necessarily imply a climatic regime any different from that of today.

The dominant mammal in the Klamath Basin now is, of course, man, and there is little reason to doubt that his position in the Klamath Basin fauna was less significant prehistorically. When whites first entered the Klamath area, they found the Lower Klamath Basin occupied by the Modoc Indians, the Upper Klamath by the Klamath Indians. Although the precise boundaries of historic Modoc territory are not precisely known, it is clear that these people controlled the bulk of the land between Goose Lake on the east and the crest of the Sierras on the west, the northern boundary running along the Lost River, then north of Lower Klamath Lake but south of the Klamath River, while the southern boundary passed south of the bulk of the Lava Beds (see Figure 1). The Modoc thus had access to the varied Lower Klamath avian and mammalian resources outlined above. The use which they made of these resources has been detailed by Ray (1963), and there seems little reason to repeat that summary here. Although adequate lists of birds used by the Modoc are not available, Ray (1963) does provide such information for the mammals (see

Table 6). As shall be seen, the kinds of mammals utilized by the historic Modoc were similar indeed to the kinds of mammals utilized by the residents of Nightfire Island.

CHAPTER 3

THE METHODOLOGY OF FAUNAL ANALYSIS

Faunal analysis, defined as the identification and analysis of animal bones from archaeological sites, has a long history in archaeological studies, as even a quick review of the mid-nineteenth century establishment of the reality of early man in the Old World soon reveals. Nonetheless, it does seem true, as Olsen (1971) has pointed out, that it it only during the past few decades that it has become commonplace for at least brief faunal studies to be included in archaeological site reports. Certainly, very few recent site reports by competent investigators have ignored the paleoecological contributions which may be made by faunal analysis, although the attention paid to such analyses has varied from minimal (for instance, Sears 1956) to meticulous (for instance, Flannery 1967). Although historically important in archaeology, it has only been during the last 20 years or so that the methods used to conduct a faunal analysis have been given critical examination. Further, these critical studies have been somewhat limited in scope. Although much excellent attention has been given to the matter of identification of bones (for instance, Chaplin 1971; Cornwall 1956;

Olsen 1960, 1964, 1968), and almost equal attention given to the kinds of inferences concerning such matters as age, sex, and pathology which may be made from identified bones (see, for instance, Chaplin 1971 and contained references), relatively little emphasis has been placed upon the development of methods which would allow valid and reliable analyses of faunal material once single bones have been identified and studied. Although a number of methods for the analysis of animal bones from archaeological sites are in use, none have really been subject to detailed scrutiny as to their reliability and validity.

The most crucial decision which a faunal analyst must make once he is beyond the identification and interpretation of individual bones and is beginning the statistical analysis of his data concerns the choice of the proper unit to use in that manipulation. Of the several kinds of units which have been used, only two--the number of specimens and the minimum number of individuals--have gained much popularity.

It is certainly tempting to use the raw data of faunal analysis--the number of identified specimens per taxon--as the unit of statistical manipulation in faunal studies, and a number of analyses in both archaeology (for instance, Thomas 1969) and paleontology (for instance, Wilson 1960) have proceeded on this basis. Unfortunately, however, the use of the number of identified specimens can be criticized on a number of grounds. First, and most seriously, one never knows whether or not the units being so manipulated--individual bone fragments--are independent of one another, whether or not one bony fragment has precisely the same original referent as 10 or 20 or perhaps 100 or more other such fragments. Clearly, the probable interdependence among osteological specimens in an archaeological collection constitutes an overwhelming reason for defining and employing units which are necessarily independent of one another. Secondly, there is little doubt that the use of numbers of specimens alone, even were that use not confounded by the problem of interdependence of elements, simply does not provide as much information, and allow as many inferences, about a body of faunal material as does the use of minimum numbers of individuals. It is this fact, and not the more serious but generally undiscussed problem of element interdependence, that has led to the great popularity of the use of minimum numbers.

In part because of the problems associated with the use of the number of specimens as the analytic unit in faunal analysis, White (1953) advocated the use of an alternative unit, the minimum number of individuals, or as succinctly defined by Shotwell (1955:272), "that number of individuals which are necessary to account for all of the skeletal elements (specimens) of a particular species found in the site." White (1953a:397) determined his minimum numbers as follows:

> The method I have used in the studies on butchering technique is to separate the most abundant element of the species found (usually the distal end of the tibia) into right and left components and use the greater number as the unit of calculation. This may introduce a slight error on the conservative side because, without the expenditure of a great deal of time with small return, we cannot be sure all of the lefts match all of the rights.

It might be added that not only are archaeologists joined by some paleontologists in their use of minimum numbers (for instance, Shotwell 1955, 1958, 1963), but also that the use of minimum numbers by paleontologists greatly predates such use by archaeologists (Howard 1930; Howard and Miller 1940; Stock 1929).

Once introduced into the archaeological literature, the minimum number of individuals became the prime unit of manipulation in faunal analysis, with a few departures from White's original approach (for instance, the expenditure by Flannery (1967:157) of " 'a great deal of time with small return' to see if all the lefts matched all the rights." It should also be noted that while White (1953b) applied his definition of minimum numbers to clusters of faunal material derived from either entire single component sites or separate components of multi-component sites, Flannery (1967:157) applied that definition to "bones from a given natural level or zone at a particular site.") Shifts such as these are discussed below. This rapid rise in the popularity of minimum numbers in archaeological research is easily understood: not only does the manipulation of these units allow more detailed inferences to be made from a collection of osteological material than does the use of number of specimens per taxon alone, but minimum numbers can in turn be used as the basis of more elaborate techniques (for instance, Thomas 1971). And, it must be noted, the use of minimum numbers in faunal studies provides us with units which are necessarily independent of one another, and which may, therefore, be validly used in further statistical manipulation if other statistical requirements are met.

Although subject to widespread use, little critical attention has been given to the use of minimum numbers by archaeologists. Surprisingly, what no archaeologist employing faunal analysis seems to have realized is that variation in the way the concept of minimum numbers has been applied brings with it variation in the values of the resultant minimum numbers of individuals. And, examination of the literature reveals that there is no agreement (indeed, even no discussion) as to how minimum numbers are to be determined from archaeological data, given White's basic definition of those units. Specifically, there seems to be no set way of determining the clusters of faunal material within an archaeological site which are in turn used to define one or more "most abundant elements" and to calculate minimum numbers.

Certainly, the choices for determining such clusters are limited. One can, for instance, use all possible archaeological distinctions in grouping the data--that is, by first dividing the faunal material on the basis of stratigraphic breaks, and then secondly subdividing that material on the basis of the excavation units in which it was found. Next, these small clusters of faunal material, each representing one vertical unit cross cut by a horizontal one, are used in calculating minimum numbers according to White's definition (see, for instance, Cleland 1966, appendix C; Coe and Flannery 1967; Harris 1963). This method of defining analytic units, which I shall call the maximum distinction technique, yields a maximum account of minimum numbers of individuals.

If vertical excavation units are not felt to be a proper means of organizing faunal material into analytic groups, the calculation of minimum numbers might proceed by examining clusters of faunal material recovered in single strata or groups of roughly coeval strata without regard to the excavation unit in which they were found (see, for instance, Alexander 1963; Flannery 1967). This procedure will yield minimum numbers which are less than those determined by the first approach outlined above, yet more than those determined by ignoring both stratigraphic breaks and vertical excavation units.

A given amount of faunal material will obviously yield the smallest minimum number of individuals if all the material from the site is considered as a whole--that is, if both stratigraphic breaks and excavation units are ignored, and White's definition used to determine minimum numbers from the resultant single, large cluster of osteological remains. Permissable, perhaps, for those sites in which stratigraphy is totally lacking, calculation of minimum numbers in this fashion, which I shall call the minimum distinction method, would seem to violate some basic tenets of archaeological methodology where stratigraphy is present. Yet, examples of the use of this approach in both of these situations exist (see, for instance, Meighan (1959b) for an example in which stratigraphy is present, and Thomas (1971) for an example in which it is not.)

Thus, the minimum number of individuals calculated from a set of faunal material from an archaeological site will be affected by the way in which this material is grouped into the larger clusters from which minimum numbers are determined, and no less than three distinct approaches to such grouping seem to be in use. The possible consequences of these differences may easily be seen by applying the two most extreme of these approaches--the maximum and minimum distinction methods as defined above--to a single body of data.

Analysis of the mammalian faunal collection from the Panamanian site of Cerro Brujo provides an excellent illustration of the magnitude of difference which can result from the application of these differing methods to faunal data. Excavated by Olga Linares of the Smithsonian Tropical Research Institute, Cerro Brujo is located in the tropical forests of western Panama about two kilometers inland from the Atlantic shores of the Aguacate Peninsula, Bocas del Toro (Linares de Sapir 1971; Linares de Sapir and Ranere 1971). Although the site is actually a group of five "shell-midden clusters within an area roughly one kilometer in diameter" (Linares de Sapir 1971:32), the bulk of the Cerro Brujo material comes from the largest and most extensively excavated of these midden clusters, CA-3a.

CA-3a contains two successive occupations, the scantily represented earlier of which, of unknown age and duration, contained a very small mammalian fauna (some 13 identified elements) and which therefore will not play a role in the following analysis. The second occupation of CA-3a seems to have been quite short, six radiocarbon dates falling between A.D. 960 and A.D. 985 (Linares, personal communication), an occupational duration which, as Linares de Sapir (1971) has pointed out, corresponds closely to the length of habitation of modern Guaymi households in the same area. Although of short duration, this occupation yielded some 10,000 animal bones and bone fragments, as well as almost 20,000 potsherds, together with a modest stone artifact complement. It is the identified mammalian fauna from this second occupation which allows a clear demonstration of the variation in calculated minimum numbers of individuals which results from the application of the maximum and minimum distinction methods.

Table 7 presents the raw data for the ensuring analysis. This table shows the total numbers of identified elements, by element category, for each of the fourteen species of mammals identified from the later occupation of CA-3a.

Minimum numbers of individuals were first calculated from this material using the maximum distinction approach--that is, the bones were first grouped according to the 2 by 2 meter excavation square in which they were found, and then divided again according to the stratigraphic breaks within that square. Only then were minimum numbers of individuals calculated for each of the resultant clusters. This calculation--as well as that to be described below--followed Flannery's modification of White's minimum numbers: that is, I was careful to see that all lefts did match all rights as regards age and size. This approach resulted in the minimum numbers seen in Table 8.

Once minimum numbers had been determined using maximum analytic distinctions, I recalculated these values according to the minimum distinction approach. Thus, I treated the entire later occupation of the site as one large unit and derived minimum numbers by applying White's amended definition to this large body of faunal material (see Table 8). A rather large discrepancy between the values yielded by identical material using these two different methods is obvious. Figure 2 graphically portrays these differing results, while Figure 3, based upon the percentages provided in Table 8, demonstrates that differences remain even when the minimum number values are normed.

It might be objected that the differences seen in Figure 3 are not great and, furthermore, that the differences in minimum numbers yielded by the maximum and minimum distinction methods are on the order of those which might be expected if identical populations were sampled twice--that is, that the minimum distinction approach has simply provided us with a smaller sample of the same population sampled by the maximum distinction approach. To test the proposition that there are no significant differences between the results of the two approaches, the minimum number of individuals of all taxa were compared, by analytic approach, using chi square. To meet the expected frequency requirements of this test, those species whose observed minimum numbers for both techniques summed to less than five were combined (Didelphis, Mazama, Caluromys, Marmosa), providing a 2 x 11 contingency table. The resultant chi square value of 26.4 is highly significant ($p < .01$), indicating that the two sets of data are indeed significantly different.

These differences involve, of course, a shift in relative species abundance between the two approaches, a shift which may be seen by examining the fluctuation in interval sizes between species categories expressed as percentages. Figure 4 plots this fluctuation in interval size, the interval sizes themselves having been obtained by subtracting the appropriate percentages presented in Table 8 (for instance, the Dasyprocta-Agouti interval size for the maximum distinction approach is 26.7 %).

The fluctuations in relative interval sizes may or may not be great enough to bring about a change in ordinal abundance, or in the ranked orders of species. To test whether or not ranked orders as well as intervals had been affected by the analytic methods employed, I correlated the rank orders of species abundance as determined by the maximum and minimum distinction approaches using Spearman's rho corrected for ties. The coefficient obtained, 0.94, is highly significant ($p < .01$) and indicates that although some minor rearrangements of ordinal abundance have occurred, these rearrangements are not statistically significant.

The immediate implications of this analysis seem clear: minimum numbers of individuals when calculated according to different methods of grouping data are not necessarily comparable. Specifically, of the three kinds of measures examined here--absolute abundance, "interval scale" relative abundance, and ordinal abundance, only ordinal abundance seems to be unaffected significantly, in this instance at least, by shifts in analytic approach, while measures of absolute abundance and "interval scale" relative abundance may not be assumed to be validly comparable when such measures have been derived from differing methods of analyzing faunal material.

Finally, perhaps the clearest implication of the Cerro Brujo analysis is the need for a standardized approach to the manipulation of faunal data. Such a standardization should be easy to reach, since both the maximum and minimum distinction methods seem to contain major drawbacks for most faunal analyses. On the one hand, the minimum distinction approach ignores the stratigraphic breaks which occur in archaeological sites, and by so doing discards much of the information which these sites have to offer. On the other hand, the maximum distinction method utilizes a totally arbitrary mechanism, the excavators' separate excavation units, as a basis for determining minimum numbers and in so doing assumes that the remains of individual animals will not be distributed across several of these units. The remaining approach--that which ignores the boundaries of excavation units but utilizes those presented by stratigraphic divisions--thus clearly emerges as the best of the three methods for determining minimum numbers. There may, of course, be situations for which one of the other methods is clearly superior, and in such instances the researcher should certainly use that alternative method which seems most appropriate. But, in so doing, he should make the reasons for this choice explicit and most certainly should not discard any data which would allow a later reevaluation of his collection.

Given these suggestions, two methods of minimum number determination seemed plausible for the Nightfire Island avian and mammalian remains: 1) determining these values from the clusters of faunal material found in single strata, or, 2) making these calculations from clusters of faunal material coming from groups of roughly coeval strata. The first approach was rejected because of the nature of many of the 4SK4 stratigraphic divisions. In the field, data were collected according to the smallest visible strata, but, in retrospect, the reality of many of these strata is in doubt, while the depositional meaning of many others seems unclear. Since the use of these units as the basis of minimum number determination might involve serious overestimation of these numbers, it was decided to determine minimum numbers of individuals from clusters of faunal remains recovered from groups of roughly coeval strata. Such groups are provided by the 16 excavation levels, composed of strata whose broad contemporaneity was, as discussed in Chapter 1, established on the basis of geomorphological and cultural data.

Determination of minimum numbers proceeded as follows: the faunal material from all the strata within a single excavation level was treated as a single unit, and minimum numbers calculated from this cluster of osteological remains. As with the Cerro Brujo material, I used White's definition of minimum numbers, but, like Flannery, was careful to see that all lefts matched all rights as regards age and size. Because there are 16 excavation levels at 4SK4, there were 16 clusters each of mammalian and avian remains from which minimum numbers were thus determined. The information so derived forms the subject of the next chapter.

CHAPTER 4

THE AVIAN AND MAMMALIAN REMAINS FROM NIGHTFIRE ISLAND

Nightfire Island yielded 7403 identifiable avian and mammalian bones and bone fragments. Of these identified remains, 430 elements (224 avian and 206 mammalian) were located in strata which cannot at the moment be placed in the excavation level sequence derived for the site. The analysis of the remaining 5593 avian and 1380 mammalian specimens is presented in this chapter.

My approach for each class of remains is similar: first, certain aspects of identification are discussed, after which the inferences which the data seem to support are presented under three headings--seasonality, continuity and change in faunal utilization, and environmental implications. The avifauna are first examined in this fashion, then the mammals. Finally, the results of the avifaunal and mammalian analyses are combined to present a phase by phase description of Nightfire Island.

Avifauna

The identified avifaunal remains are summarized in Tables 9 through 15. In Tables 9 through 13 are shown the species identified for each phase as well as the number of specimens identified per bone type for those species. Table 14 shows the distribution of elements by species for each of the 16 excavation levels present at Nightfire Island. Finally, Table 15 presents the minimum numbers of individuals calculated from the raw data, by level and phase.

With one exception, all of the avian remains were scattered across the levels in which they were found. The single exception involves a golden eagle burial from level 9: almost the entire bird was represented, with the exception of the skull which may either have been removed before burial or simply not have been preserved. It should be noted that five of the six golden eagle elements in level 10 were associated with this burial and thus do not represent a separate individual from this lower level.

A few comments on the levels of identification achieved for the waterfowl are necessary. Although the identification of bird bones is often difficult, this difficulty is greatest--for the situation at hand, at least--with the waterfowl. Until recently, little work had been done concerning the osteology of these birds. Although Shufeldt (1909) made an impressive attempt at dealing with the comparative osteology of the birds as a whole, his efforts were largely based upon inadequate samples of avian skeletons, and many of his paleontological identifications have been questioned (see Howard 1946, for example). Indeed, Howard (1929), in her classic study of the Emeryville Shellmound avifauna, chose not to attempt to identify any of the waterfowl because of the inadequate nature of the available comparative material. Improving skeletal collections and increased interest have, fortunately, led to more detailed examinations of Anatid osteology, the most notable of which is Woolfenden (1961). Woolfenden's work--a discussion of the "Postcranial osteology of nearly all the genera of waterfowl of the world" (1961:1)--now stands as the basic reference for work with the comparative osteology of these birds. Woolfenden emphasized the extreme variability of many of the postcranial elements of many of the waterfowl and, with rare exception, my studies of large collections of restricted waterfowl taxa support his conclusions. Thus, while some of the Nightfire Island geese could be identified at least generically--*Branta canadensis canadensis* is easily recognized because of its great size, while the characters analyzed in Woolfenden (1961) and to some extent in Miller (1937) allow separation of some of the elements of the genus *Anser*--I found most of the geese impossible to place to this level. Elements which at first appeared identifiable almost always lost their distinctiveness when the number of comparative specimens was increased.

Similar strictures apply to ducks of the genus *Anas*. The difficulties involved in identifying different species of this genus are well discussed in Woolfenden (1961) (Woolfenden considers many of these different species to belong to different genera.) After studying large comparative collections of these birds, I decided that the only reliable identifications that could be made were those based upon size: both the mallards and teal are clearly distinct in this dimension, while all remaining, intermediate-sized ducks of the genus Anas--gadwall, pintail, baldpate, shoveller--were placed into a third category. Although in some instances the coracoids of birds in this group seemed to allow some degree of separation, I felt so uncertain about the reliability of this separation that I decided to merge them. Nonetheless, all four do seem represented in the collection.

The pochards, birds of the genus Aythya, presented similar problems. The canvasback was fairly easily separable, the bones of this diver being larger and more robust than those of other members of the genus. The real problem emerges with the separation of the remaining species. The most readily identified elements for these birds I found to be the coracoid, an element of the pectoral girdle. The coracoid of the closely related, and at times interbreeding (Delacour 1959; Mayr and Short 1970 question these records, however) lesser and greater scaups is characterized by a relatively poorly marked ridge of bone surrounding the furcular facet (see Howard 1929 for osteological terminology). In the redhead and ring-neck, this ridge is usually raised higher above the central part of the facet than it is in the scaups (and canvasbacks), so that while the central area of the facet is relatively wide in the scaups (and canvasbacks), it is relatively narrow in the redheads and ring-necks. The ring-neck can be separated from the redhead on the basis of the furcular facet, which is both narrower and shorter in the ring-neck than it is in the redhead. In this respect, the coracoid of the ring-neck approaches that of the dabblers (Anatini) more closely than does that of any of the other North American pochards. The greater and lesser scaups are extremely similar and, although the greater scaup tends to be more robust than the lesser, the overlap is so great that even though most of the scaup from Nightfire Island seem to be lessers, reliable separation does not seem possible.

I did not find the other elements of the genus <u>Aythya</u> to allow identification as reliable as that allowed by the coracoids. Indeed, the remainder of the post-cranial material fits very well with the scaups, especially with the lesser scaup. Ring-necks having been positively identified from the coracoids, however, it is undoubtedly true that some of the postcranial material recorded with the scaup comes from this bird. And, although no redheads were identified from the collection, it is most certainly possible that some have gone unnoticed among the non-coracoid pochard remains.

These considerations explain why, in Tables 9 through 14, the ring-necks are identified only by coracoids while the other identified pochards are represented by a full range of osteological material. Clearly, the figures indicated here are an overrepresentation of the number of scaup elements actually present. Fortunately, because coracoids are in almost every instance the most abundant element of *Aytha*, and thus played the major role in determining minimum numbers of individuals, these problems of identification should have minimal affect upon the avifaunal analysis.

Perhaps one final word of warning would not be out of place. It is common in archaeological reports to see ducks and geese identified not only as to genus but also as to species. While such identifications may be possible in areas where avifaunal diversity is not great--and this lack of diversity may be reasonably extended into the past--or with very large comparative collections, they are impossible when the comparative material consists of only one or a few individuals. Unfortunately, the smaller the comparative collection, the easier identification seems, though the more inaccurate it is likely to be. As the comparative collection increases in size, many identifications blur but those which remain have at least some degree of demonstrated reliability. A word of warning is thus needed for both those who attempt waterfowl identification, as well as for those who attempt to interpret the identifications of others.

Seasonality

It was emphasized in Chapter 2 that the Klamath Basin sees such heavy utilization by birds that only rarely is any one avian species found there during restricted months of the year only. As regards the avifauna from Nightfire Island, only six of the 34 identified species allow any statements concerning occupational seasonality at the site: 1) levels 6 through 13 and 15 contain horned grebe and, thus, evidence for human occupation between March and August; 2) whistling swans in levels 2, 8, 9, and 12 suggest an occupation between October and April for these levels; 3) an occupation between October and May is suggested by the presence of goldeneyes in level 12; 4) the snowy owl identified from level 7 provides evidence for at least a winter occupation at this time; 5) the presence of a herring gull in level 12 suggests an occupation between September and February for that level; 6) finally, levels 7, 9, 11, 12, 14, 15, and 16 yielded red-breasted mergansers, birds present in recent years as spring migrants but which may in the past have been present as fall migrants also, and which suggest spring or fall occupations for these levels.

