

ON THE ANALYSIS AND INTERPRETATION OF SPECIES LIST DATA IN ZOOARCHAEOLOGY

R. LEE LYMAN

*Department of Anthropology
Oregon State University
Corvallis, Oregon 97331*

ABSTRACT.—Zooarchaeologists regularly discuss methods of quantifying faunal remains, but seldom explore the information potential found in species lists. Late Pleistocene and early Holocene mammalian species lists derived from sites in eastern Washington indicate that species list data can provide insights to details of historic zoogeography and paleoenvironmental conditions. The presence of particular taxa and the climatic regime in a region are both factors to which prehistoric people adapted, and thus play critical roles in building models of human settlement, subsistence, and land use systems.

INTRODUCTION

Discussions of how to quantify vertebrate faunal remains recovered from archaeological sites have reached a point where the specialist and novice zooarchaeologist alike must read and digest a tremendous volume of literature (see Allen and Guy 1984; Binford 1984; Grayson 1984; Horton 1984; Klein and Cruz-Urbe 1984; Lyman 1984b; Nichol and Wild 1984 for a single year of publications). Upon cursory study of this literature it might appear that in order to do zooarchaeological research, the analyst must not only decide how to count the faunal remains, but must also have a large bone sample. Statements that species lists are of little analytic and interpretive value (e.g., Smith 1976) only serve to strengthen this notion. In this paper I illustrate that such impressions are far from true by analyzing and discussing the implications of late Pleistocene/early Holocene mammalian species lists. While the intent of my discussion is to show that large samples and taxonomic abundance data are not always necessary in zooarchaeology, it is not my intent to show the converse—that large samples and abundance data are never necessary. It should be clear at the outset that the amount as well as kind of data required to answer a particular research question depend, of course, on the question asked.

DISCUSSION

The potential for deriving significant information from small faunas, rare taxa, and species lists has been recognized before. In one of the more important discussions of that potential, Grayson (1981a) argued that because of the taphonomical difficulties inherent in ascertaining the paleoenvironmental meaning of the relative abundance of taxa, the analyst may choose to simply use the ecological attributes of the taxa represented in a fauna as the basis for interpretations of paleoenvironments. The power of such interpretations lies in their parsimony; there are fewer assumptions about the taphonomic history of the fauna when taxa are treated as attributes of a fauna that are either present or absent in contrast to treating those taxa as variables whose abundances are the basis of interpretations (see also Grayson 1984).

Grayson (1981b) illustrates the elegance of the "taxa as attributes" approach by using two archaeological specimens (probably from the same individual animal) of the heather vole (*Phenacomys* cf. *intermedius*) from a single stratum sample of 406 specimens to corroborate an historic biogeographical model proposed for Great Basin mammals (Brown 1971, 1978). Those same two heather vole specimens, along with other faunal and floral taxa treated as attributes are used by Thompson and Mead (1982) as bases for their inferences regarding late Pleistocene climatic conditions in the Great Basin.

Clarifying the zoogeographic history of particular taxa (e.g., Lyman 1983) can have important zoological implications. It is seldom explicit, however, in studies of prehistoric human subsistence systems, that taxa *must be present* in an area to be exploited by humans (see Lyman 1984a for an example where this point is explicitly made). Once this fact is recognized, the utility of understanding the zoogeographic histories of potentially exploitable prey animals to studies of human subsistence becomes obvious. As well, when those zoogeographic histories have environmental and climatic implications (e.g., Lyman and Livingston 1983), their significance for gaining a fuller understanding of human settlement systems and land use practices increases. Studies by Binford (1980, 1982) and Kelly (1983), for example, indicate that the degree of mobility in a human land use system may be closely tied to resource availability and climatic factors. Simply put, then, faunal data of even statistically low-resolution (nominal) scale can be important to archaeological research.

EXAMPLES

In order to elaborate on and illustrate the above points, I have chosen late Pleistocene and early Holocene faunas recovered from sites in eastern Washington (Fig. 1). The obvious reason for this choice is that this is the area with which I am most familiar (Lyman and Livingston 1983). The second and more important reason to use examples from this area and time period is based on issues of sample size and what we know of the faunal history of the area. Quite literally, we know very little of the latter, so this paper becomes a substantive contribution. Concerning the sample size issue, only five mammalian faunal samples that are early Holocene in age are available in this area (Table 1). As well, only three late Pleistocene mammalian faunas have been described for eastern Washington. In contrast, over a dozen middle Holocene and more than fifty late Holocene mammalian archaeofaunas have been reported. Further, less than 2000 identified specimens make up six of the late Pleistocene/early Holocene samples, while several late Holocene faunas have thousands of specimens, and several middle Holocene faunas are larger than most early Holocene faunas (Table 1). Clearly, the rule of thumb that the closer to the present we are in time the more we know holds here.

Can we learn anything about late Pleistocene/early Holocene faunas and the early ecology of eastern Washington from the available data? I think we can, given the taxa represented in each of the faunas I have chosen to examine (Table 2). For clarity, I have divided the following into two sections. First, I explore the implications of the historical zoogeography of several taxa for human subsistence practices. Then, I discuss the climatic implications of two taxa, and how the inferred environment might have affected human land use practices.

