Reconstruction of Demographic Profiles from Ossuary Skeletal Samples

A CASE STUDY FROM THE TIDEWATER POTOMAC

Douglas H. Ubelaker

SMITHSONIAN CONTRIBUTIONS TO ANTHROPOLOGY

NUMBER 18

SERIAL PUBLICATIONS OF THE SMITHSONIAN INSTITUTION

The emphasis upon publications as a means of diffusing knowledge was expressed by the first Secretary of the Smithsonian Institution. In his formal plan for the Institution, Joseph Henry articulated a program that included the following statement: "It is proposed to publish a series of reports, giving an account of the new discoveries in science, and of the changes made from year to year in all branches of knowledge." This keynote of basic research has been adhered to over the years in the issuance of thousands of titles in serial publications under the Smithsonian imprint, commencing with *Smithsonian Contributions to Knowledge* in 1848 and continuing with the following active series:

Smithsonian Annals of Flight
Smithsonian Contributions to Anthropology
Smithsonian Contributions to Astrophysics
Smithsonian Contributions to Botany
Smithsonian Contributions to the Earth Sciences
Smithsonian Contributions to Paleobiology
Smithsonian Contributions to Zoology
Smithsonian Studies in History and Technology

In these series, the Institution publishes original articles and monographs dealing with the research and collections of its several museums and offices and of professional colleagues at other institutions of learning. These papers report newly acquired facts, synoptic interpretations of data, or original theory in specialized fields. These publications are distributed by mailing lists to libraries, laboratories, and other interested institutions and specialists throughout the world. Individual copies may be obtained from the Smithsonian Institution Press as long as stocks are available.

S. Dillon Ripley
Secretary
Smithsonian Institution

SMITHSONIAN CONTRIBUTIONS TO ANTHROPOLOGY

NUMBER 18

SMITHSONIAN CONTRIBUTIONS TO ANTHROPOLOGY • NUMBER 18

Reconstruction of Demographic Profiles from Ossuary Skeletal Samples

A CASE STUDY FROM THE TIDEWATER POTOMAC

Douglas H. Ubelaker

SMITHSONIAN INSTITUTION PRESS
CITY OF WASHINGTON
1974

ABSTRACT

Ubelaker, Douglas H. Reconstruction of Demographic Profiles from Ossuary Skeletal Samples: A Case Study from the Tidewater Potomac. *Smithsonian Contributions to Anthropology,* number 18, 79 pages, 27 figures, 45 tables, 1974.—The excavation and analysis of two Late Woodland ossuaries from the Juhle site (18CH89) in southern Maryland are described in detail. The report includes a discussion of archeological features of the ossuaries, but emphasizes the reconstruction of population profiles derived from the analysis of the recovered skeletal samples. Ethnohistorical and archeological sources are consulted to suggest that ossuaries contain nearly all individuals who died in the contributing populations during culturally prescribed numbers of years and, consequently, offer somewhat unique opportunities for demographic analysis.

Several methods are employed to estimate the chronological age at death of individuals in both ossuaries. Subadult ages are derived from the formation and eruption of the teeth and from the maximum length of the femora. Adult ages are calculated from examinations of the symphyseal faces of the pubes and the degree of microscopic cortical remodeling in the femora. The latter method involved the preparation of 151 ground thin sections taken from the anterior cortices of the right femora, and it represents the first application of Kerley's relatively new method (1965) to a large archeological population. The resulting death curves are compared and the methods evaluated. Data from the most reliable of these age-determinative methods are used to calculate curves of mortality and survivorship, life tables, and crude mortality rates for the populations represented.

Population estimates are attempted by utilizing the crude mortality rates (calculated from the life tables), the length of time represented by each ossuary (calculated from archeological data), and the total numbers of individuals in the ossuaries. The resulting population size estimates are considered against both archeological and ethnohistorical data to suggest the nature of the sociopolitical unit serviced by the ossuaries. Finally, both local and regional population-size estimates are compared with those estimated by others using different types of data.

OFFICIAL PUBLICATION DATE is handstamped in a limited number of initial copies and is recorded in the Institution's annual report, *Smithsonian Year.* SI PRESS NUMBER 4958.

Library of Congress Cataloging in Publication Data
Ubelaker, Douglas H.
Reconstruction of demographic profiles from ossuary skeletal samples.
(Smithsonian contributions to anthropology, no. 18)
Bibliography: p.
1. Indians of North America—Maryland—Anthropometry. 2. Juhle site, Md. I. Title. II. Series.
GN1.S54 no. 18 [E78.M3] 573'.6'09701 73-16117

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price $2.25 (paper cover)
Stock Number 4700-00287

Preface

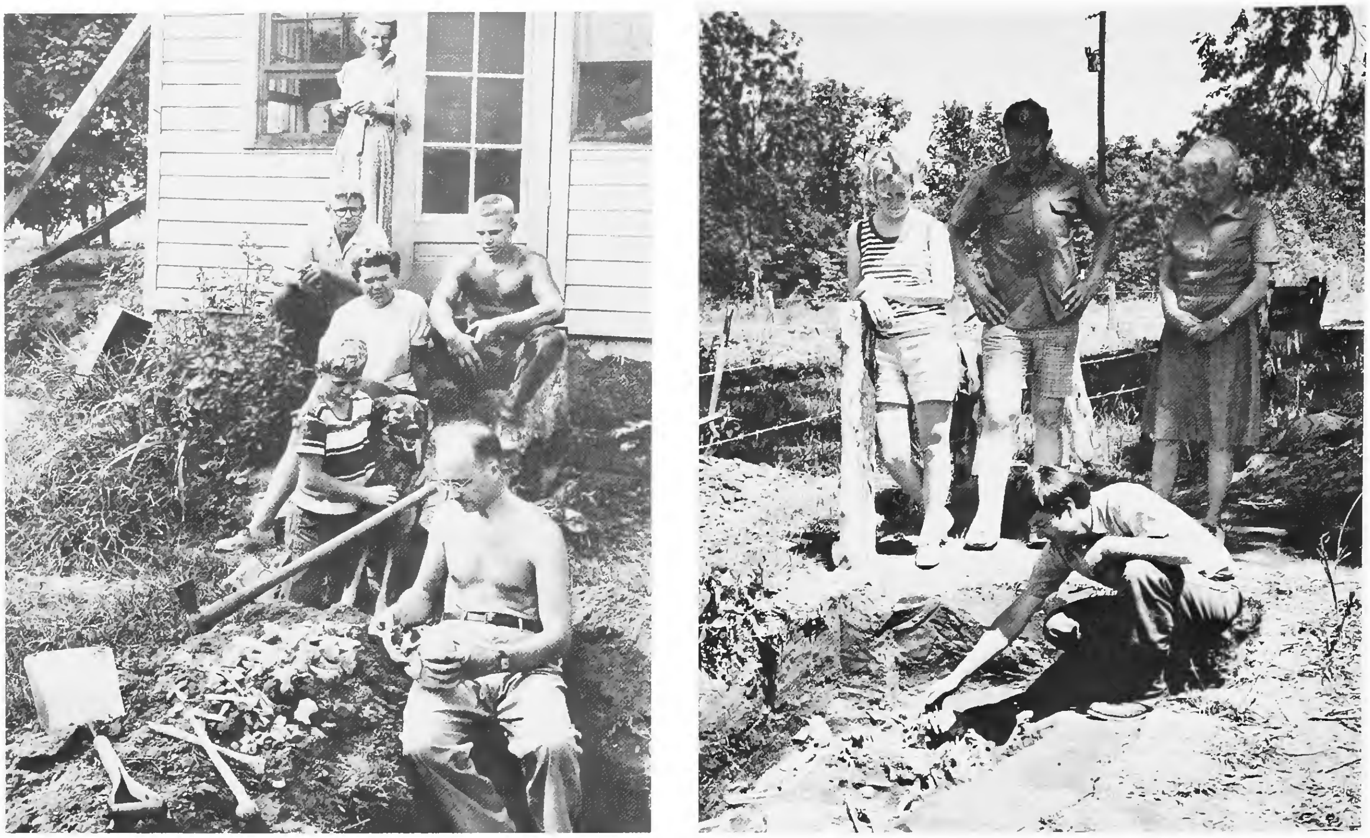
In August 1953, Mr. Bernwald Juhle and his son Hans-Bodo of Nanjemoy, Charles County, Maryland, discovered a concentration of human bone while they were connecting a water pipe to the family home on Friendship Farm. The Juhle's keen interest in local history and concern over the potential importance of the find led them to cover the remains carefully to prevent further disturbance and to call the Smithsonian Institution. At the Smithsonian, the call was directed to T. Dale Stewart, physical anthropologist in the Department of Anthropology of the National Museum of Natural History, who responded with a visit to the Juhle farm. His preliminary examination of the exposed bones revealed that an apparent ossuary had been found. Stewart returned to the ossuary with Marshall T. Newman of the Smithsonian Institution on 29 August 1953 and began the excavation. Unfortunately, the water pipe installed by the Juhles bisected the ossuary, dividing it into an eastern two-thirds section and a western one-third section. Since the water pipe could not be removed, Stewart and Newman were obliged to dig around it. Beginning with the eastern section, they worked as steadily as weather would permit and by 1 November had succeeded in removing all the skeletal material from the eastern two-thirds. They then closed the excavation for the season.

Stewart was unable to return to the excavation until 29 August 1955. At that time, he removed the topsoil from the western third and continued the 1953 procedure of exposing, recording, mapping, and removing the skeletal material. On 29 September Stewart completed the excavation, backfilled the pit and returned to Washington with the complete ossuary skeletal collection.

In the spring of 1971, eighteen years after the discovery of Ossuary I, Fredrich Berthold (Pete) Juhle was digging a post hole for a planned fence line on his mother's farm, when his auger struck bone. Recalling the excavation of the first ossuary during his childhood, he realized that the bones were probably human. Thereupon, he carefully covered the exposed bones with plastic, refilled the hole and finished the fence, without installing a post at that point. Soon thereafter, his mother notified T. Dale Stewart at the Smithsonian of the discovery. At that time, I had just joined the staff at the Department of Anthropology, National Museum of Natural History, and accepted Stewart's cordial invitation to join him in investigating the discovery. On 10 May 1971, Stewart and I visited the Juhle Farm, confirmed "Pete" Juhle's diagnosis that the bones were human, and began removing the topsoil to disclose the extent of the bone deposit. Since we were aided by numerous volunteers from Washington, D.C., and a grant from the Smithsonian Institution's Hrdlička Fund, progress continued virtually uninterrupted until 1 June. At that time I was forced to leave the excavation to direct an eight-week project in South Dakota sponsored by the National Geographic Society and the Smithsonian Institution. During my absence, T. Dale Stewart assisted by David Ruzek of Washington, D.C., continued the excavation. Accompanied by James Yost of the University of Kansas Medical Center, I rejoined Stewart and Ruzek at the ossuary on 9 August 1971. By 16 August 1971, we succeeded in removing the bones from all but the northwest quarter of the ossuary.

Again aided by volunteers from Washington, D.C., and financial support from the Smithsonian Institution's Hrdlička Fund, Stewart and I returned to the ossuary excavation on 16 May 1972. By 9 June 1972 all of the bones from this final quarter of Ossuary II had been removed and the pit refilled.

As is usually the case with a project of this magnitude, many individuals offered their assistance and encouragement. First and foremost, I extend my appreciation to T. Dale Stewart, Physical Anthropologist Emeritus at the Smithsonian Institution. Dr. Stewart provided the initial encouragement to undertake this research problem, generously placed his original, unpublished data at my disposal, enthusiastically followed the progress of my research, and read many versions of the manuscript. His continued interest and guidance have been instrumental in my completion of this monograph and I am grateful for his generosity.



Excavation of Nanjemoy Ossuaries: *left,* Ossuary I (1953). From top to bottom: Mrs. Lisa Juhle; husband, Bernwald; son, Hans-Bodo; niece, Hilda Karlsson; son, Fredrich Berthold; dog, Hero; T. Dale Stewart. *right,* Ossuary II (1971). Standing from left to right: Mrs. Marty Juhle; Fredrich Berthold (Pete) Juhle; Mrs. Lisa Juhle. Foreground: author.

Numerous other colleagues at the Smithsonian have contributed substantially to the development of my ideas and general research design. In particular I wish to thank Clifford Evans, Chairman, Department of Anthropology, and Betty J. Meggers, Research Associate, for spending many Saturday afternoon coffee breaks listening to my interpretations of research results, as well as for reading and offering suggestions on various drafts of the manuscript. Waldo and Mildred Wedel also read the final draft and offered many helpful suggestions. Many others at the Smithsonian have been helpful. In particular I wish to thank J. Lawrence Angel for his advice on techniques of demographic reconstruction; Christian Feest and William Merrill for many conversations on the ethnography of the Maryland and Virginia Indians; Donald J. Ortner for making his research histology laboratory available and for his advice on thin-section preparation; Joseph P. E. Morrison for identifying the shell, George E. Phebus and Clifford Evans for identifying the pottery, George R. Lewis for preparing the illustrations, Victor Krantz and the Smithsonian Division of Photographic Services for preparing the photographs, Neil Roth for his assistance in the statistical computations, Joan Horn for excellent editorial advice and assistance in leading me from manuscript to final published monograph without too many pitfalls.

Several individuals outside of the Smithsonian Institution have contributed significantly to this research. I especially wish to thank B. Miles Gilbert of the University of Missouri for his identification of the faunal material, Clark S. Larsen of Kansas State University, Pamela L. Horn of Springfield, Virginia, and Nicki Horton of Washington, D.C., for their assistance in specimen processing, and Marnie Briggs of Washington, D.C., for her substantially underpaid assistance in thin-section preparation and osteological analysis. David C. Ruzek of Austin, Minnesota, David Frayer of the University of Michigan, Richard Stewart of Silver Spring, Maryland, and Katchie McQuilkin of Washington, D.C., all contributed many hours of unpaid assistance during excavation. Dr. Carlyle S. Smith and Dr. Michael Crawford of the University of Kansas both read a final draft of the manuscript and offered many helpful suggestions.

Finally I would like to thank Mrs. Lisa Juhle of Nanjemoy, Maryland, not only for allowing us to excavate on her property and disrupt her summer routine, but also for continually offering us her cold lemonade, delicious desserts, and gracious hospitality on those hot summer afternoons. It was Mrs. Juhle's immediate report of the discovery of an undisturbed ossuary that made this entire investigation possible. Consequently, this monograph is dedicated to Mrs. Lisa Juhle and her concern for local history.

Douglas H. Ubelaker

Smithsonian Institution
Washington, D.C.
30 June 1973

Contents

	Page
METHODS OF POPULATION RECONSTRUCTION	1
Ethnohistorical Methods	2
Tribe-by-Tribe Inventories	2
Death Rates	2
Population Projection	2
Sociopolitical Reconstruction	3
Depopulation Rates	3
Archeological Approaches	4
Site Surface Area	4
House and Mound Frequency	4
Settlement Patterns	4
Ecological Resource Potential	5
Physical Anthropological Approaches	5
Application in Old World	5
Application in New World	6
Research Model of Present Study	7
EVIDENCE OF OSSUARY BURIAL FROM EASTERN NORTH AMERICA	8
Ethnography of Ossuary Practice	8
The Huron	8
Southeastern United States	10
Mid-Atlantic Area of the United States	10
Archeological Evidence	11
THE OSSUARIES FROM NANJEMOY CREEK	15
Ossuary I	15
Ossuary II: Excavation Procedure	15
Ossuary II: Contents	19
Animal Bone	22
Shell	26
Pottery	27
Human Remains	27
Total Number of Individuals	31
Ossuary I	32
Ossuary II	33
Variability in Bone Representation	33
Spatial Distribution Features within Ossuary II	37
Summary	40
DETERMINATION OF SEX AND AGE AT DEATH	41
Determination of Sex	41
Determination of Age of Subadults	42
Length of Long Bones	42
Epiphyseal Union	43
Dental Eruption and Calcification	44
Determination of Age of Adults	51
Pubic Symphysis	52
Internal Bone Remodeling	53
Specimen Preparation	54
Osteon Counts	56

Page
Reconstruction of Demographic Profiles and Population Size 59
Mortality Curves 59
Survivorship Curves 60
Life Tables 60
Crude Mortality Rates 65
Population Reconstruction 65
Regional Population Estimates 68
Literature Cited 71

Tables

1. Estimates of New World population size in 1492. 1
2. Distribution of bone weight within Ossuary II. 22
3. Spatial distribution of bones of turkey (*Meleagria gallopavo*) within Ossuary II 22
4. Spatial distribution of bones of white-tailed deer (*Odocoileus virginianus*) within Ossuary II 26
5. Frequencies of ceramic types in ossuaries and habitation area. 27
6. Frequencies of articulated adult bones in Ossuary II 31
7. Spatial distribution of burned bone within Ossuary II 31
8. Frequencies of skull positions in Ossuary II 31
9. Frequencies of face orientations in Ossuary II 31
10. Counts of complete and fragmentary adult long limb bones from Ossuary II. 32
11. Number of individuals represented by each type of adult bone in Ossuary I 32
12. Number of individuals represented by each type of subadult bone in Ossuary I. 33
13. Number of individuals represented by each type of subadult bone in Ossuary II. 33
14. Number of individuals represented by each type of adult bone in Ossuary II. 34
15. Order of representation of adults in Ossuary I as indicated by bone types 35
16. Order of representation of subadults in Ossuary I as indicated by bone types 36
17. Order of representation of adults in Ossuary II as indicated by bone types 36
18. Order of representation of subadults in Ossuary II as indicated by bone types 37
19. Partial inventory of bones from Fairty Ossuary, Ontario, Canada 37
20. Chi square values for distributional associations between young and old adults within Ossuary II 38
21. Chi square values for distributional associations between adult males and females within Ossuary II 38
22. Chi square values for distributional associations between adult and subadult bones within Ossuary II. 38
23. Chi square values for distributional associations between the adult femora and other adult bones within Ossuary II 39
24. Chi square values for distributional associations between the subadult clavicles and other subadult bones within Ossuary II 39
25. Sex representation of adults in Ossuary I 42
26. Sex representation of adults in Ossuary II 42
27. Maximum diaphyseal length of subadult femora from Ossuary I 44
28. Maximum diaphyseal length of subadult femora from Ossuary II 44
29. Age distribution of subadult femora from Ossuaries I and II as determined from maximum diaphyseal length and epiphyseal union. 45
30. Age distribution of subadults in Ossuary I as determined from crown-root calcification and tooth eruption. 46
31. Age distribution of subadults in Ossuary II as determined from crown-root calcification and tooth eruption 47
32. Age distribution of adults as determined from pubes in Ossuary I 52
33. Age distribution of adults as determined from pubes in Ossuary II 53
34. Percentages of remodeled bone and corresponding age estimates for 66 right femora from Ossuary I 56

Page
35. Percentages of remodeled bone and corresponding age estimates for 84 right femora from Ossuary II ... 57
36. Age distribution of adults in Ossuaries I and II as estimated from femoral microscopic remodeling ... 57
37. Age distribution of subadults and adults from Ossuaries I and II as estimated from femoral length and epiphyseal union (0–20 years) and femoral microscopic remodeling (20+ years) ... 59
38. Life table reconstructed from Ossuary I age distribution ... 62
39. Life table reconstructed from Ossuary II age distribution ... 63
40. Life expectancy at birth in 15 world-wide populations ... 64
41. Correlation of ages at death with known annual death rates ... 65
42. Death rate estimates from eight skeletal populations ... 66
43. A comparison of possible time intervals (T) represented by Ossuary II, assuming different rates of decomposition (t), as calculated by the formula $T= .42\ t$ ... 66
44. A comparison of possible population sizes assuming different time intervals, as calculated from Ossuary II by the formula $P=\frac{1000\ N}{M\ T}$ ... 67
45. A comparison of possible population sizes assuming different time intervals, as calculated from Ossuary II by the formula $P=K+\frac{D\ \mathring{e}_o}{T}$ ... 67

Figures

Excavation of Nanjemoy ossuaries ... vi
1. Geographic distribution of reported ossuaries in the region of the Chesapeake and Delaware bays ... 12
2. Location of Juhle site near Nanjemoy Creek, Charles County, Maryland ... 16
3. Nanjemoy Creek, as seen from Juhle site, looking southwest ... 17
4. Detailed map of the Juhle site, Charles County, Maryland ... 18
5. Excavation of Ossuary I ... 19
6. The 0.6-meter square system utilized in the 1971 excavation of Ossuary II ... 20
7. Division of Ossuary II into northeast and southwest halves, looking northwest ... 20
8. Excavators working in square DL1, Ossuary II ... 21
9. Excavator lying on a board-support to work in square GR1, Ossuary II, looking southwest ... 22
10. Bone concentrations in Ossuary II ... 23
11. Bone concentrations in Ossuary II with extended skeleton ... 24
12. Northeastern extremity of Ossuary II ... 25
13. Profiles of Ossuary II ... 26
14. Articulated adult skeletons on the floor of Ossuary II, looking northwest ... 28
15. Articulated adult skeletons on the floor of Ossuary II ... 29
16. Examples of partial articulation and bundles in Ossuary II ... 30
17. Comparison of femoral head diameters from Ossuary I with those of Ossuary II ... 43
18. Comparison of age distributions from Ossuary I ... 46
19. Comparison of age distributions from Ossuary I ... 47
20. Comparison of age distributions from Ossuary II ... 48
21. Comparison of age distributions from Ossuary II ... 49
22. Comparison of age distributions from Ossuary I ... 50
23. Comparison of age distributions from Ossuary II ... 51
24. Cross-section of human cortical bone ... 54
25. Comparison of adult mortality curves from Ossuaries I and II ... 58
26. Comparison of mortality curves calculated from Ossuaries I and II ... 60
27. Comparison of survivorship curves calculated from Ossuaries I and II ... 61

Methods of Population Reconstruction

An examination of the literature dealing with the century-old problem of New World pre-contact population size reveals a tremendous range of estimates (Table 1). At the lower end of this range are hemispheric estimates of 8,400,000 by Kroeber (1939: 166) and 13,385,000 by Rosenblat (1945:92) and at the upper end is Dobyns' figure of 90,043,000 (1966a:415). Such widely fluctuating estimates naturally include contradictions. Thus, while Las Casas (in MacNutt, 1909:317) in 1541 believed that 15,000,000 Indians died in the West Indies during the 40 year period after 1500, Rosenblat (1954:102) calculated that in 1492 only 13,385,000 Indians were alive in the entire western hemisphere. Whereas Kroeber's estimate works out to a population density of only one person per 5 square kilometers (0.2 per km^2), Borah (1962b: 179) suggested a density of 12 persons per 5 square kilometers (2.4 per km^2). As the dates of the cited estimates indicate, the trend is now away from the earlier conservatism in estimation, but even the modern estimates clearly retain a considerable amount of subjective interpretation.

The current emphasis in American archeology on problems of prehistoric settlement patterns, cultural ecology, and aboriginal demography has shifted attention to this old problem of prehistoric population size and accentuated the need for new and more accurate methods of estimation. Accurate evaluations of population size, density, and structure have become increasingly essential to the interpretation of population-environmental relations and to the attempt to reach an understanding of prehistoric cultural process. While the attention recently given to new attempts to estimate population size attests to the need for better estimates, the need is hardly fulfilled. As Macgowan and Hester (1965:5) state, "it is anybody's guess" just which estimates are the most accurate in the absence of more refined technique.

The wide range of population estimates reflects to a large extent the variety of methodologies employed. Each of the subdisciplines of anthropology has utilized different data and methods to reconstruct population size. In ethnohistory, scholars have turned to early descriptions of warrior counts, tax rolls, mission records, depopulation rates, and social organization. Archeologists have examined village patterns, house numbers and sizes, refuse mound composition, and pottery distributions. Physical anthropologists have reconstructed death rates and estimated population size from skeletal populations. In short, specialists have consulted a wide variety of data to produce estimates for large geographic areas through two general methods: (1) by totaling estimates for each group within an area, and (2) by projecting density estimates calculated from a single well-studied

Douglas H. Ubelaker, Department of Anthropology, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560.

TABLE 1.—*Estimates of New World population size in 1492**

Area	*Sapper (1924)*	*Kroeber (1939)*	*Rosenblat (1945)*	*Steward (1949)*	*Dobyns (1966)*
North of Mexico	2, 000, 000– 3, 500, 000	900, 000	1, 000, 000	1, 000, 880	9, 800, 000
Mexico	12, 000, 000–15, 000, 000	3, 300, 000	4, 500, 000	4, 500, 000	30, 000, 000
West Indies	3, 000, 000– 4, 000, 000	200, 000	300, 000	225, 000	443, 000
Central America	5, 000, 000– 6, 000, 000	**	800, 000	736, 000	10, 800, 000
Subtotal	22, 000, 000–28, 500, 000	–	6, 600, 000	6, 461, 880	51, 043, 000
South America: Andes	12, 000, 000–15, 000, 000	3, 000, 000	4, 750, 000	6, 131, 000	30, 000, 000
Remainder of South America	3, 000, 000– 5, 000, 000	1, 000, 000	2, 035, 000	2, 898, 000	9, 000, 000
Subtotal	15, 000, 000–20, 000, 000	–	6, 785, 000	9, 029, 000	39, 000, 000
Total for Western Hemisphere	37, 000, 000–48, 500, 000	8, 400, 000	13, 385, 000	15, 490, 880	90, 043, 000

*Modified from Steward (1949:656).

**Included in South American and Mexican Estimates.

525-413 O - 74 - 2

group within the area. Of course, each method has its own advantages and disadvantages. Perhaps the best way to evaluate the merits of individual methods is to examine them in detail, beginning with those that rely upon ethnohistorical data.

Ethnohistorical Methods

Although all ethnohistorical methods of calculating population size and structure depend upon early historical records for their basic data, they vary considerably in the type of historic data used, the manner in which population statistics are derived, and the level of population estimate attempted. In general, as already noted above, scholars have attempted to reach totals for large geographic areas by tabulating estimates for each constituent tribal group, or by projecting density calculations from smaller, well-studied areas. For small geographic areas, estimates have been derived from death rates, mission records, tax assessments, sociopolitical organization, and depopulation rates. The following comprehensive, but not all-inclusive discussion examines some of the most frequently quoted ethnohistorical attempts at population estimation. Early estimates (prior to Mooney, 1928) are not examined in detail since they are of questionable value and are seldom quoted (for example, Schoolcraft, 1851: Lefroy, 1853).