Continuity and Change in Avifaunal Utilization

The utilization of the Lower Klamath Basin avifauna by the occupants of Nightfire Island shows strong continuity in general outline throughout the entire occupation of that site. This continuity may be seen by examining Table 16, which shows the relative abundance of the avian families present at 4SK4 by phase, and Figure 5, which plots these relative abundance figures through time. Most obvious, perhaps, is the high contribution to the avifaunal collection made by three avian families: the Anatidae (ducks, geese, and swans), Rallidae (represented at 4SK4 by the coots), and the Podicipedidae (grebes). These three families contribute 85 % or more of the total number of individuals of the avifaunal collection of each phase. When adjacent phases are compared using chi square on the basis of the distribution of their avifaunas into these three families these distributions are seen to be not significantly different from one another. The only significant difference which does occur is between phases 3 and 2 and involves not the three main avian families, but instead the fact that all other families are slightly overrepresented in phase 3 (where they form 4 % of the total number of avian individuals) and slightly underrepresented in phase 2 (where they account for 2 % of the avian individuals), representational shifts which are significant at the .01 level. This one significant difference, involving as it does only 28 individuals spread across 6 avian families in 2 different phases, would not seem to have meaning beyond implying a slightly greater emphasis upon grebes, coots, and waterfowl in phase 2 and a slightly greater emphasis upon other forms in phase 3. Strong continuity through time in the major groups of birds being utilized--ducks, geese, swans, grebes, and coots--as well as in the relative emphases placed upon these groups is thus characteristic of Nightfire Island.

Perhaps even more interesting than this continuity in the major kinds of birds being utilized is the continuity which may be seen in the bias which this utilization displays. It has been shown that the modern Lower Klamath avifauna is heavily weighted numerically in favor of non-diving waterfowl, these birds outnumbering their diving relatives by a yearly average of 20 to 1. If we assume these ratios to be indicative of past Klamath Basin conditions, then random samples of the waterbirds from earlier times should reflect these ratios.

Table 17 presents the non-diver/diver ratios for the

Nightfire Island waterfowl (Anatidae), by level. A persistent bias against non-divers is immediately evident. In only three levels--6, 8, and 9--do the non-diver/diver ratios approach the lowest modern monthly values, while in all other levels, every modern monthly ratio greatly exceeds those seen for Nightfire Island. Indeed, as will be seen below, levels 8 and 9 clearly do not represent summer occupations only, and comparisons between the ratios derived for these levels and those low values obtained for the summer months are not warranted.

Comparisons of modern and archaeological non-diver/diver ratios for waterbirds other than waterfowl will not help in defining similar biases for these other waterbirds because, as seen in Chapter 2, non-divers form such a small part of this component of the modern avifauna. Nonetheless, it does seem significant that at Nightfire Island these other waterbirds were represented only by divers, with the exception of three white pelicans and a single herring gull scattered through phases 3, 4, and 5. Although rare in comparison to their diving counterparts, non-diving waterbirds other than waterfowl are nevertheless present in sizeable numbers in the modern Lower Klamath Basin (see Table 5), and their almost total absence at 4SK4 would seem to result from the same bias against non-divers defined for the waterfowl.

Although diving waterbirds thus seem overrepresented throughout Nightfire Island, the magnitude of this over-representation varies through time, and these variations seem to provide a tool for analyzing past environmental changes in the Lower Klamath area. These shifts in bias may be seen by examining changes in both absolute numbers and relative abundance of avian forms through time.

Examination of the minimum numbers shown in Table 14 reveals that the two major categories of non-divers--the surface ducks and the geese--reach clear peaks in level 9, phase 3. Figure 6 plots the abundance of all non-divers by level, and demonstrates that these waterfowl reach their numerical peaks in levels 7, 8, and 9, phase 3. On the other hand, examination of the distribution of divers seen in Table 14 reveals that the grebes, coots, and diving ducks reach their peaks in levels 11 and 12, phase 2. Figure 7 plots absolute abundance of all divers by level, and shows the numerical peak reached by these birds in levels 11 and 12, phase 2.

Approached in more general terms, Table 17 shows the relative abundance of all non-diving and diving waterbirds, as well as all other birds, by phase, while Figure 8 plots this abundance. Not only is the preference for diving birds throughout the history of the site seen here, but also clearly shown is the break between phases 2 and 3 implied by the analysis of the absolute numbers of waterbirds.

While phase 3 sees the relative abundance of non-divers reach its height, phase 2 contains an avifaunal collection composed of some 94 % diving waterbirds! Importantly, Figure 8 also shows that phase 1, too, was characterized by an intense utilization of diving waterbirds--some 91 % of the individuals of the total avifaunal sample of this phase are divers.

While interpretations of this analysis are to be offered shortly, a summary of the evidence for continuity and change in the utilization of avifaunal resources by the inhabitants of Nightfire Island might be of some value. Although a total of 13 avian families are represented in the 4SK4 collection, 3 of these families--Anatidae, Podicipedidae, and Rallidae--provide well over 80 % of the total number of avian individuals in every phase, the differences in utilization of these families from phase to phase being statistically insignificant. The continuing use of these groups is accompanied by continuing bias in their use: throughout the history of the site, there is a strong bias towards diving birds and against non-divers, a bias which supports the picture of continuity suggested by the general pattern of avifaunal family utilization. Finally, even though these continuities exist, impressive changes in the importance of divers and non-divers through time may be demonstrated: while divers are always in the majority, the magnitude of this majority shifts through time, reaching impressive peaks in phases 1 and 2, declining in phases 3 and 4, and undergoing a modest upswing in phase 5. Each of these aspects of continuity and change in the utilization of the Klamath Basin avifauna will allow inferences as to cultural and environmental continuity in the Lower Klamath region.

Environmental Implications

The Nightfire Island avifauna allows inferences regarding two aspects of the prehistoric Lower Klamath environment. First, the kinds of birds being collected by the residents of 4SK4 allow statements as to the nature of the past vegetation of Lower Klamath Lake, and, second, the pattern of collection of those birds permits statements to be made concerning the changing depth of that lake.

Lower Klamath Lake is able to support huge waterfowl populations because of its extensive bulrush and cattail marshes and large supplies of aquatic vegetation and small fish. Almost all of the waterbirds present at Nightfire Island have as preferred habitat lakes with extensive tule or reed marshes, while either aquatic vegetation (Anatidae, Fulica) or small fishes (Podicipedidae) or both form the basis of these birds' diet (for the Anatidae, see Bent 1923, 1925; Dawson 1923; Delacour 1954, 1956, 1959; Grinnell and Miller 1944; Grinnell, Bryant, and Storer 1918; Johnsgard 1968; Kortright 1967; for the coots, see Bent 1926; Bailey 1917; Grinnell and Miller 1944; Grinnell, Bryant, and Storer 1918; Gullion 1953; for the grebes, see Bent 1919; Dawson 1923; Gabrielson and Jewett 1940; Grinnell and Miller 1944; Palmer 1962). Without these marshes, or without either extensive supplies of aquatic vegetation or food fishes, the nature of the Lower Klamath Lake avifauna would be greatly changed. Thus, the presence of abundant waterfowl, grebes, and coots throughout the almost 6000 year history of Nightfire Island strongly implies that the lake throughout this period of time has been characterized by the presence of bulrush-cattail marshes, luxurious growths of aquatic vegetation--such as pondweeds--and large numbers of small fishes. Finally, the presence throughout the history of the site of birds such as swans, pelicans (Grinnell and Miller 1944; Palmer 1962), and geese, as well as the pochards, which prefer lakes with large expanses of open water on which to rest or escape danger, implies that the expansive marshes indicated by much of the avifauna either lined the shores of, or were interspersed between, large bodies of open water, or both. For at least the past 6000 years, then, Lower Klamath Lake seems to have been characterized by luxuriant bulrush and cattail marshes, large expanses of open water, extensive supplies of aquatic vegetation, and many small fish. Great stability in the nature of the lake regarding these attributes is thus implied.

This stability as regards the presence of marshes, open bodies of water, and waterbird food supplies does not, of course, imply that other general attributes of the lake were not changing. An unchanging Lower Klamath Lake through 6000 years would be somewhat surprising, although the nature of whatever changes may have occurred might be difficult to discern with the avifaunal--or avifaunal and mammalian--materials alone. Nonetheless, the birds seem to allow some statements concerning changes in the depth of the lake through time.

A clear distinction in water depth preference may be made between ducks of the genus Anas and ducks of the genus Aythya. Ducks of the genus Anas feed either by dabbling, swimming along with their bill cutting through the water, or by tipping, remaining on the surface of the water but tipping the tail into the air in order to feed on the bottom. Because of their feeding habits, these ducks prefer relatively shallow water. Ducks of the genus Aythya, on the other hand, feed by diving--canvasbacks, for instance, will dive 30 or more feet beneath the water's surface for food. Because they are excellent divers and but rarely tip for food, these ducks prefer deeper bodies of water than do the dabblers (see references cited above for the Anatidae).

This relationship between the dabblers, divers, and water depth allows the inference that a decrease in dabblers and an increase in divers in samples collected from Lower Klamath Lake should represent an increase in water depth. Further, if this inferred relationship is correct, then other avian indicators of water depth should change accordingly. Specifically, an increase in water depth should bring with it an increase in the number of all diving waterbirds--for instance, loons, grebes, and mergansers--while a decrease in water depth should be accompanied by decreasing numbers of divers and increasing numbers of non-divers.

It is precisely these changes, of course, which were established in the preceeding section, and which may be seen in Figures 5, 6, and 7. These shifts--the tremendous importance of divers in phases 1 and 2 followed by a relative and absolute decline in their numbers and the rise in importance of non-divers in phases 3 and 4--seems to indicate that during phases 1 and 2, between approximately 4000 and 2200 B.C., Lower Klamath Lake had water levels deeper than those which it had during phases 3 and 4, between approximately 2200 B.C. and A.D. 1000, after which time the third shift in non-diver/diver ratios may imply a shift towards slightly deeper water levels. At the moment, at least, it is in this fashion that the changing ratios of non-diving and diving waterbirds seem best understood.

In short, the hypotheses which the Nightfire Island avifauna suggests are as follows:

1) throughout its approximately 6000 year history represented at 4SK4, Lower Klamath Lake has supported extensive marshes, presumably of cattail and/or hardstem bulrush;

2) throughout this period of time the lake has also supported luxuriant growths of other aquatic vegetation which in turn have provided food for the plant eating waterbirds, such as the dabblers, as well as large stores of small fish, which supported large numbers of such birds as mergansers and grebes;

3) the depth of Lower Klamath Lake has fluctuated through time, having been:

a) relatively deeper between 4000 B.C. and 2200 B.C.;

b) relatively shallower between 2200 B.C. and A.D. 1000; and,

c) apparently returning to slightly deeper levels between A.D. 1000 and 1400.

Each of these statements must be considered to be an hypothesis to be tested on the basis of all other pertinent available data. As regards the data from Nightfire Island itself, the mammalian, piscine, and minute reptilian and amphibian faunas, the pollen data, and the artifacts should all help in confirming or disconfirming these hypotheses. Of these several groups of data, only one--the mammalian fauna--has as yet been analyzed.

Mammals

The identified mammals are presented in Table 19 through 25. In Tables 19 through 23 are shown the species identified for each phase as well as the number of elements identified per bone category for those species. Table 24 shows the distribution of identified elements by species for each of the 16 Nightfire Island levels. Finally, Table 25 presents the minimum number of individuals calculated from the raw data, by level and phase.

The Nightfire Island mammals did not present problems of identification as serious as those provided by the birds. The canids proved most troublesome: although wolves were readily separable from domestic dogs and coyotes, the latter pair could be separated only with difficulty. With the fortunate exception of many of the mandibles and teeth, almost all of the dog and coyote remains were highly fragmentary. These fragmentary remains often were not reliably identifiable, although more complete specimens frequently were. The Nightfire Island dogs tended to be slightly more ruggedly built than the similarly sized coyotes, with slightly larger muscle attachments and more greatly curved long bones. using these characters, most of the fragmentary postcranial material was thought to represent dog. Assignment of the mandibles and teeth, which were usually readily identifiable using characters presented in such works as Allen (1920), Gidley (1913), and Lawrence and Bossert (1967), supported these identifications. Unassignable fragments are indicated in the tables as "Canis spp": these elements represent either coyote or dog, not wolf.

Seasonality

Of the 23 mammalian taxa identified from 4SK4, only two shed any light on occupational seasonality at this site: 1) the presence of badger in levels 5, 7, 9, and 16 argues for an occupation during spring and summer months for these levels; 2) the presence of marmots in levels 8, 9, 10, and 12 suggests an occupation during spring, summer, or fall months for those levels.

Continuity and Change in Mammal Utilization

Because the kind of quantitative data available for the modern avifauna of the Klamath Basin are not available for the mammals, matters of continuity and change in the use of the region's mammalian fauna by the occupants of Nightfire Island are more difficult to define than they are for the avifauna. Nonetheless, there do seem to be a number of ways in which these patterns may be defined.

Of the six mammalian orders currently found in the Klamath Basin, lagomorphs, rodents, carnivores, and artiodactyls were used by the occupants of Nightfire Island, while insectivores and the bats were apparently ignored. The pattern of utilization of these orders is stable: Table 26 shows the relative abundance of mammalian orders by phase, while Figure 9 plots these abundances. Although the fluctuations from phase to phase are greater than those seen for the avian families (since each of these avian families was the only representative of their respective orders at 4SK4, Figures 5 and 9 are comparable), the mammalian samples are also smaller, and chi square evaluation of the fluctuation of the minimum numbers of individuals upon which these relative abundances are based indicates that none of the fluctuations between adjacent phases are greater than those which would be expected by chance at even the .20 level of significance. Use of these large mammal groups thus remains stable through time.

Stability in the use of these large groups may or may not imply stability in the use of the individual taxa which make up these large groups. To test the proposition that the stability of entire orders through time was matched by stability in the use of the component taxa of those orders, I compared each possible pair of species (or genera, depending upon the level of identification reached) within each order by adjacent phases to see if these phases could be distinguished from one another by changing representation of specific taxa. All possible within-order combinations were tested either by Fisher's p (279 comparisons) or chi square (5 comparisons). Only two of the 284 species-pair comparisons were significantly different, both of these involving an overabundance of Spermophilus in phase 3--an overabundance which, it will be argued, is best understood as a natural, not a cultural, phenomenon. These non-significant relationships provide strong support for the assertion that use of mammalian species within orders remained stable from phase to phase.

Less meaningful is the comparison between kinds of mammals used historically by the Modoc and those used by the inhabitants of Nightfire Island. As we have seen, the Modoc used almost every larger animal of the Klamath Basin as food: it should not be surprising, then, that with five exceptions all of the Nightfire Island mammals were also taken by the historic Modoc.

Three of these exceptions seem of little significance. Although not reported as having been used by the Modoc, Spermophilus, Microtus, and Peromyscus are best understood in this context as being "natural" and not "cultural" bone (sensu Thomas 1971). Almost all of the *Spermophilus* material appears fresh and unstained, while, as will be shown below, the distribution of *Microtus* is significantly top-heavy--greatest in the upper levels of the site, decreasing rapidly towards the bottom. These facts suggest that the presence of these two forms is to be explained not by their having been utilized by the inhabitants of 4SK4, but instead by their having burrowed into that site while, or even after, it was occupied by humans. *Peromyscus* was probably present for similar reasons.

The other two exceptions are not so easily explained. The Modoc treated their dogs as pets, and would avoid eating them even in times of famine (Ray 1963). With rare exception, however, the Nightfire Island dog remains are fragmentary and are found scattered through the site in the same fashion as the other mammalian remains: there seems to be no reason to assume that these remains represent other than remnants of consumed animals.

The exceptions to this scattered distribution are as follows: 1) the clustered remains of a large, immature animal--radius, ulna, femur, tibia, calcaneus, metatarsal, and mandibular condyle--found in level 15, phase 1; 2) the remains of a very young pup--some 18 elements including cervical, thoracic, and lumbar vertebrae, ribs, scapula, humerii, femur, tibia, skull and mandible fragments, as well as various teeth--whose stratigraphic position within the site is not understood; 3) a fragmentary but essentially complete skull from level 9, phase 3; and, 4) a beautifully preserved skull also from level 9, phase 3. None of the other dog remains were accorded preferential treatment. The implication would seem to be that the Modoc aversion to eating dogs is late, post-dating the latest occupation of Nightfire Island at approximately A.D. 1400.

Although eastern North American Indians not only ate dogs but specifically raised them for that purpose, dog eating was not common west of the Rockies. Among the few tribes of the northwestern United States who did eat dogs, however, were the Achomawi and the Klamath, the southern and northern neighbors, respectively, of the Modoc (Driver and Massey 1957). Assuming that dog eating among the Klamath and Achomawi has some time depth, the Nightfire Island remains indicate that in protohistoric times this trait was spread from the Achomawi through the Modoc to the Klamath. Although it would seem futile to speculate about the source of the Modoc prohibition against eating dogs, it might be noted that the Modoc's eastern and western neighbors, the Shasta and the Paiute, did not eat these animals (Driver and Massey 1957).

The only other mammal taken by the Nightfire Islanders but not by the historic Modoc was the bison, present in phases 3, 2, and 1, 4000 B.C. to A.D. 0. These animals represent the only Bison bison reported from the Klamath Basin archaeologically or otherwise. Their presence, however, is not greatly surprising: as noted in Chapter 2, bison have been reported historically from many areas of eastern Oregon and California, including several valleys quite close to the Klamath Basin. Whether or not the Nightfire Island bison represent animals actually taken within the Klamath Basin, their presence does not necessarily imply a climatic regime greatly different from that of today.

The impression which the mammalian remains provide is one of the great stability through time in the utilization of the mammalian resources of the Klamath Basin. Phase to phase artifactual shifts are not accompanied by shifts in the use of the four mammalian orders which provided all of the mammal species taken by the Nightfire Islanders; indeed, there are almost no statistically significant shifts--and no culturally significant ones--from phase to phase in the pattern of use of the component taxa of these orders. Bison come and go but certainly the historic Modoc, who were so catholic in their use of their territory's mammalian fauna, would have taken bison were they present. And, dogs, never eaten by the historic Modoc, were eaten throughout the hsitory of the Nightfire Island, but this change does not seem a dramatic one, implying as it does that at one time the Klamath, Modoc, and Achomawi were more similar in this regard than they were at contact. Indeed, this late Klamath-Modoc divergence in dog eating might even be used to bolster the argument first forwarded by Gatschet (1890) that the political split between these two groups was relatively recent. The implications of the Nightfire Island mammalian remains, thus, are of strong continuity throughout the occupation of Nightfire Island in the utilization of the area's mammalian fauna.

Environmental Implications

The mammalian remains from Nightfire Island do not imply any great environmental changes in the Lower Klamath Basin during the past 6000 years. A modern mammalian fauna, with the exception of bison, was present during the earliest occupation of the site and, as noted, not even the bison, which are gone by A.D. 0, necessarily imply a climatic regime much different from that of the present. Within-order patterns of mammal representation remain very stable and would seem to imply corresponding environmental stability. All of this does not necessarily mean, of course, that the environment was not changing through this period of time, but implies instead that if the Klamath Basin environment was changing, these changes were not such as to be reflected in the use made of the area's mammals by the inhabitants of

Nightfire Island. The hypothesis forwarded on the basis of the avifaunal data, that the period of time between 4000 B.C. and 2200 B.C. in the Lower Klamath area was a period of increased depth of Lower Klamath Lake is thus neither confirmed nor disconfirmed by the mammalian data: it is simply not tested by them. While the lake depth may have been changing, whatever was causing these changes did not greatly affect the use made of the area's mammals by the Nightfire Islanders.

A few other comments concerning the mammalian remains may be made. First, a superficial examination of the minimum numbers provided in Table 26 might suggest that mammal utilization was most intense during phase 3, with these animals of less importance before and after that time. To test whether or not this was, indeed, the case, I computed expected numbers of mammals for each phase. This I did by estimating the duration of each phase in years from the radiocarbon dates; where these dates indicated one phase ending before another started, I assumed occupational continuity, and placed the temporal division of the two phases at the midpoint of the gap indicated by the C^{14} dates. The latest occupation of the site was placed at A.D. 1400. Phase lengths so calculated were as follows: phase 1, 1100 years; phase 2, 700 years; phase 3, 2150 years; phase 4, 1250 years; phase 5, 400 years.

Expected numbers of individuals for each mammalian order, by phase, were calculated on the basis of these durations, an approach which assumed continued and equally intense occupation throughout the history of the site. Chi square values for each of the resultant 20 cells (four orders cross-cutting 5 phases) were then calculated. These values indicated that in every instance the peak in numbers seen in phase 3 is the result of the proportionately greater amount of time covered by that phase, and not of any greater use of mammals made during that time. Further, the observed values of the lagomorphs and artiodactyls were found not to differ significantly, at the .05 level, from expected values throughout the history of the site. Significant differences were, however, found for the rodents and carnivores. For the rodents, these differences result from the top-heavy distribution of Microtus, a distribution which I have already argued is a natural, not cultural, one. The deviations observed for the carnivores, significant at the .05 but not the .01 level, are caused by a slight under-representation of carnivores in phase 4 and a slight over-representation in phase 2. Calculation of expected values for each species of carnivore reveals that these differences are caused by the accumulation of slight positive or negative deviations for each taxon. I have no explanation for these deviations, nor do I consider them to have cultural or environmental significance.