Historical zoogeography.—The species lists in Table 2 illuminate certain aspects of the late Quaternary historical zoogeography of eastern Washington. For example, the Jeppson Locality fauna, the Kennewick Roadcut fauna, and the Umatilla Mammoth Site fauna provide an unprecedented view of the Wisconsinan-age mammalian biota of the area (cf. Kurten and Anderson 1980:42-43). With these faunas we find that the mammoth

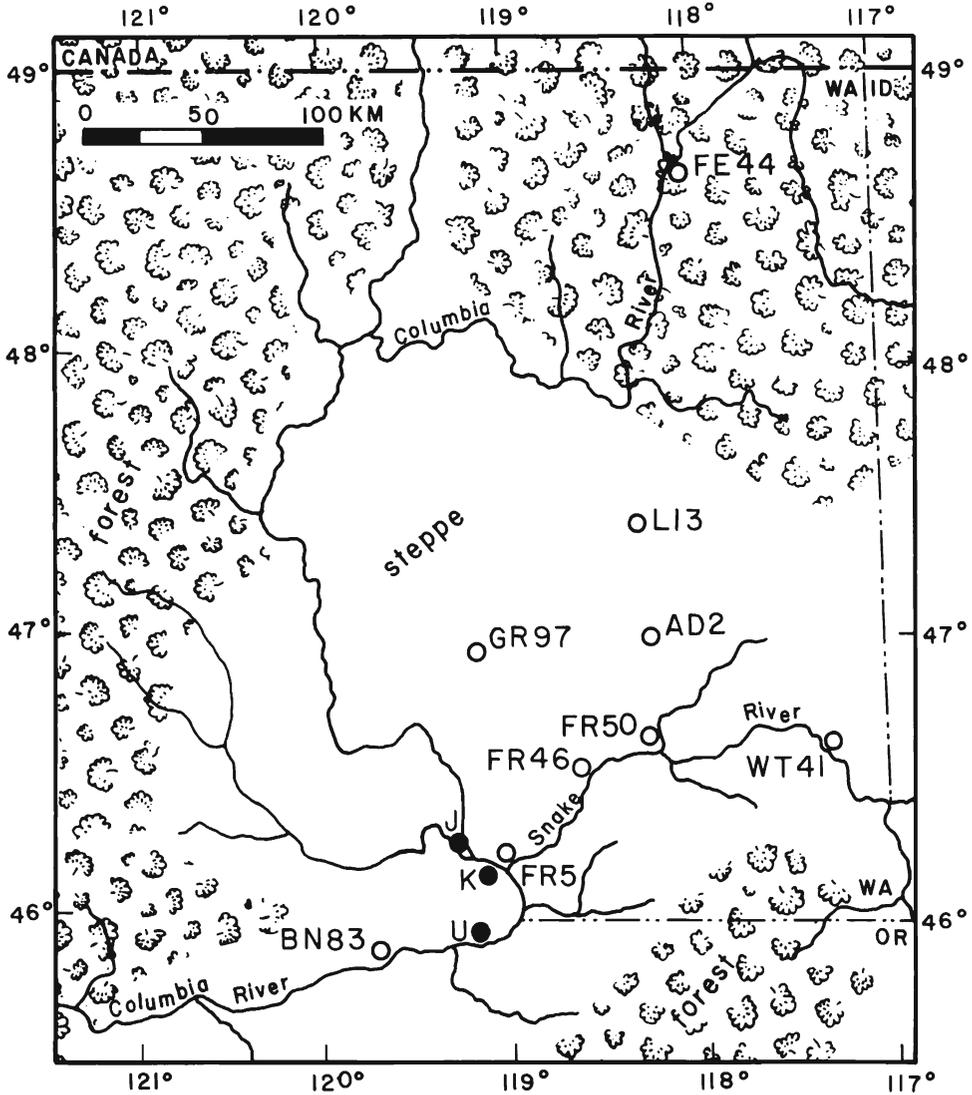


FIG. 1.—Map of eastern Washington showing major rivers, late Pleistocene faunal localities (dots: J — Jeppson Locality, K — Kennewick roadcut, U — Umatilla Mammoth Site), Holocene archaeological sites (circles), and modern distribution of forested and steppe habitats.

(*Mammuthus* sp.) was present in eastern Washington near the end of the Pleistocene, or circa 13,000 B.P. This is a detail that has until now only been suspected (Agenborad 1984; Fry 1969; Newcomb and Repenning 1970). The significance of this detail for the earliest human occupants of eastern Washington is as yet unclear because no evidence of humans associated with mammoths has been found in the area.

Other noteworthy details about the late Pleistocene species lists are the presence of musk ox (*Bootherium* sp.), pronghorn antelope (*Antilocapra americana*), northern grasshopper mouse (*Onychomys leucogaster*) Nuttall's cottontail (*Sylvilagus nuttallii*),

and Townsend's ground squirrel (*Spermophilus townsendii*). Dalquest (1948) postulated that the latter four taxa entered eastern Washington from an eastern Oregon refugium during post-Wisconsinan times (see also Lyman and Livingston 1983). The available data indicate that these four taxa had at least a limited distribution in the area during the latest Wisconsinan, and thus would have been available for exploitation by early human hunters. Bison (*Bison* sp.) were also available throughout the Holocene (Lyman and Livingston 1983), becoming locally extinct only during the late prehistoric/early historic period.

TABLE 1.—*Descriptive data for selected late Pleistocene and Holocene mammalian faunas from eastern Washington.*

Site	No. of Taxa	No. of Identified Specimens	Age in Years B.P.	Reference
Late Pleistocene:				
Jeppson Locality	9	318 +	13,000	Martin et al. 1982
Umatilla Mammoth Site	4	unknown	13,000	Gilbow 1981
Kennewick Roadcut	16	about 1000	ca. 30,000 to 10,000*	Renseberger et al. 1984
Early Holocene:				
Kennewick Roadcut	3	about 30	ca. 10,000 to 7000*	Renseberger et al. 1984
45FE44	9	42	9000-5000	Chance and Chance 1982
45GR97	17	319	8700	Irwin and Moody 1978
45FR50	13	59	10,000-7500	Gustafson 1972
45FR46	6	491	8500-8000	Mead et al. 1984
Middle Holocene:				
45L13	17	432	mid-Holocene	Bryan 1955
45FR50	11	427	7500-4000	Gustafson 1972
45WT41	17	365	8000-5000	Gustafson 1972
45FR46	13	359	8000-4000	Mead et al. 1984
Late Holocene:				
45BN83	9	2119	3100-3000	Cole 1968
45AD2	28	3128	3500-300	Deaver and Greene 1978
45FR5	16	4748	500	Olson 1983

*estimate

TABLE 2.—Species lists for three late Pleistocene and five early Holocene mammalian faunas in eastern Washington.