Tribe-by-Tribe Inventories

Perhaps the most frequently quoted population estimates in North America are those of James Mooney (1910). Having been requested to write on the topic "population" for the "Handbook of American Indians North of Mexico," Mooney undertook an intensive review of the evidence for American Indian population size at the time of European contact. His interest and scholarship carried him far beyond the requirements of the "Handbook" article and into an exhaustive study of early ethnographic accounts. He used a "tribe-by-tribe" accumulative approach, taking estimates from all available sources, including original census rolls. Unfortunately, by the time of his death in 1921 Mooney had not completed his proposed exhaustive treatise on aboriginal population size and its decline after European contact. The only published records of this work are to be found in the brief article in the "Handbook" and in his (Mooney, 1928) posthumously published monograph entitled "The Aboriginal Population of America North of Mexico." Although Mooney did not explain in detail his methods for computing each tribal estimate, he used a direct ethnohistorical approach for all areas except California, where he relied upon estimates by C. Hart Merriam (1905), calculated from mission to nonmission population ratios.

In 1939, Kroeber published his monumental *Cultural and Natural Areas of Native North America*. A major thrust of this work involves a calculation of population density at the time of contact for each of the cultural areas he defined. All of the population estimates utilized in this calculation were Mooney's except for the California estimate, where Kroeber used his own data. Although Kroeber felt Mooney's estimates were slightly high for some areas, he (1939:134) noted that "all in all, however, Mooney's estimates and computations have clearly been made on the basis of wide reading, conscientiousness, and experienced judgment. Until some new equally systematic, and detailed survey is made, it seems best to accept his figures in toto rather than to patch them here and there." Kroeber (1939:131) substituted his own figures on the California population over Merriam's, feeling that "my total is arrived at through a tribe-by-tribe addition or 'dead-reckoning' method, like all Mooney's other figures; whereas Merriam uses a mission to nonmission area multiplication ratio for the state as a whole."

Rosenblat (1935, 1945, 1954) employed a similar approach to Mooney's and Kroeber's in estimating 13,385,000 Indians in the western hemisphere at the time of contact (1492). Even though Rosenblat's estimates for North America are higher than those of Mooney and Kroeber, they would still have to be considered conservative.

Death Rates

Although the "dead-reckoned" estimates of Mooney, Kroeber, and Rosenblat are the most frequently quoted, numerous other attempts have been made using different types of ethnohistorical data. Fray Bartolome de Las Casas (in MacNutt, 1909:317) wrote in 1541, "We give as a real and true reckoning, that in the said forty years [1500–1540], more than twelve million persons, men, and women, and children, have perished unjustly and through tyranny, by the infernal deeds and tyranny of the Christians; and I truly believe, nor think I am deceived, that it is more than fifteen." Las Casas estimated that in 40 years, gold-seeking Christians killed nearly twice as many Indians as Kroeber believed existed in the entire New World. Of course, as Kunstadter (1966) has argued, these statistics would not be overly surprising even assuming a normal death rate for the population. A death rate of 40 per 1000 would indicate that over one and one-half times as many people would die during a 40 year period as would be alive at the beginning of the period. During the Spanish Conquest, the death rate would have been much higher. However, since Las Casas' mortality estimates were undoubtedly exaggerated; they have not been used extensively in modern population reconstruction.

Population Projection

MacLeod (1928:15–16) expressed some dissatisfaction with the estimates of Mooney and Kroeber and produced estimates of his own for the Maryland, Virginia, and Delaware area. Although MacLeod apparently utilized virtually the same sources as Mooney, he derived consistently higher estimates. After producing what he felt was a reliable estimate for the mid-Atlantic area, he computed the population density and then projected his figures toward an estimate of three million for North America north of Mexico and 15 million for Central and South America.

Many other investigators have attempted similar ethnographic-reconstruction projection methods for calculating population size (Aschman, 1959; Means, 1931, Meigs, 1935; Merriam, 1905; and Sauer, 1935, 1966). Merriam (1905) relied upon early mission records prior to 1834, which provided relatively accurate accounts for the strip of California south of San Francisco that was heavily missionized. Merriam calculated the total from the missions, added a factor of 25 percent to allow for unbaptized Indians, and then multiplied by five for an estimate of the total population of California.

Sauer (1935) estimated the aboriginal population size of northwestern Mexico from a careful examination of early Jesuit records. According to Sauer (1935:2), "total population was rarely taken and population figures usually must be arrived at by converting warriors, families, baptisms, or other items of the minister's record." The utilization of various types of data provided Sauer with several crosschecks on his population estimates, which certainly increased their reliability. Although Kroeber (1939:177) accepted Sauer's work as "revolutionizing," he apparently rejected his results: ". . it is difficult to meet Sauer's citations of seventeenth-century figures. . . ."

Aschman (1959), Borah (1962a, 1962b), Borah and Cook (1963), Cook (1937, 1939, 1940, 1943, 1946a, 1946b, 1955a, 1955b, 1956, 1958), Cook and Borah (1957), Cook and Simpson (1948), and Meigs (1935) also attempted population reconstruction using early ethnographic documents. Meigs (1935) turned to early mission accounts for population estimation in lower California, while Aschman (1959:147) used what he calls the "additive method" to compute population counts from individual mission roles in each of the six Baja California territories. In a similar manner, Borah, Cook, and Simpson at various times considered population estimates from a multitude of ethnographic sources in Mexico and California. Borah and Cook (1963) utilized tribute data recorded as early tax assessments. They broke the assessed tribute of each Province into terms of annual value in mantles and fanegas of grain and beans. The number of assessed families was calculated and multiplied by a factor of 4.5 to estimate the number of persons in the population. In short, their work (Borah and Cook, 1963:5) represents "an attempt to use pre-Conquest fiscal material for estimates of the pre-Conquest population of Central Mexico, as we applied fiscal and other administrative material (that is, Spanish tribute assessment, counts, and parish or missionary reports) for our estimates of post-Conquest population."

Sociopolitical Reconstruction

Means (1931) reconstructed population size for the Inca Empire through an innovative analysis of Inca sociopolitical organization. Utilizing Spanish descriptions of Indian accounts of pre-Conquest Inca political hierarchy, Means was able to reconstruct the entire Inca political organization and subsequently derive an overall population estimate from the relatively ordered individual political units. Although Baudin (1961) and Mason (1957) have suggested that the Inca system was actually less well-defined, Means still can be credited with an admirable attempt to reconstruct population size. Of course, this approach has little applicability outside of Peru.

Depopulation Rates

All of the foregoing studies examined the earliest European records to produce three types of population estimates: (1) estimates for specific groups in small geographic areas (Sauer, Meigs, Aschmann, Brau, Cook et al., Means), (2) estimates for large geographic areas by a "tribe-by-tribe" additive approach (Mooney, Rosenblat, Kroeber), or (3) estimates for large geographic areas by a projection of density calculations from small areas (Merriam, MacLeod). A final group of scholars calculated aboriginal population size directly by considering the rate at which population numbers were being diminished as a consequence of European contact. Of these, the studies of Dobyns (1962, 1963a, 1963b, 1966a, 1966b), Kubler (1942, 1946, 1948) and Rivet (1924) are the most noteworthy.

Rivet (1924) began his population estimate procedure with a comparison of the number of living Indians to the estimated number of pre-contact Indians in North America. He then assumed that the same "rate of depopulation" was generally applicable throughout the western hemisphere and calculated the aboriginal number from counts of the living. The method has been criticized by Kroeber (1939:160) as incorporating faulty logic and by Dobyns (1966a:399) as relying upon incorrect counts of both living Indians and aboriginal population (Mooney's estimates).

Kubler (1942, 1946, 1948) compiled population estimates from census records, reports, tax rolls, etc. for Mexico. Since Kubler's data were based on historic documents, he confined his study to careful examination of population shifts during historic times only and avoided the temptation to project his rates into prehistory.

Dobyns (1962, 1963a, 1963b) also began with the rate of depopulation during historic times, but then extended his depopulation rates into prehistory. In his monumental (1966a) study, he very carefully examined the rate of depopulation in different parts of the western hemisphere, producing a general, standard depopualtion ratio of 20 to one, i.e., 20 aboriginal Indians to one at the nadir or lowest point of population decline. The application of this ratio to the entire western hemisphere produced an estimate of 90,043,000 (2.1 per km^2). The Dobyns ratio has been criticized by scholars (Bennett, 1966; Bernal, 1966; Blasi, 1966; Deneven, 1966; Forbis, 1966; Kehoe and Kehoe, 1966; Kundstadter, 1966), who generally distrust his calculation of the nadir population and emphasize the variability of depopulation rates within the western hemisphere.

The above review of ethnohistorical approaches to population estimation is by no means complete. It suffices however, to document both the diversity of methodology and the similarity of assumptions employed in ethnohistorical reconstruction.

Archeological Approaches

Many Americanist anthropologists have criticized ethnohistorical methods of estimating population size, claiming they attribute excessive objectivity to early observers. Others have claimed that even if ethnohistorical estimates are accurate, they do not represent the prehistoric populations and there is no reliable way to determine the difference. Consequently, many scholars have turned to prehistoric archeological data to produce hopefully more reliable population estimates. Archeologists have estimated population size from site surface area, frequencies of mounds and houses, settlement patterns in specific areas, and regional ecological potentials. Each of these approaches produces population estimates or density statistics and each has its own assumptions and limitations.

Site Surface Area

Cook and Treganza (1950) suggested a correlation between population size and total surface area of the site. Their study produced a general formula for estimating population size: log population = constant × log area (in square meters). This basic formula was then supplemented with data on area, volume, density, and mass from many sites. According to Cook and Treganza (1950:231), "For the estimate of the number of inhabitants living on a prehistoric site, there are no concrete data whatever. We have to depend upon our knowledge of habitation methods, family number, and many purely subjective criteria. Nevertheless, there is no good reason to suppose that guesses of this sort are seriously in error when they are supported by a careful study of a specific site and an adequate background in general ethnology."

House and Mound Frequency

Investigations of house and mound frequencies at individual sites have produced several local population estimates (Ascher, 1959; Haviland, 1965, 1966; Nelson, 1909). Differences between individual estimates stem from several sources of variability such as the assessment of the number of houses occupied at any one time, the length of time of village occupation, and the number of persons per house. Haviland's recent work (1970) has demonstrated that a figure of five persons per house at the Mayan site of Tikal is reasonably correct, whereas the length of occupation and number of houses in use at one time remain questionable and highly variable from site to site. In the Mayan area, Brainerd (1956) concluded that only one house in eight had been occupied, Morley (1947) felt they had all been occupied, while Ricketson and Ricketson (1937) put the figure at one in four. In the Plains, by contrast, Wood (1967) estimated 10 individuals per Mandan earthlodge, with nine out of 10 lodges being occupied simultaneously at the Huff site in South Dakota.

Settlement Patterns

Numerous recent studies have concentrated on the settlement patterns and site frequencies within regional areas. Bullard (1960), Dumond (1972), Griffin (1956), Heizer and Baumhoff (1956), Rouse (1952), Sanders (1953, 1956, 1960, 1963), Termer (1951), Welte (1966), and Willey, et al. (1965) represent a few of the excellent studies of site densities. They all supply a wealth of information about their respective areas, but are subject to the same general limitations as estimates from individual sites. These settlement studies consider the number and size of sites within a given area, but usually employ broad periods of time. For example, Coe and Flannery (1967) discuss population trends in the Ocós area of south coastal Guatemala. Their approach involves tabulating the total number of site components representing each temporal period. The resulting table demonstrates a population decline from Middle to Late Formative, a rapid increase to Late Classic, and then another dramatic decline in the Post-Classic period. This type of presentation is very difficult to interpret since the time intervals are not equal, and there are no data on the number of components occupied contemporaneously. Their evidence of maximum population size during the Late Classic could indicate simply a longer time span or that the populations were more mobile. In the absence of detailed ceramic seriation studies or attribute analyses, the question of simultaneous component occupation remains hypothetical.

Schwartz (1956) introduced a method of studying surface pottery collections from 104 sites identified as Cohonina in Arizona. He used the plain (San Francisco-Mountain-gray) pottery as an index to delineate the affiliations of the sites and the painted pottery to provide the time scale. Schwartz (1956:28) then plotted the number of sites occupied for each 25 year period, assuming that "the relative increase or decrease in habitation units bears a direct relationship to the rise and fall of population without the necessity for taking into consideration the exact numbers of peoples. The similarity in size of the sites throughout the time span makes this type of comparison possible. The analysis, then, is based on settlement density and its fluctuations." His results show a steady increase in population growth from A.D. 600 to 900, leveling off from A.D. 900 to 1100, a rapid decline between A.D. 1100 and 1200, and a disappearance of Cohonina sites after A.D. 1200. Schwartz' evidence for population decline beginning A.D. 1100 corroborates similar data to the north (Hall, 1942) and to the east (Colton, 1936, 1939).

Ecological Resource Potential

H.P. Thompson (1966) adopted an ecological approach to the problem of population size. He began with an examination of the aboriginal Chipewyan Indian utilization of barren-ground caribou and calculated the upper and lower limits of the Chipewyan population that could be supported by the caribou. The technique has been criticized by Cook (1966) and others, but remains an innovative attempt at population reconstruction.

Others have considered an ecological approach by calculating the resource potential of a geographic area (Allan, 1965; Sapper, 1924; J.E.S. Thompson, 1951). For example, Cowgill (1962:283) studied swidden farming in the Maya lowlands, concluding that the area could support 100 to 200 persons per square mile (63–126 per km^2). Haviland's archeological data suggest an even higher density (Haviland, 1966), but even if Cowgill's data are correct, it by no means follows that the population density actually reached its maximum potential. Cowgill merely estimated what population numbers could have lived in the area.

Although the archeological approaches discussed above consult a variety of different data, they all focus on population structure within small geographic areas, and avoid estimates for the entire hemisphere. Collectively, these studies document the diversity of population size and density within the western hemisphere and stress the importance of developing accurate estimates for small areas.

Physical Anthropological Approaches

Population estimates from skeletal studies are potentially the most accurate of all. The number of skeletons found in cemeteries is not dependent upon the number of houses occupied in the village, the number of individuals per house, the accuracy of ethnohistorical accounts, or the resource potential of the area. Unfortunately, however, adequate samples are hard to come by and physical anthropological techniques have their own unique limitations and requirements. Problems and prerequisites in determining accurate demographic information from skeletal populations have been summarized recently by a number of authors (Angel, 1969a, 1969b; Acsádi and Nemeskéri, 1970; Genovés, 1963; Howells, 1960; Swedlund and Armelagos, 1969; Vallois, 1960). In general, studies from skeletal populations demand: (1) a knowledge of the completeness of the sample; (2) information about the archeological associations of the skeletons; (3) a determination of the length of time the sample represents; (4) an adequate assessment of sex and age at death, and (5) a proper selection of demographic methodology. If all of the above requirements are met, then skeletal populations may offer the most accurate data of all (Häusler, 1966; Stloukal, 1966). However, as Dobyns (1966b) and many others have emphasized, these conditions rarely are met, especially in the New World.

Application in Old World

Acsádi and Nemeskéri (1970) recently summarized the development of paleodemographic research in the Old World. They traced the first analyses to early epitaph studies by Beloch (1886), Motta (1891), and Harkness (1896). Beloch and Harkness then influenced the statistician Pearson (1901–1902) who used sex and age data from an Egyptian mummy series to reconstruct life expectancy and mortality.

Following Todd's studies of skeletal age changes in the 1920s and 1930s, numerous investigators began shifting their attention to problems in paleodemography. Epitaph studies continued through the work of Gomme (1933) for 4th and 5th century B.C. Athens, Richardson (1933) for ancient Greece as a whole, Valaoras (1938) for life expectancy in 4th century B.C. Greece, Wilcox (1938) for length of life in the Roman Empire, Hombert and Préaux (1945) for populations in Greco-Roman Egypt, Etienne (1955) for 1 to 300 A.D. Bordeaux, France, and Szilagyi (1959) for Roman-era Hungary. Using Todd's (1920, 1921, 1929, 1930a, 1930b, 1931) published age standards, numerous authors studied demography from skeletal populations in the Old World. Nougier (1949, 1950, 1954, 1959) utilized the data of others to trace the development of prehistoric populations, especially those in France. Franz and Winkler (1936) studied the demography of the Bronze Age in Lower Austria. Vallois (1937) reconstructed length of life from Paleolithic and Mesolithic skeletons. Weidenreich (1939) extended demographic analysis to earlier fossil populations. A number of others utilized skeletal samples in regional demographic studies, e.g., Riquet (1953), Giot (1951) Gerhardt (1953), Ferembach (1960, 1961, 1962), Fuste (1954, 1955), Bröste and Jörgensen (1956), Cunha (1956), Gejvall (1960), Ivanicek (1951), Kurth (1955), and Stloukal (1962). In addition Acsádi and Nemeskéri (1957a, 1957b, 1958, 1959, 1960, 1970) and Angel (1947, 1948, 1951a, 1951b, 1953, 1954, 1957, 1959, 1968, 1969a, 1969b) have published a series of articles that both develop theory and methodology, as well as apply methodology to excavated skeletal samples.

The large number of studies that successfully deal with demography of skeletal populations in the Old World reflects to a great extent the accurate documentation that exists for many Old World collections. Due to the greater antiquity of written records in the Old World, they are often available to supplement information derived from archeological features of the skeletons themselves. Such sources reduce the variables of an analysis, strengthen the sample, and ultimately assure the accuracy of the investigator's conclusions.

Application in New World

In the New World, demographic studies of prehistoric skeletal populations have remained largely theoretical (e.g., Weiss, 1973). Perhaps for a lack of adequate skeletal samples, Americanist physical anthropologists have been reluctant to attempt demographic reconstruction. As Dobyns (1966a), Howells (1960), and Vallois (1960) have indicated, numerous cultural factors (known and/or unknown) seriously limit the extent to which New World samples can be utilized. The tremendous New World cultural variation in mortuary practices continually raises the possibility of incompleteness in skeletal samples, due to such factors as selective cremation, trophy taking, death away from the village, and differential status burial. Since in most cases the scope of the mortuary complex is unknown, the assumption cannot be made that the skeletal sample is complete.

In spite of the limitations, a few New World anthropologists have attempted demographic reconstruction from skeletal samples. The most widely quoted American demographic analysis is that of Hooton (1930) from Pecos Pueblo material. Hooton considered data from his skeletal analysis to refine what he felt were inadequate population estimates derived from ethnohistorical sources. The attempt was of limited success because he could obtain so few constants. He was forced to assume that the excavated sample was representative of the entire cemetery population and that Kidder's (in Hooton, 1930:333) estimate—approximately 15 to 20 percent of the cemetery had been excavated—was correct. Hooten then had to depend upon ethnohistorical estimates for the length of time the cemetery was in use. Howells (1960) reworked Hooton's data, producing an estimate of population size directly from the number of skeletons. Utilizing new archeological information from Kidder (1958) and assuming a death rate of 30 per thousand per annum, Howells produced what is probably a more realistic estimate; but still there is no assurance that the assumed death rate and time interval are accurate.

Snow (1948) attempted a demographic analysis of the large Archaic skeletal population from Indian Knoll, Kentucky. The analysis simply involved estimating age for each skeleton and plotting the ages to form a mortality curve for the population. Unfortunately, the skeletal sample may not have been complete (Howells, 1960:169) and Snow's original aging criterion for adults was rather unreliable. Snow determined adult age merely by examining cranial suture closure, which has been demonstrated since then to produce quite variable results (Singer, 1953; McKern and Stewart, 1957). Johnston and Snow (1961) revised the original age estimates using more and supposedly improved criteria, producing new death curves and new estimations of life expectancy. However, Stewart (1962) effectively showed that their reassessment has little meaning, since again thev used unreliable aging criteria (dental attrition, for example) and did not reexamine the entire skeletal series.

Blakely and Walker (1968) presented mortality profiles constructed from 479 Middle Mississippian skeletons excavated from Dickson Mound in Fulton County, Illinois. Unfortunately, the accuracy of their age determinations cannot be evaluated since they were produced using methods derived from unpublished sources. In addition, whereas they attempt to explain the death frequencies in each age category through a discussion of age-specific disease, they do not consider how their statistics might be affected by inadequate sampling. In general however, their mortality curves reflect a high infant mortality rate with an average age at death of about 23 years.

In a later article, Blakely (1971) compares mortality profiles reconstructed from Archaic, Middle Woodland, and Middle Mississippian skeletal populations, showing that the average age at death increases from 27 years during the Archaic to 30 years during the Middle Woodland; but then drops to only 24 years during the Middle Mississippian period. He provides an excellent discussion of what disease or cultural factors could influence these statistics and correctly cautions that the differences could reflect only differences in mortuary practices.

Bass, Evans, and Jantz (1971) attempted to derive information on mortality and population size from skeletal material of the Arikara at a historic site in South Dakota. After working with assumed death rates, total numbers of excavated skeletons, and archeological and ethnohistorical estimates of population size, they concluded that the excavated skeletal sample is grossly incomplete (Bass, Evans, and Jantz, 1971: 160–161). They discussed age distributions of deaths, but again the demographic considerations are of limited value since such a large percentage of the skeletons are missing.

In short, the applications of quantitative methods in physical anthropological demographic reconstruction in the New World have been limited severely by uncontrollable variables, principally sample inadequacy. According to Howells (1960:159), "Control of these sources of error is good only by accident, as perhaps in the case of an Iroquois ossuary, known to represent a limited number of years."

Only rarely have the unique ossuary samples mentioned by Howells been considered as potential sources of demographic information. Churcher and Kenyon (1960) made such an attempt using Iroquois ossuary material. Unfortunately most of their ossuary sample was initially destroyed by power equipment and then badly looted by local collectors. The report is of limited value because of the incompleteness of the sample, their use of assumed death rates, and their reliance upon suture closure and dental attrition as age indicators. Still, the article emphasizes the importance of ossuary samples in studies of prehistoric demography.

Several other scholars have studied ossuary burials, but have stopped short of demographic reconstruction. Anderson (1964) analyzed an Iroquois ossuary near Toronto, but confined his demographic study to estimation of age at death. Since he did not state his criteria for determining adult age, it is difficult to utilize his data. Kidd (1953) excavated an ossuary in Ontario and presented a convincing argument that it corresponded to the skeletal deposit described in great detail by the Jesuit missionary, Jean de Brebeuf, in 1636. However, in spite of the tremendous opportunity to study demography from a documented ossuary, Kidd confined his study to archeological features of the site itself.

In the Plains, Kivett (1953), Strong (1935), and others excavated apparent ossuary burial sites, but confined their analyses to the archeological features, providing only estimates of the number of individuals represented and their age and sex distributions. The Plains ossuary complex lacks the ethnohistorical documentation of the Huron, but still offers a valuable skeletal sample for advanced analysis.

Research Model of Present Study

Clearly, if advanced techniques of physical anthropology can contribute to our understanding of prehistoric population size and demographic structure, they must concentrate on small regional populations and must utilize the best skeletal samples available for analysis. Unfortunately most skeletal populations recovered from New World prehistoric cemeteries are too incomplete to qualify for detailed demographic analysis. However, if archeological or ethnohistorical information indicates the extent of the completeness of the sample, then skeletal samples do have potential for such analysis. In particular, the rare ossuary samples offer exceptional opportunities to reconstruct accurate demographic profiles and even to derive reliable size estimates for populations of the small geographic areas represented by the ossuaries. Although ossuaries seldom have been considered as sources of demographic information, they probably have the greatest potential of any prehistoric New World skeletal sample.

This study utilizes two prehistoric Late Woodland ossuaries from the Juhle site in southern Maryland to reconstruct aboriginal population profiles. The following analysis first considers the nature of the skeletal samples, including a discussion of the ethnography of general ossuary burial, local history of the Juhle site, excavation approaches, cultural-archeological affinites, and cultural information derived from the excavation and analysis. Several methods are then utilized to establish age at death, including a modification of Kerley's (1965, 1969, 1970) new method involving an assessment of the degree of microscopic internal bone remodeling. Demographic data in the form of mortality curves, survivorship curves, life tables, and crude mortality rates are reconstructed and discussed. Archeological information is utilized to establish the time interval represented by the ossuary deposits. Finally, population size estimates are derived from the crude mortality rates (calculated from the life tables), time interval, and total numbers of individuals in the ossuaries.

Evidence of Ossuary Burial from Eastern North America

Ossuary burial practice may be described generally as the collective, secondary deposit of skeletal material representing individuals initially stored elsewhere. In the past, the term "ossuary" has been applied rather loosely to almost any multiple burial, either primary or secondary (Yarrow, 1880; Bushnell, 1920; Weslager, 1942). In this study, the term is restricted to those secondary deposits that probably represent the periodic redisposal of individuals, which took place after a culturally prescribed number of years.

Ethnography of Ossuary Practice

The Huron

Ethnographically, ossuary burial practices are best known from Iroquoian groups in Canada and the Great Lakes region. The Huron in particular were visited during the 17th century by a number of explorers and missionaries, some of whom recorded lengthy accounts of their customs. The most thorough description of Huron ossuary burial customs is found in the letters of Jean be Brebeuf, a Jesuit missionary from the mission of St. Joseph, who observed the burial ceremony at the Huron village Ihonatiria on 16 July 1636 (Thwaites, 1896–1901, X:279–305). Since his lengthy account has been reproduced elsewhere (Kidd, 1953:372–375) and frequently referred to by other authors, it will only be summarized here. De Brebeuf relates that every ten to twelve years, the Huron journeyed to their temporary burial areas and carefully removed the skeletons, with each family being responsible for its own deceased relatives. The decayed remains were then cleaned, wrapped in fresh robes, and brought to the site chosen for reburial. The Huron excavated a deep, circular, ossuary pit, lined it with beaver robes, and then erected a wooden platform around it. At the time of deposit, the skeletal remains were grouped according to the villages and families to which they belonged, wrapped tightly in robes and blankets, and hung from the platform. Copper kettles and necklaces of shell beads were added as mortuary offerings. Later, after extensive feasting, the Huron emptied the skeletons into the pit, saving the robes and blankets they were wrapped in. After the bones were arranged by men with poles, they were covered with robes, mats and bark, and the remainder of the pit was filled with "sand, rods, and stakes of wood which were thrown in promiscuously."