Finally, the distribution of mountain sheep, deer, and antelope at Nightfire Island is of some note since the numbers of individuals of these animals are almost identical throughout the history of the site. As mentioned in Chapter 2, mountain sheep became extinct in the Klamath Basin in 1913; the Nightfire Island data confirm the hypothesis forwarded on ecological grounds that in prehistoric times mountain sheep were plentiful in the Klamath Basin, their later demise being associated with, but not caused by, an increase in the numbers of deer in this region.

A Summary of the Avian and Mammalian Remains

Phase 1: 4000 B.C.--3000 B.C.

By the earliest occupation of 4SK4 the basic pattern of exploitation of avian and mammalian faunas had been set. Both the four mammalian orders and three avian families which together provided almost all of the birds and mammals represented in each phase of the site were being used in ways which were not drastically changed in later times. The pattern of selecting for diving waterbirds had already been established, while the great preponderance of these birds, even given this bias, implies that Lower Klamath Lake was relatively deep at this time. Within mammalian orders, the basic pattern of use of mammalian taxa was set, even the use of dogs as a food source having begun. Bison were present. Seasons of occupation cannot be firmly established: the presence of badger in level 16 implies at least a summer occupation for this level, red-breasted mergansers in level 15 implies at least a spring or fall occupation at this time, and horned grebes in levels 13 and 15 imply an occupation between spring and early fall for these levels. Neither year-round nor restricted season occupation can, however, be definitely established from the mammalian and avian data for any of the levels of phase 1.

Phase 2: 3000 B.C.-2200 B.C.

The pattern of avifaunal and mammalian utilization begun in phase 1 continues in phase 2. The same three avian families provide almost all of the avian taxa identified for phase 2, while the pattern of utilization of mammalian orders continues unchanged. Diving birds are still being selected for; their great abundance implies continuing high water levels for Lower Klamath Lake. Within-order utilization of mammals continues essentially unchanged from phase 1; bison are still present. Carnivores are present in numbers greater than those predicted on the basis of the duration of this phase, but this overrepresentation does not seem culturally or environmentally significant. Year-round residence for level 12 is suggested by the presence of marmots and whistling swans; the further presence of goldeneyes, horned grebes, red-breasted mergansers, and a herring gull in this level provides ample confirmation for this proposition. The presence of horned grebes and red-breasted mergansers in level 11 suggests occupation in at least spring, summer, and fall, but year-round residence cannot be ruled out.

Phase 3: 2200 B.C.-A.D. 0

The same four mammalian orders and three avian families continue to provide almost all of the mammalian and avian resources during phase 3. Within mammalian orders, there are no significant differences in mammal utilization from phase 2; between orders, there are no significant departures from expected values. Bison are still present. Within avian families, the bias towards diving birds continues, but there is a great shift within this pattern: while divers are still preferred, the number of non-divers increase sharply from earlier levels implying, it is hypothesized, a decrease in the level of Lower Klamath Lake at this time. Nonetheless, the still-present bias towards divers and the strong similarities in mammal utilization suggest strong continuity from phase 2. As regards seasonality of occupation, the presence of marmots in level 10 suggests an occupation between spring and fall months, a suggestion not contradicted by the presence of horned grebes here; winter occupation is not, of course, ruled out. The combination of marmots, badgers, horned grebes, and red-breasted mergansers with whistling swans suggests a year-round occupation for level 9. The presence of whistling swans, horned grebes, and marmots in level 8 likewise suggests a year-round occupation for this level. Finally, the combination of badgers, marmots, horned grebes, and red-breasted mergansers with whistling swans and a snowy owl in level 7 also suggests a year-round occupation for this level.

Phase 4: A.D. 0-A.D. 1000

The same mammalian orders and avian families continue to provide almost all of the avian and mammalian remains. Within-order utilization of mammalian taxa is not significantly different from the preceeding phase, although bison are now absent. Calculations based upon the duration of this phase show a slight underrepresentation of the carnivores, again not judged culturally or environmentally significant, and an overrepresentation of the rodents caused by the burrowing activities of montane voles. The bias towards diving waterbirds continues, although non-divers continue to be much more abundant than they were in phases 1 and 2; lake levels similar to those in phase 3 and lower than those in phases 1 and 2 are hypothesized. The patterns of mammalian and avifaunal exploitation are very similar to those seen in phase 3, and suggest strong adaptational continuity of the Nightfire Islanders to the Lower Klamath Basin. Evidence for the seasons during which the levels of phase 4 were occupied is slight: horned grebes in level 6 suggest an occupation at least between spring and fall, while the presence of badgers in level 5 imply at least a summer occupation. No other mammalian or avian seasonal indicators are present for any of the levels of phase 4.

Phase 5: A.D. 1000-A.D. 1400

The same mammalian orders and avian families continue to provide almost all of the mammalian and avian taxa utilized by the inhabitants of Nightfire Island. Patterns of within-order mammal use do not change significantly; between orders, the overabundance of rodents due to the relatively large numbers of *Microtus* continues, but no other significant deviations from expected numbers of individuals are seen. Diving waterbirds are still being selected for, while the number of non-divers begins to decrease in the face of an increase in divers. Increasing water levels may be implied. Again, these patterns of avian and mammalian utilization suggest strong continuity from the preceeding phase. There is no evidence for the seasons during which level 1 was occupied; the presence of a whistling swan in level 2 suggests an occupation at least between the fall and spring months for this level. No other avian or mammalian seasonal indicators are present.

CHAPTER 5

CONCLUSIONS

Rather than repeat any of the conclusions reached above, I would like to discuss instead the broader implications which these statements seem to have concerning both the postglacial climatic history of the Great Basin and the nature of prehistoric human adaptation in this area.

Postglacial Climatic History in the Lower Klamath Basin

Perhaps the most interesting aspect of the mammalian and avian remains from Nightfire Island involves the hypotheses concerning changing lake depths in the Lower Klamath Basin suggested by the avifauna. These hypotheses contradict traditional interpretations of postglacial climatic history of the desert West.

These traditional interpretations are, of course, based upon the work of Antevs (1948, 1952, 1955) who argued that the postglacial climatic history of the Great Basin and adjoining areas could be understood in terms of three major climatic ages: 1) the Anthermal, 7000 B.C. to 5000 B.C., characterized as being subhumid and semiarid with Great Basin lakes higher than during the Medithermal, and during which the climate was at first similar to that of today but then began to grow warmer; 2) the Altithermal, 5000 B.C. to 2500 B.C., which was distinctly hotter and drier than the present, and marked by the disappearance of the Great Basin lakes; and, 3) the Medithermal, 2500 B.C. to the present, which was arid and semiarid, moderately warm, and which saw the return of the Great Basin lakes desiccated during the Altithermal.

Antevs' model of postglacial climatic history has been accepted by most, rejected by some. While Baumhoff and Heizer (1965) review Antevs' scheme as well as reactions to it, it may be noted that most recent opinions concerning this model involve: 1) agreement with Antevs (for instance, Baumhoff and Heizer 1965; Cressman 1956; Willey 1966), or, 2) disagreement with Antevs, with insistence upon climatic stability through postglacial times, although conceding the probability of minor climatic fluctuations (for instance, Aikens 1966; Jennings 1964, 1968), or, 3) disagreement with Antevs, with insistence that the Altithermal was wetter than the present (Martin 1963a, 1963b) or that the Altithermal was at first dry but later became wetter (Malde 1964).

In this light, my hypotheses concerning shifts in Lower Klamath Lake depths may be restated in terms of Antevs' postglacial climatic ages. These postulated changes in Lower Klamath Lake depth involved: 1) relatively high lake levels during the late Altithermal (4000-2200 B.C.); 2) lower lake levels during the bulk of the Medithermal (2200 B.C.-A.D. 1000); and, 3) possibly slightly higher lake levels in very late Medithermal times (post A.D. 1000). These hypothesized changes suggest that in the Lower Klamath Basin at least the last half of the Altithermal was wet, not dry, and that Medithermal lake levels were actually lower than those of the Altithermal.

Earlier pertinent research in the Lower Klamath Basin operated under the assumption of the reality of a hot and dry Altithermal and reached conclusions at odds with those just presented. Cressman (1940, 1942) excavated sites in both the Narrows to the north of Lower Klamath Lake and Laird's Bay at the southern end of the lake. While cultural material apparently associated with extinct fauna in the Narrows would seem to predate the period of time during which Nightfire Island was occupied, artifacts from the Laird's Bay site were placed by Cressman (1942, 1951) at between 5000 and 4000 B.P., roughly coeval with 4SK4 phase 2. These artifacts were found in situ in lake-deposited peat, a situation which led Cressman (1940, 1942) to hypothesize that they had been deposited here at the end of the Altithermal on peat exposed by Altithermal lake desiccation, but after the lake had begun to refill; this reasoning, of course, led him to assign the Laird's Bay site the dates noted above. Whether or not the Laird's Bay site actually does provide evidence for a hot and dry Altithermal will be considered shortly.

Cressman's work in the Lower Klamath region included pollen studies conducted by Hansen--the earliest such studies conducted in conjunction with archaeological work in the Northwest, as has been pointed out (Cressman 1942). Hansen (1942, 1947) analyzed a series of pollen profiles from the Klamath Basin, including one from the Laird's Bay site and two from the Narrows locale, concluding from these profiles that there had, indeed, been a hot and dry Altithermal in the Klamath Basin. In fact, Hansen (1947: 122) went so far as to argue that "between 8,000 and 4,000 years ago, the drouth became severe enough to dry up Lower Klamath Lake and make that uninhabitable," and that it was only at the very end of this period that human reoccupation of Lower Klamath Lake occurred. Nightfire Island clearly shows, of course, that between 6000 and 4000 B.P., at least, Lower Klamath Lake neither dried up nor ceased to support human life. But Hansen's apparently incorrect assertion concerning the disappearance of Lower Klamath Lake is not as important as are the pollen profiles which he interpreted as providing the evidence for that assertion.

Hansen's interpretation of the Lower Klamath profiles were based primarily upon the changing frequencies of yellow and white pine which these profiles seemed to indicate. At Laird's Bay, for instance, yellow pine increased from the base of his profile from representing some 30 % of the total collection to a maximum of about 65 % approximately one foot beneath the "artifact horizon" then decreasing to some 35 % at the top of the profile. (Hansen 1947: 103, Fig. 6 is misleadingly labeled: the "artifact horizon" is placed next to the yellow pine maximum when in fact reference to Hansen 1942 shows that it should have been placed next to the 40 % yellow pine figure two 6" strata above it). White pine fluctuated in frequency at the beginning of the profile, decreased to a minimum in the same level that yellow pine reached its maximum, and then increased again. The frequency of lodgepole pine fluctuated from level to level, these fluctuations being felt to be of little climatic significance (Hansen 1942).

The correspondence of the yellow pine maximum with the white pine minimum just beneath the artifactual level led Hansen (1947:117) to consider this as reflecting the Altithermal: "In the Lower Klamath profiles the expansion of yellow pine to its maximum at stratigraphic positions that can reasonably be assumed to have been synchronous marks its response to the climatic maximum. A parallel decline of white and whitebark pine is consistent with this recorded trend." This peak thus became the Altithermal, dating to between 8000 and 4000 B.P., while Cressman's dating of the Laird's Bay artifacts as very late Altithermal was at the same time confirmed.

Hansen interpreted his pollen record as confirming Antevs' hypothesis and then used that hypothesis to date his sequence. The circulatory of this approach should be obvious, as should the fact that Hansen's pollen sequences aren't really dated at all. Until reestimates of the dates of Hansen's profiles are made, the temporal position of his yellow pine maximum-white pine minimum simply will not be known.

Unfortunately, such a reestimate cannot be accurately done at the moment, although two somewhat poor clues as to these dates are available. First, Hansen (1947) noted that the absence of Mazama pumice in his Lower Klamath profiles might imply a post-Mazama eruption date for these sequences. Since the Mazama eruption is now dated to 6600 B.P. (Wilcox 1965), a post-eruption basal date for the Lower Klamath profiles would strongly indicate a post-Altithermal date for the upper levels of these deep profiles, including the white and yellow pine concordant shift. Since, however, it is also possible that lenses of Mazama pumice were present in the deposits which gave Hansen his profiles but were missed during the coring process, the meaning of the lack of pumice in these profiles becomes equivocal.

The second clue to the age of Hansen's pollen profiles is the age of the Laird's Bay artifacts. Cressman (1942, 1951) estimated these to be 5000 to 4000 years old, but this estimate was based upon the assumption of the reality of the Altithermal, an assumption I would like to avoid. Other workers who have estimated the age of the Laird's Bay material have placed it between 2000 B.C. and A.D. 0 (Bennyhoff 1958; Meighan 1959a), which would date that occupation to the same period of time as the lowered Lower Klamath Lake levels which I have hypothesized. Such a date would also shift Hansen's pollen sequences upwards in time. Indeed, the fact that "the occurrence of the yellow pine maximum near the artifact horizon chronologically correlates these two phases of evidence" (Hansen 1947:117) could be considered as confirming my hypothesis that the Lower Klamath Lake levels declined after 2000 B.C. if Bennyhoff and Meighan are correct in assigning the Laird's Bay artifacts dates younger than those assigned them by Cressman. Unfortunately, however, because the Laird's Bay artifacts simply are not well dated, this evidence too becomes equivocal.

For many reasons it might be best to regard Hansen's profiles as disconfirming neither my hypotheses nor those of Antevs. Certainly, temporal control over these profiles is totally lacking and the yellow pine maximum-white pine minimum might easily date to either before or after 2500 B.C. More importantly, Hansen's critical assumption that an increase in yellow pine pollen means an increase in aridity might be questioned: in the Lava Beds National Monument, a recent retreat of yellow pine from lower elevations was associated at least in part with a decrease in rainfall--that is, drought reduced, not increased, the amount of yellow pine southeast of Lower Klamath Lake (Lahr 1960). This leads me to question Hansen's interpretation of a yellow pine increase as implying increased aridity.

Further, the correlation of increasing yellow pine with decreasing white pine is one based upon the changing percentages of these two species. As Martin and Gray (1962) have pointed out, such correlations are often spurious: because of the nature of percentages, an increase in the relative frequency of one species must bring about a relative decrease of other species, whether or not the absolute abundance of these other species has changed. Thus, Hansen's all-important correlation of the yellow pine maximum with the white pine minimum may be a statistical artifact and not a function of changing climate.

Even more crucial, perhaps, are the difficulties involved in identifying species of pine from their pollen. Martin and Gray (1962), for instance, note that such identification simply does not seem possible with present knowledge. Indeed, Flint and Deevey (1951) questioned Hansen's pine pollen identifications quite some time ago. If we toss out Hansen's specific identifications and attempt to deal only with fluctuations of the genus Pinus we encounter the problem which Martin and Mehringer (1965) have noted: increases in pine pollen might seem either an increase in pine or a decrease in local ground cover. Such interpretational problems greatly obscure the meaning of Hansen's pollen profiles.

For all these reasons, then, Hansen's pollen sequences not only cannot be used to falsify my hypothesis that at least the last half of the Lower Klamath Altithermal was wet, but also cannot be used to disconfirm Antevs' alternate hypothesis. And, the Laird's Bay artifacts do not challenge either hypothesis because they remain undated. Indeed, Hansen (1942) pointed out that factors totally unrelated to climatic change could have accounted for the exposure of the lake floor in the vicinity of Laird's Bay, and thus even accurate dating of the Laird's Bay site might not help resolve the conflict between alternative hypotheses concerning the Lower Klamath Altithermal.

As it stands, the Nightfire Island avifauna allows the hypothesis that Altithermal Lower Klamath Lake levels were higher than Medithermal ones, and that at least the last half of the Lower Klamath Altithermal was wet, not dry.

The same data that suggest this hypothesis also disconfirm the contentions of Antevs and others that the Lower Klamath Basin Altithermal was hot and dry.

Prehistoric Human Adaptation in the Lower Klamath Basin

Much less can--and should--be said from the mammalian and avian remains alone about the nature of the adaptation of the residents of Nightfire Island to the Lower Klamath region. Not until the artifacts are analyzed and understood and the remainder of the faunal collection--fish, reptiles, and amphibians--studied can many meaningful statements be made concerning the adjustment of the Nightfire Islanders to their prehistoric environment. And even when the total collection of faunal, floral, and artifactual remains from this one site have been studied, statements concerning past human lifeways in this area will be both tentative and partial until a full range of sites for each phase representative of the full range of human activities carried on during that phase have been identified and excavated.

Nonetheless, the 4SK4 mammalian and avian remains do support a few general statements concerning the use of Lower Klamath resources by the occupants of Nightfire Island. Most obviously, the initial occupation of the site at approximately 4000 B.C. saw an extensive utilization of the mammalian and avian taxa supported by a marsh and lake ecosystem. The earliest levels of the site see the use of both diving and non-diving waterbirds as well as of mammals whose prime association is with permanent water sources (for instance, *Castor*, *Procyon*, *Mustela*, *Lutra*). Never during the history of the site did avian taxa other than water and shore birds become numerically important. And, while the use of mammals whose prime association is not lakeshore (for instance, *Taxidea*, *Cervus*, *Odocoileus*, *Ovis*) had also begun by or soon after the initial occupation of the site, it was shown in chapter 2 that in no instance would the occupants of Nightfire Island have had to travel far from their lake and marsh environment to obtain any of the animals. Finally, well established is the point that while aspects of this adaptation to a lake and marsh ecosystem change through time, the fact of such an adaptation does not. Although a restricted view of the past, the total impression imparted by the 4SK4 avian and mammalian remains is thus one of very great stability in adaptation by the residents of Nightfire Island to the Lower Klamath Lake and marsh ecosystem through almost 6000 years of time.

APPENDIX

TECHNICAL AND COMMON NAMES OF BIRD AND MAMMAL FAMILIES, GENERA, AND SPECIES MENTIONED IN TEXT

(Taxonomy after Delacour 1959; Mayr and Short 1970; Miller and Kellogg 1955; Hall and Kelson 1959)

North America

Birds	
Gaviidae	loons
Gavia immer	common loon
Podicipedidae	grebes
Podiceps auritus	horned grebe
Podiceps nigricollis	eared grebe
Aecmophorus occidentalis	western grebe
Podilymbus podiceps	pied-billed grebe
Pelecanidae	pelicans
Pelecanus erythroryhnchos	white pelican
Phalacrocoracidae	cormorants
Phalacrocorax auritus	double-crested cormorant
Ardeidae	herons
Botaurus lentiginosus	American bittern
Nycticorax nycticorax	black-crowned night heron
Ardea cinerea (=*herodias*)	great blue heron
Anatidae	ducks, geese, swans
Anserini	swans, geese
Cygnus cygnus (=*buccinator*)	trumpeter swan
Cygnus columbianus	whistling swan
Anser albifrons	white-fronted goose
Anser caerulscens	snow goose
Anser rossii	Ross' goose
Branta canadensis canadensis	Canada goose
Branta canadensis minima	crackling goose
Cairinini	perching ducks
Aix sponsa	wood duck
Anatini	dabbling ducks
Anas americana	baldpate
Anas strepera	gadwall
Anas crecca (=*carolinensis*)	green-winged teal

Anas platyrynchos	mallard
Anas acuta	pintail
Anas discors	blue-winged teal
Anas cyanoptera	cinnamon teal
Anas clypeata	shoveller
Aythyini	pochards
Aythya valisineria	canvasback
Aythya americana	redhead
Aythya collaris	ring-neck
Aythya marila	greater scaup
Aythya affinis	lesser scaup
Mergini	sea ducks
Bucephala albeola	bufflehead
Bucephala clangula	goldeneye
Mergus cucullatus	hooded merganser
Mergus serrator	red-breasted merganser
Mergus merganser	American merganser
Oxyurini	still-tailed ducks
Oxyura jamaicensis	ruddy duck
Accipitridae	hawks, eagles
Aquila chrysaetos	golden eagle
Haliaetus leucocephalus	bald eagle
Circus cyaneus	marsh hawk
Tetraonidae	grouse
Cetnrocercus urophasianus	sage grouse
Rallidae	rails, coots
Fulica americana	American coot
Charadriidae	plovers
Charadrius vociferus	killdeer
Laridae	gulls and terns
Larus argentatus	herring gull
Strigidae	owls (part)
Bubo virginianus	great horned owl
Nyctea scandiaca (=nyctea)	snowy owl
Asio flammeus	short-eared owl
Corvidae	crows, ravens, jays
Corvus corax	raven
Mammals	
Soricidae	shrews
Sorex vagrans	vagrant shrew
Sorex palustris	water shrew
Sorex trowbridgii	Trowbridge's shrew
Sorex merriami	Merriam's shrew
Talpidae	moles
Scapanus latimanus	broad-footed mole
Vespertilionidae	Vespertilionid bats
Myotis lucifugus	little brown Myotis
Myotis yumanensis	Yuma Myotis
Myotis evotis	long-eared Myotis

Myotis thysanodes	fringed Myotis
Myotis volans	long-legged Myotis
Myotis californicus	California Myotis
Lasionycteris noctivagans	silver-haired bat
Eptesicus fuscus	big brown bat
Lasiurus cinereus	hoary bat
Corynorhinus townsendii	Townsend's big-eared bat
Antrozous pallidus	pallid bat
Molossidae	free-tailed bats
Tadarida brasiliensis	Brazilian free-tailed bat
Ochotonidae	pikas
Ochotona princeps	pika
Leporidae	rabbits and hares
Sylvilagus nuttalli	Nuttall's cottontail
Lepus americanus	snowshoe rabbit
Lepus californicus	black-tailed jack rabbit
Sciuridae	squirrels and relatives
Eutamias minimus	least chipmunk
Eutamias amoenus	yellow-pine chipmunk
Eutamias townsendii	Townsend's chipmunk
Marmota flaviventris	yellow-bellied marmot
Spermpohilus beldingi	Belding's ground squirrel
Spermophilus beecheyi	California ground squirrel
Spermophilus lateralis	golden-mantled ground squirrel
Tamiasciuris douglasii	Douglas' squirrel
Glaucomys sabrinus	northern flying squirrel
Heteromyidae	Heteromyids
Perognathus parvus	Great Basin pocket mouse
Dipodomys heermanni	Heermann's kangaroo rat
Castoridae	beavers
Castor canadensis	beaver
Cricetidae	Cricetids
Reithrodontomys megalotis	western harvest mouse
Peromyscus crinitus	canyon mouse
Peromyscus maniculatus	deer mouse
Peromyscus boylii	brush mouse
Peromyscus truei	pinon mouse
Onychomys leucogaster	northern grasshopper mouse
Neotoma fuscipes	dusky-footed wood rat
Neotoma cinerea	bushy-tailed wood rat
Microtus montanus	montane vole
Zapodidae	jumping mice
Zapus princeps	western jumping mouse
Erethizontidae	porcupines
Erethizon dorsatum	porcupine