TAXON	Late Pleistocene		Early Holocene					
	Jeppson	Umatilla	Kenne- wick RC	Kenne- wick RC	45FE44	45GR97	45FR50	45FR46
<i>Sorex palustris</i>			+					
<i>Castor canadensis</i>					+	+		
<i>Lepus</i> sp.	+		+			+	+	
<i>Marmota flaviventris</i>						+	+	
Cricetidae								+
Microtinae	+				+	+		
<i>Microtus</i> sp.			+					+
<i>Lagurus curtatus</i>			+	+				
<i>Neotoma</i> sp.								+
<i>Neotoma cinerea</i>					+	+	+	
<i>Ondatra zibethicus</i>					+	+	+	
<i>Onychomys leucogaster</i>	+							
<i>Perognathus parvus</i>	+		+			+		+
<i>Peromyscus maniculatus</i>	+		+			+	+	
<i>Eutamias</i> sp.			+					
<i>Spermophilus</i> sp.								+
<i>Spermophilus columbianus</i>						+		
<i>Spermophilus townsendii</i>	+		+	+				
<i>Sylvilagus nuttallii</i>			+			+	+	
<i>Sylvilagus idahoensis</i>			+					
<i>Thomomys talpoides</i>	+		+	+	+	+	+	+
<i>Alopex lagopus</i>							+	
<i>Canis</i> sp.					+		+	
<i>Martes americana</i>							+	
<i>Mephitis mephitis</i>						+		
<i>Taxidea taxus</i>						+		
<i>Ursus</i> sp.					+			
<i>Ursus arctos</i>					+			
<i>Vulpes vulpes</i>					+	+		
<i>Antilocapra americana</i>		+					+	
<i>Bison</i> sp.						+		
<i>Cervus elaphus</i>						+	+	
<i>Odocoileus</i> sp.		+				+	+	
<i>Mammuthus</i> sp.	+	+	+					
<i>Bootherium</i> sp.		+						

The presence of 9000 year old grizzly bear (*Ursus arctos*) remains in northeastern Washington conforms to Dalquest's (1948) conjecture that this taxon entered the area in post-Wisconsinan times. There is limited evidence that grizzlies occupied a larger range in eastern Washington during the Holocene than this taxon did in the historic period (Lyman 1986), but additional details on the zoogeographic history of this taxon are unknown.

The above examples indicate that any model of human adaptations during the latest Pleistocene and earliest Holocene cannot simply be based on modern faunal data. Mammoths, musk ox, bison, antelope, and grizzly bears are all locally extinct at present, and may never have been very abundant in eastern Washington. And yet, because these taxa constitute some of the largest mammals exploited by prehistoric North American peoples, their presence alone warrants careful modeling of early Holocene human adaptive strategies.

Hayden (1981) has argued that human subsistence can be precarious in areas where the richness (number) of taxa present is low because overexploitation of one taxon may stress the entire ecosystem, including the human element, and natural fluctuations in the abundance of one taxon may also cause stress because of the limited number of alternative prey species. Are the known faunas dating to the late Pleistocene and early Holocene more or less taxonomically rich than the middle or late Holocene faunas of eastern Washington? While there is no statistically significant correlation of sample size (NISP) and taxonomic richness for the faunas listed in Table 1 (Kendall's tau = 0.119; $p > 0.2$; two-tailed test), given the available data it is difficult to answer this question. It appears that Gustafson's (1972) suggestion of over a decade ago that the mammalian taxonomic composition of eastern Washington during the earliest Holocene was not appreciably different from the late Holocene fauna of that area cannot be seriously challenged (see also Lyman and Livingston 1983). The taxonomic composition of eastern Washington's mammalian fauna apparently changed during the late Pleistocene to early Holocene transition (e.g., loss of *Mammuthus* sp., *Bootherium* sp., and *Alopex lagopus*, with coincident addition of *Antilocapra americana*, *Onychomys leucogaster*, and *Spermophilus townsendii*), but species richness may not have changed significantly. The focus of research on human subsistence should then change from monitoring simple species richness to taxonomic composition, that is, determining which taxa were present, and ascertaining how those taxa might have most efficiently been exploited. For example, successful hunting techniques for taking mammoths may not be appropriate for efficient exploitation of pronghorn antelope (see for instance the discussion in Frison 1978).

Ecological zoogeography.—Late Quaternary environmental conditions in eastern Washington have been postulated on the basis of palynological data (Mehring 1985 and references therein). Essentially, the late Pleistocene to early Holocene transition is reflected by climatic warming in conjunction with a gradual decrease in effective precipitation. Nonetheless, the environment about 10,000 years ago seems to have been generally cooler and moister than at present.

Interpreting the mammalian zoogeographic data for eastern Washington in climatic terms, Lyman and Livingston (1983) simply tracked the distributions of selected taxa across environmental and faunal zones defined by Dalquest (1948). They suggested the zoogeographic data broadly reflected the environmental history suggested by the palynological data for this area (see also Lyman 1980, 1984a, 1986). There is what might be thought of as a more direct technique for measuring the environmental significance of zoogeographic data, and it is that technique I will now illustrate.