While Jean de Brebeuf provides the most detailed discussion of ossuary burial practice, the earliest description was probably by the explorer, Samuel de Champlain. Champlain's account (Biggar, 1929:160–163) generally complements that of de Brebeuf, but adds the fact that the primary deposit was either in "a cabin covered with tree-bark" erected above ground on four posts, or in the ground with the cabin erected over the grave. He also stresses the regular scheduling of reburial and believed the ceremony took place every eight or ten years.

A third detailed description of Huron ossuary burial is provided in the journals of Father Gabriel Sagard, a lay brother of the Franciscans who was in Canada from June 1623 to Autumn 1624. Since the concise and informative Sagard account rarely is discussed, it is reproduced in full (Wrong, 1939: 211–212).

> Every ten years, or thereabouts, our savages and other sedentary tribes hold the great festival or ceremony of the dead in one of their towns or villages, according as it has been decided and ordered by a general council of all the people of the district; for the bones of the dead are entombed separately only for a time. The other neighbouring tribes are notified in order that those persons who have chosen that town to be the burying-place of their relations' bones may bring them thither, and others who wish to come out of respect may honour the festival with their presence. For all are made welcome and feasted during the days that the ceremony lasts, and nothing is to be seen there except kettles on the fire, and continual feasting and dancing, and this brings an immense number of people who flock in from all sides.
>
> The women who have to bring the bones of their relatives go to the cemeteries for them, and if the flesh is not entirely destroyed they clean it off and take away the bones. These they wash and wrap up in fine new beaver-skins, and with glass beads and wampum necklaces, which the relations and friends contribute and bring, saying, "Here, this is what I am giving for the bones of my father, my mother, my uncle, cousin or other relative." And putting them into a new bag they carry them on their backs, and also adorn the top of the bag with many little ornaments, with necklaces, bracelets, and other decorations. Then the skins, tomahawks, kettles, and other articles of value in their estimation, as well as plenty of provisions, are also carried to the place appointed, and when all are assembled there they put the provisions together to be used for the feasts, which are a great expense to them, and then hang up decently in the lodges of their hosts all their bags and skins to await the day on which everything must be buried in the earth.

The grave is dug outside the town, very large and deep, capable of containing all the bones, furniture, and skins offered for the dead. A high scaffolding is erected along the edge, to which all the bags containing bones are carried; then the grave is draped throughout, both the bottom and the sides, with new beaver skins and robes; then they lay in it a bed of tomahawks, next kettles, beads, necklaces, and bracelets of wampum, and other things given by the relations and friends. When this has been done the chiefs, from the top of the scaffold, empty and turn out all the bones from the bags into the grave upon the goods, and they cover them again with other new skins, then with tree-bark, and after that they put back the earth on top, and big pieces of wood. To mark their respect for the place they sink wooden posts into the ground all round the grave, and put a covering over it, which lasts as long as it can. Then they have a feast again, and take leave of one another, and return to the places whence they came, with great joy and satisfaction at having provided the souls of their relatives and friends with something that day to plunder and wherewith to become rich in the other life.

These ethnographic accounts clearly elucidate the importance of the ossuary burial practice to the Huron people and the significance they attached to carrying out details of the ceremony correctly. Although the early ethnographers disagree whether the length of time between ossuary deposits was 8 years (Champlain) or 10 to 12 years (de Brebeuf), there is little doubt that it was a fixed, reoccurring event that was integrated into their belief system and religiously adhered to. According to Bressani (Thwaites, 1896–1901, XXXIX: 29), the Huron feast of the dead was "the most sacred and solemn ceremony that they had. . . ." The Jesuit Jerome Lalemant (Thwaites, 1896–1901, XXIII: 31) adds in 1642: "If there be anything in the world that is Sacred among the Hurons, it is their law of Burial. Their care in this matter greatly exceeds anything that is done in France. They are singularly lavish in proportion to their means, and despoil themselves to clothe their Dead and to preserve carefully the bones of their Relatives, in order that they may repose after their death in the same spot." In situations where fire threatened both their homes and the scaffolds holding their dead, the Huron "did not feel troubled at incurring an irreparable loss, that they might save the bones of their departed before extinguishing the fire in their own cabins" (Bressani, in Thwaites, 1896–1901, XXXIX: 31). Clearly, the Huron valued their dead highly and made every attempt to preserve each individual for ossuary burial.

At the time of ossuary deposit, the Huron collected the remains of everyone who had died since the last ceremony. Each family assumed the responsibility for gathering the remains of their deceased relatives and preparing the bones for reburial. To insure the completeness of the skeletal material, the Huron even included those individuals who had just died. According to Jean de Brebeuf (Thwaites, 1896–1901, X: 283), "The flesh of some is quite gone, and there is only parchment on their bones; in other cases, the bodies look as if they had been dried and smoked, and show scarcely any signs of putrefaction; and in still other cases they are still swarming with worms." In 1636, de Brebeuf (Thwaites, 1896–1901, X: 285) describes how the Huron treated the body of an old man who had died the autumn before.

This swollen corpse had only begun to decay during the last month, on the occasion of the first heat of Spring; the worms were swarming all over it, and the corruption that oozed out of it gave forth an almost intolerable stench; and yet they had the courage to take away the robe in which it was enveloped, cleaned it as well as they could, taking the matter off by handfuls and put the body into a fresh mat and robe, and all this without showing any horror at the corruption.

All of these accounts document both the complexity and social significance of the ossuary practice to the Huron people. The ceremonies involved were not just an expensive method of disposal, but rather an important functional element of their culture that combined their religious belief concerning life after death with the communal gathering which reinforced social relationships and added cohesion to the community. Of course, in spite of the social significance of the ceremony, the missionaries looked upon it with disgust. Eventually they voiced their disapproval, especially for those Huron people who became Christians. The following paragraph from Biard's account of 1611 (Thwaites 1896–1901, I: 169) reflects the cultural conflict involved and the usual Christian response:

I shall here relate another act of the same Sieur de Potrincourt, which has been of great benefit to all these heathen. A christian savage had died, and (as a mark of his constancy) he had sent word here to the settlement during his sickness, that he desired our prayers. After his death the other Savages prepared to bury him in their way; they are accustomed to take everything that belongs to the deceased, skins, bows, utensils, wigwams, etc., and burn them all, howling and shouting certain cries, sorceries, and invocations to the evil spirit. M. de Potrincourt firmly resolved to oppose these ceremonies. So he armed all his men, and going to the Savages in force, by this means obtained what he asked, namely, that the body should be given to the Patriarch, and so the burial took place according to christian customs. This act, inasmuch as it could not be prevented by the Savages, was and still is, greatly praised by them.

Gradually, the Huron custom of ossuary burial was replaced by Christian mortuary practices. However, the modern Iroquois still placate their dead with semi-annual feasts reminiscent of the feast of the dead. Fenton and Kurath (1951) have shown that the modern ceremony is descended directly from the former practice and even retains many of the original terms.

The practice of ossuary burial among the Iroquois produced many ossuary pits over the years. However, because of the abundance of artifacts contained, the skeletal deposits have been looted heavily by local collectors. Although Anderson (1964) documents at least 216 ossuary sites in the Province of Ontario alone, Kidd (1952: 73) notes that few remain undisturbed. Kidd (1952: 73) estimates that some of the looted ossuaries contained as many as 1000 individuals. Smaller ossuaries have been professionally excavated and reported by Anderson (1964), Churcher and Kenyon

(1960), Kidd (1953), and Ridley (1961). All of the excavations provided evidence consistent with the ethnographic accounts. In particular, Kidd (1953) believed that the one he excavated was that observed in use in 1636 by Jean de Brebeuf. The pit was bowl-shaped and about 24 feet in diameter. Many of the bones were scattered, some were partially articulated, and two were completely articulated and lying on the floor of the ossuary. A ring of 9-inch postholes surrounded the pit and probably represents the platform described by de Brebeuf. Artifacts included shell beads and fragments of copper kettles. All of these features corroborate de Brebeuf's observation.

Southeastern United States

Burial customs in the Southeast include ceremonies similar to those described for the Huron, but with some regional differences. According to Romans (1775:88), the Choctaw also practiced "bone cleaning" of the deceased. However, the bones were not cleaned by relatives, but by a group of specialists who traveled through the Choctaw nation. These mobile Choctaw morticians were described by Romans (1775:88) as "a certain set of venerable old Gentlemen who wear very long nails as a distinguishing badge on the thumb, fore and middle finger of each hand." Their long nails not only symbolized their trade, but allowed them to remove the decaying flesh with ease. The removed flesh was then burned and the bones were painted, placed in a chest, and deposited in a "bone-house." Other accounts report the practice of bone-cleaning to have been common among other Southeastern groups. The method of final bone disposal seems to have varied considerably, however, with some groups apparently leaving the bones in the temples permanently.

Mid-Atlantic Area of the United States

Mortuary customs in the mid-Atlantic area are best known from the writing of Captain John Smith and Thomas Hariot, and the drawings of John White. John Smith (Arber, 1910) recorded the manners and customs of the Virginia Indians as he observed them during the years immediately following the founding of Jamestown in 1607. Smith was especially fascinated with their manner of treating deceased leaders and wrote (Arber, 1910:75):

> Their bodies are first bowelled, then dryed vpon hurdles till they bee verie dry, and so about the most of their iointes [joints] and necke they hang bracelets or chaines of copper, pearle, and such like, as they vse to weare: their inwards they stuffe with copper beads and couer with a skin, hatchets, and such trash. Then lappe they them very carefully in white skins, and so rowle them in mats for their winding sheetes. And in the Tombe, which is an arch made of mats, they lay them orderly. What remaineth of this kinde of wealth their kings haue, they set at their feet in baskets. These Temples and bodies are kept by their Priests.

Thomas Hariot (1590) adds another description of how the southern Virginia Indians disposed of their deceased leaders. According to him, they opened the body to remove the entrails and cleaned the flesh from the bones, leaving ligaments intact. They then packed the body with leather until it resumed its original shape. The bodies of all leaders were placed side by side on a 9- or 10-foot scaffold or death house. The famous drawing by John White that accompanies the Hariot text visually illustrates the description. The drawing shows nine deceased chiefs stretched out on a scaffold in the death house, with a fire burning at the entrance. Unfortunately, none of the accounts indicate what eventually happens to the deceased leaders after their stay in the death house.

Early accounts of the treatment of deceased common people are less revealing. According to Smith (Arber, 1910:75), "For their ordinary burials, they digge a deep hole in the earth with sharpe stakes; and the corpes being lapped in skins and mats with their iewels, they lay them vpon sticks in the ground, and so couer them with earth. . . ." Smith's description is difficult to interpret in that his reference to "a deep hole" suggests an ossuary type burial, but his use of the word "corpes" implies primary burial. In an earlier account, Smith wrote (Arber, 1884:22) in 1608, that "their Kings they burie betwixt two mattes within their houses, with all his beads, iewels, hatchets, and copper: the other in graves like ours . . . ," suggesting that the common people were buried individually in the ground.

Spelman (1609–1610, in Arber, 1884:cx) in his Realtion of Virginia adds a contradictory account of common burial. He relates that after death, the body was wrapped in a mat and deposited on a scaffold, 3 to 4 meters (3 to 4 yds) above the ground. After the flesh decomposed, the Indians wrapped the remaining bones together in a new mat and hung them in "their howses, wher they continew whille ther house falleth and then they are buried in the ruinges of ye house. . . ." In 1676 Glover (1676:24–25) adds that the Virginia Indians burned the bodies of the dead and placed the ashes in mats near their relatives' dwellings.

Clearly the variations in these ethnographic accounts indicate either variability in Alqonquian mortuary practice or inaccurate observation and reporting. Few scholars doubt that the drawing by White and accounts by Smith and Hariot accurately describe the treatment of deceased leaders. However, there is no agreement on methods of treating deceased common people.

In the Maryland and Delaware area, direct, reliable, ethnographic accounts are not available. A considerable amount of indirect ethnographic evidence, however, suggests that the practice of bone cleaning and ossuary burial did occur. The missionary John Heckewelder (1819:92) observed in 1776 that the Nanticokes moving north out of Maryland through Pennsylvania carried with them the cleaned bones of their ancestors.

These Nanticokes had the singular custom of removing the bones of their deceased friends from the burial place to a place of deposit in the country they dwell in. In earlier times, they were known to go from the Eastern shore of Maryland, even when the bodies were in a putrid state, so that they had to take off the flesh and scrape the bones clean, before they could carry them along. I well remember having seen them between the years 1750 and 1760, loaded with such bones, which being fresh, caused a disagreeable stence, as they passed through the town of Bethlehem.

Heckewelder's observations were confirmed by his missionary supervisor, David Zeisberger in 1779 (Hulbert and Schwarze, 1910) and later by Brinton (1885).

Evidence of bone cleaning among the Conoy of southwestern Maryland can be found in the *Proceedings of the Council of Maryland, 1676–1678* (Archives of Maryland, 1896:185). On 19 August 1678, "Nicotaghsen" (the Piscattaway or Conoy "emperor") and other Indian representatives were assembled at Lord Baltimore's Council to discuss business matters. Noticing that many of the Indian representatives were missing, the council inquired about the small attendance when such important business was to be discussed. After a pause, a Conoy leader replied that "most of their great men were very busie in gathering together their dead bones. . . ."

Another passage in the Maryland Archives suggests that the Nanticokes at Assateague saved the bones of their leaders. The following account was recorded for 6 May 1686 (Archives of Maryland, 1887:480):

The King of Assateague complaines that severall of the Inglish (viz) Mr. William Browne, Edward Hammond, William Bowen, John Fossett, Henry Bishop &c were come and seated among them in the very Towne where they live—but particularly he complaineth against Edward Hamond for that whereas it is a custom among them upon the death of an Indian King to save his bones and make a case with skinns wherein they inclose the bones and fill it up with Ronoke, and other their riches, he the said Hamond about a month since had upon the like occasion of one of their kings dyeing stolen away the skinns and roanoke from the place where he was layd, which one Epimore a greate man of Assateague did see at the sayd Hammond's house and very well know to be the same, and alsoe one Manassen an Indian that lives with said Hammond did see him bring them home.

Bozman (1837, I:173–174) mentions a boyhood recollection that the Choptank Indians kept the remains of their dead chiefs and leaders in a death house called the "Quioccason House." The term "Quioccason House" is used commonly by Algonquian Indians to refer to their religious temples.

In 1792, Dr. William Vans Murry of Cambridge, Eastern Shore of Maryland, submitted to Thomas Jefferson a vocabulary taken from the Nanticoke Indians of Maryland. The letter of explanation to Jefferson contains the following note (Speck, 1927:41): "Wynicaco—the last king crowned of the Nanticoke tribe, he died at past 80 years since. His body was preserved and very formally kept in a Quacasun—house—chio-ca-son house, 70 years dead."

Marye (1936:43–45) indicates that several references to the term "Quioccason" or modifications of it can be found in early land records in the Maryland area. Marye located two entries in a proprietary rent-roll of Somerset County, Maryland, describing a tract of land on the south side of the Nanticoke River. The first entry refers to the land as "Quiakeson Neck." The second entry describes the land as being by a swamp near "Indian Quiankeson houses." Marye believed that "Quiakeson Neck" was named because of its location near the death houses.

Marye (1936) cites another occurrence of the word in a land record of 15 August 1761 in Dorchester County, Maryland. The boundary of the tract was defined at one point by a group of trees standing in "cuiackason Swamp." In a later article, Marye (1937) reported a tract of land in Worcester County, Maryland, described in 1762 as being located on "Quaacotion House Point." He located the site near the Indian town of Askiminakonson, which was occupied by the Pocomokes.

Adams (1890) and Harrington (1921) discussed the "Skeleton Dance" practiced by the Wolf Clan of the Delawares, who traced their origin to the Nanticoke. In the ceremony, the Delaware stripped the flesh from the bones of the deceased and buried it. The bones were then dried for 12 days, wrapped in white buckskin, and taken to the ceremonial dance. After the dance, the bones were interred collectively.

The Nanticoke who were relocated in Kansas prior to 1875 placed the bodies on a 5 to 6 foot scaffold, immediately after death. After the flesh decayed, the bones were included in the "Ghost Dance" ceremony and later buried (Speck, 1937:148–149). Weslager (1942:144) feels both this practice and the Delaware Skeleton Dance represent survivals of the earlier practices of bone scraping, temporary scaffold deposit, and final interment in ossuaries.

The above ethnographic gleanings collectively constitute strong evidence for the practice of temporary placement on scaffolds or in death houses, systematic bone cleaning, and final secondary interment in ossuaries among the aboriginal inhabitants of the Maryland and Virginia areas. The accounts agree that this general mortuary practice applied to the aboriginal leaders. However, there may have been some regional variance in the treatment of the common people, especially in Virginia, since the accounts of Smith, Spelman, and Glover describe other patterns.

Archeological Evidence

The best documentation for ossuary burial in the mid-Atlantic region consists of the archeological discoveries of some 34 secondary skeletal deposits from sites distributed through Virginia, Maryland, and southern Delaware (Figure 1). Although a few of these probably do not represent ossuary burial as defined herein, many possess archeological features nearly identical to those of Huron osssuaries.

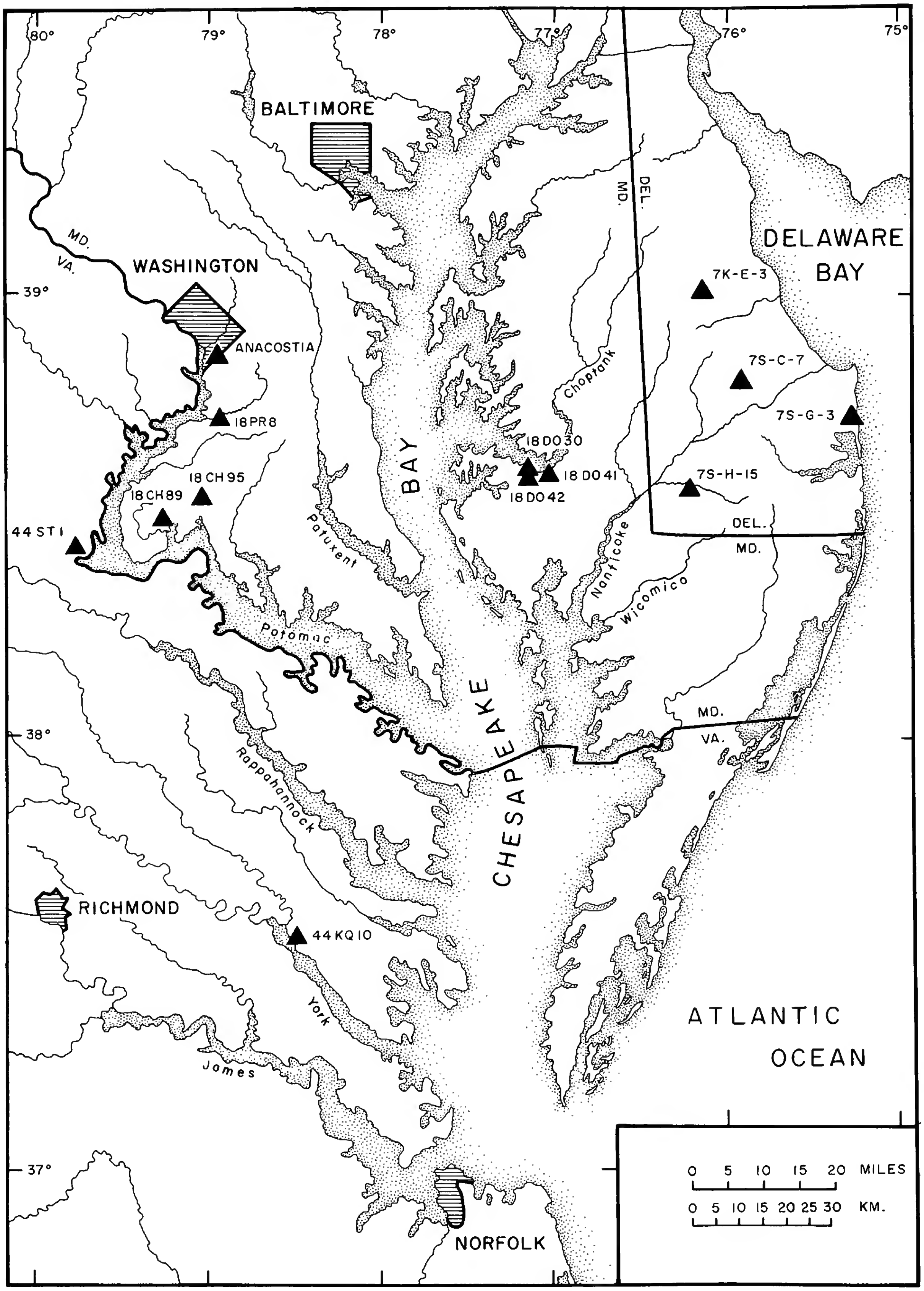


FIGURE 1.—Geographic distribution of reported ossuaries in the region of the Chesapeake and Delaware bays.

Perhaps the first skeletal deposit described as an ossuary in the mid-Atlantic area was found at site 7S–H–15 in 1808 about 2 kilometers (1 mi) from Laurel, Delaware. Apparently, some workers removing earth from a stream bank to repair a mill dam uncovered a concentration of human bones. According to Huffington (1838:16), several wagon loads of bones were removed and a considerable number were left in situ. Several old men at that time recalled that the Indians had buried the bones just before they departed from Delaware. Their recollection that the Indians brought "bones" for burial and not bodies suggests secondary, ossuary burial. However, Huffington (1838:16) relates that the skeletons "were laid side by side and each bone in its proper place. Among them were several frames which must have belonged to men of large growth. One in particular was said to have measured seven feet in length." With the conflicting evidence and in the absence of any contemporary records, it is impossible to determine whether the Laurel discovery was an ossuary or even a secondary burial.

In 1883, workmen uncovered 16 skeletons at site 18D042 while constructing a jail foundation in Cambridge, Maryland. The skeletons were supposedly arranged in a circle, with no associated artifacts (MacLeod, 1928:208). The term "ossuary" has been applied to this skeletal sample by Weslager (1942:145) but again it does not fit the ossuary definition used here.

Henry C. Mercer reported the exploration of an Indian ossuary on the Choptank River, Dorchester County, Maryland (18D030) in 1897. The Choptank ossuary was 3 kilometers (2 mi) north of Cambridge, Dorchester County, Maryland, on the left bank of the Choptank estuary. The deposit had been previously disturbed by amateurs seeking crania, but still contained scattered human bones in an irregular pit, 7.62 meters (25 ft) in length by 6.10 meters (20 ft) in width. The bone deposit was 0.46 meters (1.5 ft) thick. A second deposit measuring 2.1 meters (7 ft) long, 2.4 meters (8 ft) wide, and 0.2 meters (8 in) thick was located above the larger concentration and separated from it by 0.46 meters (1.5 ft) of sand. At least 100 individuals were represented, with no bones in articulation and no artifacts associated.

What may be a third ossuary was uncovered at this site in the late 1930s close to Mercer's original excavation. The feature was completely destroyed by local collectors, who reportedly removed an unknown number of skeletons with a tremendous amount of accompanying grave goods, including over 100 complete gorgets, over 100 copper beads, effigy pipes, and a large quantity and variety of worked stone (Weslager, 1942:146). Although this discovery may represent an ossuary, the artifacts suggest it more probably represents an earlier deposit, perhaps Adena.

Fowke (1894) reported two possible ossuaries from Alleghany County, Virginia. The 2.4-meter (8 ft) pits each contained the disarticulated remains of approximately 25 individuals of all ages. Graham (1935:33) mentions a third ossuary found by Fowke in Orange County, Virginia, but Fowke's (1894:24–25) description indicates the discovery was just a mound containing some secondary skeletal material.

Wigglesworth (1933) reported excavating 15 articulated skeletons from a cliff face just south of Rehoboth Beach, Delaware (7S–G–3). The skeletons (14 adults and 1 child) were apparently completely articulated and communally deposited in a pit 2.8 meters (9.2 ft) long by 2.0 meters (6.7 ft) wide. Although Weslager (1942:145) includes the site in his discussion of ossuaries, it probably represents a group deposit of individuals, who for unknown reasons died at approximately the same time.

Davidson (1935:91–96) recorded the excavation of five individuals at Slaughter Creek (7S–C–7), 10 miles south of Milford, Delaware. One individual was represented by a bundle in a separate pit, one by an articulated flexed skeleton in a separate pit, and the last three by disarticulated bones in a common pit. Davidson (1935:91–96) interpreted the variety of burial forms present at the site as indicating that the material was transitional between the earlier practice of individual burial and the later practice of ossuary deposit.

Weslager (1942:145) mentions that an ossuary was encountered by a state highway crew near Killens' Mill Pond (7K–E–3) east of Felton, Delaware. Many skeletons were apparently removed, but no details were recorded.

Weslager (1942:145) claimed to discover an ossuary on the Vincent Farm (18DO41) near the junction of Whitehall Creek and the Choptank River, several miles east of Cambridge, Maryland. Actually, the site had been visited in 1936 by T. Dale Stewart (1940b:363) and even earlier by local collectors. Stewart salvaged some of the material and verified the ossuary as authentic, but unfortunately could glean little further information.

In 1935, William J. Graham, Presiding Judge of the United States Court of Customs and Patent Appeals, Washington, D.C., privately published his analysis of five ossuaries from site 18CH95 near Port Tobacco, Maryland. Aided by T. Dale Stewart, Graham personally excavated four of these ossuaries. The fifth had apparently washed out of a bank and had been looted heavily before Graham discovered it. All of the ossuaries contained secondary, disarticulated skeletal material, and two produced artifacts of European manufacture. Graham (1935) estimated the four undisturbed ossuaries to contain 10, 25, 50, and 100 individuals.

Judge Graham continued his excavation of ossuaries in 1937, this time moving to the site of Patawomeke (44ST1) on Potomac Creek. The habitation site is located on the west bank of the Potomac River, near what is now Marlboro Point, Stafford County, Virginia, and supposedly had close to 1000 inhabitants at the time Smith visited the site in 1608. Graham's excavations revealed three ossuaries, one of which contained artifacts of European manufacture. A fourth ossuary was discovered later by an associate of Graham's and a fifth was added by T. Dale Stewart in 1939 (Stewart, 1940a, 1941). Stewart's ossuary contained 135 individuals and many shell beads. The first four ossuaries were estimated by Graham (1935) to contain 181, 287, 67, and 41 individuals.