Canidae	wolves, coyotes, dogs, foxes
Canis latrans	coyote
Canis lupus	wolf
Canis familaris	dog
Vulpes fulva	red fox
Urocyon cinereoargenteus	gray fox
Ursidae	bears
Ursus americanus	black bear
Ursus horribilis	grizzly bear
Procyonidae	raccoons and allies
Procyon lotor	raccoon
Mustelidae	Mustelids
Mustela erminea	ermine
Mustela frenata	long-tailed weasel
Mustela vison	mink
Taxidea taxus	badger
Spilogale gracilis	western spotted skunk
Mephitis mephitis	striped skunk
Lutra canadensis	river otter
Felidae	cats
Felis concolor	mountain lion
Lynx rufus	bobcat
Cervidae	Cervis
Cervus canadensis	elk
Odocoileus hemionus	mule deer
Antilocapridae	pronghorn
Antilocapra americana	pronghorn antelope
Bovidae	Bovids
Bison bison	bison
Ovis canadensis	mountain sheep

Central America

Didelphidae	opossums
Didelphis marsupialis	opossum
Marmosa mitis	Mexican mouse-opossum
Caluromys derbianus	wooly opossum
Dasypodidae	armadillos
Dasypus novemcinctus	nine-banded armadillo
Cricetidae	Cricetid rodents
Oryzomys talamancae	Talamanca rice rat
Sigmodon hispidus	hispid cotton rat
Dasyproctidae	agoutis and pacas
Agouti paca	paca
Dasyprocta punctata	agouti
Echimyidae	spiny rats
Hoplomys gymnurus	armored rat

Trichechidae	manatees
Trichechus manatus	manatee
Tayassuidae	peccaries
Tayassu tajacu	collared peccary
Tayassu pecari	white-lipped peccary
Cervidae	Cervids
Odocoileus virginiana	white-tailed deer
Mazama americana	red brocket

TABLE 1

RADIOCARBON DATES FROM NIGHTFIRE ISLAND (4SK4)

Age	Laboratory Number	Phase
930 ± 90 B.P.	GaK-2418	4
1420 ± 90 B.P.	GaK-2419	
1540 ± 100 B.P.	GaK-1841	
2080 ± 90 B.P.	GaK-1842	
2180 ± 80 B.P.	GaK-1831	3
2180 ± 90 B.P.	GaK-1833	
2220 ± 90 B.P.	GaK-1844	
2340 ± 100 B.P.	GaK-1832	
3040 ± 100 B.P.	GaK-2420	
3110 ± 110 B.P.	GaK-2421	
3450 ± 90 B.P.	GaK-1835	
3470 ± 80 B.P.	GaK-1834	
4070 ± 100 B.P.	GaK-1843	
4140 ± 110 B.P.	GaK-2423	
4380 ± 90 B.P.	GaK-1121	2
4410 ± 80 B.P.	GaK-1122	
4750 ± 110 B.P.	GaK-1837	
5150 ± 520 B.P.	GaK-2426	1
5750 ± 130 B.P.	GaK-1840	
6080 ± 140 B.P.	GaK-2427	

TABLE 2

NUMBER OF BIRD SPECIES, BY ORDER, IN THE LOWER KLAMATH REGION

(from U.S.D.I. 1969)

Gaviiformes (Loons)	1
Podicipediformes (Grebes)	4
Pelecaniformes (Pelicans, Cormorants)	2
Ciconiiformes (Herons, Ibises)	7
Anseriformes (Ducks, Geese, Swans)	33
Falconiformes (Vultures, Hawks, Ospreys, Falcons)	14
Galliformes (Grouse, Quail)	5
Gruiformes (Cranes, Rails)	4
Charadriiformes (Plovers, Sandpipers, Avocets, Phalaropes, Gulls and Terns)	33
Columbiformes (Pigeons)	2
Strigiformes (Owls)	4
Caprimulgiformes (Nightjars)	2
Apodiformes (Swifts, Hummingbirds)	2
Coraciiformes (Kingfishers)	1
Piciformes (Woodpeckers)	6
Passeriformes (Flycatchers, Songbirds)	92

TABLE 3

MODERN ABUNDANCE OF WATERFOWL AND COOTS
(Three year averages compiled from
USDI 1960, 1965, 1970)

	January	February	March	April	May	June
Cygnus cygnus	0	0	0	0	0	0
C. columbianus	3240	7675	4165	15	10	5
Anser albifrons	210	11180	25775	23225	5940	40
A. caerulescens	1430	42095	44560	11960	510	10
A. rossii	0	170	830	395	45	0
Branta canadensis canadensis	7715	2745	5740	5950	6750	7555
B. c. minima	890	2305	19970	46765	5900	35
Aix sponsa			5	15	55	5
Anas americana	8565	17645	29665	19195	3390	880
A. strepera	1655	4245	7305	12945	9920	10485
A. crecca	860	7490	27970	18415	3255	205
A. platyrynchos	9370	29315	18520	13170	12915	10560
A. acuta	14720	280600	274910	18050	8320	8170
A. discors	0	85	0	1	130	245
A. cyanoptera	0	0	915	3590	5320	6000
A. clypeata	30470	74215	107285	102125	17640	6060
Aythya valisineria	345	1820	2210	2320	495	170
A. americana	125	520	2080	4460	7375	10685
A. collaris	10	35	410	145	85	35
A. marila and affinis	1255	4680	7535	6330	4975	2500
Bucephala albeola	500	2380	4085	2125	750	210
B. clangula	205	745	280	195	20	0
Mergus merganser	235	635	1265	855	85	25
Oxyura jamaicensis	2735	12395	51550	53075	12055	8470
Total non-divers	79125	479765	567615	275815	79400	50255
Total divers	5410	23210	69415	69505	25840	22095
Fulica americana two year average	3560	14775	76005	102725	68000	52810

TABLE 3 (Continued)

MODERN ABUNDANCE OF WATERFOWL AND COOTS
(Three year averages compiled from
USDI 1960, 1965, 1970)

	July	August	September	October	November	December
Cygnus cygnus	0	0	0	0	0	0
C. columbianus	4	1	1	55	1170	6270
Anser albifrons	10	210	28435	134130	35720	1395
A. caerulescens	10	15	195	5635	8630	110
A. rossii	0	0	0	20	15	5
Branta canadensis canadensis	10085	12990	17065	20065	8045	6785
B. c. minima	20	25	35	76520	84855	550
Aix sponsa	10	3	15	0	0	0
Anas americana	940	10670	196240	212975	107990	30855
A. strepera	18640	32615	46785	62940	12335	1055
A. crecca	1180	4765	29115	42065	15465	2495
A. platyrynchos	16425	42505	96470	153885	100755	50195
A. acuta	25550	268425	1140225	2243645	710175	82075
A. discors	365	530	20	0	0	0
A. cyanoptera	5270	10970	8210	1045	570	0
A. clypeata	8680	19630	91585	138765	100605	44825
Aythya valisineria	210	455	1235	8610	9310	1270
A. americana	17750	30270	19075	13485	1670	265
A. collaris	165	280	65	35	55	110
A. marila and affinis	2725	3520	3435	5055	5610	3955
Bucephala albeola	105	120	80	1155	2525	950
B. clangula	0	3	0	10	130	250
Mergus merganser	10	30	5	70	510	180
Oxyura jamaicensis	1530	15370	17860	36745	24240	4855
Total non-divers	87190	403355	1654395	3091745	1186330	22615
Total divers	32495	50050	41755	65165	44050	11835
Fulica americana two year average	52200	71435	239310	358905	145890	5120

TABLE 4

MONTHLY RATIOS OF NON-DIVING TO DIVING WATERFOWL, LOWER KLAMATH LAKE

Month	Non-Divers/Divers
January	14.6
February	20.7
March	8.1
April	4.0
May	3.1
June	2.3
July	2.7
August	8.1
September	39.6
October	47.4
November	26.9
December	19.1
Yearly Average	20.9

TABLE 5

MODERN ABUNDANCE OF WATERBIRDS OTHER THAN WATERFOWL

(Three year averages compiled from
U.S.D.I. 1960, 1965, 1970)

	Number of Individuals		
	Jan.-April	May-Aug.	Sept.-Dec.
Eared Grebe	1565	2535	2365
Western Grebe	415	1165	1265
Pied-Billed Grebe	180	250	340
White Pelican	765	1735	1000
Double-Crested Cormorant	400	800	365
Gulls*	7715	11000	9360
Terns**	220	4200	3100

*1961 data (U.S.D.I. 1961) used in absence of 1960 data

**1962 data (U.S.D.I. 1962) used in absence of 1960 data

TABLE 6

MAMMALS OF THE KLAMATH BASIN

- Insectivora
  - Soricidae
    - *Sorex vagrans*
    - *S. palustris*
    - *S. trowbridgii*
    - *S. merriami*
  - Talpidae
    - *Scapanus latimanus*
- Chiroptera
  - Vespertilionidae
    - *Myotis lucifugus*
    - *M. yumanensis*
    - *M. evotis*
    - *M. thysanodes*
    - *M. volans*
    - *M. californicus*
    - *Lasionycteris noctivagans*
    - *Eptesicus fuscus*
    - *Lasiurus cinereus*
    - *Corynorhinus townsendii*
    - *Antrozous pallidus*
  - Molossidae
    - *Tadarida brasiliensis*
- Lagomorpha
  - Ochotonidae
    - *Ochotona princeps*
  - Leporidae
    - * *Sylvilagus nuttalli*
    - * *Lepus americanus*
    - * *L. californicus*
- Rodentia
  - Sciuridae
    - * *Eutamias minimus*[1]
    - * *E. amoenus*[1]
    - * *E. townsendii*[1]
    - * *Marmota flaviventris*
    - *Spermophilus beldingi*
    - *S. beecheyi*
    - *S. lateralis*
    - * *Tamiasciuris douglasii*[2]
    - * *Glaucomys sabrinus*
  - Heteromyidae
    - *Perognathus parvus*
    - *Dipodomys heermanni*

TABLE 6 (Continued)

MAMMALS OF THE KLAMATH BASIN

- Castoridae
  - * *Castor canadensis*
- Cricetidae
  - *Reithrodontomys megalotis*
  - *Peromyscus crinitus*
  - *P. maniculatus*
  - *P. boylii*
  - *P. truei*
  - *Onychomys leucogaster*
  - *Neotoma fuscipes*
  - *N. cinerea*
  - *Microtus montanus*
  - *M. longicaudus*
- Zapodidae
  - *Zapus princeps*
- Erethizontidae
  - * *Erethizon dorsatum*
- Carnivora
  - Canidae
    - * *Canis latrans*
    - * *C. lupus*
    - * *Vulpes fulva*
    - * *Urocyon cinereoargenteus*
  - Ursidae
    - * *Ursus americanus*
    - * *U. horribilis*
  - Procyonidae
    - * *Procyon lotor*
  - Mustelidae
    - *Mustela erminea*
    - *M. frenata*
    - * *M. vison*
    - * *Taxidea taxus*
    - * *Spilogale gracilis*[3]
    - * *Mephitis mephitis*[3]
    - * *Lutra canadensis*
  - Felidae
    - * *Felis concolor*
    - * *Lynx rufus*

TABLE 6 (Continued)

MAMMALS OF THE KLAMATH BASIN

- Artiodactyla
  - Cervidae
    - *_Cervus canadensis_
    - *_Odocoileus hemionus_
  - Antilocapridae
    - *_Antilocapra americana_
  - Bovidae
    - *_Ovis canadensis_

* Reported as eaten by the Modoc (Ray 1963)

[1] Reported as "chipmunk"

[2] Reported as "pine squirrel"

[3] Reported as "skunk"

TABLE 7

IDENTIFIED SPECIMENS PER SPECIES BY ELEMENT OR ELEMENT CATEGORY: CERRO BRUJO MAMMALS

(Key to Species: 1-*Dasyprocta punctata*, 2-*Agouti paca*, 3-*Dasypus novemcinctus*, 4-*Tayassu tajacu*, 5-*Sigmodon hispidus*, 6-*Odocoileus virginianus*, 7-*Oryzomys talamancae*, 8-*Tayassu pecari*, 9-*Trichechus manatus*, 10-*Hoplomys gymnurus*, 11-*Didelphis marsupialis*, 12-*Mazama americana*, 13-*Caluromys derbianus*, 14-*Marmosa mitis*)

	Species													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Skull	54	19	1	44	1	5		9	3					
Mandible	43	9	2	3	8		1	1		1			2	1
Vertebrae	95	28	67	23					5	5	4			
Pelvis	57	8	32	3	1		3			1				
Humerus	78	12	8	2	1	1			1					
Radius	28	10	4	6		2								
Ulna	31	11	4	1							1			
Scapula	16	4	6									1		
Metacarpals	20	9	2	2		6								
Carpals						2								
Femur	83	28	20	1	10		7			1		2		
Fibula	1	1												
Tibia	64	20	28				5							
Patella	3	1												
Metatarsals	73	16	7			1								
Talus	9	3	2					2						
Calcaneus	25	12	2					1						
Other Tarsals			1			1								
Phalanges	9	2												
Ribs	14	2							4					
Upper Incisors	35	6						1						

TABLE 7 (Continued)

IDENTIFIED SPECIMENS PER SPECIES BY ELEMENT OR ELEMENT CATEGORY: CERRO BRUJO MAMMALS

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Upper Canines				4				1						
Upper Premolars	1	3		1										
Upper Molars	3	2		3										
Lower Incisors	44	8		1	7									
Lower Canines														
Lower Premolars	8	2												
Lower Molars	25	8												
Unassigned:														
Metapodials						2								
Cheek Teeth	3													
	822	224	186	94	28	20	16	15	13	8	5	3	2	1

TABLE 8

MINIMUM NUMBERS OF INDIVIDUALS CALCULATED BY THE MAXIMUM (M_x) AND MINIMUM (M_i) DISTINCTION METHODS: CERRO BRUJO MAMMALS

	Number of Specimens	Minimum Number: M_x	of Total	Minimum Number: M_i	of Total
Dasyprocta	822	204	43.8	29	38.7
Agouti	224	104	22.3	9	12.0
Dasypus	186	69	14.8	10	13.3
Tayassu tajacu	94	27	05.8	3	04.0
Sigmodon	28	16	03.4	8	10.7
Odocoileus	20	14	03.0	2	02.7
Oryzomys	16	11	02.4	3	04.0
Tayassu pecari	15	4	00.9	2	02.7
Trichechus	13	9	01.9	3	04.0
Hoplomys	8	3	00.6	2	02.7
Didelphis	5	1	00.2	1	01.3
Mazama	3	2	00.4	1	01.3
Caluromys	2	1	00.2	1	01.3
Marmosa	1	1	00.2	1	01.3

TABLE 9

NUMBER OF IDENTIFIED ELEMENTS BY ELEMENT CATEGORY AND SPECIES: BIRDS

PHASE 1

	Skull	Mandible	Vertebrae	Ribs	Scapula	Coracoid	Sternum	Furcula	Humerus	Radius	Ulna	Carpometacarpus	Pelvis	Femur	Fibula	Tibiotarsus	Tarsometatarsus	Phalanges
Gavia																		
immer							1		1			1				1		
Podiceps																		
auritus						4	1											
nigricollis						1										1		
spp.						4											2	
Aecmophorus																		
occidentalis			3			11	6		1		1		4	2		1	3	
Podilymbus																		
podiceps						4	2		2				1	1			3	
Pelecanus																		
erythrorynchus																		
Phalacrocorax																		
auritus																2		
Botaurus																		
lentiginosus						1												
Nycticorax																		
nycticorax																		
Ardea																		
cinerea																		

TABLE 9 (Continued)

NUMBER OF IDENTIFIED ELEMENTS BY ELEMENT CATEGORY AND SPECIES: BIRDS

PHASE 1

	Skull	Mandible	Vertebrae	Ribs	Scapula	Coracoid	Sternum	Furcula	Humerus	Radius	Ulna	Carpometacarpus	Pelvis	Femur	Fibula	Tibiotarsus	Tarsometatarsus	Phalanges
Cygnus																		
cygnus																		
columbianus									1									
Branta																		
canadensis									1									
Anser																		
spp.																		
Geese																		
spp.					1				2					1		1	1	
Anas																		
teal						2			3			2						
platyrynchos							1		2								1	
"mid-size"					1	3	1	1	1									
Aythya																		
valisineria					7	8			1		1							
collaris						23												
affinis-marila					44	84	30	4	7		4	27		1		1	5	
spp.							1		1								1	
Bucephala																		
albeola					1	3			3			1						
clangula																		

TABLE 9 (Continued)

NUMBER OF IDENTIFIED ELEMENTS BY ELEMENT CATEGORY AND SPECIES: BIRDS

PHASE 1

	Skull	Mandible	Vertebrae	Ribs	Scapula	Coracoid	Sternum	Furcula	Humerus	Radius	Ulna	Carpometacarpus	Pelvis	Femur	Fibula	Tibiotarsus	Tarsometatarsus	Phalanges
Mergus																		
cucullatus					7	6			5			5					1	
serrator						1												
merganser					8	8	1	1	3			1						
Oxyura																		
jamaicensis						12	1		6		3	2				2	1	
Circus																		
cyaneus																		
Aquila																		
chrysaetos																		
Haliaetus																		
leucocephalus																		
Centrocercus																		
urophasianus																		
Fulica																		
americana					35	103	33		11	1	13	20		4		43	6	
Charadrius																		
vociferous																		
Larus																		
argentatus																		

TABLE 10

NUMBER OF IDENTIFIED ELEMENTS BY ELEMENT CATEGORY AND SPECIES: BIRDS

PHASE 2

	Skull	Mandible	Vertebrae	Ribs	Scapula	Coracoid	Sternum	Furcula	Humerus	Radius	Ulna	Carpometacarpus	Pelvis	Femur	Fibula	Tibiotarsus	Tarsometatarsus	Phalanges
Gavia																		
immer						4	1					3	4			1		
Podiceps																		
auritus						9	2		5					3		1		
nigricollis						3								2		3		
spp.						11	1		6				1	1		3	9	
Aecmophorus																		
occidentalis			14		13	102	28		10		14	3	15	21		16	32	
Podilymbus																		
podiceps						19	4		7					2		1	5	
Pelecanus																		
erythrorynchus																		
Phalacrocorax																		
auritus									1					1				
Botaurus																		
lentiginosus																		
Nycticorax																		
nycticorax					1	1												
Ardea																		
cinerea							1											

TABLE 10 (Continued)

NUMBER OF IDENTIFIED ELEMENTS BY ELEMENT CATEGORY AND SPECIES: BIRDS

PHASE 2

	Skull	Mandible	Vertebrae	Ribs	Scapula	Coracoid	Sternum	Furcula	Humerus	Radius	Ulna	Carpometacarpus	Pelvis	Femur	Fibula	Tibiotarsus	Tarsometatarsus	Phalanges
Cygnus																		
cygnus												1						
columbianus					2	1						1						
Branta																		
canadensis					1	2			1								1	
Anser																		
spp.							3		1									
Geese																		
spp.					5	2	1	1	4		1	1				4		
Anas																		
teal					2	2						3						
platyrynchos	2				10	13	5	2	10		1	4						
"mid-size"					6	10	11		12		1	4		1				
Aythya																		
valisineria					26	70	6	3	9									
collaris						90												
affinis-marila					410	717	202	31	37		33	94		4		9	22	
spp.																		
Bucephala																		
albeola					2	7	2		4	1				1				
clangula						2												

TABLE 10 (Continued)

NUMBER OF IDENTIFIED ELEMENTS BY ELEMENT CATEGORY AND SPECIES: BIRDS

PHASE 2

	Skull	Mandible	Vertebrae	Ribs	Scapula	Coracoid	Sternum	Furcula	Humerus	Radius	Ulna	Carpometacarpus	Pelvis	Femur	Fibula	Tibiotarsus	Tarsometatarsus	Phalanges
Mergus cucullatus					37	15	7		7			12					1	
serrator																		
merganser			3		36	29	11		7			2					1	
Oxyura jamaicensis					9	30	4		12		6	3				1		
Circus cyaneus																	1	
Aquila chrysaetos																		
Haliaetus leucocephalus																1		
Centrocercus urophasianus																		
Fulica americana				3	161	468	90		31	3	26	40	2	12		89	25	1
Charadrius vociferous																		
Larus argentatus						1												

TABLE 10 (Continued)

NUMBER OF IDENTIFIED ELEMENTS BY ELEMENT CATEGORY AND SPECIES: BIRDS

PHASE 2

	Skull	Mandible	Vertebrae	Ribs	Scapula	Coracoid	Sternum	Furcula	Humerus	Radius	Ulna	Carpometacarpus	Pelvis	Femur	Fibula	Tibiotarsus	Tarsometarsus	Phalanges
Bubo virginianus														1				
Nyctea nyctea																		
Asio flammeus																		
Corvus corax												1						