A climatograph (Graham 1984) can be constructed for any taxon with a limited distribution by recording the temperature and precipitation regimes at a series of points plotted at the edge of the taxon's modern range. While it is clear that many variables control a taxon's distribution, such as interspecific competition and historical events (see reviews in Brown and Gibson 1983 and Pielou 1979), "many of these variables are dependent on or interface with climatic parameters" (Graham 1984:111). As well, regardless of how we measure it, the present distribution and resultant *apparent* ecology and environmental tolerances of taxa constitute the basis of all interpretations of past environments derived from prehistoric faunal remains.

Two taxa in the early Holocene faunas of eastern Washington have modern distributions that are particularly conducive to constructing climatographs. These are the 10,000 year old arctic fox (*Alopex lagopus*) from 45FR50, and the 8700 year old Columbian ground squirrel (*Spermophilus columbianus*) from 45GR97. To construct climatographs for these taxa, I plotted ten points around the modern range of each taxon (Figs. 2 and 3). Climatic data were derived for each plotted point on each taxon's range and both archaeological sites by consulting Hare and Thomas (1979) and Visser (1954) (Tables 3 and 4). The climatic data were then plotted on graphs with temperature on the vertical axis and precipitation on the horizontal axis (Fig. 4 and 5).

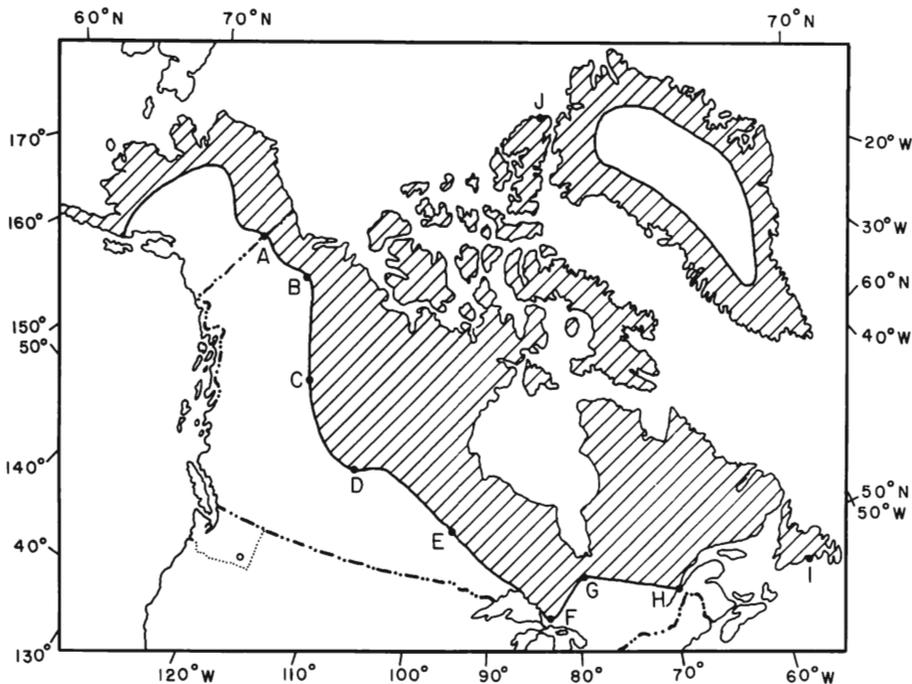


FIG. 2.—Modern distribution of arctic fox (*Alopex lagopus*) in North America (cross-hatched) (after Hall 1981), points where climatic data were recorded (dots and capital letters; see Table 3), and location of 45FR50 (open circle in southeastern Washington) where remains of this taxon have been found in 10,000 year old sediments.