Possibly the first ossuary excavated at Patawomeke was reported by E. R. Reynolds (1883). In 1869, a group of amateurs from the Shenandoah Valley excavated 12 skeletons, buried together at a depth of six feet. Although Reynolds (1883) described the site as being at the junction of Accotink Creek and the Potomac, Stewart (1958a) showed that Reynolds actually meant "Accakeek" and not "Accotink." Consequently, the discovery was probably close to the site of Patawomeke. However, E. R. Reynolds' (1883) reference to articulated skeletons indicates the feature was probably not an ossuary, as defined in this report.

In 1937, T. Dale Stewart and Waldo R. Wedel of the Smithsonian Institution excavated two ossuaries in Anacostia, just outside and southeast of Washington, D.C. Apparently, the ossuaries were associated with the village of Nacotchtanke visited by Smith in 1608, who observed "80 able men" at that time. The bones were uncovered by a power shovel when nearby Bolling Field was being extended. Between 63 and 70 individuals were present in each pit, represented by disarticulated bones grouped in bundles. Several shell beads and pottery sherds were recovered.

Stewart (1940b) investigated another ossuary in 1939, this time at 44KQ10 along the York River in Virginia. The bones had been discovered several years earlier eroding out of the north bank of the river, between 6.4 and 8.1 kilometers (4 to 5 mi) south of the present town of West Point. By the time Stewart was notified and could investigate, over half of the ossuary had washed away. Bones could be found along the beach for a considerable distance. The remaining bones were stacked in bundles, some partly articulated. Six potsherds represented the only cultural material.

During the years 1936–1937, Alice L. Ferguson, an amateur archeologist from southern Maryland, conducted an excavation at the site of Moyaone (18PR8) near the mouth of Piscataway Creek, in Prince George's County, Maryland, just across the Potomac from Mount Vernon (Ferguson, 1937; Stephenson and Ferguson, 1963). In the process of exploring the village area, she uncovered four ossuaries. Stewart again had an opportunity to examine, but not to excavate the skeletal material. Because of the manner in which the bones were recovered, exact statements as to the number of individuals, etc., are not possible. According to Stewart (per. comm.), Ferguson's archeological approach involved digging a deep trench around the deposit, and then inviting friends for an afternoon of bone collecting from the trench wall. A few selected bones were saved for Stewart to examine. In general the ossuaries presented the same type of associations found at Patawomeke. The remains were mostly disarticulated and partially arranged in bundles. The first two ossuaries contained an estimated 288 skulls, the third 248 skulls and the fourth 618 skulls. Later a fifth ossuary was found at the nearby site of Piscataway that contained 254 skulls, as well as a multitude of trade material.

Specimen accession records at the Division of Physical Anthropology, National Museum of Natural History, indicate that a possible sixth ossuary was discovered in the Moyaone-Piscataway area as early as 1908. The records indicate that 99 human bone specimens were accessioned in 1908 as a result of excavations by A. Hrdlička, J. D. McGuire, and J. H. Reams at the mouth of Piscataway Creek.

By the time Weslager published his synthetizing article on ossuaries on the Delmarva peninsula in 1942, 32 suggested ossuaries had been discovered in the mid-Atlantic area. Of these, 21 probably represent true ossuaries (2–Choptank River, 1–Vincent Farm, 5–Port Tobacco, 5–Patawomeke, 2–Anacostia, 1–York River, and 5–Piscataway Creek), six were definitely not ossuaries (1–Orange County, 1–Cambridge Jail, 1–Rehoboth, 1–Slaughter Creek, 1–Choptank River, and 1–Patawomeke), and five (1–Laurel, 2–Alleghany County, 1–Killens Mill Pond, and 1–Piscataway Creek) remain unknown due to the manner in which they were excavated. However, the 21 true ossuaries clearly substantiate the ethnographic implication that the practice of ossuary burial was important in the mid-Atlantic region, just as it was among the Huron to the north. The finding of both partially articulated and scattered bones of many individuals representing all age groups strongly suggests that, like the Huron, the people of the prehistoric mid-Atlantic region buried all of their deceased in ossuary graves. The presence of calcined bones in ossuaries at Anacostia, Choptank, Patawomeke, and Accokeek indicates that if different mortuary practices were employed (i.e. cremations), the skeletal remains still were included in the ossuary collective deposits. The ethnographic-archeological evidence warrants the assumption that the large ossuary skeletal samples in the mid-Atlantic region represent nearly complete collections of aboriginal deaths for the time periods and populations the ossuaries served. Of course, the possible omission of the leaders, accidental deaths of individuals whose remains could not be recovered, and occasional loss of individuals from the primary deposit, theoretically prevent the sample from being 100 percent representative. Still, such losses must have been minimal if present at all, making ossuary skeletal collections far more complete than any other archeological skeletal sample in North America. If properly excavated, such relatively complete samples offer unique opportunities to reconstruct population profiles for the formerly living populations. The last two ossuaries discovered in the mid-Atlantic area, those from the Juhle site (18CH89), Charles County, Maryland, support the evidence summarized above for a Huron-like ossuary practice in the Tidewater Potomac. In the remainder of this report, these two ossuaries will be discussed in detail, and the skeletal material from them will be utilized to reconstruct demographic profiles for the formerly living populations.

The Ossuaries from Nanjemoy Creek

By the late 1940s, students of mid-Atlantic archeology had learned a great deal about aboriginal ossuary burial. Enough ossuaries had been discovered to indicate that the practice was geographically distributed throughout eastern Virginia, southern Maryland, and southern Delaware (Figure 1), and chronologically confined to the late Woodland and early Historic periods (Davidson, 1935; Weslager, 1942). Ossuaries were known to contain large numbers of both articulated and disarticulated skeletons, some scattered throughout the pit and others arranged in bundles. Some ossuaries contained large amounts of artifacts (aboriginal and European manufactured) and some included small amounts of burned bone.

Although much had been learned, many questions remained concerning details of the mortuary custom, the physical type, and the demographic structure of the population. Most of the ossuaries had been excavated by amateurs, with only occasional professional supervision. Those that had received professional attention (Anacostia and York River, 44KQ10, for example) had been disturbed partially prior to excavation. Since the skeletal samples were incomplete, they were of limited use to physical anthropologists. Clearly, there existed a need for the professional excavation of an undisturbed ossuary and the analysis of a complete skeletal sample. As discussed in the preface, this need was fulfilled with the discovery and excavation of two ossuaries from the Juhle site in southern Maryland in 1953 and 1971.

The Juhle farm (named Friendship Farm after an early English Ship) is located approximately 50 miles (80 kilometers) south of the present District of Columbia on the north bank of Nanjemoy Creek, a small tributary of the Potomac River. The ossuaries found by the Juhles and the probable associated habitation site (18CH89) are on a 33.5-meter (110 ft) bluff overlooking Nanjemoy Creek (Figures 2, 3). Ossuary I lies 3 meters (10 ft) north of the north kitchen porch of the present Juhle residence and one meter east of the circular, unpaved drive that connects the Juhle farmyard to the county road 91.0 meters (100 yds) to the north (Figure 4). Ossuary II lies about 30.5 meters (100 ft) northwest of Ossuary I. The site falls within the region occupied by the Algonquian-speaking Conoy or Pistcataway in early historic times, and possibly represents the Late Woodland pre-contact ancestors of these people. Although contact between the Potomac River Indians and Europeans began shortly after the founding of Jamestown in 1607, the Nanjemoy area was not colonized until the mid-17th century as evidenced by the ruins of one of Charles County's old homesteads, dating from ca. 1660, and located less than one mile north of Ossuary I.

Ossuary I

Stewart's 1953–1955 excavation of Ossuary I was directed principally toward recovering the complete skeletal sample in a manner that would facilitate the later assemblage of complete individuals. Feeling that the bones of each individual would be scattered over a small area, he constructed a 1.5 meter (5 ft) grid system over the ossuary and kept the bones from each square separated from each other. Unfortunately, few complete skeletons could be assembled, but his excavation did document many important features of ossuary burial. He found that the bones were typically disarticulated and scattered throughout the pit, although some articulation and a few distinct bundles were noted (Figure 5). At least seven individuals were almost completely articulated and were concentrated on the floor. Numerous examples of partial articulation were observed to be scattered throughout the bone layer. At least 12 distinct bundles were recognized, usually at the periphery of the bone concentration. The bundles contained both articulated and disarticulated skeletal parts, frequently representing more than one individual. Ninety-four skulls were recognized and numbered by Stewart, although the presence of numerous infant cranial fragments associated with the numbered skulls indicated the count would be much higher (my own analysis indicates a total of at least 131 individuals). The few artifacts found with the skeletons were all aboriginal and suggestive of a Late Woodland occupation, just prior to European contact.

Ossuary II: Excavation Procedure

Excavation of Ossuary II was designed to remove the skeletal material as rapidly as possible without sacrificing archeological data. Initially, this involved removing the 25.4-centimeter (10 in) layer of over-burden to disclose the pit outline. The outline was easily distinguishable since the soil outside of it was much lighter in color, more compact, and lacked the small particles of charcoal and shell that permeated the pitfill. The pit enclosed an area 5.2 meters (17 ft) long by 2.1 meters (7 ft) wide.

Our excavation of the bones themselves utilized a 0.6-meter (2 ft) grid system superimposed over the bone mass

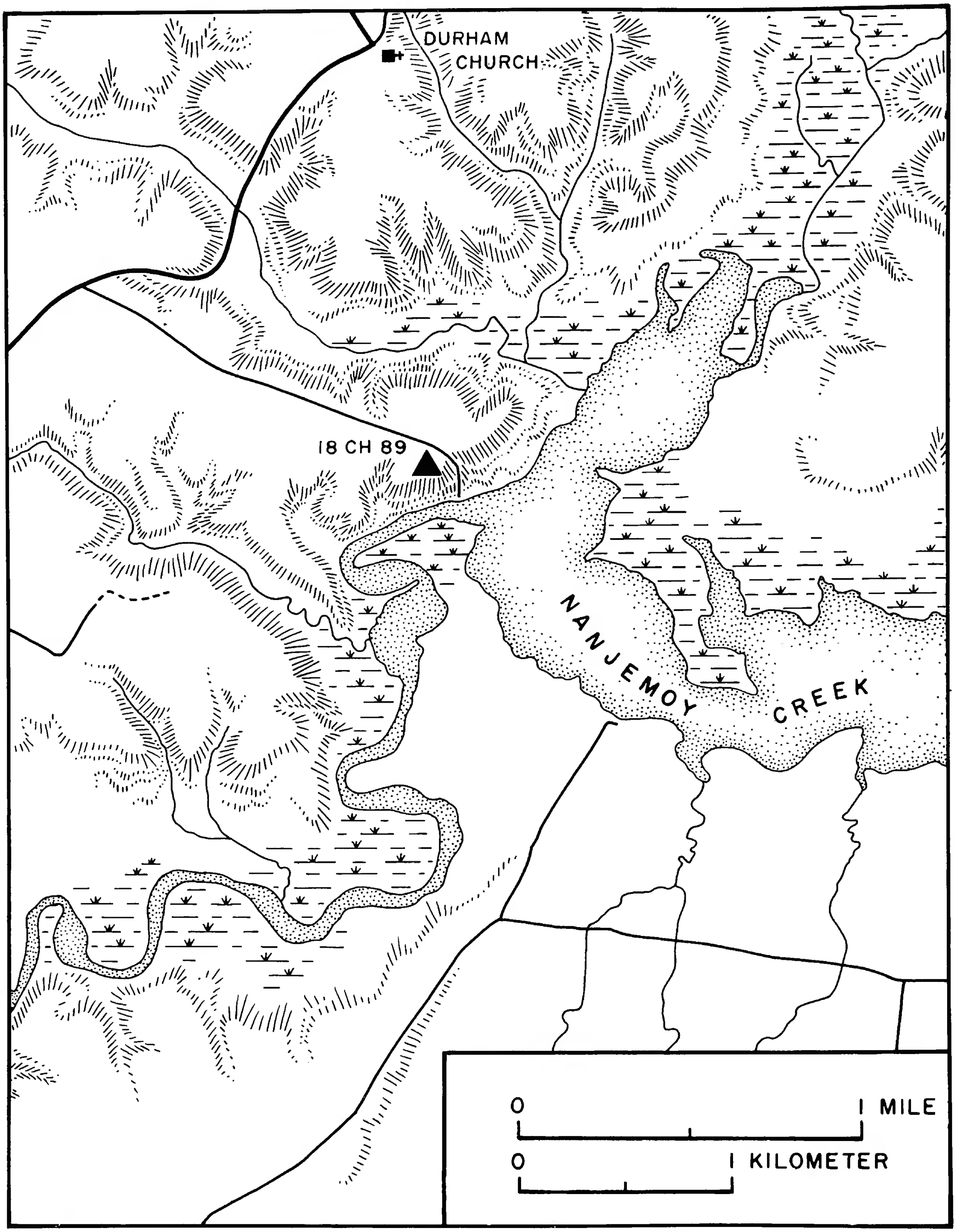


FIGURE 2.—Location of Juhle site (18CH89) near Nanjemoy Creek, Charles County, Maryland.

FIGURE 3.—Nanjemoy Creek, as seen from Juhle site (18CH89), looking southwest.

(Figure 6). This unit size was chosen over a 1.5-meter (5 ft) system because it was large enough to include a sizeable amount of bone, yet small enough to allow us to study distribution variation within the pit, and possibly to facilitate association of bones of the same individual scattered over a localized area. Since preliminary testing indicated that the bone concentration was approximately 1.8 meters (6 ft) wide, three rows of 0.6-meter (2 ft) squares were laid out parallel to the long axis of the bone concentration. By chance, the barbed wire fence being erected by the Juhles at the time the bones were encountered bisected the ossuary longitudinally and divided it into southwest and northeast halves (Figure 7). At Stewart's suggestion, we labeled the three longitudinal rows according to their positions relative to the fence. We assigned the letter "L" (left) to the row southwest of the fence (i.e., to the left as one faces away from Ossuary I); "C" (center) to the row directly under the fence; and "R" (right) to the row northeast of the fence (i.e., to the right as one faces away from Ossuary I). The 0.6-meter (2 ft) squares in each of the three longitudinal rows were lettered consecutively from A to H, beginning from the southeast end. Thus, the first squares of the three rows bore the designations AL1, AC, and AR1 (Figure 6). This arrangement proved easy to use and to remember. Although small amounts of bones extended beyond the left and right limits of the squares, and our original intention was to give them the number "2" (AL2, AR2, etc.), in actual practice we included these bones with those in the squares number "1". The number "1" was retained (AR1 as opposed to just AR) since our field notes originally were recorded in this manner.

Our excavation procedure involved exposing the bones in situ; describing, mapping, and photographing them in the context of the grid system, and then removing them with as little damage as possible. Initially we planned to preserve the original shape of the trench, documenting the positions of the bones relative to the trench walls. Leaving the trench wall intact, however, forced the excavator into the somewhat uncomfortable position of leaning down into the pit to work (Figure 8*a*, *b*). The situation was improved by the construction of a board support system which enabled the excavator to lie above the bone concentration while working (Figures 8*c*, 9). However, best results were obtained when

525-413 O - 74 - 3

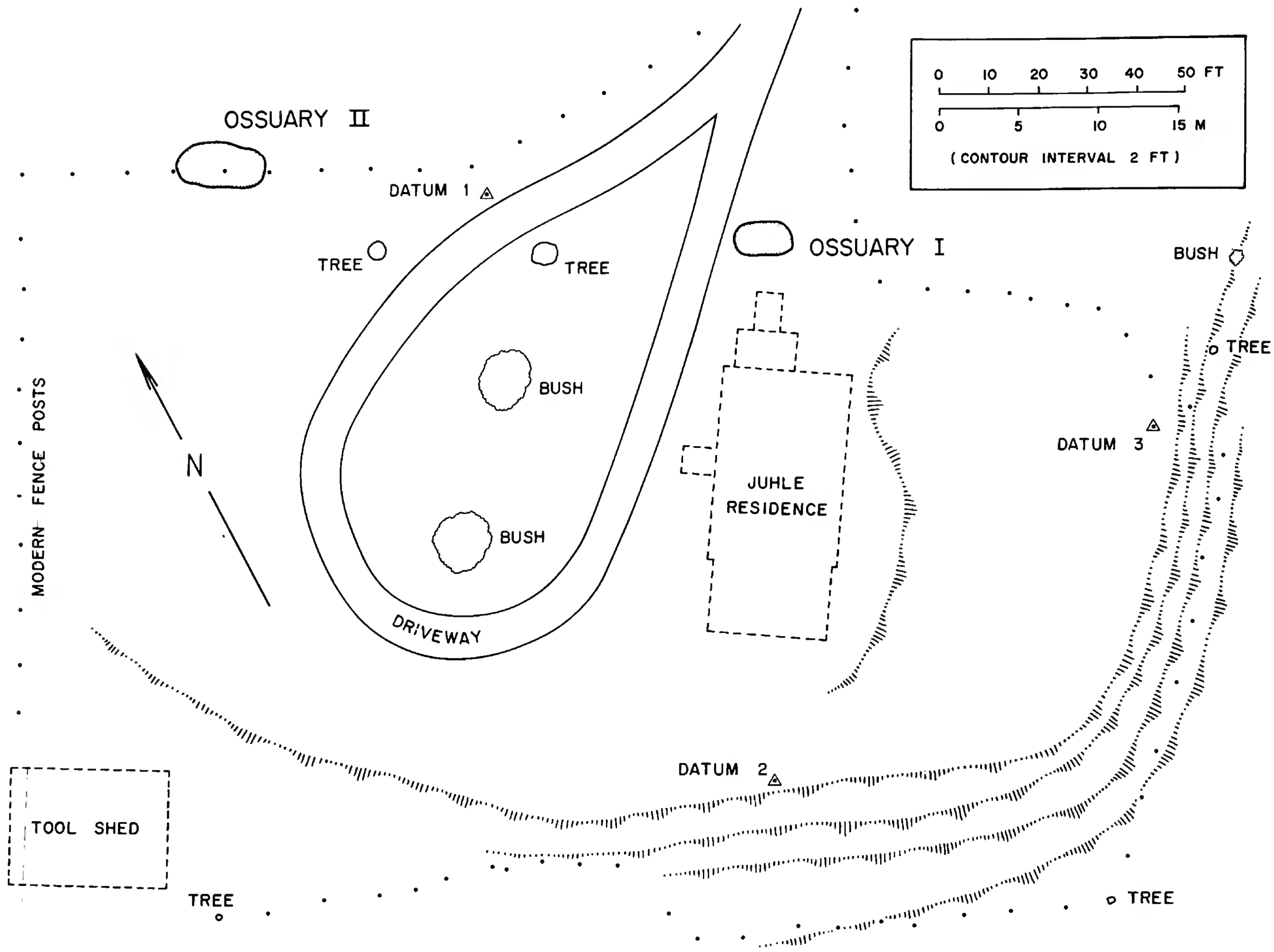


FIGURE 4.—Detailed map of the Juhle site (18CH89), Charles County, Maryland.

the area outside of the ossuary was removed, enabling the excavator to lie at the same level as the bone concentration. To minimize damage from exposure, we confined our excavation to approximately one-third of the ossuary at one time, beginning with the row of squares AL1 through HL1 (Figure 10*a, b*). When that material had been exposed, recorded, and removed, we shifted our attention to the row of squares AR1–ER1 (Figure 10*c*) and then ended the 1971 season with the center row of squares AC–EC (Figure 11). The final six squares in the northwest corner (FC–HC and FR–HR) were excavated simultaneously during the 1972 season (Figure 12). Because of the interlocking nature of the bone concentration, some material in the left and right rows could not be removed until the center row was excavated. These log-jams of bones constantly complicated the excavation. In addition, the 0.6-meter (2 ft) grid system only could be applied very generally since a high percentage of the large bones extended across the arbitrary unit boundaries. In such cases, a bone was assigned to the square containing over 50 percent of its length. Occasional bones appeared to be divided equally between two squares and these were assigned both square numbers (AL1–BL1; AL1–AC; etc.). In spite of these complications, analysis later demonstrated that the 0.6-meter (2 ft) grid system provided a satisfactory approach to ossuary excavation.

After the bones were removed, they were divided into four categories: (1) complete individuals, (2) partially articulated bones, (3) bundles, and (4) scattered, disarticulated remains. The few complete individuals were each assigned a number and their positions in the grid were recorded. Bones that were still partially articulated (hands, feet, etc.) were assigned separate "partial articulation" numbers and their positions in the grid were also recorded. Bundles of both scattered and partially articulated bones were assigned "bundle numbers" and their grid positions were plotted. Finally, scattered, disarticulated bones were assigned individual square numbers. This four-fold classification system allowed the recording of several culturally significant bone categories without the loss of information on spatial distribution. Aside from general observation, no at-

FIGURE 5.—Excavation of Ossuary I: *a,* 1953—upper level of eastern section, looking northeast; *b,* 1953—lower level of eastern section, looking northeast (note articulated skeletons and bundles); *c,* 1955—western section, looking northeast; *d,* 1955—western section, looking east.

tempt was made to distinguish upper from lower layers in the bone concentration, because no natural layering could be detected and long bones often were observed to extend from top to bottom.

Ossuary II: Contents

In general, our excavation revealed that the archeological features of Ossuary II were very similar to those of Ossuary I and other Late Woodland ossuaries in the area. The bones had been placed in a trenchlike pit with rounded ends (Figure 13). The trench was shallow (maximum depth 0.5 meters (1.8 ft) at the northeast end and gradually tapered to a maximum depth of about 0.9 meters (2.9 ft) at the southwest end). The overall maximum pit dimensions were 5.0 meters (16.5 ft) by 2.2 meters (7.3 ft) with the long axis oriented northeast-southwest. A 20.3 cm (8 in) to 25.4

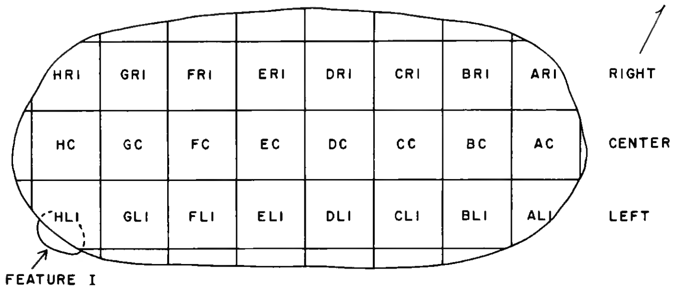


FIGURE 6.—The 0.6-meter (2 ft) square system utilized in the 1971 excavation of Ossuary II.

cm (10 in) upper layer of dark soil marking the plow zone extended uniformly over the area. Below the plow zone, bones were encountered at depths ranging from 30.5 centimeters (12 in) in square AL1 to 43.2 centimeters (17 in) in square CL1. No evidence of a Huron-like platform was found on the periphery of the pit; however, a small intersecting pit was discovered in the western corner. The circular intersecting pit (designated feature I) was 0.8 meters (2.7 ft) in diameter and 0.5 meters (1.8 ft) in depth. It contained several small charcoal fragments and quartz flakes, several broken shells of oyster (*Crassostrea virginica*), a distal tibia of a white-tailed deer (*Odocoileus virginianus*), 10 fragments of softshell turtle (*Trionyx spinifer*), and two fragments from the three-toed box turtle (*Terrapene carolina*). Intersecting pit outlines failed to reveal whether the probable trash pit was later, contemporary, or earlier than the ossuary. One of the oyster shells displayed a serrated edge composed of 13 notches that extended around the lip of the shell from the hinge. The notches are 1 to 2 mm in depth and 1 to 4 mm apart. Stephenson (in Stephenson and Ferguson, 1963:163) described 226 serrated mussel shells from the nearby Accokeek Creek site and suggested they may have served as scrapers or cutting tools.

The bone concentration as a whole varied in thickness from 0.5 meters (1.8 ft) in square AC to only 7.6 cm (3 in) in square HC. Table 2 demonstrates the distribution of bone weight per square. These figures represent the total weight (in kilograms) of the cleaned bones by squares and provide a clear indication of the overall distribution of bone within the pit. Although the southeast-center area was the deepest part of the pit, square DLI produced the most skeletal material. This is because the bones were piled higher on the

FIGURE 7.—Division of Ossuary II (by barbed wire fence) into northeast and southwest halves, looking northwest.

FIGURE 8.—Excavators working in square DL1, Ossuary II: *a*, looking southeast; *b*, looking northwest; *c*, looking northwest.

FIGURE 9.—Excavator lying on a board-support to work in square GR1, Ossuary II, looking southwest.

sides. Of the total of 233.900 kilograms of bone in the pit, 90.915 kilograms (39 percent) were on the left side, 84.954 kilograms (36 percent) were on the right side and only 58.031 kilograms (25 percent) were in the center. Along the northwest-southeast axis, the maximum bone weight occurred in the "D" squares with the minimum in the "H" squares. The weight distribution through the longitudinal axis largely reflects the greater depth of the southeast part of the trench. Whereas 125.835 kilograms (54 percent) came from the southeast half of the pit, only 108.065 kilograms (46 percent) were recovered from the northwest half. Since the bone concentration only partially extended into the "A" squares of the southeast end, only 19.319 kilograms (8 percent) of bone were recovered from those squares.

TABLE 2.—*Distribution of bone weight (in km) within Ossuary II*

Square	*Weight*	*% total weight*	*Square*	*Weight*	*% total weight*
AL1	12. 066	05. 16	FR1	11. 588	04. 95
BL1	14. 069	06. 01	GR1	8. 649	03. 70
CL1	7. 860	03. 36	HR1	2. 048	00. 88
DL1	19. 675	08. 41	L	90. 915	38. 86
EL1	15. 572	06. 66	C	58. 031	24. 81
FL1	10. 741	04. 59	R	84. 954	36. 32
GL1	8. 475	03. 62	A	19. 319	08. 26
HL1	2. 457	01. 05	B	31. 521	13. 47
AC	. 682	00. 29	C	33. 223	14. 20
BC	3. 730	01. 59	D	41. 772	17. 86
CC	6. 671	02. 85	E	39. 202	16. 76
DC	8. 107	03. 47	F	39. 825	17. 02
EC	13. 936	05. 96	G	24. 302	10. 39
FC	17. 496	07. 48	H	4. 736	02. 03
GC	7. 178	03. 07	A–B	50. 840	21. 74
HC	. 231	00. 10	C–D	74. 995	32. 06
AR1	6. 571	02. 81	E–F	79. 027	33. 79
BR1	13. 722	05. 87	G–H	29. 038	12. 42
CR1	18. 692	07. 99	A–D	125. 835	53. 80
DR1	13. 990	05. 98	E–H	108. 065	46. 20
ER1	9. 694	04. 14			
			Total	233. 900	100. 00

In addition to human remains, Ossuary II included shell (worked and unworked), pottery sherds, projectile points, and animal bone. With the possible exception of shell beads, the cultural material appeared to be scattered haphazardly throughout the pit fill. Shell beads were found either inside crania or in concentrations that did suggest possible intentional placement. These beads may either have been placed in the pit in connection with the ritual of ossuary burial or were with the remains originally.