TABLE 11

NUMBERS OF IDENTIFIED ELEMENTS BY ELEMENT CATEGORY AND SPECIES: BIRDS

PHASE 3

	Skull	Mandible	Vertebrae	Ribs	Scapula	Coracoid	Sternum	Furcula	Humerus	Radius	Ulna	Carpometacarpus	Pelvis	Femur	Fibula	Tibiotarsus	Tarsometatarsus	Metatarsals	Phalanges
Gavia																			
immer					1	1	2		1										
Podiceps																			
auritus							1		3					1					
nigricollis						3			4							8			
spp.						10	1		5				1			7	3		
Aecmophorus																			
occidentalis			1		1	12	4		1		1		1	4		1	2		
Podilymbus																			
podiceps						5	4		7				1	1		5	4		
Pelecanus																			
erythrorynchus					1				2		1								
Phalacrocorax																			
auritus																			
Botaurus																			
lentiginosus									1										
Nycticorax																			
nycticorax					1	1	1												
Ardea																			
cinerea						1													

TABLE 11 (Continued)

NUMBER OF IDENTIFIED ELEMENTS BY ELEMENT CATEGORY AND SPECIES: BIRDS

PHASE 3

	Skull	Mandible	Vertebrae	Ribs	Scapula	Coracoid	Sternum	Furcula	Humerus	Radius	Ulna	Carpometacarpus	Pelvis	Femur	Fibula	Tibiotarsus	Tarsometatarsus	Metatarsals	Phalanges
Cygnus																			
cygnus						1	1												
columbianus						1													
Branta																			
canadensis					3	5	4		3								1		
Anser																			
spp.		1				9	25		1								1		
Geese																			
spp.					33	32	2	7	44			14	7			9	6		
Anas																			
teal					3	2	13	1	11			4					2		
platyrynchos	2				6	10	4	5	8			4		1			1		
"mid-size"	2				9	19	31	3	16			9		2			4		
Aythya																			
valisineria					3	6	3		3										
collaris						1													
affinis-marila					11	16	9	3	6			10					5		
spp.					1		7	1	1			2							
Bucephala																			
albeola					1	3			5		1			2			1		
clangula																			

TABLE 11 (Continued)

NUMBERS OF IDENTIFIED ELEMENTS BY ELEMENT CATEGORY AND SPECIES: BIRDS

PHASE 3

	Skull	Mandible	Vertebrae	Ribs	Scapula	Coracoid	Sternum	Furcula	Humerus	Radius	Ulna	Carpometacarpus	Pelvis	Femur	Fibula	Tibiotarsus	Tarsometarsus	Metatarsals	Phalanges
Mergus																			
cucullatus					2							1							
serrator																			
merganser					4	5	7	1	3			1				2	1		
Oxyura																			
jamaicensis						16	7	2	10		2	5		1		4	1		
Circus																			
cyaneus									1										
Aquila																			
chrysaetos			7		2	3	3	1	3	2	2	1	3	2	1	2	2	1	26
Haliaetus																			
leucocephalus									1										
Centrocercus																			
urophasianus					1							1	2						
Fulica																			
americana	1				43	92	71			2	6	21	3	11		82	29		2
Charadrius																			
vociferous																			
Larus																			
argentatus																			

TABLE 11 (Continued)

NUMBER OF IDENTIFIED ELEMENTS BY ELEMENT CATEGORY AND SPECIES: BIRDS

PHASE 3

	Skull	Mandible	Vertebrae	Ribs	Scapula	Coracoid	Sternum	Furcula	Humerus	Radius	Ulna	Carpometacarpus	Pelvis	Femur	Fibula	Tibiotarsus	Tarsometatarsus	Metatarsals	Phalanges
Bubo virginianus																			
Nyctea nyctea									1										
Asio flammeus																1			
Corvus corax																			

TABLE 12

NUMBER OF IDENTIFIED ELEMENTS BY ELEMENT CATEGORY AND SPECIES: BIRDS

PHASE 4

	Skull	Mandible	Vertebrae	Ribs	Scapula	Coracoid	Sternum	Furcula	Humerus	Radius	Ulna	Carpometacarpus	Pelvis	Femur	Fibula	Tibiotarsus	Tarsometatarsus	Phalanges
Gavia																		
immer																		
Podiceps																		
auritus						1												
nigricollis									1									
spp.						2										2		
Aecmophorus																		
occidentalis														2				
Podilymbus																		
podiceps						5	1		1								2	
Pelecanus																		
erythrorynchus									1									
Phalacrocorax																		
auritus																		
Botaurus																		
lentiginosus					1													
Nycticorax																		
nycticorax						1												
Ardea																		
cinerea																		

TABLE 12 (Continued)

NUMBER OF IDENTIFIED ELEMENTS BY ELEMENT CATEGORY AND SPECIES: BIRDS

PHASE 4

	Skull	Mandible	Vertebrae	Ribs	Scapula	Coracoid	Sternum	Furcula	Humerus	Radius	Ulna	Carpometacarpus	Pelvis	Femur	Fibula	Tibiotarsus	Tarsometatarsus	Phalanges
Cygnus																		
cygnus																		
columbianus					2	2			2									
Branta																		
canadensis					1	2		1										
Anser																		
spp.						1	4											
Geese																		
spp.					2	1			5				1				1	
Anas																		
teal						1			1									
platyrynchos					4	3	3	6						1			1	
"mid-size"					5	9	10	2	13		1	4		1				
Aythya																		
valisineria						1	1	1	1								1	
collaris																		
affinis-marila					4	6			1			1	2				1	
spp.							1		1				1	1				
Bucephala																		
albeola						2			1									
clangula																		

TABLE 12 (Continued)

NUMBER OF IDENTIFIED ELEMENTS BY ELEMENT CATEGORY AND SPECIES: BIRDS

PHASE 4

	Skull	Mandible	Vertebrae	Ribs	Scapula	Coracoid	Sternum	Furcula	Humerus	Radius	Ulna	Carpometacarpus	Pelvis	Femur	Fibula	Tibiotarsus	Tarsometatarsus	Phalanges
Mergus																		
cucullatus																		
serrator																	1	
merganser	1				1	6	2	2				2	1			2	1	
Oxyura																		
jamaicensis					1	4			2		1					1		
Circus																		
cyaneus																		
Aquila																		
chrysaetos																		1
Haliaetus																		
leucocephalus							1									1	1	
Centrocercus																		
urophasianus																		
Fulica																		
americana					4	11	16		8		1	1		3		7	2	
Charadrius																		
vociferous									1									
Larus																		
argentatus																		

TABLE 13

NUMBER OF IDENTIFIED ELEMENTS BY ELEMENT CATEGORY AND SPECIES: BIRDS

PHASE 5

	Skull	Mandible	Vertebrae	Ribs	Scapula	Coracoid	Sternum	Furcula	Humerus	Radius	Ulna	Carpometacarpus	Pelvis	Femur	Fibula	Tibiotarsus	Tarsometatarsus	Phalanges
Gavia																		
immer																		
Podiceps																		
auritus																		
nigricollis																1		
spp.									1									
Aecmophorus																		
occidentalis																		
Podilymbus																		
podiceps						1	2									2		
Pelecanus																		
erythrorynchus																		
Phalacrocorax																		
auritus																	1	
Botaurus																		
lentiginosus									1									
Nycticorax																		
nycticorax																		
Ardea																		
cinerea																1		

TABLE 13 (Continued)

NUMBER OF IDENTIFIED ELEMENTS BY ELEMENT CATEGORY AND SPECIES: BIRDS

PHASE 5

	Skull	Mandible	Vertebrae	Ribs	Scapula	Coracoid	Sternum	Furcula	Humerus	Radius	Ulna	Carpometacarpus	Pelvis	Femur	Fibula	Tibiotarsus	Tarsometatarsus	Phalanges
Cygnus																		
cygnus					1													
columbianus																		
Branta																		
canadensis									1								1	
Anser																		
spp.								1										
Geese																		
spp.					1							2				1		
Anas																		
teal							1											
platyrynchos						1	1					1						
"mid-size"									2			1						
Aythya																		
valisineria																		
collaris																		
affinis-marila					1	4	1		4									
spp.							2	1						1				
Bucephala																		
albeola									1		1			1				
clangula																		

TABLE 13 (Continued)

NUMBER OF IDENTIFIED ELEMENTS BY ELEMENT CATEGORY AND SPECIES: BIRDS

PHASE 5

	Skull	Mandible	Vertebrae	Ribs	Scapula	Coracoid	Sternum	Furcula	Humerus	Radius	Ulna	Carpometacarpus	Pelvis	Femur	Fibula	Tibiotarsus	Tarsometatarsus	Phalanges
Mergus																		
cucullatus																		
serrator																		
merganser					3	1			3				1					
Oxyura																		
jamaicensis					2	3	3		6		1					1	1	
Circus																		
cyaneus																		
Aquila																		
chrysaetos																		1
Haliaetus																		
leucocephalus											1					1		1
Centrocercus																		
urophasianus					1													
Fulica																		
americana	1				2	2	2		2			1		5		4	1	

TABLE 14

NUMBER OF IDENTIFIED ELEMENTS: BIRDS

		LEVEL															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Gavia																
	immer							1		3	1	4	9	2			2
	Podiceps																
Horned Grebe →	auritus						1	2	1	1	1	8	12	1		4	
	nigricollis		1				1	3	3	7	2	1	7			1	1
	spp.			2		2		7	5	15		12	20	1	1	3	1
GREBE	Aecmophorus																
	occidentalis	1		1	1			4	2	8	14	37	231	6	1	14	11
	Podilymbus																
	podiceps	5		4	3		2	6	5	11	5	15	23	2	2	5	4
	Pelecanus																
	erythrorynchus						1		1	3							
	Phalacrocorax																
	auritus	1										1	1	2			
	Botaurus																
	lentiginosus		1				1	1						1			
	Nycticorax																
	nycticorax					1		1	1	1		1				1	
	Ardea																
	cinerea	1						1					1				
	Cygnus																
	cygnus		1						1	1			1				
	columbianus		1	3		1	2			1		2	3	1			
GEESE	Anser																
	spp.		1			1	4	12	3	14	8	2	2				
	Branta																
	canadensis		2	2	1		1	5	4	7		1	4			1	
	Geese																
	spp.	2	2	4		4	2	29	31	70	24	9	10	3		2	1

TABLE 14 (Continued)

NUMBER OF IDENTIFIED ELEMENTS: BIRDS

	LEVEL															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Anas																
teal	1					2	4	4	27	1	1	6	1		2	4
MALARD → platyrynchos		3	5	4	2	8	6	5	21	9	18	29	1		1	2
? "mid-size"		3	14	14	9	8	28	18	38	11	12	33	2		4	1
Aythya																
valisineria				2			2	4	5	4	39	75		4	12	1
collaris							1				31	59		1	20	11
L+L SCAUP → affinis-marila	4	6	7	2	5			10	42	7	599	960		16	164	17
spp.		4	3		1	3	12						3			
Bucephala																
albeola	2	1	1			2	1	2	9	1	3	14			5	3
clangula												2				
Mergus																
cucullatus							1		2		25	54		1	13	10
serrator			1										1			
merganser	3	5	5	7	3	3	1	6	16	1	26	63	1	5	11	5
Oxyura																
jamaicensis	8	9	5	2	1	1	7	11	25	5	33	32			18	9
Circus																
cyaneus									1			1				
Aquila																
chrysaetos	1		1				51	6	4							
Haliaetus																
leucocephalus	3		2			1		1				1				
Centrocercus																
urophasianus		1					4									
COOT Fulica																
americana	12	8	13	11	13	16	101	75	170	41	292	659	14	15	137	103
Charadrius																
vociferous					1											

TABLE 14 (Continued)

NUMBER OF IDENTIFIED ELEMENTS: BIRDS

LEVEL

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Larus argentatus												1				
Bubo virginianus												1				
Nyctea nyctea							1									
Asio flammeus										1						
Corvus corax												1				

TABLE 15

MINIMUM NUMBERS OF AVIAN INDIVIDUALS BY LEVEL

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Gavia immer							1		1	1	2	3	1			1
	Podiceps auritus						1	1	1	1	1	2	4	1		2	
	nigricollos		1				1	1	1	3	1	1	3			1	1
	spp.			1		1		1		1		1	1		1	1	
GREBE	Aecmophorus occidentalis	1		1	1			1	1	2	3	11	36	2	1	2	3
	Podilymbus podiceps	2		2	1		1	2	1	2	1	5	5	1	1	2	2
	Pelecanus erythrorhynchos						1		1	1							
	Phalacrocorax auritus	1										1	1	1			
	Botaurus lentiginosus		1				1	1						1			
	Nycticorax nycticorax					1		1		1		1				1	
	Ardea cinerea	1						1					1				
	Cygnus cygnus		1						1	1			1				
	Cygnus columbianus		1	2		1	1			1	1	1	1				
GEESE	Anser spp.		1			1	3	9	2	10	5	3					
	Branta canadensis		1	1	1		1	2	2	2		1	1			1	
	Geese spp.	1	1	2		2	1	5	8	16	3	3	2	1		1	1

TABLE 15 (Continued)

MINIMUM NUMBERS OF AVIAN INDIVIDUALS BY LEVEL

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	Anas																
	teal	1					1	2	2	11	1	1	2	1		1	1
?	"mid-size"		1	3	4	2	2	7	9	12	3	5	6	1		1	1
MALLARD	platyrhynchos		1	3	2	1	2	1	1	3	2	3	7	1		1	1
	Aythya																
	valisineria			1				1	2		3	10	30		5	2	
	collaris							1				16	28		1	11	2
SCAUP	affinis-marila	3	1	2	1	1			1	7		153	207		1	37	7
	spp.		2			1	1	5						1			
	Bucephala																
	albeola	1	1	1			1	1	1	2	1	2	4			1	2
	clangula												2				
	Mergus																
	cucullatus							1		1		7	13		1	3	2
	serrator			1										1			
	merganser	2	2	2	2	1	1	1	2	4	1	7	18	2	2	3	2
	Oxyura																
	jamaicensis	2	2	1	1	1	1	2	2	4	1	9	12			6	2
	Circus																
	cyaneus									1			1				
	Aquila																
	chrysaetos	1		1				1		2							
	Haliaetus																
	leucocephalus	1		1			1		1				1				
	Centrocercus																
	urophasianus		1					1									
COOT	Fulica																
	americana	2	2	4	3	4	5	17	13	31	4	60	123	4	4	17	17
	Charadrius																
	vociferus					1											

TABLE 15 (Continued)

MINIMUM NUMBERS OF AVIAN INDIVIDUALS BY LEVEL

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Larus argentatus												1				
Bubo virginianus												1				
Nyctea scandiaca							1									
Asio flammeus											1					
Corvus corax												1				

TABLE 16

RELATIVE ABUNDANCE OF AVIAN FAMILIES IN PERCENT, BY PHASE

	Phase				
	5	4	3	2	1
Water and Shore Birds					
Podicipedidae	10	11	09	09	12
Ardeidae	05	02	02	00	01
Anatidae	65	63	61	67	61
Rallidae	10	18	24	23	24
Others	03	02	02	01	02
Phalacrocoracidae					
Pelecanidae					
Gaviidae					
Charadriidae					
Laridae					
Miscellaneous Other Birds	08	03	02	01	00
Accipitridae					
Tetraonidae					
Strigidae					
Corvidae					

TABLE 17

NON-DIVER/DIVER RATIOS: ALL WATERFOWL

	Level	Non-Divers (ND)	Divers (D)	$\frac{N D}{D}$
1000-1400 AD	1	2	11	0.2
5	2	7	11	0.6
0 - 1000 AD	3	11	11	1.0
	4	7	5	1.4
4	5	7	6	1.2
	6	11	5	2.2
	7	26	19	1.4
2200 to 0	8	25	11	2.3
3	9	56	25	2.2
	10	14	10	1.4
	11	17	383	0.0
3000-2200 BC 2	12	20	549	0.0
4000-3000 BC	13	5	4	1.3
1	14	0	17	0.0
	15	5	113	~~0.4~~ 0,04
	16	4	26	0.2

TABLE 18

ABUNDANCE OF DIVING AND NON-DIVING WATERBIRDS, BY PHASE

	5	4	3	2	1
Diving Birds					
Loons	0	0	3	5	2
Grebes	4	10	25	69	21
Cormorants	1	0	0	1	1
Ducks	17	19	45	508	93
Coots	4	16	65	183	42
Proportion of total	.65	.51	.51	.94	.91
Non-Diving Birds					
Pelicans	0	1	2	0	0
Swans	2	4	3	3	1
Geese	4	12	64	10	4
Ducks	3	20	54	24	9
Gulls	0	0	0	1	0
Proportion of total	.23	.42	.45	.05	.08
All Other Birds	5	6	10	7	2
Proportion of total	.12	.07	.04	.01	.01

TABLE 19

NUMBER OF IDENTIFIED ELEMENTS BY ELEMENT CATEGORY AND SPECIES: MAMMALS

PHASE 1

	Sylvilagus	Lepus	Marmota	Spermophilus	Castor	Peromyscus	Microtus	Erethizon	Canis latrans	C. lupus	C. familiaris	C. spp.	Ursus	Procyon	Mustela	Taxidea	Mephitis	Lutra	Lynx	Cervus	Odocoileus	Antilocapra	Ovis	Bison
Skull																							1	
Mandible		1					1				6	4	1	1		1		1		1			1	
Vertebrae																							1	1
Ribs												2												
Scapula								1		1													1	
Humerus											2				1									
Radius											2	1										2	1	
Ulna										1	2	1									1			
Metacarpals									5		1													
Carpals																				3				
Pelvis		1								1														
Femur					1						3				1									
Patella																								
Tibia	1	1									3	1									1	1	3	
Fibula																								
Metatarsals											1			1				2						
Astragalus																							1	
Calcaneus	1										2	1												1

TABLE 19 (Continued)

NUMBER OF IDENTIFIED ELEMENTS BY ELEMENT
CATEGORY AND SPECIES: MAMMALS

PHASE 1

	Sylvilagus	Lepus	Marmota	Spermophilus	Castor	Peromyscus	Microtus	Erethizon	Canis latrans	C. lupus	C. familiaris	C. spp.	Ursus	Procyon	Mustela	Taxidea	Mephitis	Lutra	Lynx	Cervus	Odocoileus	Antilocapra	Ovis	Bison
Other Tarsals																								
Upper Incisors												2												
Upper Canines											1													
Upper Premolars											1	1												
Upper Molars											1							1				1		
Lower Incisors																								
Lower Canines											1	2						1						
Lower Premolars		1									1													
Lower Molars									1		3	3								1		5		
Unassigned:																								
Metapodials													1											
Phalanges												1						1	1		2			
Sesamoids																								
Canines												1												
Cheek Teeth																								

TABLE 20

NUMBER OF IDENTIFIED ELEMENTS BY ELEMENT CATEGORY AND SPECIES: MAMMALS

PHASE 2

	Sylvilagus	Lepus	Marmota	Spermophilus	Castor	Peromyscus	Microtus	Erethizon	Canis latrans	C. lupus	C. familiaris	C. spp.	Ursus	Procyon	Mustela	Taxidea	Mephitis	Lutra	Lynx	Cervus	Odocoileus	Antilocapra	Ovis	Bison
Skull							1	1			2				1			1		2		1		
Mandible	1							2			3	5		1	8			2		1		2		3
Vertebrae		1									3	7		1	5			1		2		1	10	1
Ribs																								5
Scapula		1									1	1											1	
Humerus		2			1				1			1			1							2	2	
Radius											3	5			3							2	1	1
Ulna	1								1		1				2			1				1	1	1
Metacarpals										1			1					1				1	1	
Carpals										1		2	2											
Pelvis																								
Femur						1		1				1			4									
Patella																								
Tibia										1	2	1			2									1
Fibula																								
Metatarsals									1	2										1		2	2	4
Astragalus											1										3	2	2	

TABLE 20 (Continued)

NUMBER OF IDENTIFIED ELEMENTS BY ELEMENT CATEGORY AND SPECIES: MAMMALS

PHASE 2

	Sylvilagus	Lepus	Marmota	Spermophilus	Castor	Peromyscus	Microtus	Erethizon	Canis latrans	C. lupus	C. familiaris	C. spp.	Ursus	Procyon	Mustela	Taxidea	Mephitis	Lutra	Lynx	Cervus	Odocoileus	Antilocapra	Ovis	Bison
Calcaneus			1																			1		
Other Tarsals																								3
Upper Incisors												2						1						
Upper Canines											1													
Upper Premolars								1			2	4										1	2	
Upper Molars											1	1	1					1					11	
Lower Incisors																								
Lower Canines											2	1												
Lower Premolars											2	2									2	1	1	
Lower Molars								1	4		9	3									2	1	3	1
Unassigned:																								
Metapodials																							1	
Phalanges		1										7	1					1			6	3	5	3
Sesamoids												2				1						1	1	
Canines												3												
Cheek Teeth								1														1		

TABLE 21

NUMBER OF IDENTIFIED ELEMENTS BY ELEMENT CATEGORY AND SPECIES: MAMMALS

PHASE 3

	Sylvilagus	Lepus	Marmota	Spermophilus	Castor	Peromyscus	Microtus	Erethizon	Canis latrans	C. lupus	C. familiaris	C. spp.	Ursus	Procyon	Mustela	Taxidea	Mephitis	Lutra	Lynx	Cervus	Odocoileus	Antilocapra	Ovis	Bison
Skull		2	2	6			2		1		24	6			1	1				1	5	5	5	
Mandible	7	2		7			2	3		1	15	5		2	10		1	5	1	1	4	2	8	
Vertebrae		1									5	9		1					1	1		1	19	1
Ribs												2										3	1	1
Scapula	2	2									1	2				1		1		2	5	2	3	
Humerus	7	6							1		2	2			3			2	1	1	3	5	3	
Radius		7									4	3						2	1		1	1	8	
Ulna	1	2						1			3	3			1				1			1		
Metacarpals		2							1	1	2	1	1	1								4	2	
Carpals											3	1						1				3	4	
Pelvis	1	1	1	1		1						3									2	4	7	2
Femur	2	3		1							1	2			4					4			1	
Patella																								
Tibia	3	3	1								2	1			4						1	3	5	
Fibula																								
Metatarsals	2	6							1		2	1						1		2	4	2	2	
Astragalus											2									2	7	10	7	

TABLE 21 (Continued)