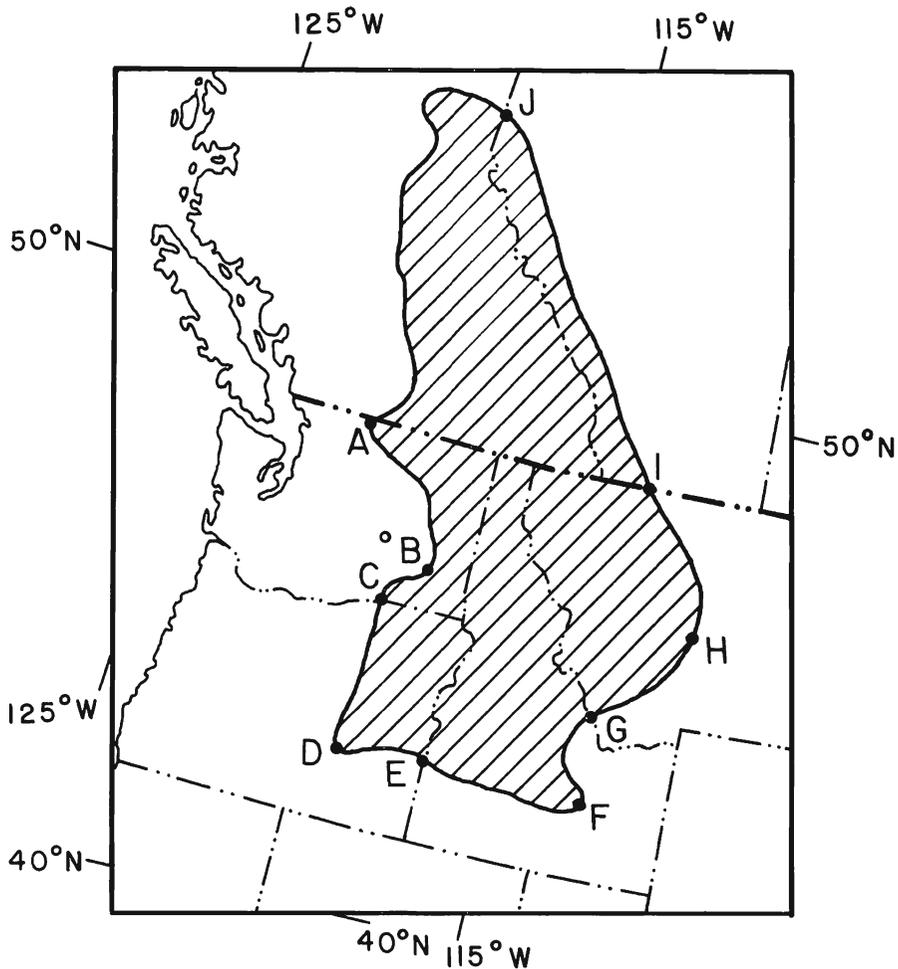


FIG. 3.—Modern distribution of Columbian ground squirrel (*Spermophilus columbianus*) in North America (cross-hatched) (after Hall 1981), points where climatic data were recorded (dots and capital letters; see Table 4), and location of 45GR97 (open circle in central Washington) where remains of this taxon have been found in 8700 year old sediments.

The type of climatic data available for the range of the arctic fox dictated the resulting climatograph; specifically, no seasonal precipitation data were available, and only seasonal temperature data were available (Table 3). The climatograph is nonetheless informative, and suggests summer temperatures would have had to be about 1°C cooler than at present for arctic foxes to have lived in southeastern Washington (Fig. 4). Underwood and Mosher (1982) suggest that the population size of this taxon seems to be dictated by the size of the rodent populations upon which arctic foxes prey, and that arctic foxes are opportunistic feeders and climatic factors may only secondarily control their abundance and distribution as some races can tolerate relatively warm, mild winters. The climatograph and the observations on the modern distribution of arctic foxes tend to

TABLE 3.—Climatic data for the distributional limits of the arctic fox (*Alopex lagopus*) and 45FR50. See Figs. 2 and 4.

Point	January Temperature (°C)	July Temperature (°C)	Annual Precipitation (mm)
A	-30	15	203
B	-30	15	305
C	-25	15	305
D	-20	17	406
E	-20	17	508
F	-12.5	17.5	813
G	-20	17	813
H	-12.5	15	1000
I	-2.5	15	1000
J	-35	5	102
45FR50	1.5	18	381

TABLE 4.—Climatic data for the distributional limits of the Columbian ground squirrel (*Spermophilus columbianus*) and 45GR97. See Figs. 3 and 5.

Point	Temperature (°C)			Precipitation (mm)		
	January	July	Annual	January	July	Annual
A	-1	21	7	152	101	508
B	-1	21	10	101	101	508
C	1.5	21	10	76	101	508
D	-1	18.5	7	76	101	508
E	-4	21	7	101	101	508
F	-6.5	21	4.5	101	101	508
G	-6.5	15.5	1.5	101	101	508
H	-4	18.5	4.5	101	127	508
I	-9.5	15.5	4.5	101	127	508
J	-15	15	ND	100*	100*	508
45GR97	-1.5	18	10	45	0	254

ND; no data available.

*values are estimates.

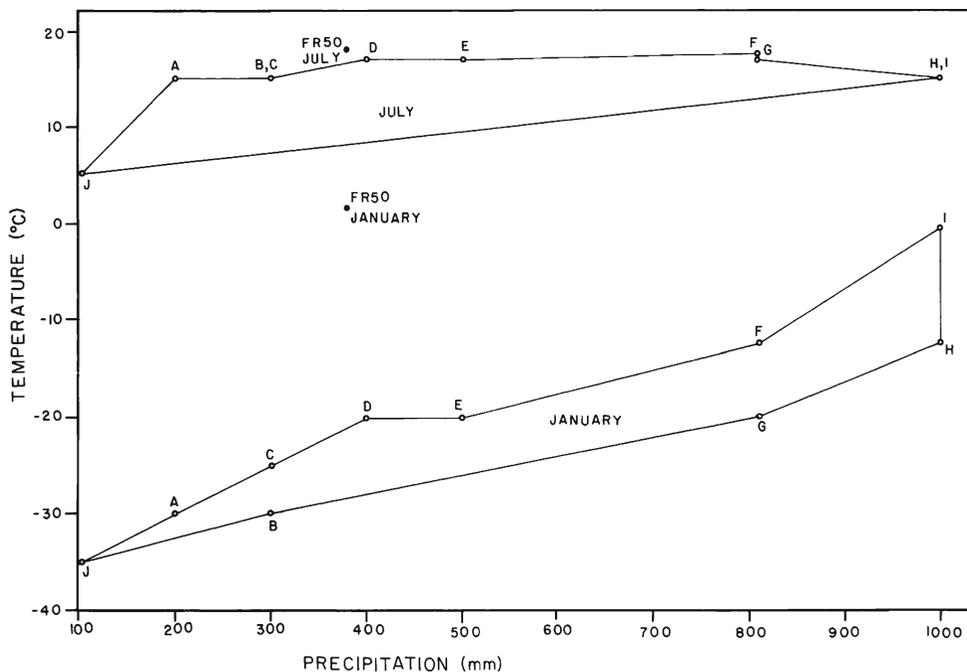


FIG. 4.—Climatograph for arctic fox (*Alopex lagopus*) derived from data in Table 3. The open circles with letter labels are the geographic points (Fig. 2). The upper part of the graph represents July temperatures plotted against annual precipitation; the lower part of the graph represents January temperatures plotted against annual precipitation. The upper dot is the July temperature plotted against annual precipitation for 45FR50; the lower dot is the January temperature plotted against annual precipitation for 45FR50.

corroborate Gustafson's (1972) original interpretations of earliest Holocene environments of eastern Washington as involving milder winters and cooler summers than at present.