ANIMAL BONE

Animal bones, all fragmentary, represent seven species: white-tailed deer (*Odocoileus virginianus*), squirrel (*Sciurus* sp.?), fox (*Vulpes* sp.? or *Urocyon* sp.?), meadow jumping mouse (*Zapus hudsonius*), turkey (*Meleagria gallopavo*), muskrat (*Ondatra zibethicus*), and pine vole (*Pitymys pinetorum*). Most of the bones were either from white-tailed deer (over 32 fragments) or from turkey (eight fragments). Tables 3 and 4, which list the bones of these two species and their square distributions within Ossuary II, show clearly that the bones were randomly distributed throughout the pit. The other bones consisted of a right radius of a squirrel (*Sciurus* sp.?) from square ER1, a left ulna of a fox (*Vulpes* sp.? or *Urocyon* sp.?) from CL1, a right femur of a meadow jumping mouse (*Zapus hudsonius*) from DL1, and the following bones of a muskrat (*Ondatra zibethicus*): vertebrae from AL1, right innominate from DL1, left femur from EC, the distal end of a right tibia from DR1 and a left mandible from the plow zone. These faunal remains probably do not represent grave offerings, but rather occupational refuse accidentally included. In addition, much

TABLE 3.—*Spatial distribution of bones of turkey* (Meleagria gallopavo) *within Ossuary II*

Square	*Bone*
DL1	Right innominate
DL1	Femoral shaft
DL1	Vertebra
FL1	Left femur
FL1	Vertebra
DR1–ER1	Tarso-metarsus
DR1	Tarso-metarsus

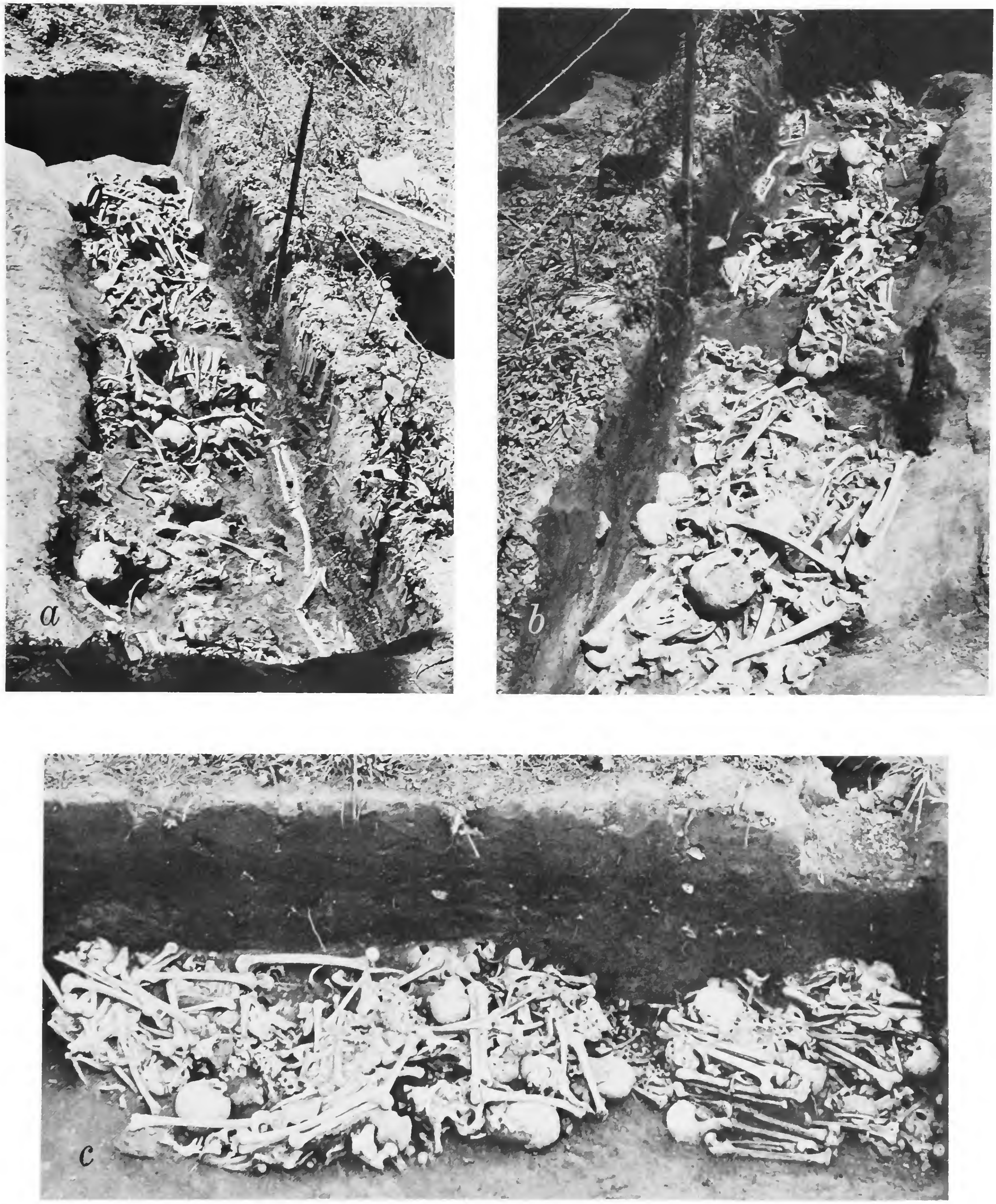


FIGURE 10.—Bone concentrations in Ossuary II: *a,* squares AL1–HL1, looking southeast (note partially exposed articulated skeleton in wall); *b,* squares AL1–HL1, looking northwest; *c,* squares AR1–ER1, looking southwest.

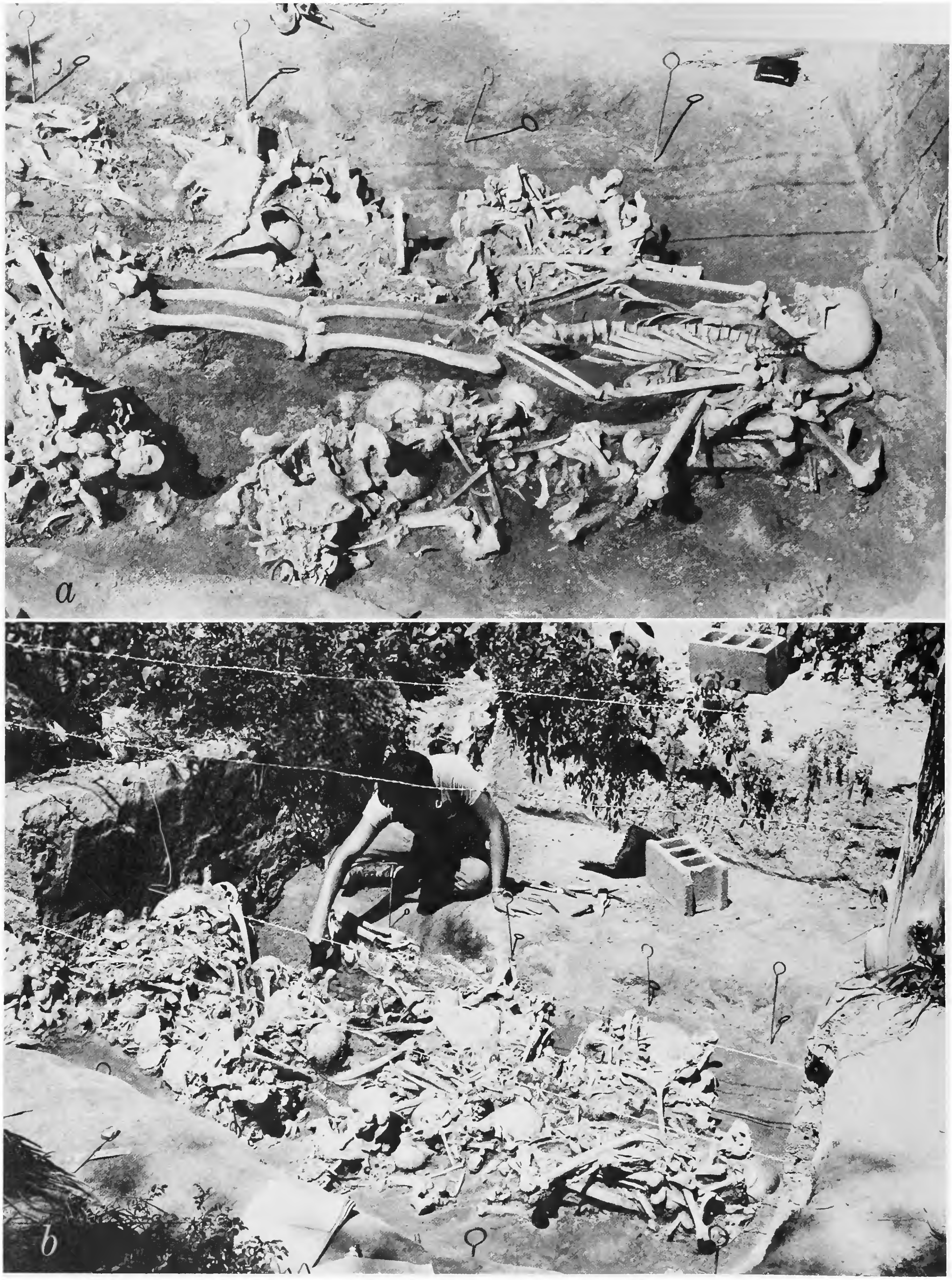

a
b

FIGURE 11.—Ossuary II: *a,* extended articulated skeleton in squares AC–DC, looking northeast; *b,* bone concentration in squares AC–EC, after removal of extended skeleton, looking north.

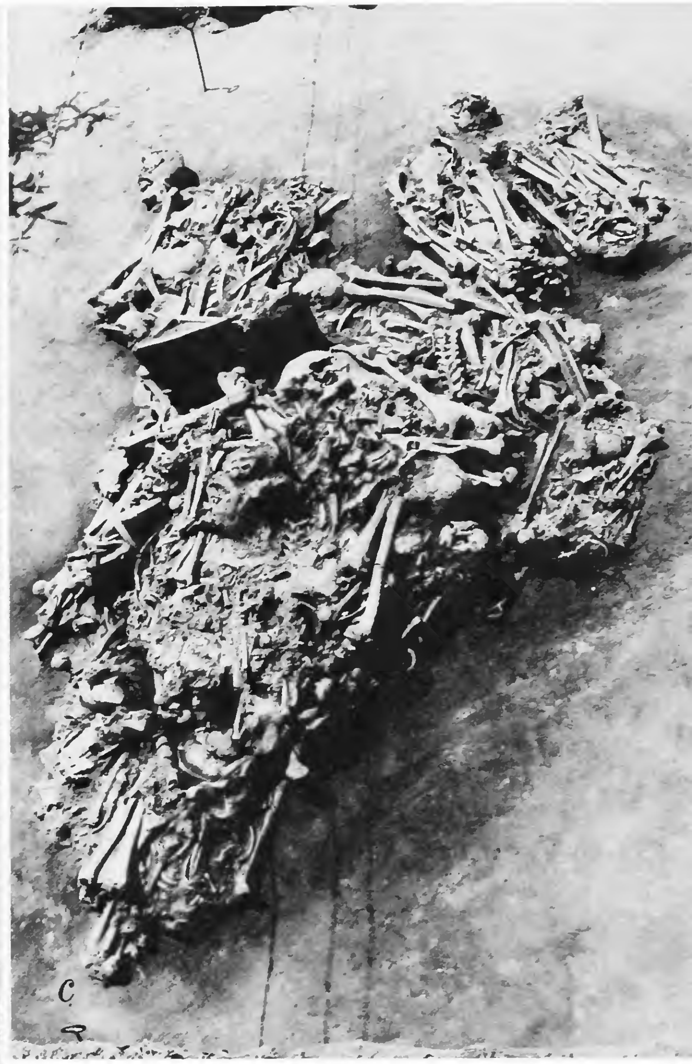


FIGURE 12.—Northeastern extremity of Ossuary II: *a,* pit outline with bone concentration shown in profile, looking northeast; *b,* same section after soil was removed, looking northeast (note isolated bundles in the periphery of the bone concentration); *c,* looking northwest.

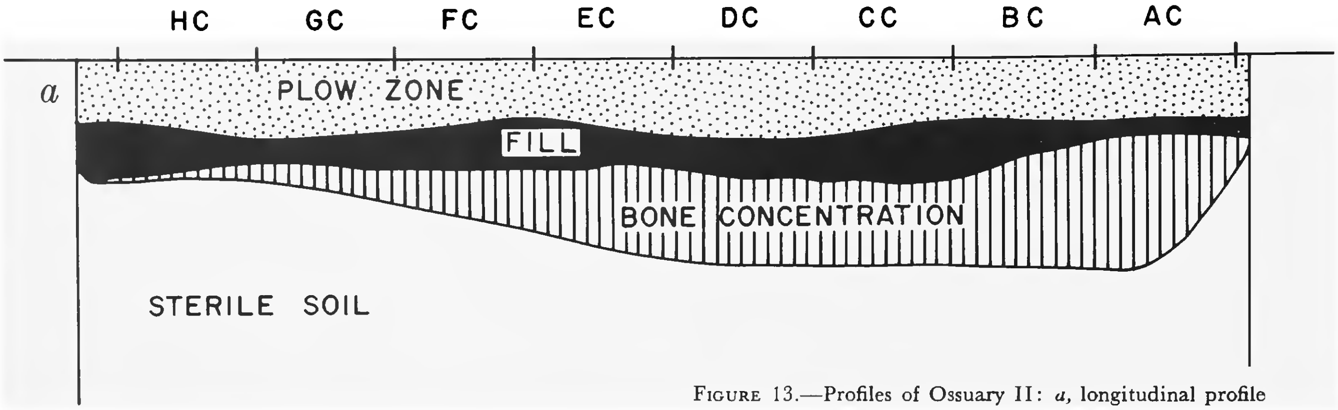
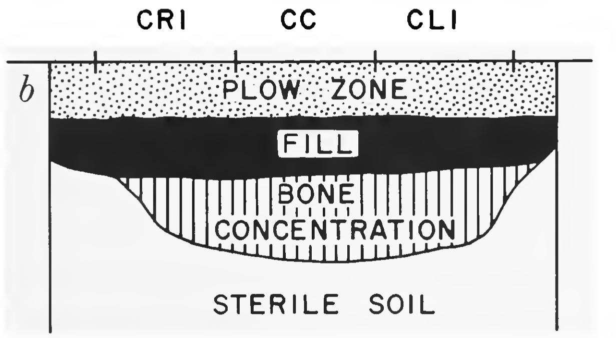


FIGURE 13.—Profiles of Ossuary II: *a*, longitudinal profile through the center of ossuary; *b*, cross-section profile through the center of the "C" squares.



of the skeleton of a pine vole (*Pitymys pinetorum*) was found inside a skull from square DC. The vole probably represents a secondary intruder into the ossuary.

SHELL

Shells representing seven species were found in Ossuary II: oyster: *Crassostrea virginica;* land snails: *Anguispira alternata, Mesodon thyroidus, Triodopsis allolabris, Triodopsis juxtidens;* and seacoast land snail: *Busycon carica.* Oyster was the most plentiful, and examples were evenly scattered through all squares. In contrast, only 16 fragments of freshwater mussel (*Elliptio complanata*) were identified from seven squares. Like the faunal remains described above, the oyster and mussel shells probably do not represent offerings, but rather habitation refuse accidently mixed in with the pit fill.

Land snails total 153 and represent four species. A single specimen of *Triodopsis juxtidens* was recovered from inside a skull in DL1. Square GL1 produced one specimen of *Triodopsis allolabris.* Seven examples of *Mesodon thyroidus* were found within squares AL1, FL1, GL1, and AC. Two of these were inside crania and one appeared to be a recent specimen. The remaining 144 land snails, identified as *Anguispira alternata,* were found throughout the pit. Many of these snails were encountered inside crania, with a total of

TABLE 4.—*Spatial distribution of bones of white-tailed deer* (Odocoileus virginianus) *within Ossuary II*

Square	*Bone*
AL1	Left first phalanx
AL1	Temporal
BL1	Right first phalanx
CL1	Left astragulus
DL1	Left central fourth tarsal
DL1	Several long bone shafts
DL1	Right first phalanx
EL1	Several long bone shafts
FL1	Left scapula
FL1	Right rib
GL1	Left distal femur
GL1	Metacarpal shaft
GL1	Left third phalanx
AC	Several long bone shafts
AC	Tarsal
BC	Right humerus
DC	Left zygomatic
DC	Left rib
EC	Several long bone shafts
FC	Several long bone shafts
FC	Right radius
GC	Left zygomatic
CR1	Left astragulus
CR1	Long bone shaft
DR1	Right proximal tibia
DR1	Right acetabulum of innominate
ER1	Long bone shafts
Inside skull	Left calcaneus
Inside skull	Left distal tibia
Inside skull	Lift distal radius
Plow zone	Right humerus
Plow zone	Left proximal femur

65 originating from a single skull between AL1 and BL1. Initially, it appeared that the shells had been intentionally placed inside the skull. Later examination by Dr. Joseph Morrison, Curator of Mollusks, Department of Invertebrate Zoology, National Museum of Natural History, suggested that while they could have been placed in the skulls, they more probably entered either by crawling up the scaffolds during the summer months or by tunneling down to the buried bones in late autumn. The presence of the fresh *Mesodon thyroidus* from AL1 favors a cold weather tunneling interpretation.

The remainder of the shell sample from Ossuary II consists of 107 large and 111 small shell beads. Ninety-one of the large beads are barrel-shaped, drilled from both ends, and vary in width from 6–11 mm and in length from 6–16 mm. A concentration of the large beads was noted in the middle of the ossuary and is borne out by the following square frequencies: four in BC, 30 in CC, 13 in DC, 12 in EC, 7 in FC, 2 in CR1, 21 in DR1, and 2 in GR1. Thirty-two were found inside crania, 27 in a skull in CC, and 5 in 2 skulls in DR1.

The remainder of the large shell beads (16) were elongated, cylinders ranging in width from 5–7 mm and in length from 13–20 mm. These also were concentrated in the middle of the center and right rows, with 1 in BC, 5 in CC, 3 in DC, 1 in CR1, and 6 in DR1. Just one bead was found inside a skull (DR1). According to Dr. Joseph Morrison, all of the large beads probably were cut from the columella of *Busycon carica,* a sea-coast land snail that occurs on the Maryland eastern shore. The concentration of the beads in one area within the pit and the occurrence of many within skulls strongly suggest that they were either placed in the ossuary at the time of burial or perhaps were placed with the body on the scaffold and then brought along when the bones were transferred to the pit.

All of the 111 small beads were found around the articulated bones of a left foot associated with a bundle in GR1. They consistently measure 3 mm in width by 2 mm in length. Stephenson (in Stephenson and Ferguson, 1963:163–164) reported 986 of these beads from the Accokeek Creek site and stated they were made from mussel shell.

Pottery

The 126 pottery sherds recovered from Ossuary II were scattered rather uniformly throughout the pit and probably were accidently added to the skeletal deposit when the pit was filled. According to Clifford Evans and George R. Phebus, Department of Anthropology, National Museum of Natural History, the sherds may be classified into the following type frequencies: Potomac Creek, 105; Moyoane, 10; Rappahannock, 6; and unknown, 5. These wares and pottery types have been described by Evans (1955) and Stephenson and Ferguson (1963) and will not be discussed in detail here. As Table 5 indicates, the type frequencies are very similar to those from Ossuary I, and to a sample collected in the adjacent occupation area. All three of these samples demonstrate a high frequency of Potomac Creek and markedly low frequencies of other, probably earlier, wares.

TABLE 5.—*Frequencies of ceramic types in ossuaries and habitation area*

Ceramic type	*Ossuary I*		*Ossuary II*		*Habitation area*	
	No.	%	*No.*	%	*No.*	%
Potomac Creek	97	87.39	105	83.33	657	91.25
Moyoane	3	2.70	10	7.94	48	6.67
Rappahannock	3	2.70	6	4.76	12	1.67
Keyser	7	6.31	0	0	0	0
Stony Creek	0	0	0	0	3	0.42
Unknown	1	0.90	5	3.97	0	0
Total	111	100.00	126	100.00	720	100.00

Other artifacts recovered in the excavation of Ossuary II include two bowl and two stem fragments from angular, undecorated native-manufactured clay pipes; two small, triangular, quartz projectile points, and numerous quartz fragments. The projectile points strongly resemble the small, thin, triangular Potomac Points described by Stephenson and Ferguson (1963), that were produced by the pressure-flaking of white quartz.

Collectively the cultural material suggests that both ossuaries and the nearby occupation area represent a 16th-century Late Woodand occupation, just before European contact in that area. The strong similarity between artifact assemblages from the two ossuaries suggests that although one may be older than the other, the difference in age between them is very slight. Since standards for recognizing subtle, temporal changes in artifacts are not yet available in the mid-Atlantic region, it cannot at this time be determined from the cultural associations which of the ossuaries is the older. The associated artifacts indicate, however, that both of the ossuaries were pre-European, and that they represent approximately the same time period.

Human Remains

The excavation of Ossuary II produced a total of 233.900 kilograms of human bone. Most of the material was well preserved and probably only a few of the smaller, infant bones were decomposed and lost after interment in the pit. All of the soil was sifted through a one-quarter inch screen, so it is doubtful that any important fragments were missed during excavation. As stated earlier, four categories of human skeletal material were found in the pit: (1) completely articulated skeletons; (2) scattered, partially articulated skeletal parts; (3) bundles of both articulated and disarticulated bones; and (4) scattered, disarticulated bones.

There were three completely articulated adult skeletons, apparently representing individuals who died shortly before the ceremony. One a young female, was lying on her back on top of the bone pile (Figure 11*a, b*) with legs extended. The other two were on the floor of the pit in CR1 and DR1 (Figure 14). One of these (35–40 year old male) was lying on his back (Figure 15*a*) with his legs very tightly flexed. The other (30-35 year old female) was lying face down with her femora extended (Figure 15*b, c*) and her lower leg bones unnaturally flexed underneath the femora. Since the knee articulations were preserved, it appears that the lower legs had been placed deliberately in the above position, presumably to conserve space, as Stewart (1941:70) has suggested.

Many partially articulated bones were found scattered throughout the bone concentration (Figures 15*d*, 16*a*). Such remains undoubtedly represent individuals who were incompletely decomposed at the time of ossuary deposit. These individuals had been dead longer than the three completely articulated individuals, but not as long as those represented by completely disarticulated bones. Table 6 presents a general listing of frequencies of partial articulation representing different parts of the adult body. The table reveals that the greatest number of individuals (23) was represented by foot bones, followed closely by the tibia and fibula (20), and the thoracic vertebrae (20). To a large extent, the distribution in Table 6 reflects the relative strength of muscle and ligament attachments and their resistance to decomposition. Apparently, decomposition produces separation first at the major joints such as the shoulder, elbow, wrist, hip, and knee. Separation next occurs at the joints between the sacrum and pelvis, bones of the hand, lower leg and foot, radius and ulna, sacrum and fifth lumbar vertebrae, skull and first cervical vertebrae, the lumbar segments, first and second cervical vertebrae, skull and mandible, and the third to seventh cervical segments. The thoracic vertebrae, tibia and fibula, and bones of the feet are the last to become disarticulated. Only 14

FIGURE 14.—Articulated adult skeletons on the floor of Ossuary II, looking northwest.

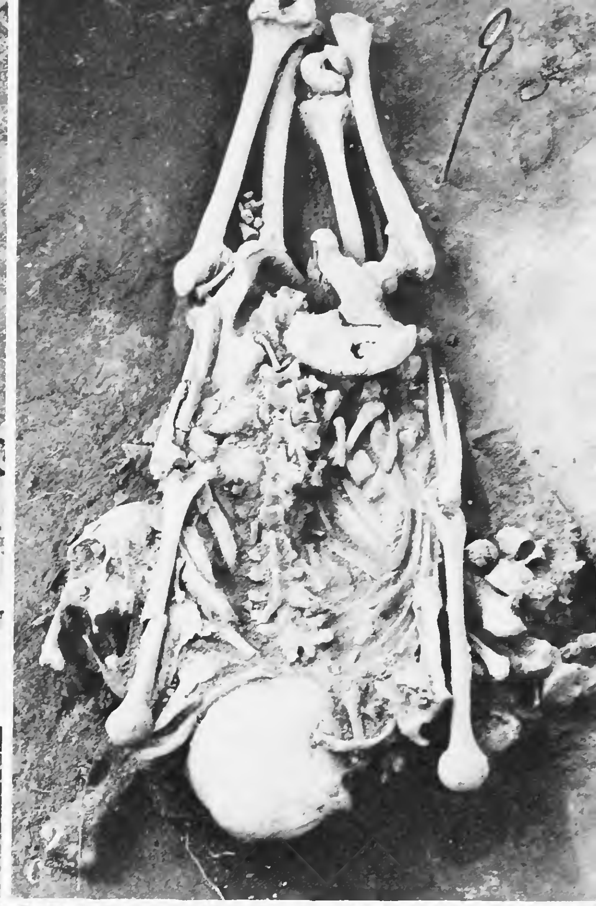


FIGURE 15.—Ossuary II: *a,* nearly completely articulated 35 to 40-year-old male from squares CR1–DR1, looking northwest; *b,* articulated 30 to 35-year-old female from squares CR1–DR1, looking northwest; *c,* closer view of articulated female (note unnatural position of the lower legs); *d,* eight articulated thoracic vertebrae from square GR1.