NUMBER OF IDENTIFIED ELEMENTS BY ELEMENT CATEGORY AND SPECIES: MAMMALS

PHASE 3

	Sylvilagus	Lepus	Marmota	Spermophilus	Castor	Peromyscus	Microtus	Erethizon	Canis latrans	C. lupus	C. familiaris	C. spp.	Ursus	Procyon	Mustela	Taxidea	Mephitis	Lutra	Lynx	Cervus	Odocoileus	Antilocapra	Ovis	Bison
Calcaneus	3	2										2		2	1			1		2	1	2	5	
Other Tarsals												1								3		2	4	
Upper Incisors		2		2								3						1						
Upper Canines											4													
Upper Premolars									2		6				1						2	1	2	
Upper Molars				1							3	2						1		1	4	5	13	
Lower Incisors	2			3				2				2								3				
Lower Canines											5	2						1						
Lower Premolars	2	2									1										1	1	4	
Lower Molars	1	1						1	4	2	8	1						1		3	3	3	15	
Unassigned																								
Metapodials												2												
Phalanges												12		1				10	1		4	8	9	1
Sesamoids																				1				
Canines												2												
Cheek Teeth	2																							

TABLE 22

NUMBER OF IDENTIFIED ELEMENTS BY ELEMENT CATEGORY AND SPECIES: MAMMALS

PHASE 4

	Sylvilagus	Lepus	Marmota	Spermophilus	Castor	Peromyscus	Microtus	Erethizon	Canis latrans	C. lupus	C. familiaris	C. spp.	Ursus	Procyon	Mustela	Taxidea	Mephitis	Lutra	Lynx	Cervus	Odocoileus	Antilocapra	Ovis	Bison
Skull		1					3				1	5						5				2		
Mandible	3	3					8	1	5		3					3		2			2	2		
Vertebrae		1									5	2				2		2					1	
Sternum																						1		
Ribs												1											2	
Scapula		1							1			1				1		1				1	1	
Humerus		1							1						2	2		2			1		2	
Radius	1										2	1				1		3				2		
Ulna											2				1						1			
Metacarpals											1	1	1					2		1				
Carpals																					1	1		
Pelvis	3										1				2	2		1						
Femur	1	2				1					1	1			2			1			1			
Patella																								
Tibia		2									1	1			5						1	1		
Fibula																								
Metatarsals	2											1									2	4	2	
Astragalus		1														1		1		1		3		

TABLE 22 (Continued)

NUMBER OF IDENTIFIED ELEMENTS BY ELEMENT
CATEGORY AND SPECIES: MAMMALS

PHASE 4

	Sylvilagus	Lepus	Marmota	Spermophilus	Castor	Peromyscus	Microtus	Erethizon	Canis latrans	C. lupus	C. familiaris	C. spp.	Ursus	Procyon	Mustela	Taxidea	Mephitis	Lutra	Lynx	Cervus	Odocoileus	Antilocapra	Ovis	Bison
Calcaneus	3				1													1			2	1		
Other Tarsals																						1		
Upper Incisors																								
Upper Canines																		1					2	
Upper Premolars											1							1				7	6	
Upper Molars												1									1			
Lower Incisors	2	1																2						
Lower Canines											1													
Lower Premolars																					1			
Lower Molars							1				1							1	1			5	3	
Unassigned:																								
Metapodials												1												
Phalanges					1							7						2				2	1	
Sesamoids																								
Canines																								
Cheek Teeth	1																							

TABLE 23

NUMBER OF IDENTIFIED ELEMENTS BY ELEMENT CATEGORY AND SPECIES: MAMMALS

PHASE 5

	Sylvilagus	Lepus	Marmota	Spermophilus	Castor	Peromyscus	Microtus	Erethizon	Canis latrans	C. lupus	C. familiaris	C. spp.	Ursus	Procyon	Mustela	Taxidea	Mephitis	Lutra	Lynx	Cervus	Odocoileus	Antilocapra	Ovis	Bison
Skull		1					5				1											4	1	
Mandible							10							1	2			2				3		
Vertebrae																		4	1				4	
Ribs																						1	2	
Scapula									1													2		
Humerus	1																					3		
Radius											1				1								2	
Ulna											1				1			1					1	
Metacarpals									1									3				1	1	
Carpals																						1		
Pelvis	2														1							2		
Femur		1																				1		
Patella																						2		
Tibia		2																				2		
Fibula																		1				1		
Metatarsals	1	1																3				1	1	
Astragalus		1							1		1										1		2	

TABLE 23 (Continued)

NUMBER OF IDENTIFIED ELEMENTS BY ELEMENT CATEGORY AND SPECIES: MAMMALS

PHASE 5

	Sylvilagus	Lepus	Marmota	Spermophilus	Castor	Peromyscus	Microtus	Erethizon	Canis latrans	C. lupus	C. familiaris	C. spp.	Ursus	Procyon	Mustela	Taxidea	Mephitis	Lutra	Lynx	Cervus	Odocoileus	Antilocapra	Ovis	Bison
Calcaneus		1													3			1			1	3	1	
Other Tarsals																						1	1	
Upper Incisors												1						1						
Upper Canines																		1						
Upper Premolars																								
Upper Molars							1															5	1	
Lower Incisors																								
Lower Canines																		2						
Lower Premolars																						1		
Lower Molars							2											1				4	1	
Unassigned:																								
Metapodials												3												
Phalanges		1										5						5		1		2		
Sesamoids																								
Canines																								
Cheek Teeth	4																							

TABLE 24

NUMBER OF IDENTIFIED ELEMENTS: MAMMALS

LEVEL

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Sylvilagus	6	2	4	4	7	1	9	6	19	1	3		1		1	
Lepus	4	4	6	4	2	1	7	3	30	4	2	3	2		2	4
Marmota								1	2	2		1				
Spermophilus							21									
Castor			1	1								1			1	
Peromyscus					1				1			1				
Microtus	15	3	1	6	3	2	2			2		1	1			
Erethizon					1			5	1	1	6	1	1			
Canis latrans		3	5			2	3	3	2	2	4	3	1		5	
C. lupus								1	3			5			3	
C. familiaris	3	1	3	6	8	3	14	11	56	12	22	11	6	4	19	1
C. spp.	5	4	3	2	11	7	9	9	32	20	33	16	2	5	11	2
Ursus					1				1		4		1		1	
Procyon		1					4	1	2		1	1			1	1
Mustela	4	4	7	4	1		7	1	14	3	17	10	1		1	
Taxidea					12		1		1							1
Mephitis							1									
Lutra	19	6	9	7	6	6	8	4	8	7	5	4			5	1
Lynx	1				1				6						1	
Cervus		1	1			1	4	4	12	7	4	2	3			2
Odocoileus		2	1	3	5	4	9	8	20	10	7	6	2		2	
Antilocapra	26	14	3	3	16	11	18	11	24	15	10	14	3		6	
Ovis	6	12	5	6	7	5	21	26	63	17	33	11	5	1	2	1
Bison								1	4		13	10		2		
TOTAL	89	57	49	46	87	43	138	95	301	98	164	101	29	12	61	13 = 1383

TABLE 25

MINIMUM NUMBERS OF INDIVIDUALS: MAMMALS

	LEVEL																PHASE				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	5	4	3	2	1
Sylvilagus	1	1	2	2	2	1	2	1	3	1	1		1		1		2	7	7	1	2
Lepus	1	1	2	1	1	1	2	1	3	2	1	1	2		1		2	5	8	2	3
Marmota								1	1	1		1							3	1	
Spermophilus							5												5		
Castor			1	1								1			1			2		1	1
Peromyscus					1				1			1	1					1	1	1	
Microtus	6	2	1	2	3	1	2			1		1	1				8	7	3	1	1
Erethizon					1			1	1	1	1	1	1					1	3	2	1
Canis latrans		1	1			1	1	1	1	1	2	1	1		1				2	1	3
C. lupus								1	1			1	1		2		1	2	4	3	2
C. familiaris	1	1	1	1	2	1	3	2	6	3	3	3		1	3	1	2	5	14	6	6
C. spp.									1		1		1	1					1	1	1
Ursus					1				1		2				1			1	1	2	2
Procyon		1					2	1	1		1	1	1		1	1	1		4	2	2
Mustela	2	1	2	1	1		2	1	6	1	2	3			1		3	4	10	5	2
Taxidea					1		1		1							1		1	2		1
Mephitis							1												1		
Lutra	2	1	1	2	1	1	2	1	2	2	1	2			1	1	3	5	7	3	2
Lynx	1				1				1						1		1	1	1		1
Cervus		1	1			1	1	1	1	1	1	1	1			1	1	2	4	2	2
Odocoileus	2	1	1	1	1	1	3	3	2	2	2	1	1		1		3	4	10	3	2
Antilocapra	2	1	1	1	2	2	2	1	5	2	1	1	2		1		3	6	10	2	3
Ovis	1	2	1	2	2	1	1	3	5	2	2	1	1	1	1	1	3	6	11	3	4
Bison								1	1		1	1		1					2	2	1

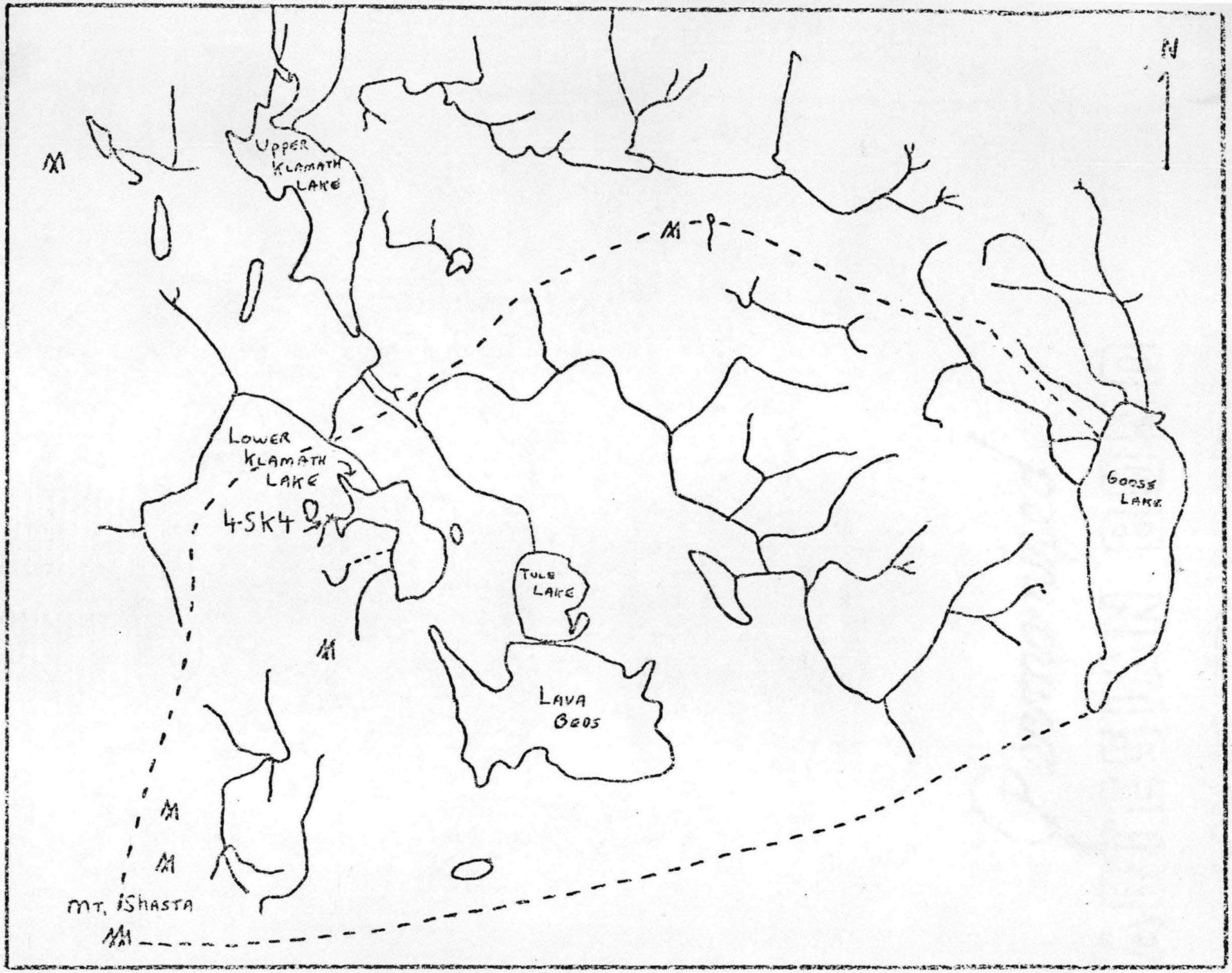
TABLE 26

RELATIVE ABUNDANCE OF MAMMALIAN ORDERS IN PERCENT, BY PHASE

	5	4	3	2	1
Lagomorpha	12	20	13	07	12
Rodentia	24	18	13	14	07
Carnivora	33	32	41	52	53
Artiodactyla	30	30	33	27	28

FIGURE 1

THE LOWER KLAMATH BASIN AND ABORIGINAL MODOC TERRITORY



25 MILES

MODOC

TERRITORY

FIGURE 2

VARIATION IN ABSOLUTE MINIMUM NUMBERS OF INDIVIDUALS (MNI) DERIVED FROM THE MAXIMUM (M_x) AND MINIMUM (M_i) DISTINCTION METHODS

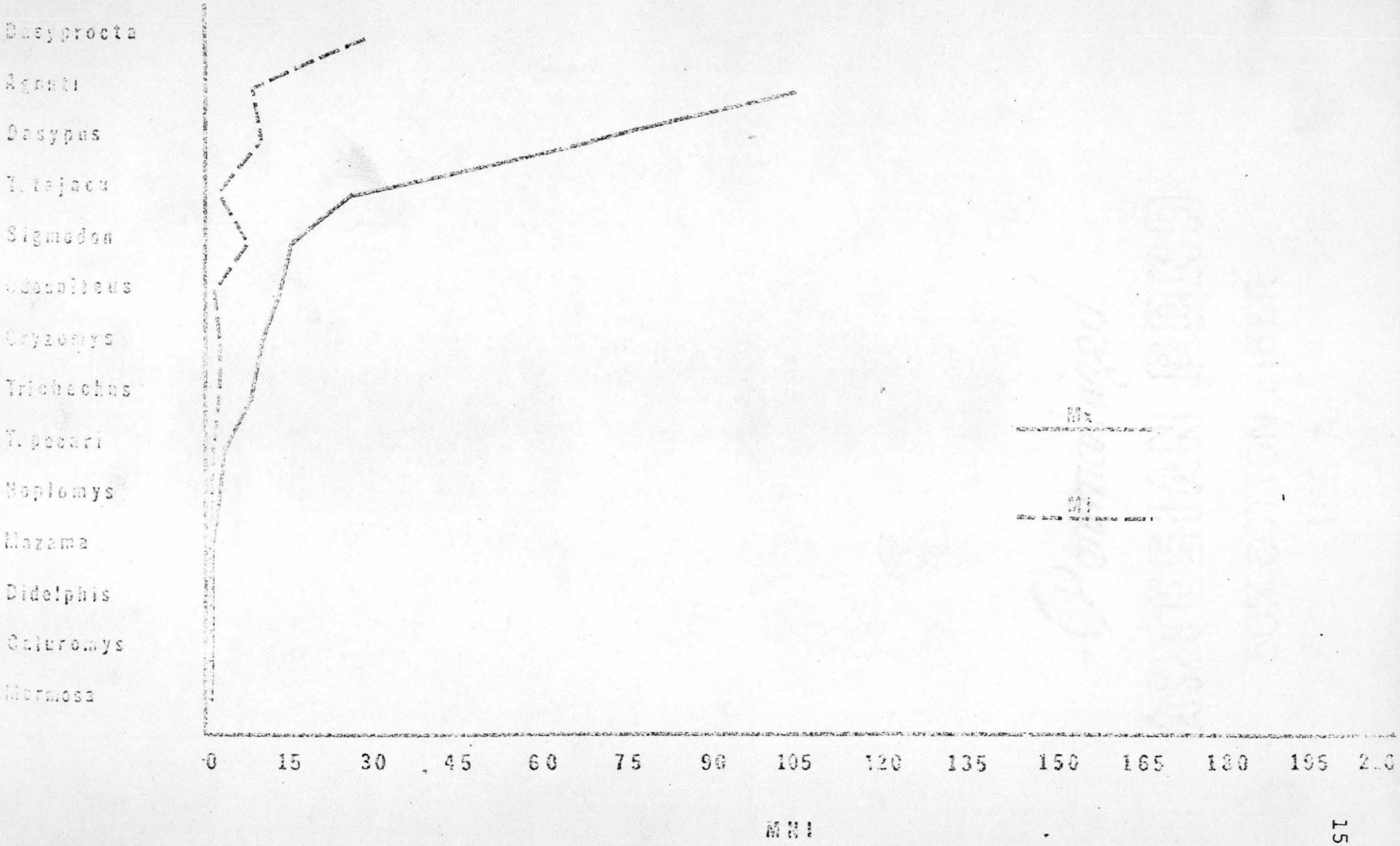

Dasyprocta
Agouti
Dasypus
T.tajacu
Sigmodon
Odocoileus
Oryzomys
Trichechus
T.pecari
Hoplomys
Mazama
Didelphis
Caluromys
Marmosa
Mx
Mi
0
15
30
45
60
75
90
105
120
135
150
165
180
195
210
MNI

FIGURE 3

VARIATION IN NORMED MINIMUM NUMBERS OF INDIVIDUALS (MNI) DERIVED FROM THE MAXIMUM (M_x) AND MINIMUM (M_i) DISTINCTION METHODS

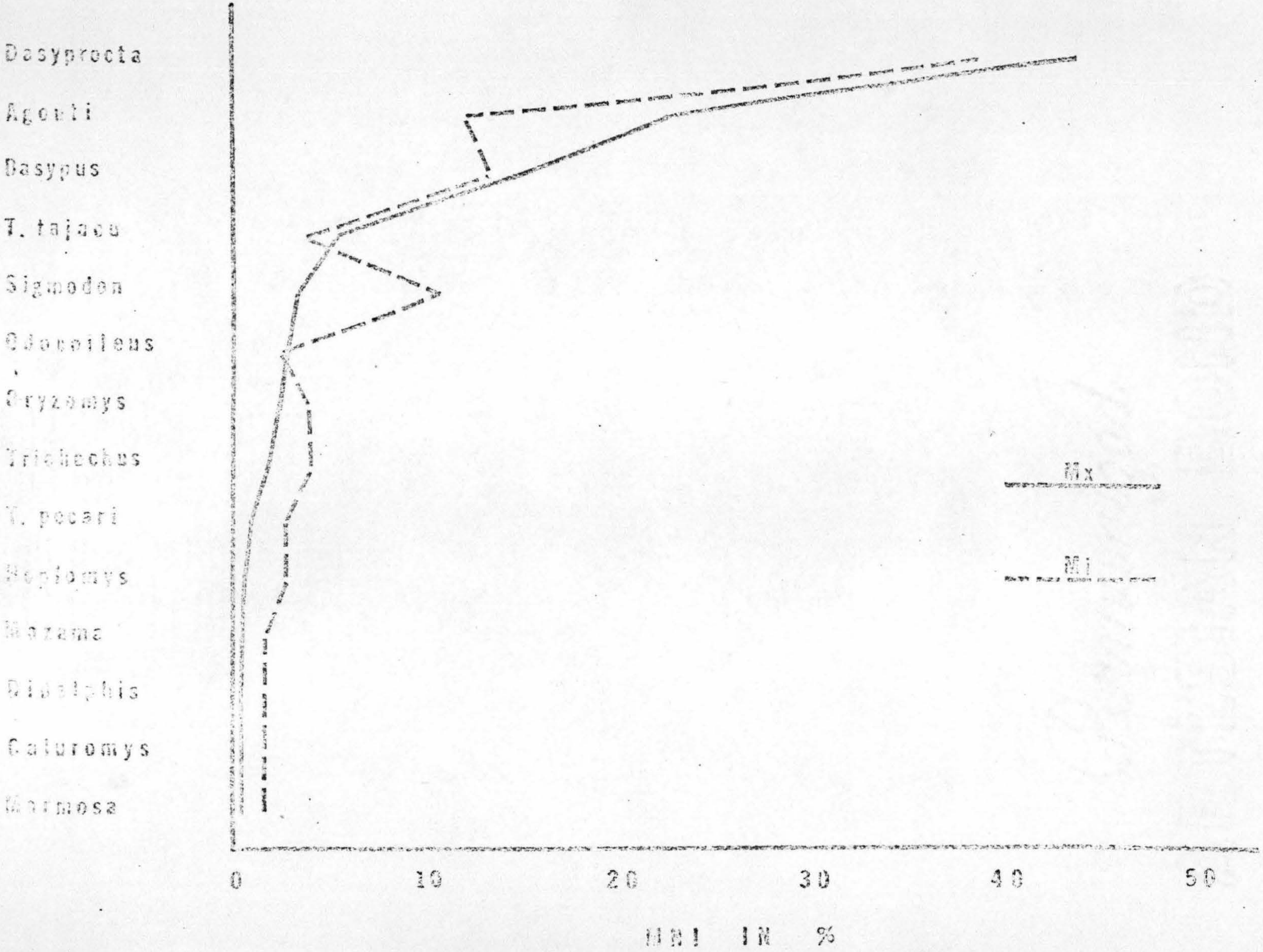

Dasyprocta
Agouti
Dasypus
T. tajacu
Sigmodon
Odocoileus
Oryzomys
Trichechus
T. pecari
Hoplomys
Mazama
Didelphis
Caluromys
Marmosa
Mx
Mi
0
10
20
30
40
50
MNI IN %