The type of climatic data available for the distribution of the Columbian ground squirrel (Table 4) also dictated the nature of the resulting climatograph (Fig. 5) for this taxon. Clearly, it is much too xeric at 45GR97 today for the Columbian ground squirrel, particularly during the summer months when about 100 mm of additional precipitation would be needed to make the site area suitable habitat for this taxon today. Even the winter months at the site are too dry for this ground squirrel. This taxon today prefers relatively mesic habitats, usually in grasslands because the Columbian ground squirrel is a grazer (Tyser and Moermond 1983). This species is never far from water, whether free-flowing or in the form of moist sub-surface sediments (Turner 1972). In fact, seasonal sediment moisture, because it determines the vegetation cover, may be a factor which limits aboveground activity and dictates summer aestivation periods of this taxon (Turner 1972). The climatograph thus matches and corroborates the inferences derived from palynological data that central Washington was moister during the early Holocene than at present.

The significance of the climatographs for understanding prehistoric human land use is reflected in a Holocene sequence of cultural adaptations postulated by Galm et al. (1981). They suggest that between 11,000 and 8000 B.P. people hunted large and small

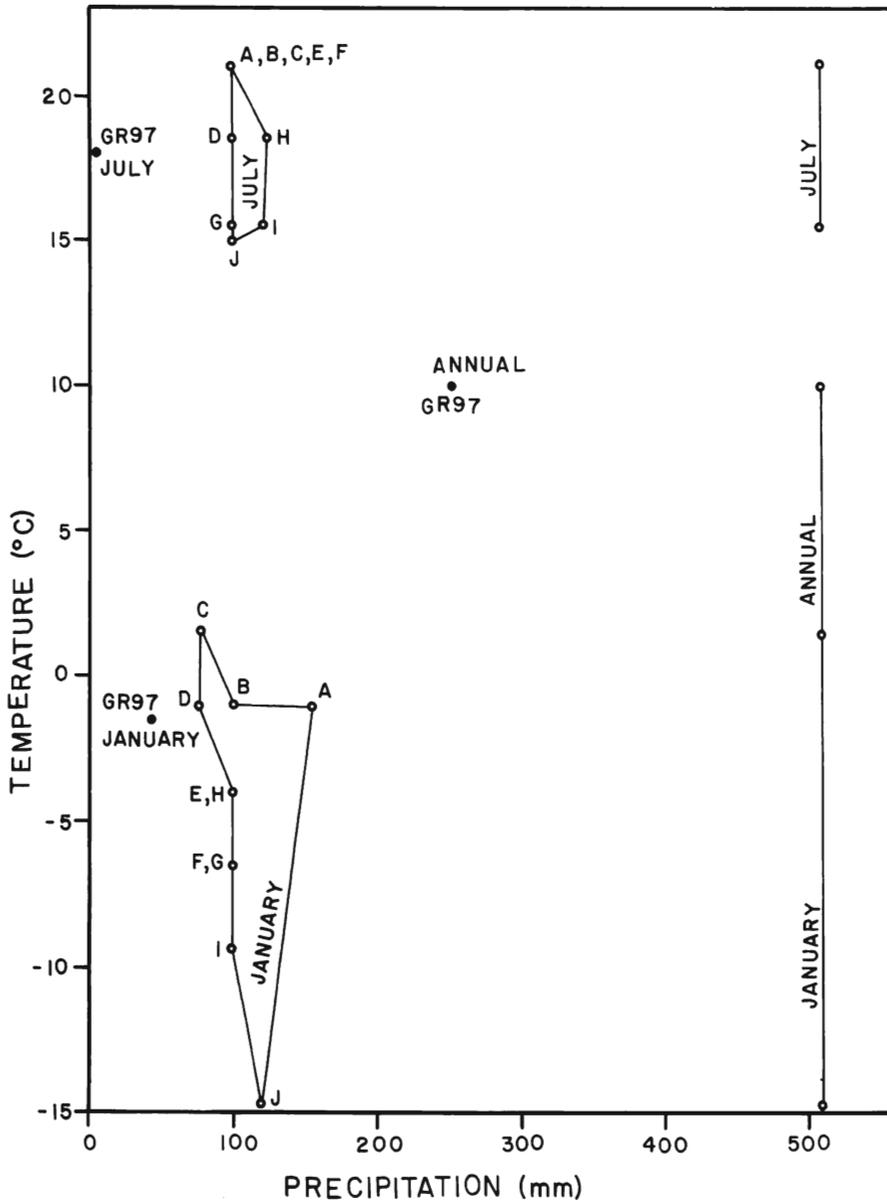


FIG. 5.—Climatograph for Columbian ground squirrel (*Spermophilus columbianus*) derived from data in Table 4. The open circles with letter labels are the geographic points (Fig. 3). The graphs on the left represent the July precipitation plotted against July temperature, the January precipitation plotted against January temperature, and the dots represent the July and January climate at 45GR97 today. The lines on the right represent the July, Annual, and January temperature ranges for all geographic points plotted against annual precipitation (508 mm) for all geographic points. The dot in the center represents the annual climate for 45GR97.

mammals, fished for non-salmonids, and followed a nomadic but seasonally scheduled pattern of movements between winter camps located in the major river canyons and summer camps and resource extraction loci in the uplands. With warming and drying of environments between 8000 and 4500 B.P., people intensified fishing activities and the exploitation of seeds and roots, and spent more time in river canyons and less time in the increasingly xeric uplands than previously (see also Chatters 1982). In Binford (1980) and Kelly's (1983) terms, it appears that a shift from a residential mobility strategy to a logistical mobility strategy took place as environments became progressively warmer and drier. The typical explanation for such a shift in land use strategies concerns changes in resource availability, especially in this case expressed as decreases in (animal) biomass (e.g., Kelly 1983 and references therein). The faunal data on which the climatographs are based tend to conform to this kind of explanation: the disappearance of arctic foxes and Columbian ground squirrels from increasingly xeric habitats in eastern Washington represents a decrease in exploitable faunal biomass in those habitats.