FIGURE 16.—Ossuary II: *a,* two examples of partial articulation (three articulated thoracic vertebrae and five articulated left metatarsals); *b,* isolated bundle in squares GR1–HR1.

examples of partially articulated subadult bones were recorded. Of these, 12 involved vertebrae, one carpal bones, and one a foot. The fewer examples of partially articulated subadult bones reflect both a faster subadult decomposition rate and the greater difficulty in detecting subadult articulation during excavation.

Many of the partially articulated and wholly disarticulated bones probably were arranged originally in bundles. Unfortunately, formerly distinct bone clusters tended to blend together in the bone mass, and bundles could be distinguished only in the shallow northwest end (Figures 12*b, c,* 16*b*). In this area, five bundles were located on the periphery of the bone mass from squares ER1, FR1, GR1, HR1, GC, and HC. All contained both articulated and disarticulated bones, and all but one were composed of parts of several individuals, both adult and subadult. The exception was a bundle from GC that contained the relatively complete remains of an 18 or 19 year old female.

Possible cremations were represented by 416 fragments of burned human bone. Of 320 identifiable fragments, 82 were from crania, 5 from mandibles, 2 from the scapulae, 4 from vertebrae, and 227 from long bones. Only adult bone was recognized but the presence of subadults could not be ruled out. The occurrence of two charred adult right mandibular condyles suggests that at least two individuals were represented. As Table 7 shows, burned bones were found in 14 squares of Ossuary II, but were most frequent in EC and FC in the center of the pit. Within these squares, they were concentrated on top of the bone pile. None of the surrounding bones had been scorched, indicating that the burning had occurred elsewhere before the remains were brought to the pit for burial. The evidence of exposure to fire varied, some fragments being completely calcined, some bleached and others barely scorched. Van Vark's (1970) laboratory studies suggest the calcined (white) fragments had been fired at a temperature over 800° C (1472° F) and the others at lower temperatures.

TABLE 6.—*Frequencies of articulated adult bones in Ossuary II*

Articulated bones	*Number of occurrences*	*Minimum no. of individuals*
Bones of foot	46	23
Tibia–fibula	40	20
Thoracic vertebra	59 (238 vert.)	20
3–7 cervical vertebra	21 (62 vert.)	13
Skull-mandible	12	12
1–2 cervical vertebra	11	11
Lumbar vertebra	19 (5 vert.)	11
Occipital–1st cervical vertebra	9	9
Sacrum-lumbar vertebra	88	8
Radius-ulna	14	7
Tibia, fibula-bones of foot	12	6
Bones of hand	7	4
Sacrum-pelvis	3	3
Femur-innominate	2	1
Radius, ulna-bones of hand	2	1
Humerus-scapula	1	1
Humerus-radius, ulna	1	1
Femur-tibia, fibula	1	1
Femur-patella	1	1
Tibia, fibula-patella	1	1

TABLE 7.—*Spatial distribution of burned bone within Ossuary II*

Square	*Mandibular and cranial*		*Postcranial*		*Undetermined*		*Total*	
	No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
AL1	–	–	5	2	–	–	5	1
AC	–	–	–	–	–	–	–	–
AR1	–	–	–	–	–	–	–	–
BL1	–	–	1	1	–	–	1	–
BC	–	–	–	–	–	–	–	–
BR1	–	–	–	–	–	–	–	–
CL1	–	–	–	–	–	–	–	–
CC	–	–	–	–	–	–	–	–
CR1	–	–	4	1	–	–	4	1
DL1	–	–	2	1	19	20	21	5
DC	–	–	–	–	–	–	–	–
DR1	–	–	1	1	1	1	2	1
EL1	6	7	16	7	8	8	30	7
EC	3	3	37	16	15	16	55	13
ER1	–	–	3	1	–	–	3	1
FL1	–	–	1	1	–	–	1	–
FC	65	75	151	65	46	48	262	63
FR1	–	–	3	1	–	–	3	1
GL1	1	1	–	–	2	2	3	1
GC	8	9	3	1	3	3	14	3
GR1	4	5	6	2	2	2	12	3
HL1	–	–	–	–	–	–	–	–
HC	–	–	–	–	–	–	–	–
HR1	–	–	–	–	–	–	–	–
Total	87	100	233	100	96	100	416	100

One hundred and forty-one skulls of all ages were found more or less intact and numbered during the excavation of Ossuary II. Contrary to Ferguson's observations at Accokeek Creek, the skulls appeared to be neither segregated from the rest of the bone mass nor placed in any particular section of

TABLE 8.—*Frequencies of skull positions in Ossuary II*

	Left side	*Base*	*Face*	*Vertex*	*Right side*	*?*	*Total*
Number	38	36	12	26	21	8	141
Percent	27	26	8	18	15	6	100

? = Orientation uncertain due to excessive fragmentation of crania.

TABLE 9.—*Frequencies of face orientations in Ossuary II*

	N	*NW*	*W*	*SW*	*S*	*SE*	*E*	*NE*	*?*	*Face down*	*Total*
Number	22	20	18	10	24	10	20	8	7	2	141
Percent	16	14	13	7	17	7	14	6	5	1	100

?=Orientation uncertain due to excessive fragmentation of crania.

the pit. In addition nearly all skull orientations were represented (Tables 8, 9) with no particular position or direction predominating. The presence of numerous smaller adult and subadult bones inside many skulls suggests that the skulls may have been utilized as containers to transport bones from the primary deposit to the ossuary.

Total Number of Individuals

At least 131 individuals are represented in Ossuary I and 188 in Ossuary II. Since ossuaries are secondary deposits of largely disarticulated bones, these totals were obtained by carefully listing the frequencies of each type of bone from both ossuaries and then comparing the minimum numbers of individuals represented. All complete and fragmentary bones were examined to make this count as accurate as possible. From Ossuary II, the counts of proximal and distal ends of complete and fragmentary long limb bones were used to indicate the number of adult individuals represented (Table 10). The number and size of isolated shaft fragments were examined also, but only in the fibula did they affect the minimum number of individuals represented. Likewise in Ossuary I (Table 11) the minimum number of adult individuals represented was determined from counts of proximal and distal ends for all long bones except the fibula where 54 left and 53 right adult fibulae were represented by proximal and distal ends, whereas the shaft fragments indicated that at least 61 adult individuals were actually present.

TABLE 10.—*Counts of complete and fragmentary adult long limb bones from Ossuary II*

Bone	*Complete*		*Proximal*		*Distal*		*Minimum no. individuals represented*	
	L	*R*	*L*	*R*	*L*	*R*	*L*	*R*
Humerus	68	70	7	12	19	14	87	84
Radius	66	63	13	14	14	17	80	80
Ulna	64	62	24	24	13	15	88	86
Femur	78	73	4	10	3	8	82	83
Tibia	75	78	6	5	6	15	81	93
Fibula	44	48	13	14	30	33	74	81

OSSUARY I

At the time my analysis began, the skeletal material from Ossuary I already had been segregated into major bone groups. This preliminary sorting facilitated the collective examination that revealed the minimum number of adults (Table 11) and subadults (Table 12) represented by each kind of bone. In general, the "adult category" includes those individuals over 18 years at death, while those 18 and younger were classified as subadults. Since many of the smaller bones of the skeleton attain morphological maturity prior to 18 years, there may have been a tendency to include some smaller subadult bones in the adult category. However, this number is probably minimal since there were few indi-

TABLE 11.—*Number of individuals represented by each type of adult bone in Ossuary I* (numbers in parentheses indicate actual number of bones)

Bone	*Left*	*Right*
LONG BONES:		
Humerus	68	64
Radius	64	65
Ulna	65	60
Femur	66	68
Tibia	68	69
Fibula	54*	53*
IRREGULAR BONES:		
Clavicle	60	54
Scapula	64	57
Temporal	55	56
Maxilla	50	50
Mandible	62	63
Gladiolus	30	
Manubrium	29	
Innominate	62	61
Patella	51	54
VERTEBRAE:		
Cervical:		
1	46	
2	63	
3–7	51(255)	
Thoracic:		
1–9	50(446)	
10	28	
11	36	
12	37	
10–11	37	
10–11–12	32	
Lumbar	50(248)	
Sacrum	56	
HAND BONES:		
Carpals:		
Navicular	33	36
Lunate	29	26
Triquetral	25	17
Pisiform	10(19)	
Greater Multangular	22	25
Lesser Multangular	19	22
HAND BONES—Continued		
Carpals—Continued		
Capitate	34	33
Hamate	30	32
Metacarpals:		
1	48	39
2	51	51
3	50	57
4	34	43
5	53	44
Phalanges:		
Proximal 1–5	48(472)	
Middle	31(243)	
Distal 1–5	16(155)	
FOOT BONES:		
Tarsals:		
Calcaneus	60	60
Talus	61	58
Cuboid	57	54
Navicular	58	54
Cuneiforms:		
1	52	52
2	43	38
3	54	42
Metatarsals:		
1	50	53
2	52	54
3	49	47
4	55	47
5	62	57
Phalanges:		
Proximal:		
1	42(83)	
2–5	27(214)	
Middle	6(41)	
Distal:		
1	28(56)	
2–5	3(19)	

*Shaft fragments indicate at least 61 adults present.

TABLE 12.—*Number of individuals represented by each type of subadult bone in Ossuary I* (numbers in parentheses indicate actual number of bones)

Bone	Left	Right
Humerus	55	55
Radius	33	32
Ulna	51	45
Femur	51	58
Tibia	49	50
Fibula	17(68)	
Clavicle	38	26
Scapula	30	36
Temporal	62	61
Maxilla	33	37
Mandible	48	44
Ilium	47	48
Sternum	5(28)	
Ischium	32	39
Pubis	18	24
Patella	5(9)	
Calcaneus	17	16
Talus	8	10

viduals in either ossuary between ages 15 and 20 years. The adult right tibia (69) and the subadult left temporal (62) were most numerous and indicate at least 131 individuals were present in Ossuary I.

OSSUARY II

To compute bone totals for Ossuary II, the contents of each square were analyzed separately and then totaled. This approach was taken because (1) following excavation and processing, the bones of each square were cataloged and stored together, and (2) bone frequencies from each square were needed to study spatial distribution features within the ossuary. Totals from all squares in Ossuary II are presented in Table 13 (subadults) and Table 14 (adults). The minimum number of individuals in Ossuary II (188) was determined from the left subadult femora (89) and the right adult mandibles (99) which had the highest frequencies.

Variability in Bone Representation

This "bone-by-bone" inventory not only revealed the number of individuals in each ossuary, but also showed the great variability in numbers of the different bones. In Ossuary I, 69 adults were represented by tibiae, but only 3 by the second through fifth distal foot phalanges. Whereas 62 subadults were represented by temporals, only 5 were represented by patellae. In Ossuary II, 99 adults were represented by adult right mandibles, but only 9 by coccygeal vertebrae. Subadult variation ranged from 89 (left femora) to 1 (carpals). This variance in bone representation is clearly evident in Tables 15 (Ossuary I, adults), 16 (Ossuary I, subadults), 17 (Ossuary II, adults), and 18 (Ossuary II, subadults). These tables rank the bones in the order of the number of individuals they represent. Thus, according to Table 15, 69 adult individuals are represented in Ossuary I by tibiae, 68 by femora, 55 by fourth metatarsals, etc. These tables also show the percentages of represented and unrepresented individuals by each bone. According to Table 15, the patellae of 54 adults were recovered from Ossuary I (78 percent of the total number of all of the adults represented therein), and the patellae of 15 adults (22 percent) are missing.

The differential representation of bones in Ossuaries I and II could reflect such factors as (1) loss of bone prior to secondary burial, (2) intentional cultural selection at the time of ossuary deposit, (3) differential decomposition in the ground, (4) accidental loss during excavation, or (5) accidental loss after excavation. Decomposition in the ground may account for the loss of some of the smaller infant bones and adult phalanges, ribs, and occasionally vertebrae. During excavation of Ossuary II, several of the infant bones crumbled upon removal. Although an attempt

TABLE 13.—*Number of individuals represented by each type of subadult bone in Ossuary II* (numbers in parentheses indicate actual number of bones)

Bone	Left	Right
Humerus	71	68
Radius	47	45
Ulna	58	54
Femur	89	82
Tibia	67	75
Fibula	35	35
Clavicle	47	49
Scapula	59	52
Temporal	81	84
Maxilla	49	49
Mandible	52	49
Gladiolus	10	
Manubrium	13	
Ilium	71	58
Ischium	43	48
Pubis	41	22
Patella	0	1
Rib	19 (494)	
Vertebrae*	29 (775)	
Sacrum	10	
Coccyx	1 (4)	
Calcaneus	18	25
Talus	10 (20)	
Other Tarsals	3 (28)	
Carpals	1 (10)	
Metatarsals or Metacarpals	16 (295)	
Phalanges	6 (271)	

*Cervicals, thoracics, lumbars.

TABLE 14.—*Number of individuals represented by each type of adult bone in Ossuary II* (numbers in parentheses indicate actual number of bones)

Bone	Left	Right
LONG BONES		
Humerus	87	84
Radius	80	80
Ulna	88	86
Femur	82	85
Tibia	81	93
Fibula	74	81
Clavicle	70	72
Scapula	85	92
Temporal	92	91
Maxilla	86	81
IRREGULAR BONES		
Mandible	98	99
Gladiolus	56	
Manubrium	58	
Innominate	84	86
Patella	73	78
Rib	72(1727)	
VERTEBRAE		
Cervical:		
1	98	
2	97	
3–7	76(389)	
Thoracic:		
1–9	72(645)	
10	63	
11	80	
12	59	
10 or 11	37	
11 or 12	1	
10, 11 or 12	11	
Lumbar	77(385)	
Sacrum	84	
Coccyx	9(33)	
HAND BONES		
Carpals:		
Navicular	59	63
Lunate	54	46
Triquetral	41	24
Pisiform	18(35)	
Greater Multangular	45	55
Lesser Multangular	37	38
HAND BONES—Continued		
Carpals—Continued		
Capitate	69	58
Hamate	51	55
Metacarpals:		
1	66	68
2	74	65
3	74	77
4	56	54
5	69	74
Phalanges:		
Proximal:		
1	53(106)	
2–5	66(524)	
Middle	44(348)	
Distal:		
1	29(57)	
2–5	23(181)	
FOOT BONES		
Tarsals:		
Calcaneus	86	86
Talus	93	90
Cuboid	70	73
Navicular	69	80
Cuneiforms:		
1	78	73
2	73	68
3	73	75
Metatarsals:		
1	82	74
2	72	63
3	77	85
4	77	74
5	81	73
Phalanges:		
Proximal:		
1	60(125)	
2–5	46(385)	
Middle	19(118)	
Distal:		
1	45(89)	
2–5	9(55)	

was made to record bones lost in this manner, it is possible that a few decomposed bones were overlooked. Stewart's field notes and personal comments indicate that some small decomposed bones may have been lost from Ossuary I as well.

It is doubtful that any bones were lost by vandalism or by accident while excavation was in progress. Since both were located on private property within 30 meters (100 ft) of the Juhle residence, vandalism was discouraged, and probably would have been detected had it occurred. During the excavation of Ossuary II, all backdirt was sifted through a 5 mm (¼-in) screen that made the loss of even small infant bones unlikely. The material from Ossuary II was cleaned, restored, cataloged, and analyzed immediately after excavation, either by myself or by Smithsonian volunteers directly under my supervision. Similar efforts were made to safeguard the Ossuary I sample. During the 17 years between the excavation and analysis, the material had been isolated from the regularly studied collections and stored on the fourth rotunda floor of the Natural History Building of the Smithsonian Institution. Consequently there is little reason to believe that any of that material had been lost over the years.

It follows from the foregoing that most of the missing bones were lost prior to the time of ossuary burial. Apparently the Indians did not transfer all of the bones from the primary deposit to the ossuary. Instead, they selected those that best represented the individual. Thus, in Ossuary I (Table 15), the greatest number of adults is represented by long bones. This is surprising since one would expect the Indians to associate maxillae and mandibles more closely with the individuals known in life. Yet 9 percent of the mandibles and 28 percent of the maxillae are missing. Of course, it remains anyone's guess what happened to them, but it is unlikely that the skull and mandible were left lying around the scaffold or death house. More probably a few of the skulls and mandibles were taken elsewhere for memorial purposes. The rest of the adult bone frequencies presented in Table 15 generally reflect what one would expect, namely, the occurrence of larger and more conspicious bones in greater abundance. Twelve percent of fibulae are missing, reflecting to a large extent the tendency of the fibulae to break easily. Once broken, the fragments could have been misplaced. The adult second cervical vertebrae are surprisingly well represented, with only 9 percent missing. A high representation of second cervicals would be expected if many of them were still attached to the base of the skull when the bones were transferred. However, the fact that 19 percent of the skulls (temporals) and 33 percent of the first cervical vertebrae are missing seems to discourage that interpretation. Foot bones are better represented than hand bones. (62 individuals represented by fifth metatarsals, 57 by third metacarpals), probably reflecting the greater tendency of the ligaments of the foot to resist decomposition and allow the bones to remain articulated.

Bone representation of subadults in Ossuary I is shown in Table 16. In general, the inventory shows a high frequency of the larger bones and a poor representation of smaller bones, suggesting that the latter often may have been lost from the original scaffolds or dropped during the transfer to the ossuary. The subadults were represented most frequently by temporals, followed closely by long bones. Since the temporal is part of the skull and highly resistant to decomposition, it is not surprising that it occurs with such a high frequency.

Although adult representation in Ossuary II (Table 17) is similar to that in Ossuary I, there are some striking differences. In both ossuaries, more individuals are represented by larger, easily recognized bones than by the smaller, inconspicuous bones. However, the frequency of occurrence is different. In Ossuary I, the maximum counts come from the tibiae and femora, with 9 percent of the mandibles missing, whereas in Ossuary II the maximum counts come from the mandible, with 14 percent of the femora missing. Second and third in frequency in Ossuary II, are the first and second cervical vertebrae. There are more tali than ulnae and humerii, and more individuals represented by third metatarsals than by femora, fibulae, or radii. For some reasons, 6 percent of the tibiae, 11 percent of the ulnae, 12 percent of the humeri, 14 percent of the femora, 18 percent of the

TABLE 15.—*Order of representation of adults in Ossuary I as indicated by bone types*

Bone	*Represented*		*Absent*	
	No.	*%*	*No.*	*%*
Tibia	69	100	0	0
Femora	68	99	1	1
Humerus	68	99	1	1
Radius	65	94	4	6
Ulna	65	94	4	6
Scapula	64	93	5	7
Mandible	63	91	6	9
2nd cervical vertebrae	63	91	6	9
Fifth metatarsal	62	90	7	10
Innominate	62	90	7	10
Talus	61	88	8	12
Fibula	61	88	8	12
Clavicle	60	87	9	13
Calcaneus	60	87	9	13
Foot navicular	58	84	11	16
Third metacarpal	57	83	12	17
Cuboid	57	83	12	17
Temporal	56	81	13	19
Thoracic 10–12	56	81	13	19
Sacrum	56	81	13	19
Fourth metatarsal	55	80	14	20
Second metatarsal	54	78	15	22
Patella	54	78	15	22
Fifth metacarpal	53	77	16	23
First metacarpal	53	77	16	23
First cuneiform	52	75	17	25
Second metacarpal	51	74	18	26
3–7 cervical vertebrae	51	74	18	26
Maxilla	50	72	19	28
1–9 thoracic vertebrae	50	72	19	28
Lumbar vertebrae	50	72	19	28
Third metatarsal	49	71	20	29
First metacarpal	48	70	21	30
1–5 prox. hand phalanges	48	70	21	30
First cervical vertebrae	46	67	23	33
Fourth metacarpal	43	62	26	38
Second cuneiform	43	62	26	38
First prox. foot phalange	42	61	27	39
Hand navicular	36	52	33	48
Capitate	34	49	35	51
1–4 middle hand phalanges	31	45	38	55
Hamate	30	43	39	57
Gladiolus (sternum)	30	43	39	57
Manubrium (sternum)	29	42	40	58
Lunate	29	42	40	58
First dist. foot phalange	28	41	41	59
2–5 prox. foot phalanges	27	39	42	61
Greater multangular	25	36	44	64
Triquetral	25	36	44	64
Lesser multangular	22	32	47	68
1–5 distal hand phalanges	16	23	53	77
Pisiform	10	14	59	86
Middle foot phalange	6	9	63	91
2-5 distal foot phalanges	3	4	66	96

TABLE 16.—*Order of representation of subadults in Ossuary I as indicated by bone types*

Bone	Represented		Absent	
	No.	*%*	*No.*	*%*
Temporal	62	100	0	0
Femur	58	94	4	6
Humerus	55	89	7	11
Ulna	51	83	11	17
Illium	48	77	14	23
Tibia	50	80	12	20
Mandible	48	77	14	23
Ischium	39	63	23	37
Maxilla	37	60	25	40
Radius	33	53	29	47
Clavicle	28	45	34	55
Pubis	24	39	38	61
Fibula	17	27	45	73
Calcaneus	17	27	45	73
Talus	10	16	52	84
Patella	5	8	57	92
Sternum	5	8	57	92

fibulae, and 19 percent of the radii were lost prior to ossuary burial. It is doubtful that such large bones could have been accidentally lost or left in the scaffolds. More probably, those bones were selected for disposal elsewhere. Once again, the predominance of foot bones (93 individuals represented by the talus) over hand bones (74 individuals represented by 5th metacarpals) probably reflects the tendency for the former to remain articulated (see Table 6). The high frequency of first and second cervical vertebrae is again difficult to explain. One would expect that some of these vertebrae might still have been attached to the skull at the time of ossuary burial. This would explain why more individuals are represented by the first and second cervicals than by the rest of the cervical vertebrae (76 percent), but not why there are more first and second vertebrae than bones of the skull (temporals 93 percent, maxillae 87 percent).

The representation of subadults in Ossuary II (Table 18) is very similar to that in Ossuary I (Table 16). Here too, the long bones, temporals, and other larger bones occur most frequently. In Ossuary I, however, the most subadults are represented by temporals and 6 percent of the femora are missing, whereas in Ossuary II the maximum count comes from the femora with 6 percent of the temporals missing.

These differences in the skeletal inventories from the two ossuaries not only reveal the type of skeletal material selected for ossuary burial, but also demonstrate the fallacy of relying upon counts of a single skeletal part for reconstruction of the number of individuals in an ossuary burial. An adult count based on femora would be 99 percent correct in Ossuary I, but would underestimate the total in Ossuary II by 14 percent. Estimates based solely on the number of skulls are

TABLE 17.—*Order of representation of adults in Ossuary II as indicated by bone types*

Bone	Represented		Absent	
	No.	*%*	*No.*	*%*
Mandible	99	100	0	0
1st cervical vertebrae	98	99	1	1
2nd cervical vertebrae	97	98	2	2
Tibia	93	94	6	6
Talus	93	94	6	6
Scapula	92	93	7	7
Temporal	92	93	7	7
Ulna	88	89	11	11
Humerus	87	88	12	12
Innominate	86	87	13	13
Maxilla	86	87	13	13
Calcaneus	86	87	13	13
3rd metatarsal	85	86	14	14
Femur	85	86	14	14
10–11–12 thoracic vertebra	84	85	15	15
Sacrum	84	85	15	15
1st metatarsal	82	83	17	17
5th metatarsal	81	82	18	18
Fibula	81	82	18	18
Radius	80	81	19	19
Foot navicular	80	81	19	19
Patella	78	79	21	21
1st cuneiform	78	79	21	21
4th metatarsal	77	78	22	22
3rd metatarsal	77	78	22	22
Lumbar vertebrae	77	78	22	22
3–7 cervical vertebrae	76	77	23	23
3rd cuneiform	75	76	24	24
5th metacarpal	74	75	25	25
2nd metacarpal	74	75	25	25
Cuboid	73	74	26	26
2nd cuneiform	73	74	26	26
2nd metatarsal	72	73	27	27
1–9 thoracic vertebrae	72	73	27	27
Clavicle	72	73	27	27
Rib	72	73	27	27
Capitate	69	70	30	30
1st metacarpal	68	69	31	31
Prox. 2–5 hand phalanges	66	67	35	33
Hand navicular	63	64	36	36
1st prox. foot phalange	60	61	39	39
Manubrium	58	59	41	41
Gladiolus	56	57	43	43
4th metacarpal	56	57	43	43
Greater multangular	55	56	44	44
Hamate	55	56	44	44
Lunate	54	55	45	45
1st prox. hand phalange	53	54	46	46
2–5 distal foot phalanges	46	46	53	54
1st distal foot phalange	45	45	54	55
Middle hand phalanges	44	44	55	56
Triquetral	41	41	58	59
Lesser multangular	38	38	61	62
1st distal hand phalange	29	29	70	71
2–5 distal hand phalanges	23	23	76	77
Middle foot phalanges	19	19	80	81
Pisiform	18	18	81	82
Coccygeal vertebrae	9	9	90	91
2–5 distal foot phalanges	9	9	90	91

TABLE 18.—*Order of representation of subadults in Ossuary II as indicated by bone types*

Bone	Represented		Absent	
	No.	*%*	*No.*	*%*
Femur	89	100	0	0
Temporal	84	94	5	6
Tibia	75	84	14	16
Ilium	72	81	17	19
Humerus	71	80	18	20
Scapula	60	67	29	33
Ulna	58	65	31	35
Mandible	52	58	37	42
Maxilla	49	55	40	45
Ischium	49	55	40	45
Clavicle	49	55	40	45
Radius	47	53	42	48
Pubis	41	46	48	54
Fibula	35	39	54	61
Vertebrae	29	33	60	67
Calcaneus	25	28	65	72
Ribs	24	27	66	73
Metatarsals-carpals	16	18	73	82
Manubrium	13	15	76	85
Gladiolus	10	11	79	89
Talus	10	11	79	89
Phalanges	6	7	83	93
Other tarsals	3	3	86	97
Sacrum	3	3	86	97
Carpals	1	1	88	99
Patella	1	1	88	99

also misleading. Although 94 skulls were recorded during the excavation of Ossuary I and 141 during the excavation of Ossuary II, the actual number of individuals in the pits are 131 and 188, respectively.

The differential representation of bones in ossuary deposits has been discussed by others. Anderson (1964) noted in his study of an Iroquois ossuary that a wide range existed in the minimum number of individuals represented by each bone (Table 19). His largest adult count came from the talus, followed by the temporal, ulna, and humerus, while his largest subadult count came from the humerus, followed by the femur, pelvis, ulna, and radius. No data were given on the frequencies of mandibles and maxillae.