FIGURE 4

FLUCTUATION IN RELATIVE INTERVAL SIZES

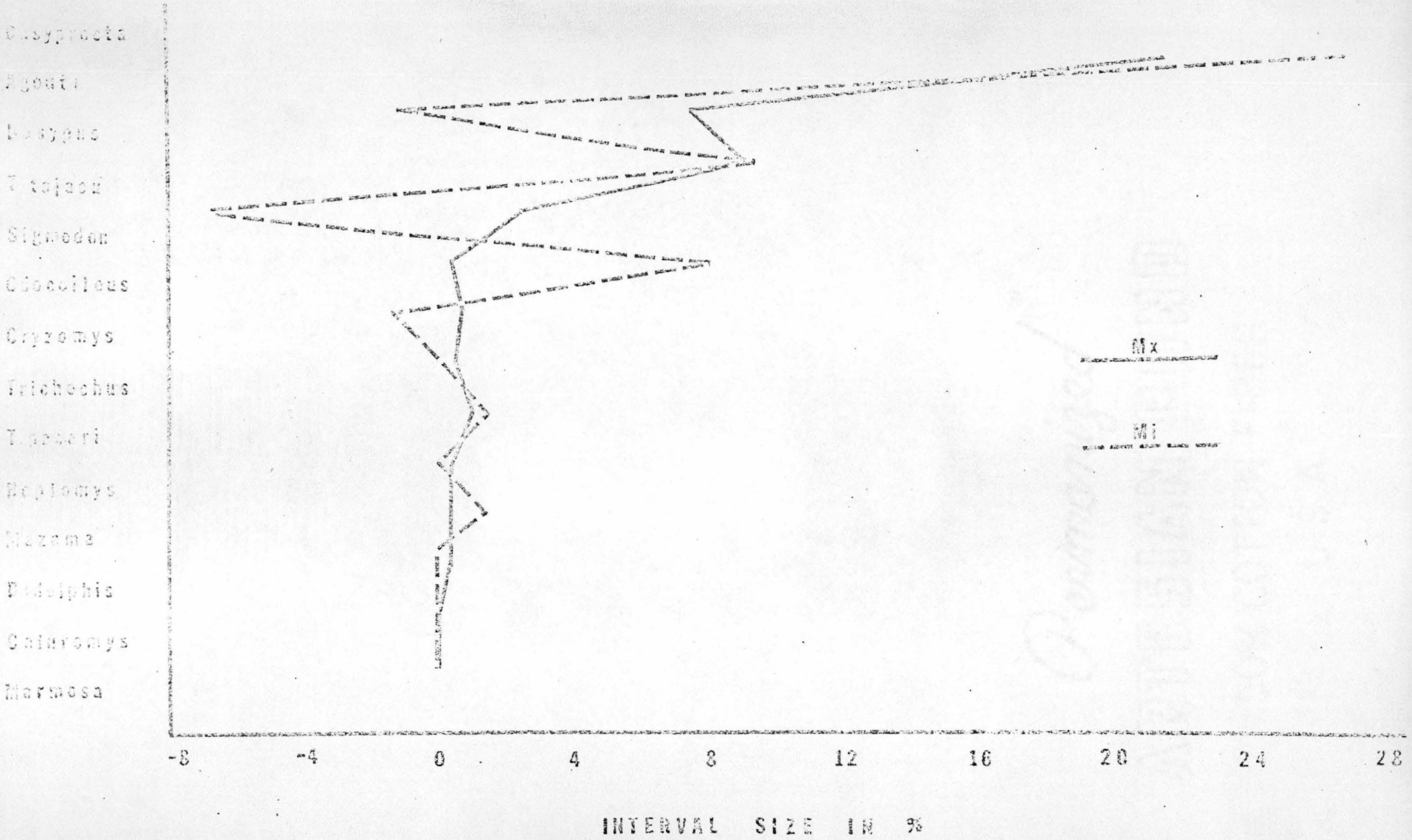

Dasyprocta
Agouti
Dasypus
T.tajacu
Sigmodon
Odocoileus
Oryzomys
Trichechus
T.pecari
Hoplomys
Mazama
Didelphis
Chiuromys
Marmosa
Mx
Mi
-8
-4
0
4
8
12
16
20
24
28
INTERVAL SIZE IN %

FIGURE 5

RELATIVE ABUNDANCE OF AVIAN FAMILIES

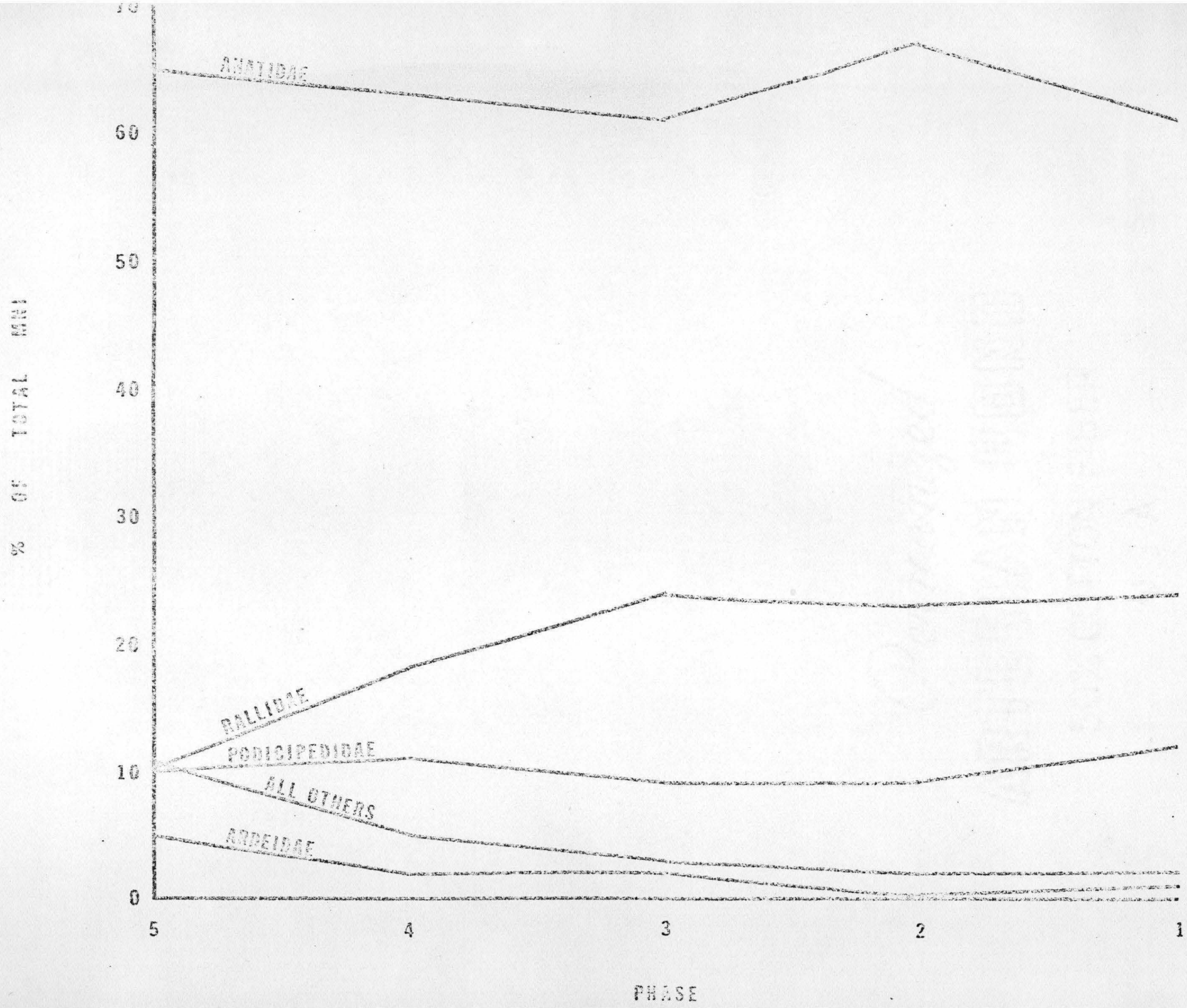

ANATIDAE
RALLIDAE
PODICIPEDIDAE
ALL OTHERS
ARDEIDAE
% OF TOTAL MNI
60
50
40
30
20
10
0
5
4
3
2
1
PHASE

FIGURE 6

MINIMUM NUMBERS OF INDIVIDUALS (MNI) OF NON-DIVING WATERBIRDS, BY LEVEL

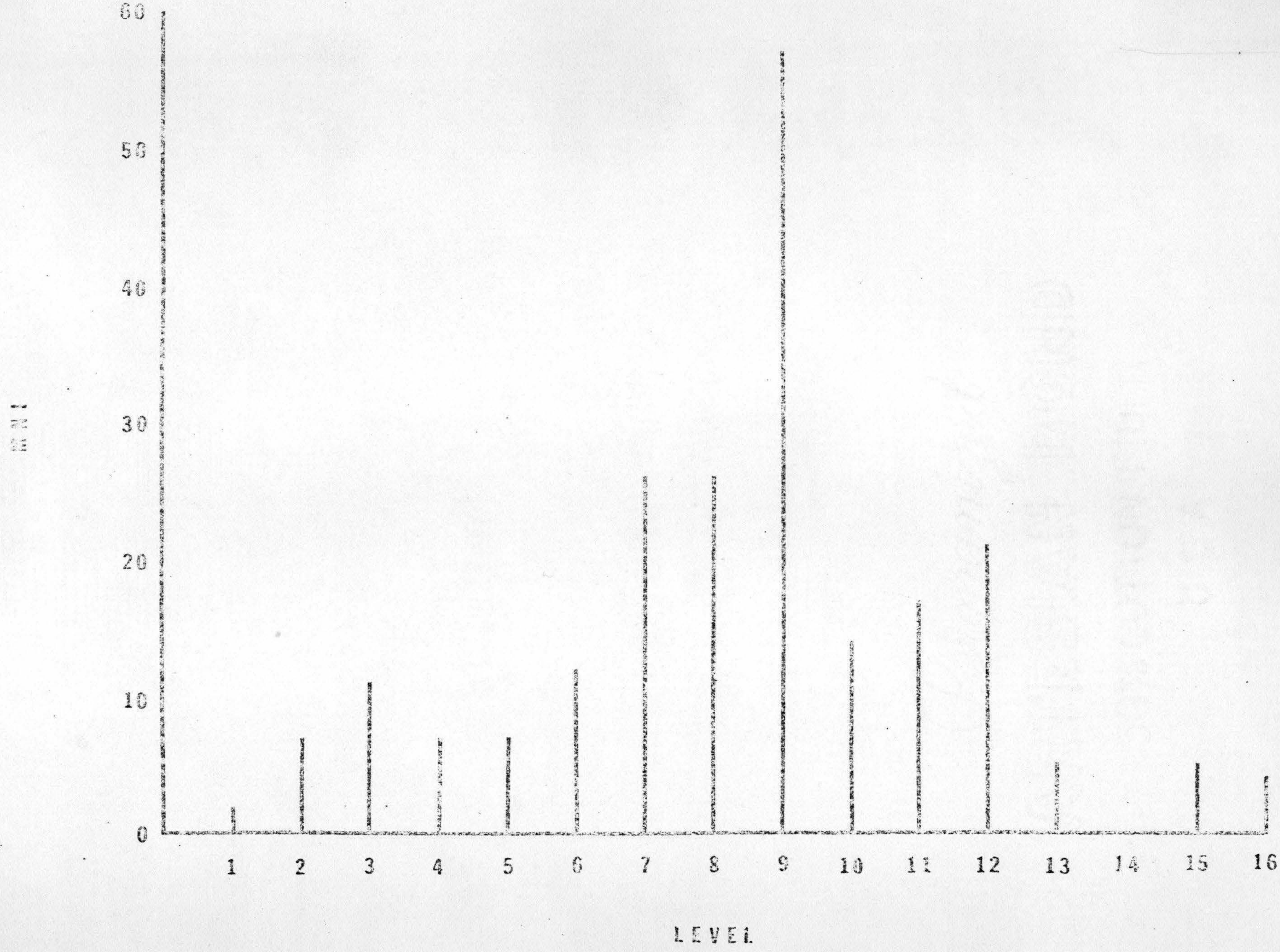

MNI
0
10
20
30
40
50
60
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
LEVEL

FIGURE 7

MINIMUM NUMBERS OF INDIVIDUALS (MNI) OF DIVING WATERBIRDS, BY LEVEL

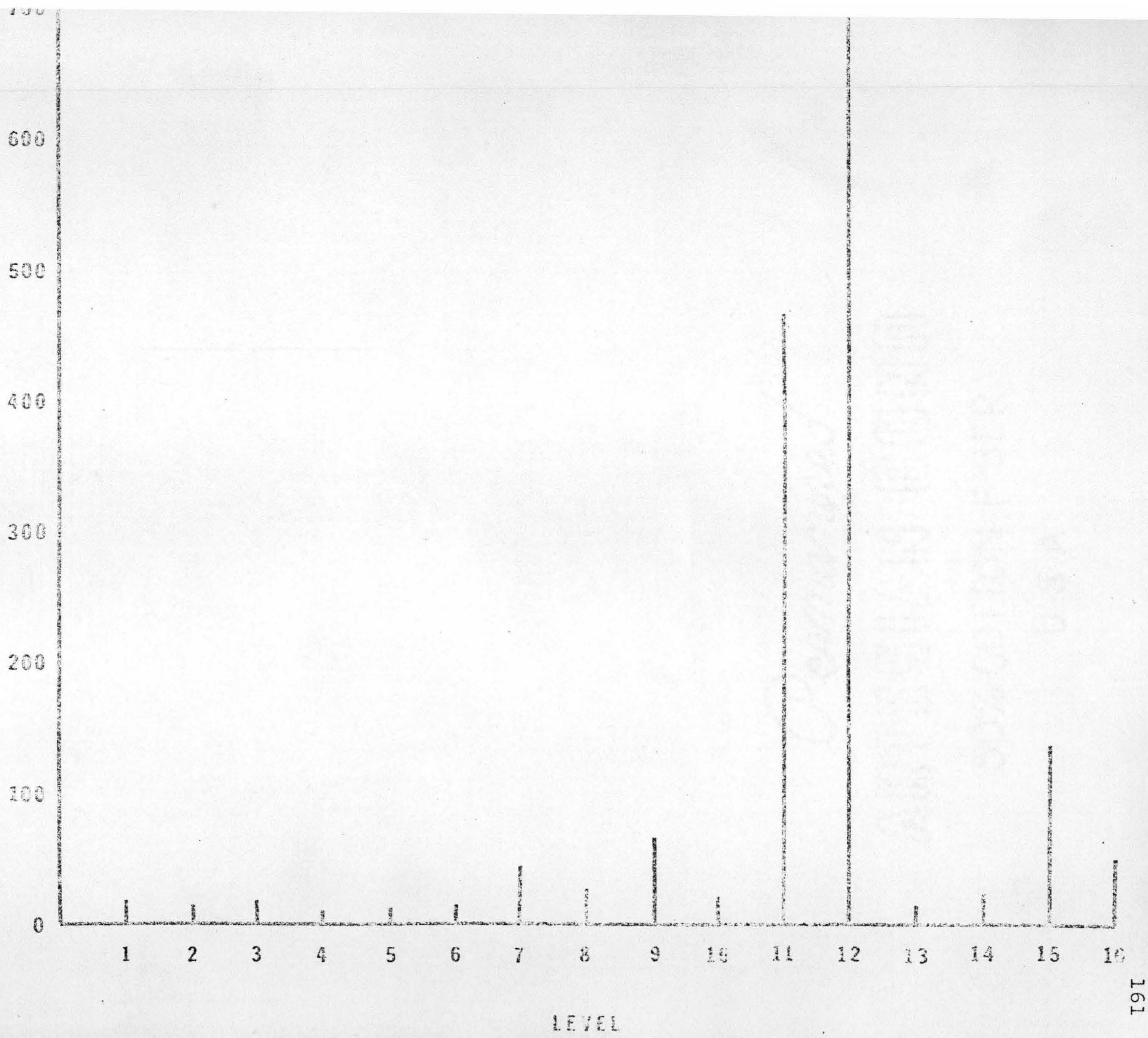

600
500
400
300
200
100
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
LEVEL

FIGURE 8

RELATIVE ABUNDANCE OF DIVING AND
NON-DIVING WATERBIRDS, BY PHASE

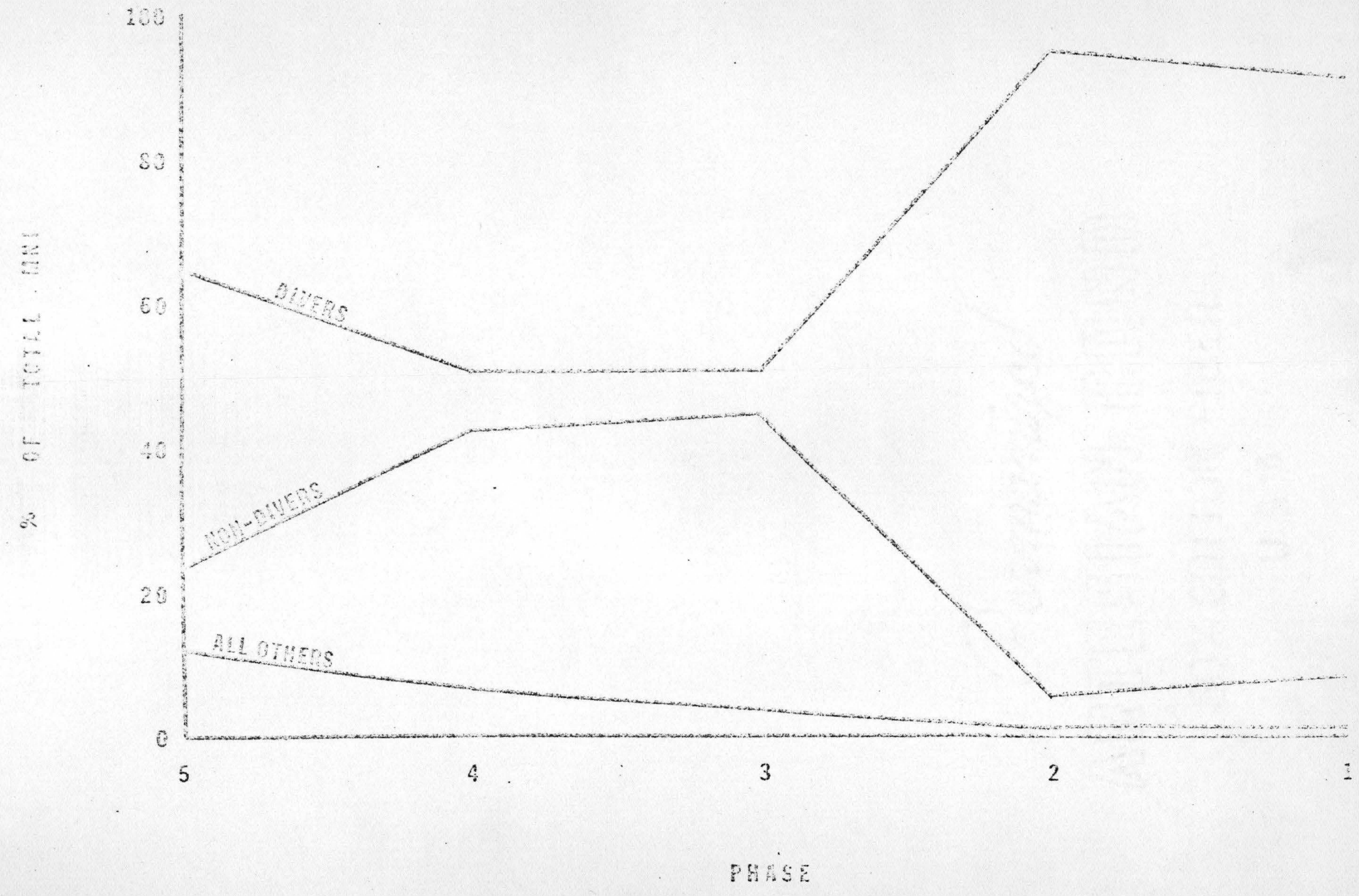
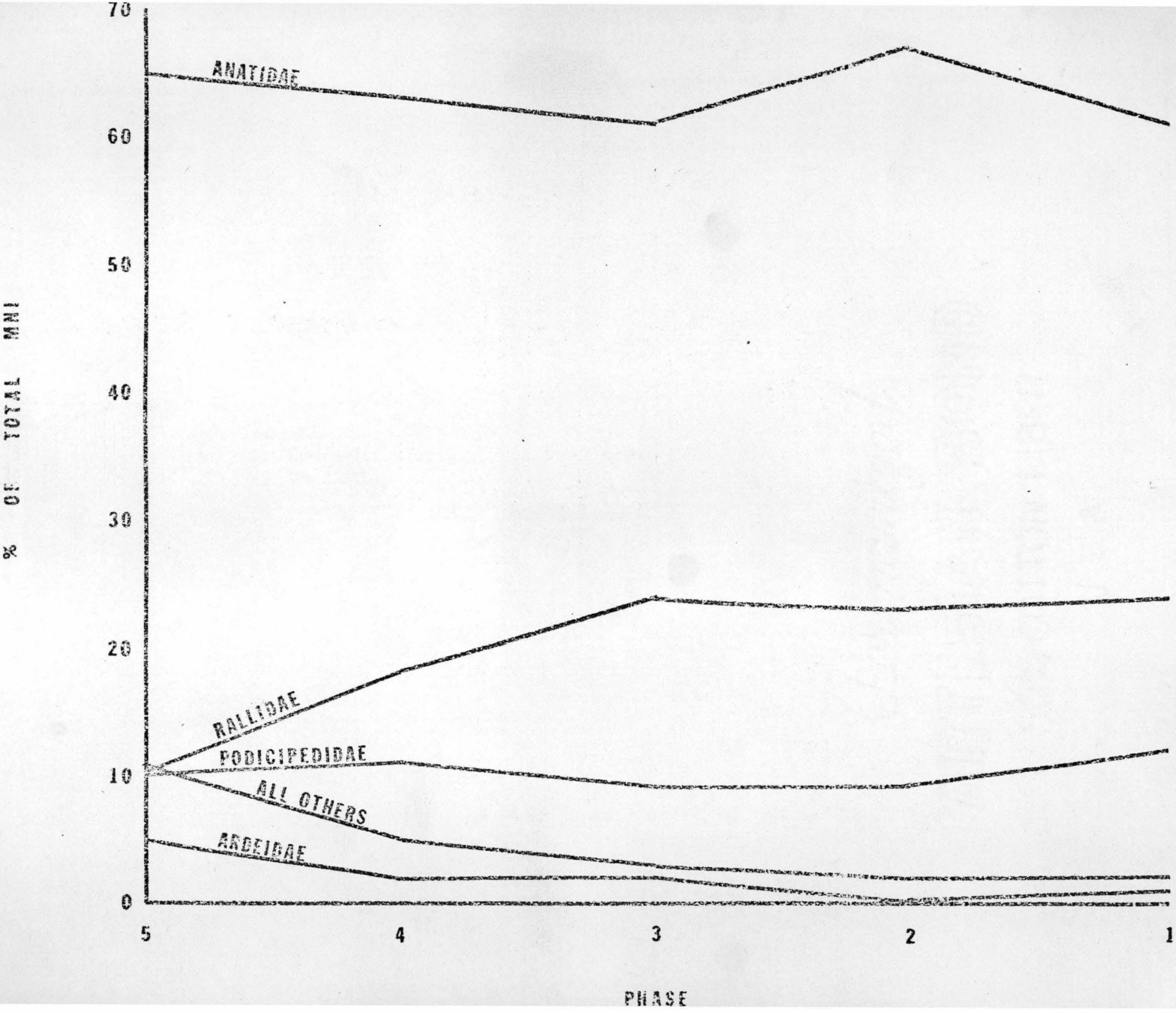

% OF TOTAL IND
100
80
60
40
20
0
DIVERS
NON-DIVERS
ALL OTHERS
5
4
3
2
1
PHASE

FIGURE 9

RELATIVE ABUNDANCE OF MAMMALIAN ORDERS, BY PHASE


70
60
50
40
30
20
10
0
% OF TOTAL MNI
ANATIDAE
RALLIDAE
PODICIPEDIDAE
ALL OTHERS
ARDEIDAE
5
4
3
2
1
PHASE

LITERATURE CITED

Aikens, C. Melvin
1966 Virgin-Kayenta Cultural Relationships. Department of Anthropology, University of Utah, *Anthropological Papers* 79.