SUMMARY AND CONCLUSIONS

The increasingly numerous discussions of quantitative methods in zooarchaeology present a bewildering set of alternatives and opinions on how to best quantify a sample of faunal remains. Comparable discussions of taxa as attributes of a fauna and techniques for analyzing and deriving inferences from species lists are, in contrast, rare. Perhaps this is due to the relative parsimony of deriving inferences based on nominal scale faunal data and/or the suspected greater potential resolution afforded by ordinal and interval scale faunal data. Regardless of the reasons for the paucity of literature on nominal scale faunal data (a large portion of that literature is found in paleontological journals; see for example Raup and Crick 1979 and references therein), such data are potentially useful and informative. Using examples from the late Pleistocene and early Holocene of eastern Washington, I have shown here that nominal scale faunal data may (1) clarify the zoographic history of a taxon, (2) indicate fruitful analytical pathways towards modeling human subsistence by providing information on the taxonomic composition of faunas of particular time periods, (3) provide data indicative of past climatic conditions, and (4) suggest causes of changes in human land use practices.

ACKNOWLEDGEMENTS

I thank Donald K. Grayson and Stephanie D. Livingston for their comments on an earlier version of this paper. While they do not always agree with my methods and conclusions, they always make sure that I understand what I am doing.

LITERATURE CITED

- AGENBROAD, LARRY D. 1984. New world mammoth distribution. Pp. 90-108. *In* Quaternary extinctions: A prehistoric revolution, P.S. Martin and R.G. Klein, eds. Univ. Arizona Press, Tucson.
- ALLEN, JIM and J.B.M. GUY. 1984. Optimal estimations of individuals in archaeological faunal assemblages: How minimal is the MNI? *Archaeology in Oceania* 19:41-47.
- BINFORD, LEWIS R. 1980. Willow smoke and dogs' tails: hunter-gatherer settlement systems and archaeological site formation. *Amer. Antiq.* 45:1-17.
- _____. 1982. The archaeology of place. *J. Anthro. Archaeology* 1:5-31.

LITERATURE CITED (continued)

- _____. 1984. Faunal remains from Klasyes river mouth. Academic Press, New York.
- BROWN, JAMES H. and ARTHUR C. GIBSON. 1983. Biogeography. C.V. Mosby Co., St. Louis.
- BRYAN, ALAN. 1955. Excavations at Meyer Caves in east central Washington. Davidson J. of Anthro. 1(1): 11-20. Seattle.
- CHANCE, DAVID H. and JENNIFER V. CHANCE. 1982. Kettle Falls: 1971 and 1974: Salvage Archaeology in Lake Roosevelt. Univ. Idaho Anthro. Research Manuscripts Series No. 69. Moscow.
- CHATTERS, JAMES C. 1982. Prehistoric settlement and land use in the dry Columbia Basin. Northwest Anthro. Res. Notes 16:125-147.
- COLE, DAVID L. 1968. Report on archaeological research in the John Day Dam Reservoir Area—1967. Univ. Oregon Museum of Natural History, Eugene.
- DALQUEST, WALTER W. 1948. Mammals of Washington. Univ. Kansas Publ. the Museum of Natural History No. 2.
- DEAVER, KEN and GLEN S. GREENE. 1978. Faunal utilization at 45AD2: A prehistoric archaeological site in the channeled scablands of eastern Washington. Tebiwa, Misc. Papers of the Idaho State Univ. Museum of Natural History, No. 14.
- FRISON, GEORGE C. 1978. Prehistoric hunters of the high plains. Academic Press, New York.
- FRY, WILLIS E. 1969. A Paleontological site survey conducted in the Horse Heaven Hills of South-Central Washington. Northwest Sci. 43:156-161.
- GALM, JERRY R. and GLENN D. HARTMANN, RUTH A. MASTEN and GARRY O. STEPHENSON. 1981. A cultural resources overview of Bonneville power administration's Mid-Columbia Project, Central Washington. Eastern Washington Univ. Reports in Arch. and Hist. 100-116. Cheney.
- GILBOW, DELBERT W. 1981. Inference of human activity from faunal remains. Unpubl. thesis, (Anth.), Washington State Univ., Pullman.
- GRAHAM, RUSSELL W. 1984. Paleo-environmental implications of the quaternary distribution of the eastern chipmunk (*Tamias striatus*) in Central Texas. Quaternary Res. 21:111-114.
- GRAYSON, DONALD K. 1981a. A critical view of the use of archaeological vertebrates in paleoenvironmental reconstruction. J. Ethnobiol. 1:28-38.
- _____. 1981b. A Mid-Holocene record for the heather vole, *Phenacomys cf. intermedius*, in the Central Great Basin and its Biogeographic Significance. J. Mammalogy 62:115-121.
- _____. 1984. Quantitative Zooarchaeology. Academic Press, New York.
- GUSTAFSON, CARL E. 1972. Faunal remains from the marmes rock-shelter and related archaeological sites in the Columbia Basin. Unpubl. dissert. (Zoology), Washington State Univ., Pullman.
- HALL, E. RAYMOND. 1981. The Mammals of North America, second edition, 2 vols. Wiley, New York.
- HARE, F. KENNETH and MORLEY K. THOMAS. 1979. Climate Canada, second edition. Wiley, Toronto.
- HAYDEN, BRIAN. 1981. Subsistence and ecological adaptations of modern hunter/gatherers. Pp. 344-421. In Omnivorous Primates, R.S.O. Harding and G. Teleki, eds. Columbia Univ. Press, New York.
- IRWIN, ANN M. and ULA MOODY. 1978. The Lind Coulee Site (45GR97).