Churcher and Kenyon (1960:256) relied solely upon long-bone counts for their reconstruction of the number of individuals in two Iroquoian ossuaries from Toronto, since long bones were well preserved and could easily be identified as left or right. Although their analysis would be more meaningful if their bone inventory was complete, they do show that long bone frequencies varied from 213 individuals represented by femora to only 64 represented by radii.

Unfortunately, complete skeletal samples were not saved from ossuary excavations in the mid-Atlantic region prior to 1950. Stewart encouraged Ferguson, Graham, and others to

TABLE 19.—*Partial inventory of bones from Fairty Ossuary, Ontario, Canada* (after Anderson, 1964:28)

Bone	*Number of items cataloged*	*Minimum number of individuals*		
		Mature	*Immature*	*Total*
Temporal	931	346	144	490
Atlas	507	274	47	321
Axis	747	287	93	380
Other cervical	1,541	258	49	307
Thoracic	3,238	221	49	270
Lumbar	1,460	218	75	293
Sacral	182	182	?	182+
Sternum	404	122	46	168
Clavicle	908	214	129	343
Scapula	907	232	135	367
Humerus	1,591	295	217	512
Radius	951	196	151	347
Ulna	1,169	307	152	459
Pelvis	1,753	198	156	354
Femur	1,176	223	172	395
Patella	484	250	?	250+
Tibia	981	207	147	354
Fibula	850	177	83	260
Talus	769	354	40	394
Calcaneus	675	281	69	350

save certain bones for his analysis, but he had no assurance that the samples were complete. Still, he determined that more individuals were represented by the skull and mandible than by long bones and judged that of all individual bones, the temporal would "furnish the best check on the number of individuals" (Stewart, 1940c:15).

Spatial Distribution Features within Ossuary II

Past students of mid-Atlantic ossuary burial practices generally have suggested that skeletal material is randomly scattered within ossuaries with no evidence for order or structure. Referring to her excavation at Accokeek Creek, Ferguson (in Stephenson and Ferguson, 1963:68) stated that "the ossuaries were very similar. Most of the bones were flung into the pit with no regard for order or sequence." In his discussion of the Port Tobacco ossuaries, Graham (1935:17) similarly reported that "there was apparently no particular order used in placing the bodies, or skeletons in the pit." Other discussion by Ferguson and Graham suggests that, except for the presence of bundles, articulated individuals, and small pockets of cremated bone, no order exists within ossuary burials.

The use of the arbitrary system of 0.6-meter (2 ft) squares in the excavation of Ossuary II allowed the "random-scattered" pattern to be examined objectively. The contents of each square were analyzed independently. The total number of each type of adult and subadult bone, and the sex and age of adults as estimated from the skull and pubis were listed for each square. Adult age was divided into two general categories: those over 30 years and those between 18 and 30 years. Variables such as age, sex, and variety of bone in each square could then be tested against each other to determine if the spatial distribution within Ossuary II was truly random. A multivariate canonical analysis was used to examine a number of the variables simultaneously and the univariate chi square statistic was applied to test individual variables against each other. A combination of these two approaches revealed which variables were probably randomly distributed and which demonstrated spatial differences of possible cultural significance.

According to the multivariate canonical analysis, there were no significant distributional differences among adults in age (under 30 years vs. over 30 years), sex (male vs. female), or type of bone (skull vs. pubis). All distribution variance among these variables can be accounted for by chance alone as Ferguson and Graham had concluded. Significant differences were discovered, however, when the distribution of adult bones was compared to that of subadult bones. These differences are perhaps best expressed by the individual chi square values.

Chi square values were calculated for each pair of variables tested according to the formula $X^2=\frac{\Sigma(0-E)^2}{E}$, where 0 equals the observed frequency and E equals the expected frequency. Table 20 presents chi square values for differences between the distribution of young and old adults. Chi square values of 2.28 for the pubis and 2.48 for the skull support the results of the multivariate analysis indicating that the differences are probably due to chance. Table 21 presents the data on distributional differences between adult males and females. Again, chi square values suggest that the differences are probably due to chance alone and agree with the results obtained through the multivariate analysis.

Table 22 presents chi square values for subadults vs. adult distributional differences in 13 different bones. The temporals, clavicles, radii, femora, and scapulae show no significant differences between subadults and adults. Significant differences, however, were recorded from the tibiae, humeri, pubes, ribs, tarsals, carpals, and vertebrae. Values for the vertebrae, and tarsals and carpals (168 and 68) indicate the odds are less than one in 1000 that the distributional differences could have resulted from chance alone. These data suggest that the major bones of adults and subadults were placed in the pit in the same manner, perhaps at the same time. Miscellaneous bones, however, such as ribs, carpals, and tarsals appear to have been handled differently, suggesting that they may have been segregated originally.

More insight into the specifics of the bone groupings may be gained by examining associations within the adult and subadult groups. In Table 23, chi square values are presented for distributional differences between the adult femora and all other adult bones. The femur was chosen as a standard since it appeared to be the most overall randomly distributed bone, based on the distribution of weight in each unit. As the table indicates, most of the major bones of the skeleton have distributions highly correlated with that of the femora; only the phalanges and carpals have significantly different distributions at the .05 level of significance. Perhaps the most revealing aspect of the table is the order of the bone associations. The skull, mandibles, and first cervical vertebrae demonstrate the highest correlation with the randomly scattered femora, followed closely by other major long bones, innominates, scapulae, tali, etc. The bones showing the most disparate distributional patterns are small bones such as the carpals, phalanges, patellae, etc. The order of bone distributional associations closely approximates the order of total bone representation in the ossuary as a whole (Table 17). Since the chi square statistic operates independently of

TABLE 20.—*Chi square values for distributional associations between young and old adults within Ossuary II*

Variables tested	*Chi square value*	*Degrees of freedom*	*Probability*
Pubis age 18–29 vs. pubis age 30 plus	2.28	1	.·10–.20
Skull age 18–29 vs. skull age 30 plus	2.48	1	.10–.20

TABLE 21.—*Chi square values for distributional associations between adult males and females within Ossuary II*

Variables tested	*Chi square value*	*Degrees of freedom*	*Probability*
Male pubis vs. female pubis	3.80	1	.05–.10
Male skull vs. female skull	1.31	1	.20–.30
Adult skull vs. adult pubis	2.28	1	.10–.20

TABLE 22.—*Chi square values for distributional associations between adult and subadult bones within Ossuary II*

Bones	*Chi square value*	*Degrees of freedom*	*Probability*
Vertebrae	167.63	1	0.00 –0.001
Tarsals and carpals	68.02	1	.00 – .001
Ribs	12.07	1	.00 – .001
Pubis	6.79	1	.001– .01
Humerus	6.76	1	.001– .01
Tibia	6.28	1	.01 – .02
Ulna	4.93	1	.02 – .05
Scapula	3.95	1	.02 – .05
Fibula	1.62	1	.20 – .30
Femur	1.53	1	.20 – .30
Radius	0.75	1	.30 – .50
Clavicle	0.50	1	.30 – .50
Temporal	0.13	1	.70 – .80

TABLE 23.—*Chi square values for distributional associations between the adult femora and other adult bones within Ossuary II*

Femora vs.—	*Chi square value*	*Degrees of freedom*	*Probability*
Carpals	7. 84	1	0. 001–0. 01
Foot phalanges	7. 75	1	. 001– . 01
Patellae	3. 31	1	. 05 – . 10
Cervicals	3. 14	1	. 05 – . 10
Tarsals	3. 09	1	. 05 – . 10
Hand phalanges	2. 81	1	. 05 – . 10
Metacarpals	2. 75	1	. 05 – . 10
Thoracics	2. 52	1	. 10 – . 20
Metatarsals	2. 43	1	. 10 – . 20
Radius	2. 05	1	. 10 – . 20
Lumbars	1. 85	1	. 10 – . 20
Coccyx	1. 74	1	. 10 – . 20
Sternum	1. 74	1	. 10 – . 20
Ribs	1. 51	1	. 20 – . 30
Clavicle	1. 44	1	. 20 – . 30
Calcaneus	. 89	1	. 30 – . 50
Fibula	. 89	1	. 30 – . 50
Pubis	. 77	1	. 30 – . 50
Sacrum	. 73	1	. 30 – . 50
Humerus	. 73	1	. 30 – . 50
Talus	. 57	1	. 30 – . 50
Scapula	49	1	. 30 – . 50
Ulna	. 49	1	. 30 – . 50
Tibia	. 40	1	. 50 – . 70
Ilium	. 39	1	. 50 – . 70
First cervical	. 33	1	. 50 – 70
Mandible	. 29	1	. 50 – 70
Whole skull	. 26	1	. 50 – 70

sample size, the data suggest a general correlation of bone representation with bone distribution that has to be explained culturally.

Similar bone distribution correlations exist within the subadult group. Table 24 gives the ranking of chi square values for distributional associations between the subadult clavicles and other subadult bones. The subadult clavicles were chosen for comparison since they demonstrated a close distributional correlation with the adult clavicles. Like the adult data, the subadult data indicate a strong distributional association among the major bones of the skeleton and a poor association between the clavicles and such miscellaneous bones as tarsals, carpals, metatarsals, metacarpals, vertebrae, and phalanges. Once again, the order of the distributional correlation generally approximates the relative frequency of representation in the ossuary.

The data presented above indicate that three spatially distinct, generalized groups can be recognized within the bone concentration in Ossuary II: (1) major bones of both subadults and adults; (2) miscellaneous smaller bones of subadults, and (3) miscellaneous smaller bones of adults. Although these groups are neither spatially isolated nor mutually exclusive, they do present distinct distribution patterns that appear to have cultural significance.

TABLE 24.—*Chi square values for distributional associations between the subadult clavicles and other subadult bones within Ossuary II*

Clavicles vs.—	*Chi square value*	*Degrees of freedom*	*Probability*
Tarsals and carpals	31. 30	1	0. 000–. 001
Metatarsals and metacarpals	25. 43	1	. 000–. 001
Vertebrae	22. 71	1	. 000–. 001
Phalanges (hand and foot)	6. 52	1	. 01 – . 02
Pubis	5. 70	1	. 01 – . 02
Ulna	5. 26	1	. 02 – . 05
Fibula	4. 69	1	. 02 – . 05
Humerus	3. 92	1	. 02 – . 05
Tibia	2. 99	1	. 05 – . 10
Ribs	2. 60	1	. 10 – . 20
Maxilla	2. 43	1	. 10 – . 20
Femur	2. 18	1	. 10 – . 20
Ischium	2. 10	1	. 10 – . 20
Ilium	2. 04	1	10 – . 20
Scapula	1. 35	1	. 20 – . 30
Sternum	. 54	1	. 30 – . 50
Temporal	. 25	1	. 50 – . 70
Radius	. 12	1	. 70 – . 80
Mandible	. 12	1	. 70 – . 80

These patterns could have been produced by the following procedure. The major bones of adults and subadults may have been mixed together at the time of ossuary burial. Since the miscellaneous, smaller bones of both adults and subadults display distribution patterns different from both the major bones and from each other, they must have been segregated prior to ossuary burial. Perhaps the villagers traveled to the place of primary burial (scaffolds or death houses) and gathered together the bones of their dead for reburial. At this time, they may have grouped together the major bones of adults and subadults and transferred them to the ossuary. Then, they may have cleaned out the scaffolds to prepare them for future use and during this process gathered much of the skeletal material originally missed. These bones may then have been added to the ossuary, giving them a different distribution within the pit from the bones already there. If placement on the scaffolds was originally segregated by age, then these collections of miscellaneous bones might retain that segregation in the ossuary. Bodies placed in the scaffold areas may have been segregated according to whether they had gone through "huskanaw." According to Beverley (1705, ch. 6:41) males in the Virginia area went through this rite of passage from boyhood to adulthood at about age 15. Since this pre- and post-huskanaw dichotomy was maintained in many cultural institutions during life there is no reason to believe that it could not have been maintained after death as well.

Summary

In summary, the ossuaries from 14CH89 appear to represent the relatively complete remains of nearly all the individuals who died in the population contributing to the ossuaries during two culturally prescribed periods of time during the Late Woodland. Associated cultural remains indicate that the two ossuaries were nearly contiguous in time and probably date from the 16th century A.D., just before European contact in the area. The ossuaries are very similar to those described for the Huron, the only major differences being the absence of large numbers of mortuary offerings and of a platform. Distributional features of skeletal material within Ossuary II suggest some segregation of bones prior to ossuary deposit, perhaps reflecting either the differential selection of bones for ossuary burial or an initial segregation in the scaffold area or death houses, or both. Although not all bones were equally represented in the ossuaries, the presence of burned bones and partially articulated skeletons suggests an attempt was made to include remains of all individuals who had died since the last burial ceremony, regardless of the manner of initial mortuary treatment or the stage of preservation and decomposition of the body. The ossuaries from 14CH89 represent nearly complete cross-sectional skeletal samples and offer a unique opportunity to examine population profiles for the populations represented.

Determination of Sex and Age at Death

Demographic reconstruction from skeletal populations demands an accurate assessment of sex and age at death. Because the reliability of interferences about longevity and life expectancy is directly related to the accuracy of age assessments, it is vital to select those criteria that produce the most accurate estimates under the circumstances. Several methods are here employed to generate the basic information needed for demographic reconstrutcion. The results of each method are then evaluated to identify the most accurate age and sex estimates for the overall populations.

DETERMINATION OF SEX

Estimation of sex is not attempted for subadults in the ossuary remains because none of the previous studies (e.g., E. L. Reynolds, 1945, 1947; A. Thompson, 1899; Boucher, 1955, 1957) provides sufficiently accurate methods for estimating subadult sex from fragmentary skeletal material. One of the most encouraging efforts is that of Hunt and Gleiser (1955), who based their sex criterion on the assumption that sexual dimorphism is more clearly marked in skeletal maturation than in dental eruption. By comparing the degree of skeletal maturation with the stage of dental eruption, they were able to identify sex with an accuracy of 73 percent at 2 years, 76 percent at five years, and 81 percent at eight years. Bailit and Hunt (1964) estimated subadult sex by observing the stage of canine eruption relative to premolar eruption. Their predictions were only 58 percent accurate and they concluded that sexual dimorphism in eruption sequence is not sufficiently marked to allow accurate sex estimates to be made. Garn, Lewis, and Kerewsky (1964) reached the same conclusion about tooth size. Of all methods of determining subadult sex, only that of Hunt and Gleiser (1955) for older children approaches the accuracy necessary for meaningful demographic analysis. Unfortunately this method has little application in an ossuary situation, where subadults are represented by isolated bone fragments and both skeletal and dental information are not available for the same individual.

Sex determination of adult skeletal material is of course much more reliable, with the pelvis providing the best data. Sex differences in the pelvis have been studied by many investigators and their conclusions are available in several good summary articles (Krogman, 1962; Stewart, 1968). In general, female pelves are distinguished by the occurrence of a quadrangular-shaped pubis body, broader subpubic arch, markedly everted ischio-pubic ramus, low symphysis, small obturator foramen, small acetabulum, wide and shallow sciatic notch, lower and more flaring ilium, smaller sacro-iliac articulation, high frequency of a deep pre-auricular sulcus, and general gracility. In addition, Phenice (1969) has developed a method that utilizes three areas of the pubis: the ventral arc, subpubic concavity, and medial aspect of the ischio-pubic ramus, to estimate sex with 96 percent accuracy. Although metric methods are available for the pelvis (Washburn's 1948 ischium-pubic index for example), none is more accurate than the Phenice nonmetric method.

General sex differences in the skull also are well defined and have been summarized by a number of authors (Krogman, 1962; Stewart, 1968). Utilizing a subjective assessment of cranial morphology alone, however, an experienced investigator can determine sex correctly in only 80–90 percent of the cases (Krogman, 1962; Stewart, 1968). Slightly better accuracy has been reported for more objective methods using discriminant functions (Giles and Elliot, 1963; Giles, 1964, 1970a,b).

So far as other bones are concerned, sexual differences are well documented but not as helpful as the foregoing. In particular, femoral head diameter is regarded as a fair sex indicator (Dwight, 1904; Maltby, 1917–1918; Parsons, 1913–1914, 1914–1915). Femoral head diameters of 43 mm or smaller are usually female and those 46 mm or larger are male. The overlap, however, between male and female diameter-ranges and their variation among different populations reduce the accuracy of identifications.

The application of the above criteria to the skeletal remains from the Juhle ossuaries generally shows that males and females are about equally represented in Ossuary I, but females probably outnumber males in Ossuary II. Table 25 summarizes the sex distribution in Ossuary I as determined from the skull, pubis, ischium, and ilium. Each bone shows approximately an equal representation of males and females.

TABLE 25.—*Sex representation of adults in Ossuary I*

Bone	Male No.	Male %	Female No.	Female %	Total	Percent of total adults
Skull	31	55	25	45	56	81
Pubis	23	51	22	49	45	65
Ischium	30	54	26	46	56	81
Ilium	32	52	29	48	61	88

Although slightly more males than females appear to be represented, the fact that between 12 to 35 percent of the total adult sample are missing from each bone category suggests that the slight differences have little meaning. The figures serve mainly to document that both sexes occur in approximately equal numbers.

In contrast, skeletal evidence from Ossuary II suggests that more females may be present than males. Table 26 summarizes the sex representation in Ossuary II as deduced from the skull, pubis, and ilium. All three criteria suggest more females are present than males; however, only 61 and 82 percent of the total adult ossuary population are represented by pubes and ilia, respectively. If the missing 39 and 18 percent are predominantly males, then the representation of males and females would be approximately equal. Only 10 percent of the crania are missing; however, if as many as 20 percent of the crania present have been incorrectly estimated to be females, then again equal sex representation would be indicated.

More insight into male-female representation in the two ossuaries may be gained by examining femoral head diameters. Figure 17 shows the frequency distribution of head diameters of left femora from Ossuary I, and right femora from Ossuary II, after the raw data have been grouped into 2-mm units and converted to percentages of the total. The distribution of head diameters for Ossuary I closely fits the model of equal male-female representation indicated by other criteria. An equal representation would suggest those femoral heads 43 mm and smaller are predominantly female,

TABLE 26.—*Sex representation of adults in Ossuary II*

Bone	Male No.	Male %	Female No.	Female %	Total	Percent of total adults
Skull	36	40	53	60	89	90
Pubis	24	40	36	60	60	61
Ilium	29	36	52	64	81	82

those 46 mm and larger are predominantly male, with the two ranges strongly overlapping between 44 mm and 45 mm. This distribution generally agrees with the variation documented for other populations (Krogman, 1962).

The distribution of femoral head diameters from Ossuary II is somewhat different from that of Ossuary I. The shape of the frequency polygon in Figure 17 suggests a higher percentage of smaller head diameters in Ossuary II than in Ossuary I. Of course, whereas only 2 percent of the adult femora are missing in Ossuary I, 18 percent are absent from Ossuary II. However, even if most of the missing femora are males, not all of the difference exhibited in Figure 17 can be accounted for. The evidence suggests either that males of Ossuary II had generally smaller femoral head diameters than males of Ossuary I, or that more females than males are represented in Ossuary II. The latter explanation is much more probable, since a higher frequency of females is suggested independently by data from the crania, ilia, and pubes. A higher frequency of females in Ossuary II would indicate either a higher female death rate or that some of the deceased males were not included in the ossuary. The missing males could have been leaders that were deposited permanently in death houses or, more probably, males that either died away from their village, or for some reason were treated differently after death. Only the greater frequencies of female-appearing skulls, pubes, ilia, and femoral heads can be positively documented. Explanations of these frequencies must remain speculations until further evidence can be obtained. Whatever the explanation it is doubtful that the possible slight shortage of males in Ossuary II significantly affects the demographic calculations.

DETERMINATION OF AGE OF SUBADULTS

Subadult age at death may be determined from any one or a combination of the following criteria: long-bone size, epiphyseal union or nonunion, dental calcification, or dental eruption. When possible, it is best to examine all of them. Since complete skeletons usually cannot be assembled from ossuaries, however, techniques for aging must be employed independently. The present analysis estimates subadult age by using three criteria: long-bone growth and maturation, dental eruption, and dental calcification. The resulting distributions of ages at death are then compared and evaluated.

Length of Long Bones

Few good standards exist for estimating age from individual bone length. Stewart (1968) published data on the size of Eskimo femora from birth to 18 years, developing regression lines to express the correlation between femoral length and chronological age estimated from tooth eruption. His analysis is confined to a small sample of femora, but represents the only cross-sectional growth study of aboriginal American skeletal populations that records growth from birth to 18

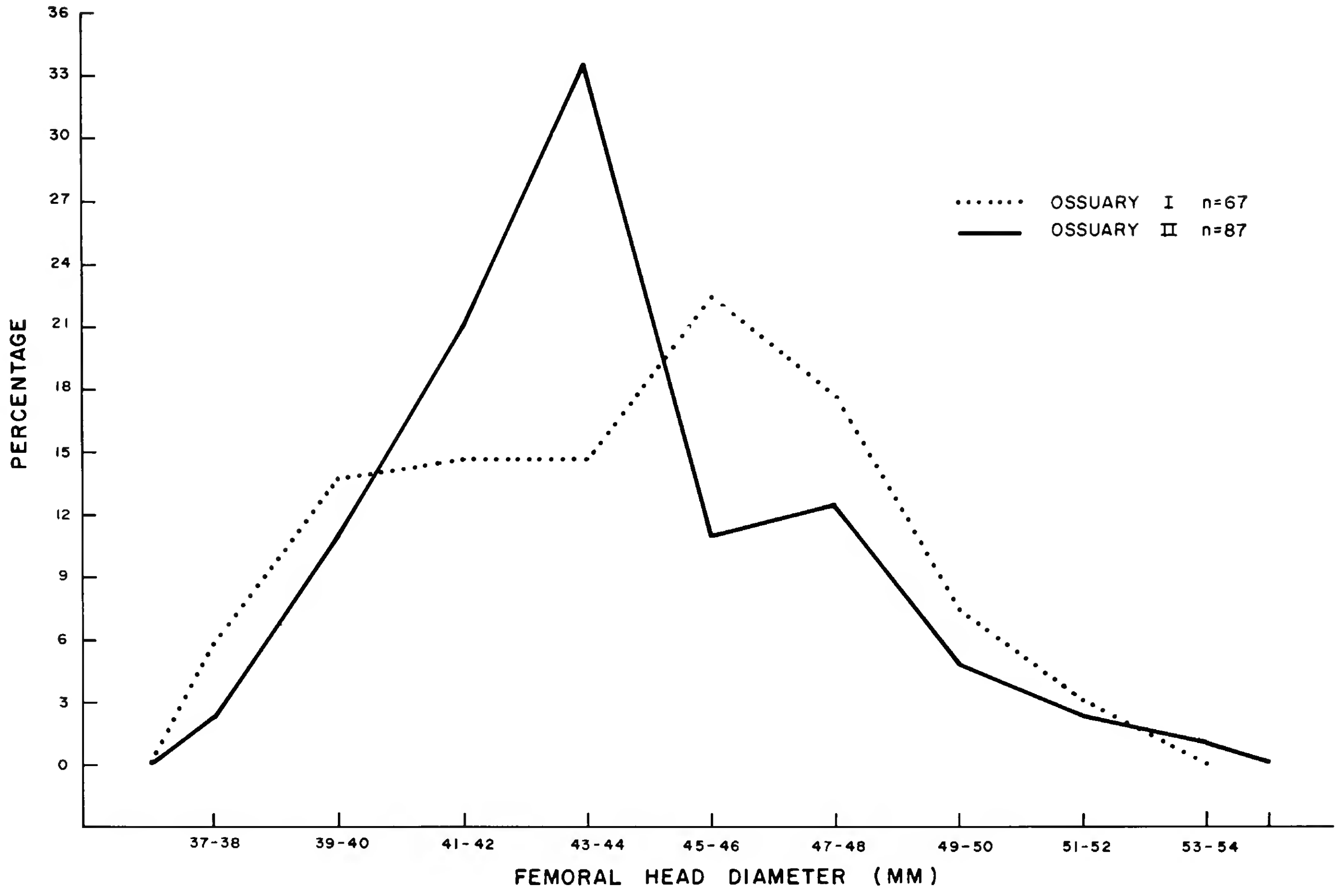


FIGURE 17.—Comparison of femoral head diameters from Ossuary I with those from Ossuary II.

years. Johnston (1962) published data on the growth of long bones in archaic skeletal populations from Indian Knoll, Kentucky, but his study only extends from birth to 5.5 years.

Numerous cross-sectional growth studies have been made on the living (Anderson and Green, 1948; Maresh, 1955). They are of limited value for skeletal analyses of archeological populations for two reasons: (1) they are based on living populations which may have different growth patterns from those of earlier populations, and (2) they utilize radiographic measurements instead of measurements of dry bone. Consequently, Stewart's (1968) Eskimo data would appear to be the most appropriate for estimating subadult age from isolated femora.

Epiphyseal Union

For later subadult years (after about 17 years), standards are available for estimating age from epiphyseal union. Through their study of 417 Korean War dead, McKern and Stewart (1957) documented age of epiphyseal union for young American males. Their study presents excellent data on the variability of epiphyseal closure, but lacks information about the early ages of closure since the Army sample did not extend below the age of 17.

Stevenson (1924) and Krogman (1939, 1955) have published data on the age of epiphyseal union in both sexes. Both investigators examined dissecting-room skeletal samples which were weighted toward older individuals and represented predominantly the lower economic class from regional areas. Krogman (1939) presented ranges or "central tendencies" for the postnatal union of ossification centers. However, Stewart (1934) and McKern and Stewart (1957) emphasize that more variability occurs than Krogman and Stevenson indicated.