Alexander, H.L., Jr.
1963 The Levi Site: A Paleo-Indian Campsite in Central Texas. *American Antiquity* 38: 510-528.

Allen, G.M.
1920 Dogs of the American Aborigines. *Bulletin of the Museum of Comparative Zoology* 63:431-517.

Antevs, Ernst
1948 Climatic Changes and Pre-white Man. *University of Utah Bulletin* 38: 168-191.

1952 Climatic History and the Antiquity of Man in California. *University of California Archaeological Survey Reports* 16: 23-31.

1955 Geologic-climatic Dating in the West. *American Antiquity* 20: 317-335.

Bailey, Florence Merriam
1917 *Handbook of the Birds of the Western United States.* Houghton-Mifflin Co., New York.

Bailey, Vernon
1902 Unprotected Breeding Grounds. *Condor* 9: 35-41.

1923 Buffalo in Oregon. *J. Mammalogy* 4: 254-255.

1936 The Mammals and Life Zones of Oregon. *North American Fauna* 55, U.S. Department of Agriculture.

Barrett, S.A.
1910 The Material Culture of the Klamath Lake and Modoc Indians of Northeastern California and Southern Oregon. *University of California Publications in American Archaeology and Ethnology* 5: 239-292.

Baumhoff, Martin A. and Robert F. Heizer

1965 Postglacial Climate and Archaeology in the Desert West. In, H.E. Wright, Jr. and David G. Frey, editors, *The Quaternary of the United States*, 696-707. Princeton.

Bennyhoff, James A.

1956 The Desert West: A Trial Correlation of Culture and Chronology. In, Current Views of Great Basin Archaeology, *Univ. California Archaeological Survey Reports* 42: 98-113.

Bent, Arthur Cleveland

1919 Life Histories of North American Diving Birds. *United States National Museum Bulletin.*

1923 Life Histories of North American Wild Fowl, Part I. *United States National Museum Bulletin* 126.

1925 Life Histories of North American Wild Fowl, Part II. *United States National Museum Bulletin* 135.

1926 Life Histories of North American Marsh Birds. *United States Museum Bulletin* 135.

1938 Life Histories of North American Birds of Prey, Part II. *United States Museum Bulletin* 170.

Bloch, Alvin Sheldon

1962 *Range and Wildlife Research, Lava Beds National Monument.* Ms. on file at the Lava Beds National Monument, Tulelake, California (LBNM, Tulelake).

1963 *Range and Wildlife Research, Lava Beds National Monument.* Ms. on file at the LBNM, Tulelake.

Brainerd, Lawson H.

1939-1940 *Journal of Observations in Biology, Lava Beds National Monument.* Ms. on file at the LBNM, Tulelake.

1941 *Past Wildlife of the Lava Beds National Monument.* Ms. on file at the LBNM, Tulelake.

Bryant, Harold C.
1914 A Survey of the Breeding Grounds of Ducks. *Condor* 16: 217-239.

Cahalane, Victor H.
1951 *Wildlife Resources of the National Park System--A Report on Wildlife Conditions in 1951.* Ms. on file at the LBNM, Tulelake.

Chaplin, R.E.
1971 *The Study of Animal Bones from Archaeological Sites.* Seminar Press, New York.

Cleland, Charles E.
1966 The Prehistoric Animal Ecology and Ethnozoology of the Upper Great Lakes Region. *University of Michigan, Museum of Anthropology, Anthropology Papers*, 29.

Coe, Michael D. and Kent V. Flannery
1967 Early Cultures and Human Ecology in South Coastal Guatemala. *Smithsonian Contributions to Knowledge in Anthropology*, V. 1.

Cornwall, I.W.
1956 *Bones for the Archaeologist.* Phoenix House, London.

Cressman, Luther S.
1940 Studies on Early Man in South Central Oregon. *Carnegie Institute of Washington Yearbook,* 39: 300-306.

1951 Western Prehistory in the Light of Carbon 14 Dating. *Southwestern Journal of Anthropology* 7:

1956 Klamath Prehistory. *Transactions of the American Philosophical Society* 46: 4.

Cressman, Luther S. et. al.
1942 Archaeological Researches in the Northern Great Basin. *Carnegie Institute of Washington Publication* 538.

Dasmann, Raymond F. and Richard D. Taber
1956 The Behavior of Columbia Black-Tailed Deer with Reference to Population Ecology. *J. Mammalogy* 37: 143-164.

Dawson, William Leon
1923 The Birds of California. South Moulton Co., San Diego and Los Angeles.

Delacour, Jean
1954 Waterfowl of the World, Volume 1. Country Life Limited, London.

1956 Waterfowl of the World, Volume 2. Country Life Limited, London.

1959 Waterfowl of the World, Volume 3. Country Life Limited, London.

Driver, Harold E. and William C. Massey
1957 Comparative Studies of North American Indians. Transactions of the American Philosophical Society 47: 2.

Finley, William L.
1907 Among the Pelicans. Condor 9: 35-41.

n.d. Reclamation in the Klamath District and its Effect on Waterfowl. Ms. on file at the Klamath Basin National Wildlife Refuges, Tulelake, California (KBNWR, Tulelake).

Fisher, Don C.
n.d. Report on Animals in the Lava Beds National Monument. Ms. on file at the LBNM, Tulelake.

Flannery, K.V.
1967 The Verbebrate Fauna and Hunting Patterns, In, Douglas S. Byers, editor, The Prehistory of the Tehaucan Valley, Volume 1, 132-178. Univ. Texas Press, Austin.

Flint, Richard Foster, and Edward S. Deevey, Jr.
1951 Radiocarbon Dating of Late Pleistocene Events. American Journal of Science 249: 257-300.

Forsell, Warner M.
1961 Wildlife and Range Study, Lava Beds National Monument. Ms. on file at the LBNM, Tulelake.

Gatschet, Albert S.
1890 The Klamath Indians of Southwestern Oregon. Contributions to North American Ethnology, V. 2.

Gabrielson, Ira and Stanley G. Jewett
1940 Birds of Oregon. Oregon State College, Studies in Zoology, 2. Corvallis.

Gidley, James Williams
1913 Preliminary Report on a Recently Discovered Pleistocene Cave Deposit near Cumberland, Maryland. U.S. National Museum Proceedings 46: 2014, 93-102.

Grinnell, Joseph
1928 The Mountain Sheep of California. California Fish and Game 17: 27-39.

1933 Review of the Recent Mammal Fauna of California. Univ. California Publications in Zoology 40: 71-234.

Grinnell, Joseph and Alden H. Miller
1944 The Distribution of the Birds of California. Pacific Coast Avifauna 27.

Grinnell, Joseph, Harold Child Bryand and Tracy Irwin Storer
1918 The Game Brids of California. Univ. California Press, Berkeley.

Grinnell, Joseph, Joseph S. Dixon and Jean M. Linsdale
1937 Fur Bearing Mammals of California. University of California, Berkeley.

Gullion, Gordon W.
1953 Territorial Behavior of the American Coot. Condor 55: 196-186.

Hall, E. Raymond
1927 The Deer of California. California Fish and Game 13: 233-259.

Hall, E. Raymond and Keith R. Kelson
1959 The Mammals of North America. Ronald Press, New York.

Hansen, Henry P.
1942 A Pollen Study of Peat Profiles from Lower Klamath Lake of Oregon and California. In, Luther S. Cressman, et. al., Archaeological Researches in the Northern Great Basin. Carnegie Institute of Washington Publication 538, 103-114.

1947 Postglacial Forest Succession, Climate, and Chronology in the Pacific Northwest. Transactions, American Philosophical Society 37: 1.

Harris, Arthur H.
1963 Vertebrate Remains and Past Environmental Reconstruction in the Navajo Reservoir District. Museum of New Mexico Papers in Anthropology, 11.

Henshaw, Henry W.
1917 Report of the Chief of Bureau of Biological Survey. In, Annual Reports of the Department of Agriculture, 1916, 237-252.

Howard, Hildegard
1929 The Avifauna of the Emeryville Shellmound. Univ. California Publications in Zoology 32: 2.

1930 A Census of the Pleistocene Birds of Rancho la Brea from the Collections of the Los Angeles Museum. Condor 32: 81-88.

1946 A Review of the Pleistocene Birds of Fossil Lake, Oregon. In, Fossil Vertebrates from Western North American and Mexico, 141-195. Carnegie Institute of Washington Publication 551.

Howard, Hildegard and Alden H. Miller
1940 The Avifauna Associated with Human Remains at Rancho La Brea, California. In, Studies of Cenozoic Vertebrates and Stratigraphy of Western North America. Carnegie Institute of Washington Publication 514.

Ingles, Lloyd G.
1965 Mammals of the Pacific States, Stanford University Press.

Jennings, Jesse D.
1964 The Desert West. In, Jesse D. Jennings and Edward Norbeck, editors, Prehistoric Man in the New World, 149-174. Chicago.

1968 Prehistory of North America. McGraw-Hill.

Jewett, Stanley G.
1943 Klamath Basin National Wildlife Refuges. United States Department of the Interior Wildlife Leaflet 238.

Johnsgard, Paul H.
1968 *Waterfowl.* Nebraska Press, Lincoln.

Jones, Fred L.
1950 A Survey of the Sierra Nevado Bighorn. *Sierra Club Bulletin* 35: 29-76.

Kortright, Francis H.
1967 *The Ducks, Geese, and Swans of North America.* Stackpole, Harrisburg, Pa.

Lahr, John W.
1960 *A Preliminary Survey of the Plant and Animal Resources of Lava Beds National Monument.* Ms. on file at the LBNM, Tulelake.

Lava Beds National Monument
n.d. *A Checklist of Mammals.* Lava Beds National Monument.

Lawrence, Barbara and William H. Bossert
1967 Multiple Character Analysis of *Canis lupus*, *latrans* and *familiars* with a Discussion of the Relationships of *Canis* Sizes. *American Zoologist* 7: 223-232.

Linares de Sapir, Olga
1971 Cerro Brujo: A Tiny Guaymi Hamlet of the Past. *Expedition* 13: 27-35.

Linares de Sapir, Olga and Anthony J. Ranere
1971 Human Adaptation to the Tropical Forests of Western Panama. *Archaeology* 24: 346-355.

McCann, Lester J.
1956 Ecology of the Mountain Sheep. *American Midland Naturalist* 56: 297-324.

Mailliard, Joseph
1927 The Birds and Mammals of Modoc County, California. *Proceedings of the California Academy of Sciences*, Fourth Series 16: 261-359.

Malde, Harold E.
1964 Environment and Man in Arid America. *Science* 145: 123-129.

Martin, Paul S.
1963a Early Man in Arizona: The Pollen Evidence. *American Antiquity* 29: 67-73.

1963b The Last 10,000 Years. Univ. Arizona Press, Tucson.

Martin, Paul S. and Jane Gray
1962 Pollen Analysis and the Cenozoic. Science 137: 103-111.

Martin, Paul S. and Peter Mehringer, Jr.
1965 Pleistocene Pollen Analysis and Biogeography of the Southwest. In, H.E. Wright, Jr. and David G. Frey, editors, The Quaternary of the United States, 433-451. Princeton.

Maser, Chris and Robert M. Storm
1970 A Key to the Microtinae of the Pacific Northwest. Oregon State University Book Stores, Inc., Corvallis.

Mayr, Ernst and Lester L. Short
1970 Species Taxa of North American Birds. Publications of the Nuttall Ornithological Club 9, Cambridge.

Meacham, A.B.
1875 Wigwam and War-Path. J.P. Dale and Co., Boston.

1876 Wi-ne-ma and Her People. American Publishing Co., Hartford.

Meighan, C.W.
1959a California Cultures and the Concept of an Archaic Stage. American Antiquity 24: 289-305.

1959b The Little Harbor Site, Catalina Island: An Example of Ecological Interpretation in Archaeology. American Antiquity 24: 383-405.

Merriam, C. Hart
1921 Former Range of Mountain Sheep in Northern California. J. Mammalogy 2: 239.

1926 The Buffalo in Northeastern California. J. Mammalogy 7: 211-214.

Miller, Alden H.
1937 Structural Modification in the Hawaiian Goose (Nesochen sandvichensis). Univ. California Publications in Zoology 42: 1.

Miller, G.S., Jr. and R. Kellogg
1955 List of North American Recent Mammals. *United States Museum Bulletin* 205.

Miller, Joaquin
1874 *Unwritten History: Life Amongst the Modocs.* American Publishing Co., Hartford.

Moffitt, James
1934 Mule Deer Study Program. *California Fish and Game* 20: 52-66.

Murie, Olaus J.
1951 *The Elk of North America.* Stackpole, Harrisburg, Pa., and the Wildlife Management Institute, Inc., Washington.

Ober, E.H.
1931 The Mountain Sheep of California. *California Fish and Game* 17: 27-39.

Olsen, Stanley J.
1960 Post-Cranial Skeletal Characters of *Bison* and *Bos.* *Papers of the Peabody Museum of Archaeology and Ethnology* 35: 4.

1964 Mammal Remains from Archaeological Sites, Part 1, Southeastern and Southwestern United States. *Papers of the Peabody Museum of Archaeology and Ethnology* 61: 1.

1968 Fish, Amphibian, and Reptile Remains from Archaeological Sites, Part 1, Southeastern and Southwestern United States. *Papers of the Peabody Museum of Archaeology and Ethnology* 61: 2.

1971 *Zooarchaeology: Animal Bones in Archaeology and their Interpretation.* Addison-Wesley, Reading.

Palmer,
1962 *Handbook of North American Birds*, Volume 1. Yale University Press.

Powers, Stephen
1877 Tribes of California. *Contributions to North American Ethnology*, V. 3.

Ray, Verne
1963 *Primitive Pragmatists: The Modoc Indians of Northern California.* Univ. Washington Press, Seattle.

Riddell, Francis A.
1952 The Recent Occurrence of Bison in Northeastern California. *American Antiquity* 18: 168-169.

Sears, W.H.
1956 Excavations at Kolomoki (Final Report). *Univ. Georgia Series in Anthropology*, 5.

Seton, Ernest Thompson
1909 *Life Histories of Northern Animals*, V. 2. Scribners, New York.

1929 *Lives of Game Animals.* Doubleday and Co., New York.

Shotwell, J. Arnold
1955 An Approach to the Paleoecology of Mammals. *Ecology* 36: 327-337.

1958 Inter-Community Relations in Hemphillian (Mid-Pliocene) Mammals. *Ecology* 39: 271-282.

1963 Pliocene Mammalian C ommunities of the Juntura Basin. In, The Juntura Basin: Studies in Earth History and Paleoecology, by J. Arnold Shotwell, et. al., *Transactions, American Philosophical Society* 53: 1

Shufeldt, R.W.
1909 Osteology of Birds. *New York State Museum Bulletin* 130.

Spier, Leslie
1930 Klamath Ethnography. *Univ. California Publications in American Archaeology and Ethnology* 30.

Starr, F.R.
1934 *Field Correspondence to Don Fisher, Oct. 23, 1934.* Ms. on file at the LBNM, Tulelake.

Stern, Theodore
1966 *The Klamath Tribe.* Univ. Washington Press, Seattle.

Stock, Chester

1929 A Census of the Pleistocene Mammals of Rancho La Brea Based on the Collections of the Los Angeles Museum. *J. Mammalogy* 10: 281-289.

Storer, Tracey I. and Lloyd P. Tevis, Jr.

1955 *The California Grizzly.* Univ. California Press, Berkeley.

Stutz, Sherwood S. and Ray L. Ward

1966 *Glass Mountain Habitat Management Plans, Modoc National Forest.* United States Department of Agriculture.

Stutz, Sherwood S., Ray L. Ward, and Elmo Brough

1967 Pronghorn Antelope Management Plan, Modoc National Forest, United States Department of Agriculture.

Sweet, A.T. and I.G. McBeth

1910 Soil Survey of the Klamath Reclamation Project, Oregon. In, L.S. Cressman, et. al. Archaeological Researches in the Northern Great Basin, *Carnegie Institute of Washington Publication* 538: 145-147.

Thayer, Douglas J.

1970 *1970 Antelope Herd Composition Survey, California Fish and Game Region I.* Ms. on file at the KBNWR, Tulelake.

Thomas, David H.

1969 Great Basin Hunting Patterns: A Quantitative Method for Treating Faunal Remains. *American Antiquity* 34: 392-401.

1971 On Distinguishing Natural from Cultural Bone in Archaeological Sites. *American Antiquity* 36: 366-371.

United States Department of Agriculture (USDA)

1964 *Big Game Habitat Management Plan, Mt. Dome Deer Herd, Klamath National Forest.* United States Department of Agriculture.

United States Department of the Interior (USDI)

1942 *Narrative Report. Tule Lake, Lower Klamath Lake, Clear Lake, Upper Klamath and Klamath Forest National Wildlife Refuges. California and Oregon* (Narrative Report...). Ms. on file at the KBNWR, Tulelake.

1944 *Narrative Report....* Ms. on file at the KBNWR, Tulelake.

1954 *Narrative Report....* Ms. on file at the KBNWR, Tulelake.

1955 *A Special Report on Fish and Wildlife Resources Affected by Developments Proposed for the Upper Klamath Basin, Oregon and California.* Fish and Wildlife Service, Portland.

1957 *Annual Project History: Klamath Project--Oregon-California.* Ms. on file at the KBNWR, Tulelake.

1958 *Background Information for Program Participants, Lower Klamath Anniversary Commemorative Program.* Ms. on file at the KBNWR, Tulelake.

1960 *Narrative Report....* Ms. on file at the KBNWR, Tulelake.

1961 *Narrative Report....* Ms. on file at the KBNWR, Tulelake.

1962 *Narrative Report....* Ms. on file at the KBNWR, Tulelake.

1965 *Narrative Report....* Ms. on file at the KBNWR, Tulelake.

1969 Birds of the Klamath Basin National Wildlife Refuges. *Refuge Leaflet 104-R-5*, Bureau of Sport Fisheries and Wildlife.

1970 *Narrative Report....* Ms. on file at the KBNWR, Tulelake.

n.d.a *Report on a Proposed Reflooding of Lower Klamath Lake.* Ms. on file at the KBNWR, Tulelake.

n.d.b *Tule Lake Refuge: Resume of Conditions.* Ms. on file at the KBNWR, Tulelake.

Walker, Ernest P.

n.d. Untitled manuscript, on file at the KBNWR, Tulelake.

Wheeler-Voegelin, E.
1957 E.A. Stevenson to T.J. Huxley, Red Bluffs, September 30, 1857. Ethnohistory 4: 66-95.

White, T.E.
1953 A Method of Calculating the Dietary Percentages of Various Food Animals Utilized by Aboriginal Peoples. American Antiquity 18: 396-398.

Wilcox, Ray E.
1965 Volcanic-Ash Chronology. In, H.E. Wright, Jr. and David G. Frey, The Quaternary of the United States, 807-816. Princeton.

Willey, Gordon R.
1966 An Introduction to American Archaeology, Vol. I, North and Middle America. Prentice-Hall, Inc., Englewood-Cliffs, New Jersey.

Wilson, R.
1960 Early Miocene Rodents and Insectivores from Northeastern Colorado. University of Kansas Paleontological Contributions 7.

Woolfenden, Glen
1961 Postcranial Osteology of the Waterfowl. Bulletin of the Florida State Museum 6.

Wunner, Robert C.
1964 Range and Wildlife Research, Lava Beds National Monument. Ms, on file at the KBNWR, Tulelake.

Yoakum, Jim
1968 A Review of the Distribution and Abundance of American Pronghorn Antelope. Antelope States Work Shop, Proceedings. Ms. on file at the KBNWR, Tulelake.

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