LITERATURE CITED (continued)

- Washington Archaeol. Res. Center Proj. Rep. No. 56. Pullman.
- KELLY, ROBERT L. 1983. Hunter-gatherer mobility strategies. *J. Anthro. Res.* 39:277-306.
- KLEIN, RICHARD G. and KATHRYN CRUZ-URIBE. 1984. *The Analysis of Animal Bones from archaeological sites.* Univ. Chicago Press, Chicago.
- KURTEN, BJORN and ELAINE ANDERSON. 1980. *Pleistocene Mammals of North America.* Columbia Univ. Press, New York.
- HORTON, D.R. 1984. Minimum numbers: a consideration. *J. Archaeol. Sci.* 11:255-271.
- LYMAN, R. LEE. 1980. Bivalve molluscs and southern plateau prehistory: A discussion and description of three genera. *Northwest Sci.* 54: 121-136.
- _____. 1983. Prehistoric extralimital records for *Pappogeomys castoanops* (Geomyidae) in Northwestern New Mexico. *J. Mammalogy* 64:502-505.
- _____. 1984a. A model of large freshwater clam exploitation in the prehistoric southern Columbia Plateau culture area. *Northwest Anthro. Res. Notes* 18:97-107.
- _____. 1984b. Bone density and differential survivorship of fossil classes. *J. Anthro. Arch.* 3:259-299.
- _____. 1986. On the Holocene history of *Ursus* in eastern Washington. *Northwest Sci.* 60, in press.
- _____ and STEPHANIE D. LIVINGSTON. 1983. Late quaternary mammalian zoogeography of eastern Washington. *Quaternary Res.* 20: 360-373.
- MARTIN, J.E., A.D. BARNOSKY and C.W. BARNOSKY. 1982. Fauna and flora associated with the west richland mammoth from the pleistocene touchet formation in south-central Washington. Thomas Burke Memorial Museum Res. Rep. No. 3. Seattle.
- MEAD, JIM I., EMILEE MEAD and D.W. STEADMAN. 1985. Faunal studies. Pp. 35-42. *In* *Paleoenvironmental investigations at Seed Cave (Windust CaveH—45FR46), Franklin County, Washington,* by Robert S. Thompson. Eastern Washington Univ. Rep. in *Arch. and Hist.* 100-141. Cheney.
- MEHRINGER, PETER J., JR. 1985. Late-quaternary pollen records from the interior pacific northwest and northern great basin of the United States. P. 167-189. *In* *Pollen Records of Late-Quaternary North American Sediments,* V.A. Bryant and R.G. Holloway, eds. Amer. Assoc. Strati. Palynol., Dallas.
- NEWCOMB, R.C. and C.A. REPENNING. 1970. Occurrence of mammoth fossils in the touchet beds, south-central Washington. *Northwest Sci.* 44:16-18.
- NICHOL, R.K. and C.J. Wild. 1984. "Numbers of Individuals" in faunal analysis: the decay of fish bone in archaeological sites. *J. Archaeol. Sci.* 11:35-51.
- OLSON, DEBORAH L. 1983. A descriptive analysis of the faunal remains from the Miller Site, Franklin County, Washington. Unpubl. thesis, (Anth.), Washington State Univ., Pullman.
- PIELOU, E.C. 1979. *Biogeography.* Wiley-Interscience, New York.
- RAUP, DAVID M. and REX E. CRICK. 1979. Measurement of faunal similarity in paleontology. *J. Paleontology* 53:1213-1227.
- RENSBERGER, JOHN M., ANTHONY D. BARNOSKY and PATRICK SPENCER. 1984. Geology and Paleontology of a Pleistocene-to-Holocene loess succession, Benton County, Washington. Eastern Washington Univ. Rep. in *Arch. and*

LITERATURE CITED (continued)

- Hist. 100-139. Cheney.
- SMITH, BRUCE D. 1976. "Twitching": A minor ailment affecting human paleoecological research. Pp. 275-292. *In* Cultural Change and Continuity, C.E. Cleland, ed. Academic Press, New York.
- THOMPSON, R.S. and J.I. MEAD. 1982. Late Quaternary environments and biogeography in the Great Basin. *Quaternary Res.* 17:39-55.
- TURNER, LARRY W. 1972. Habitat differences between *Spermophilus beldingi* and *Spermophilus columbianus* in Oregon. *J. Mammalogy* 53:914-917.
- UNDERWOOD, LARRY and JAMES A. MOSHER. 1982. Arctic Fox. Pp. 491-503. *In* Wild Mammals of North America, J.A. Chapman and G.A. Feldhamer, eds. Johns Hopkins Univ. Press, Baltimore.
- VISHER, STEPHEN S. 1954. Climatic Atlas of the United States. Harvard Univ. Press, Cambridge.
- TYSER, ROBIN W. and TIMOTHY C. MOERMOND. 1983. Foraging behavior in two species of different-sized sciurids. *Amer. Midl. Natur.* 109:240-245.