Tables 27 and 28 present the total maximum lengths of the subadult femora recovered from Ossuaries I and II. The "bone numbers" of Ossuary I are field numbers recorded on individual bones and refer to their locations relative to nearby skulls. All measurements were taken on bones that lack proximal and distal epiphyses, using a sliding caliper or osteometric board (depending on the size of the bone) and were recorded to the closest millimeter. Total length was estimated for fragmentary femora by comparing them to unbroken bones of about the same size. In addition to those femora listed from Ossuary II, 9 left and 6 right occurred that displayed epiphyseal fusion at the greater and lesser trochanters and femoral heads, but nonunion of the distal

TABLE 27.—*Maximum diaphyseal length (in mm) of subadult femora from Ossuary I, arranged in increasing order of length*

Bone no.	*Length*	*Bone no.*	*Length*	*Bone no.*	*Length*
		RIGHT FEMORA			
51	67	126–112	106	42	193
37	67	15	108	43	193
103A	68	39	117	9–10	209
102–125	70	NR128	118	37	209
W-117-119	71	42	119	119	225
9–10	72	26	120	41	252
W-117-119	72	52–54	122	52	258
115	74	54	125	42	270
9–10	75	42	130	1	275
W-117-119	75	101–120	130	3	277
?	75	N189	140	NE126	280
102-125	77	39	140	118	280
W-117-119	79	5	145	44	310
4–6	80	54	148	19	315
122–124	83	42	150	4–6	323
103	84	26	161	23	330
19	95	4–6	175	B+112–113	331
41	100	104	182	14	333
30	101	46+	187	W102	378
				39	380
		LEFT FEMORA			
NE126	46	26	97	126–112	200
?	50	19	98	4–6	200
?	62	9–15	106	9–10	211
102–125	68	101–120	113	49	235
102–125	68	52–54	114	41	256
9–10	73	42	115	52	261
W-117-119	75	42	119	2–17	275
9–10	75	26	120	118	278
NE126	75	3, 100	143	NE126	281
26	76	42	144	2–17	310
W-117-119	77	117-8-9	146	44	313
118–119	81	54	147	B+112–113	320
NE126	81	5	152	4–6	324
42	86	126–112	180	23	330
9–10	92	46+	181	+5, 14	345
9–15	92	104	183	39	380
126–112	95	1	185	W-102	385

epiphyses. Krogman (1962) suggests that the femoral distal epiphysis fuses to the diaphysis at about 15 to 17 years in females and 16 to 18 years in males, although McKern and Stewart (1957) indicate the male range extends up to 20 years.

Table 29 compares femora from Ossuary I with those of Ossuary II after they have been grouped into 5-year age categories based on maximum femoral length and the stages of epiphyseal union. Age categories for femoral lengths are based on Stewart's (1968) Eskimo data, and the ages of epiphyseal union on data presented by Krogman (1962) and McKern and Stewart (1957). Actually all ages are derived from maximum lengths except the nine left and six right femora from Ossuary II already mentioned. All of these were aged between 15.0–19.9 years. As Table 28 reveals, the right femora from Ossuary I and the left femora from Ossuary II produced the maximum femoral counts, and consequently provide the most reliable indicators of subadult age. Most of the age differences between left and right femora occur in the 0 to 4.9 year category, probably since smaller bones of that category could easily be lost prior to ossuary burial.

TABLE 28.—*Maximum diaphyseal length (in mm) of subadult femora from Ossuary II, arranged in increasing order of length*

Square	*Length*	*Square*	*Length*	*Square*	*Length*	*Square*	*Length*
			RIGHT FEMORA				
DC	53	GC	16	FL1	131	BR1	241
DR1	60	FL1	78	EC	135	DR1	248
CR1	63	CR1	78	AL1–BL1	135	BL1–CL1	276
DR1	64	CR1	79	FR1	150	FC	287
DL1	65	EC	80	GL1	165	DR1	287
DR1	65	FL1	80	CL1	175	BR1–CR1	300
GL1	67	ER	82	FL1	175	AR1	313
D 1	68	AL1	85	FL1	175	BR1	320
FC	68	AL1–BL1	86	BR1	178	EC	330
BL1	68	DC	87	GC	181	DR1–ER1	330
FC	72	ER1	90	FR1	190	FL1	332
BR1–CR1	72	DR1–ER1	100	FC	200	DR1	342
BL1	73	FC	100	DL1	202	GL1	364
DR1	73	FC	100	FL1	205	BR1	387
EC	73	DL1	103	CR1	212	DL1	390
AL1–BL1	74	EC	105	EC	213	DC	412
DL1	75	AL1	105	CR1	221	CR1	413
ER1	75	EC	120	GR1	222	EL1	423
FL1	76	AR1	122	GC	236	GR1	429
			LEFT FEMORA				
DC	53	DC	77	BR1–CR1	125	EC	208
DR1	55	CR1	80	FL1	129	FL1	213
BL1	57	FL1	80	DL1–EL1	131	EC	220
CR1	60	EC	80	DR1	132	GR1	223
CR1	62	DC	82	AL1–BL1	137	CR1	223
DR1	63	FL1	82	CR1	140	BR1	234
DR1	64	FL1	83	EC	140	DR1	239
DR1	65	AL1	85	GC	144	BL1	267
FR1	65	BL1	87	DR1–BR1	150	FC	287
GR1	66	FC	89	EC	150	DR1	288
GL1	67	EC	90	CR1	170	BR1–CR1	298
FL1	67	ER	90	DR	171	BR1	308
EC	70	CR1	93	DL1	175	BR1	327
FL1	71	DR1	96	CL1	175	FR1	331
EC	72	EC	96	FL1	175	DC	333
AL1–BL1	73	DL1	98	FL1	178	GL1	362
BR1–CR1	75	DR1	100	GR1	182	DL1	395
ER1	75	EC	100	DL1	183	BR1	405
FL1	75	AR1	122	CR1	190	CR1	416
GC	77	FL1	122	BC	202	GR1	426

Dental Eruption and Calcification

Most investigators agree that dental eruption and calcification probably constitute the most accurate indicators of subadult chronological age. Garn, Lewis, and Polacheck

TABLE 29.—*Age distribution (in years) of subadult femora from Ossuaries I and II as determined from maximum diaphyseal length*[1] *and epiphyseal union*

Side	0–4.9 No.	0–4.9 %	5.0–9.9 No.	5.0–9.9 %	10.0–14.9 No.	10.0–14.9 %	15.0–19.9 No.	15.0–19.9 %	Total no.
					OSSUARY I				
Left.......	30	59	13	25	6	12	2	4	51
Right......	36	62	14	24	6	10	2	4	58
					OSSUARY II				
Left.......	56	63	12	15	7	8	14	16	89
Right......	47	57	13	16	9	11	13	16	82

[1] Using Stewart's (1968) generalized growth curve of the Eskimo femora: <178 mm=0–4.9 years; 179–263 mm=5.0–9.9 years; 264–357 mm=10.0–14.9 years; >358 mm=15.0–19.9 years.

(1959), and Lewis and Garn (1960) have demonstrated that dental development is more closely associated with chronological age than is skeletal development. Dental development has been shown to have a strong genetic component (Glasstone, 1938, 1963, 1964) and is little influenced by nutritional or other environmental factors (Paynter and Grainger, 1961, 1962). Although specific diseases, such as hypopituitarism and syphilis can modify dental development (Bauer, 1944), most major diseases minimally affect teeth even though skeletal parts may be greatly altered (Niswander and Sujaku, 1965). Endocrine disorders and other maturational malfunctions affect teeth only one-fourth as much as the skeleton (Garn, Lewis, and Blizzard, 1965). Overall, general dental development appears to provide the closest correlation with subadult chronological age.

In the past, physical anthropologists have utilized extensively an assessment of the degree of dental eruption and calcification to determine age at death of subadults. For the actual age correlations, most investigators have relied heavily upon a chart compiled by Schour and Massler (1941). The chart draws upon the observations of Logan and Kronfeld (1933), and Kronfeld (1935) on the teeth of 30 infants and children under 15 years of age (Kraus, 1959). It has been criticized by Garn, Lewis, and Polacheck (1959), Miles (1963), and recently Sundick (1972), since it is based on a small sample and many of the subjects examined suffered from illnesses that may have affected the time of tooth eruption. In addition, the chart combines data on eruption and calcification. Garn, Lewis, and Polacheck (1959), and Lewis and Garn (1960) have demonstrated that tooth formation and calcification have a higher correlation with age than does tooth eruption. Tooth calcification is less affected by premature loss of deciduous and permanent teeth, crowding, and dietary factors, than is the timing of tooth eruption (Fanning, 1961, 1962a, 1962b; Niswander and Sujaku, 1960, 1964).

In place of the Schour and Massler (1941) chart, Hunt and Gleiser (1955) recommend the use of data provided by Robinow, Richards, and Anderson (1942) and by Meredith (1946) for the age of eruption of the deciduous dentition and by Hurme (1948) for the age of permanent eruption. These studies soundly document eruption for North American Whites. Studies by Steggerda and Hill (1942), Hurme (1948), Garn and Moorrees (1951), Dahlberg and Menegaz-Bock (1958), and Hrdlicka (1908) all suggest that eruption of at least the posterior teeth occurs slightly earlier in Indian and other non-White groups. Unfortunately the studies do not agree on the actual eruption ages for various teeth, and it is not clear from the discussion whether the variance is due to population genetic variation, dietary-nutritional differences, or methodological discrepancies.

Of all studies of dental calcifications, those of Moorrees, Fanning, and Hunt (1963a, 1963b) supply standards most suitable for aging immature dentitions from archeological samples. They present two standards of tooth formation; one for three deciduous teeth, and one for ten permanent teeth. Their study is based on a large sample (n=236) and provides both mean age and standard deviation values for exactly defined stages of development. Although they published separate standards for males and females, their results can be pooled for assessment of archeological specimens where sex cannot be determined with confidence.

All subadult dentitions from both ossuaries were aged first by a comparison with the Schour and Massler (1941) dental eruption chart and then by the calicification standards of Moorrees, Fanning, and Hunt (1963a, 1963b). This approach not only provided an accurate assessment of subadult age at death, but permitted comparison of the standards as well. Table 30 presents the results of that assessment for Ossuary I. The age categories in Table 30 represent convenient categories to judge dental eruption from the Schour and Massler chart. Numerical age values determined from the calification standard could easily be placed into those categories for comparison. As Table 30 reveals, the eruption standard gave consistently higher age estimates than the calcification standard. The differences between the two aging methods are presented more clearly in Figure 18 for the right maxillae and mandibles, and Figure 19 for the left maxillae and mandibles. In these figures, the number in each category has been multiplied by a normalizing factor so that sample size (n=62) is the same for each curve. The curves were normalized to a sample size of 62 since that is the minimum number of subadults represented in Ossuary I. The actual sample sizes are keyed to each particular curve in the figures. Both figures also demonstrate that ages calculated from dental eruption are consistently higher than those calculated from dental calcification. Consequently, the calcification standard produces more age estimates for the earlier years and fewer for the later years in both the maxilla and mandible. A comparison of the two figures

TABLE 30.—*Age distribution in years of subadults in Ossuary I as determined from crown-root calcification and tooth eruption*

Tooth group	*0–1.9*		*2.0–5.9*		*6.0–11.9*		*12.0–17.9*		*18.0–19.0*		*Total*
	No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	
					CALCIFICATION						
Right mandible	18	41	15	34	8	18	3	7	0	0	44
Left mandible	22	46	15	31	9	19	2	4	0	0	48
Right maxilla	13	40	8	24	10	30	2	6	0	0	33
Left maxilla	15	41	9	24	11	30	2	5	0	0	37
					ERUPTION						
Right mandible	16	36	14	32	10	23	3	7	1	2	44
Left mandible	20	42	14	29	11	23	2	4	1	2	48
Right maxilla	10	30	10	30	10	30	2	6	1	3	33
Left maxilla	11	30	11	30	12	32	2	5	1	3	37

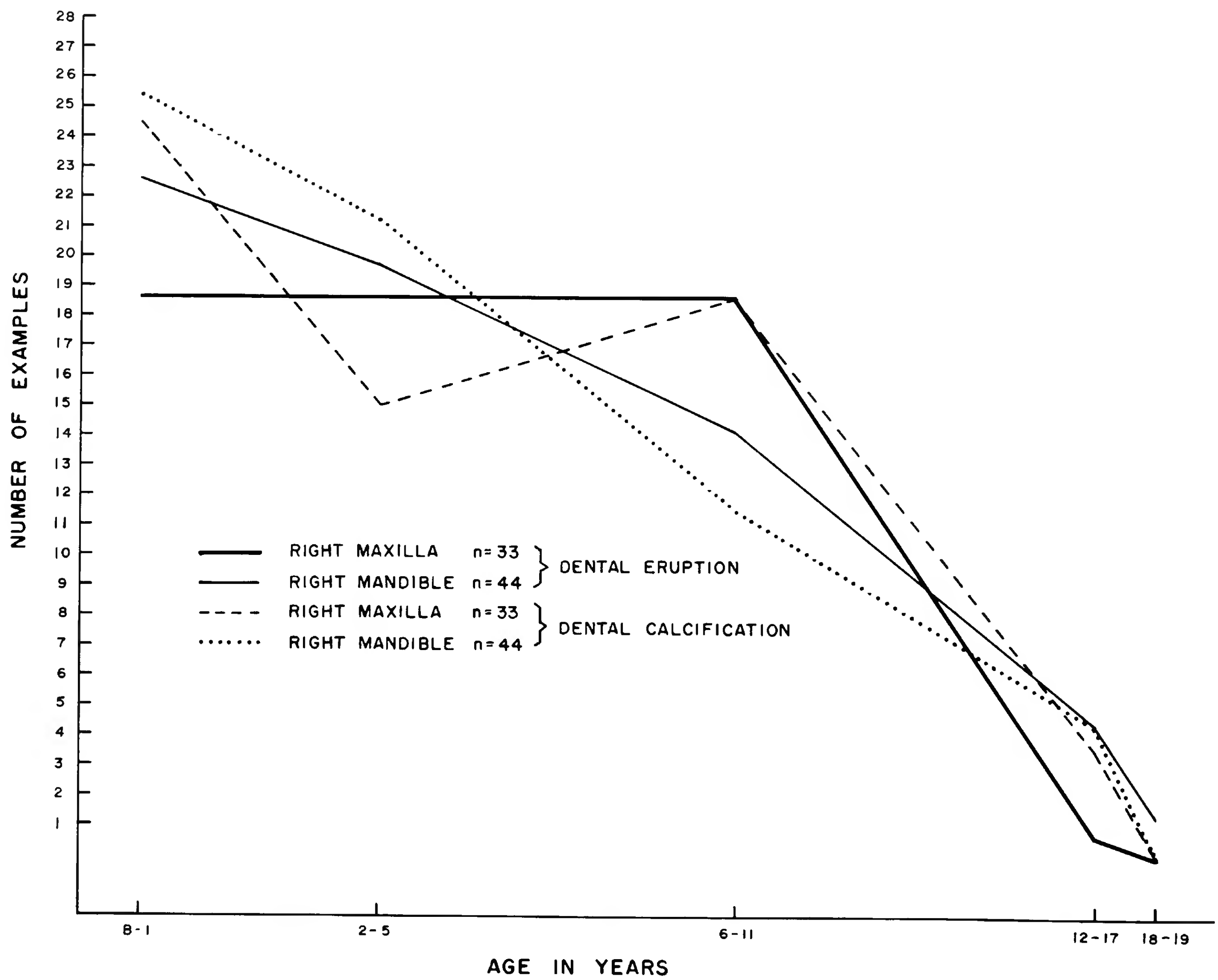


FIGURE 18.—Comparison of age distributions determined fom dental eruption and dental calcification in right mandibles and maxillae from Ossuary I. All normalized to n=62.

TABLE 31.—*Age distribution in years of subadults in Ossuary II as determined from crown-root calcification and tooth eruption*

Tooth group	0–1.9		2.0–5.9		6.0–11.9		12.0–17.9		18.0–19.0		Total
	No.	%	No.	%	No.	%	No.	%	No.	%	
					CALCIFICATION						
Right mandible	24	45	15	28	6	12	8	15	0	0	53
Left mandible	27	49	14	25	7	13	7	13	0	0	55
Right maxilla	15	29	18	35	9	17	10	19	0	0	52
Left maxilla	17	33	15	29	9	17	11	21	0	0	52
					ERUPTION						
Right mandible	17	32	21	40	7	13	8	15	0	0	53
Left mandible	22	40	18	33	9	16	6	11	0	0	55
Right maxilla	14	27	19	37	8	15	10	19	1	2	52
Left maxilla	15	29	16	31	9	17	11	21	1	2	52

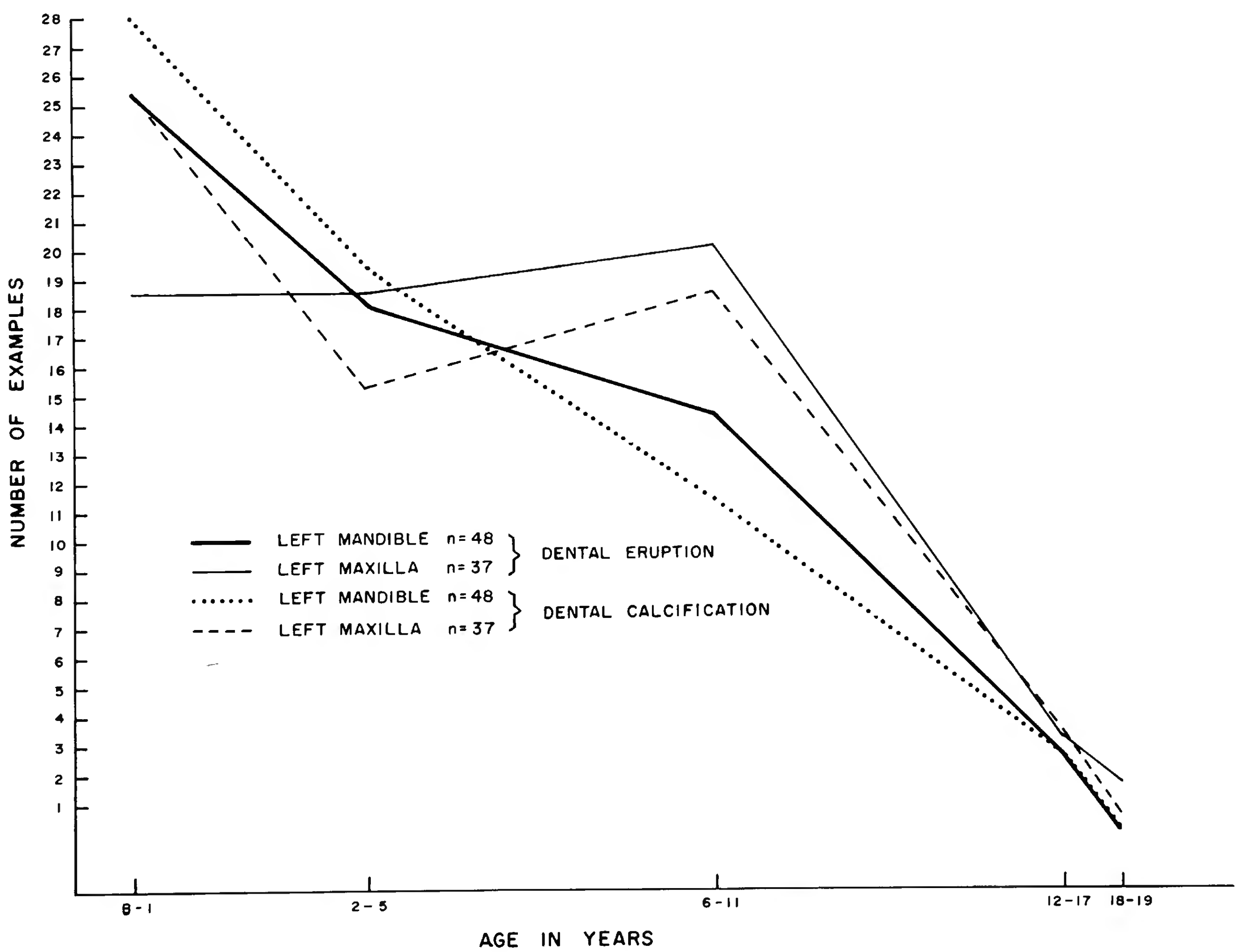


FIGURE 19.—Comparison of age distributions determined from dental eruption and dental calcification in left mandibles and maxillae from Ossuary I. All normalized to n=62.

shows few differences between the left and right sides, and confirms the differences described above. In both figures, estimates from the mandible are lower than those from the maxilla. Differences between the maxillae and mandibles are largely a product of sampling, since on both the left and right sides, 11 more mandibles were present than maxillae. Furthermore, it is apparent from the shape of the curve that most of the missing maxillae were from individuals in the birth to 1.9-year and 2.0 to 5.9-year categories.

These data suggest that the eruption standard of Schour and Massler (1941) produces consistently higher age estimates than the calcification standard of Moorrees, Fanning, and Hunt (1963a, 1963b). Although the calcification standard probably is the more accurate, the actual ages at death may be even slightly earlier for this non-White archeological population. Of all curves presented in Figures 18 and 19, that obtained from the calcification of teeth from the left mandible is probably the most reliable since it is based on the more accurate standard (calcification) and largest sample (n=48).

Table 31 compares calcification and eruption estimates from Ossuary II. As in Ossuary I, calcification age determinations are generally lower than those obtained from dental eruption. Figures 20 and 21 compare ages at death as determined by eruption and calcification from the maxilla and mandible, left and right sides. Again, there is close agreement between age assessments from the two sides. As expected, the two main causes of age discrepancies are the bones selected for examination (maxilla or mandible) and the age standard utilized. The standards show close agreement on the maxillary teeth, with the calcification standard producing only slightly younger estimates. In contrast, the aging standards produced widely divergent results when applied to the left and right mandibular teeth. Estimates

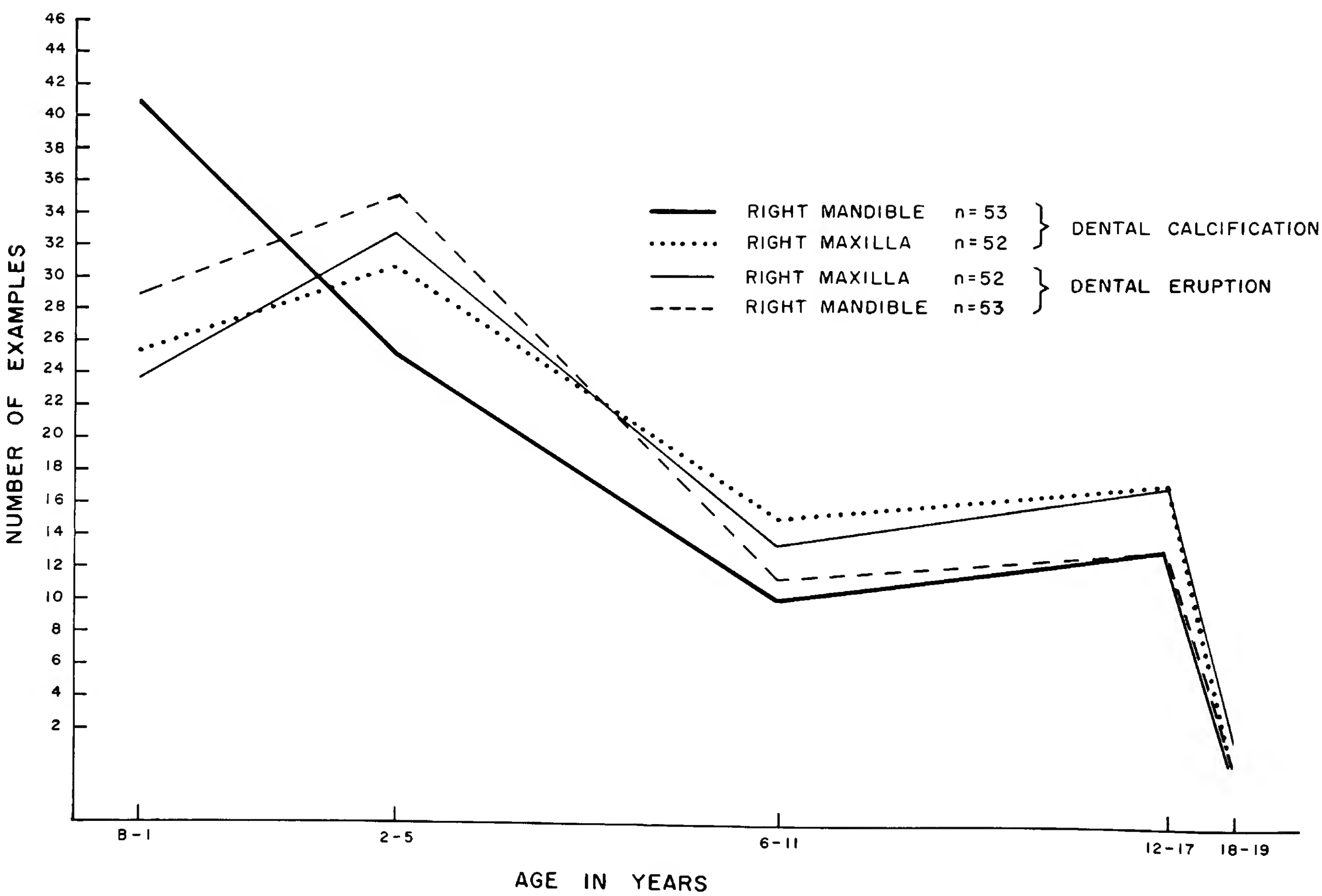


FIGURE 20.—Comparison of age distributions determined from dental eruption and dental calcification in right mandibles and maxillae from Ossuary II. All normalized to n=89.

from the maxilla are higher than those from the mandible, but the discrepancy is not as large as in Ossuary I. Of these curves, that of the left mandible aged by the calcification standard is probably the most reliable since it is based on the largest sample (n=55) and the more accurate standard (Moorrees, Fanning, and Hunt, 1963a, 1963b).

The above discussion not only provides a basis for the accurate assessment of subadult age for the Juhle ossuaries, but also documents the great variation in results obtained from different methods and the hazards inherent in the arbitrary selection of a single criterion. In Ossuary I, a death curve based upon dental eruption of the maxillae would induce quite different demographic considerations from a curve based on mandibular tooth formation. A "students t-test" for differences between the mean ages estimated by the Schour and Massler chart and the mean ages derived from the standards of Moorrees, Fanning, and Hunt reveals a significant difference at the .02 level. These results not only demonstrate the error involved in arbitrary age estimation, but stress the need for investigators to utilize the best standards available and to specify which standards and which teeth were employed in the analysis.

Figures 22 and 23 compare age distributions calculated from the most representative femoral length data and the most representative dental eruption and calcification data. The age categories were selected to allow meaningful comparisons with dental eruption. In Ossuary I, all three curves are in close agreement, although the calcification curve indicates slightly more younger individuals are present than are suggested by the other two curves. In Ossuary II, the curves for femoral length and tooth calcification agree closely, but the curve based on dental eruption differs mark-

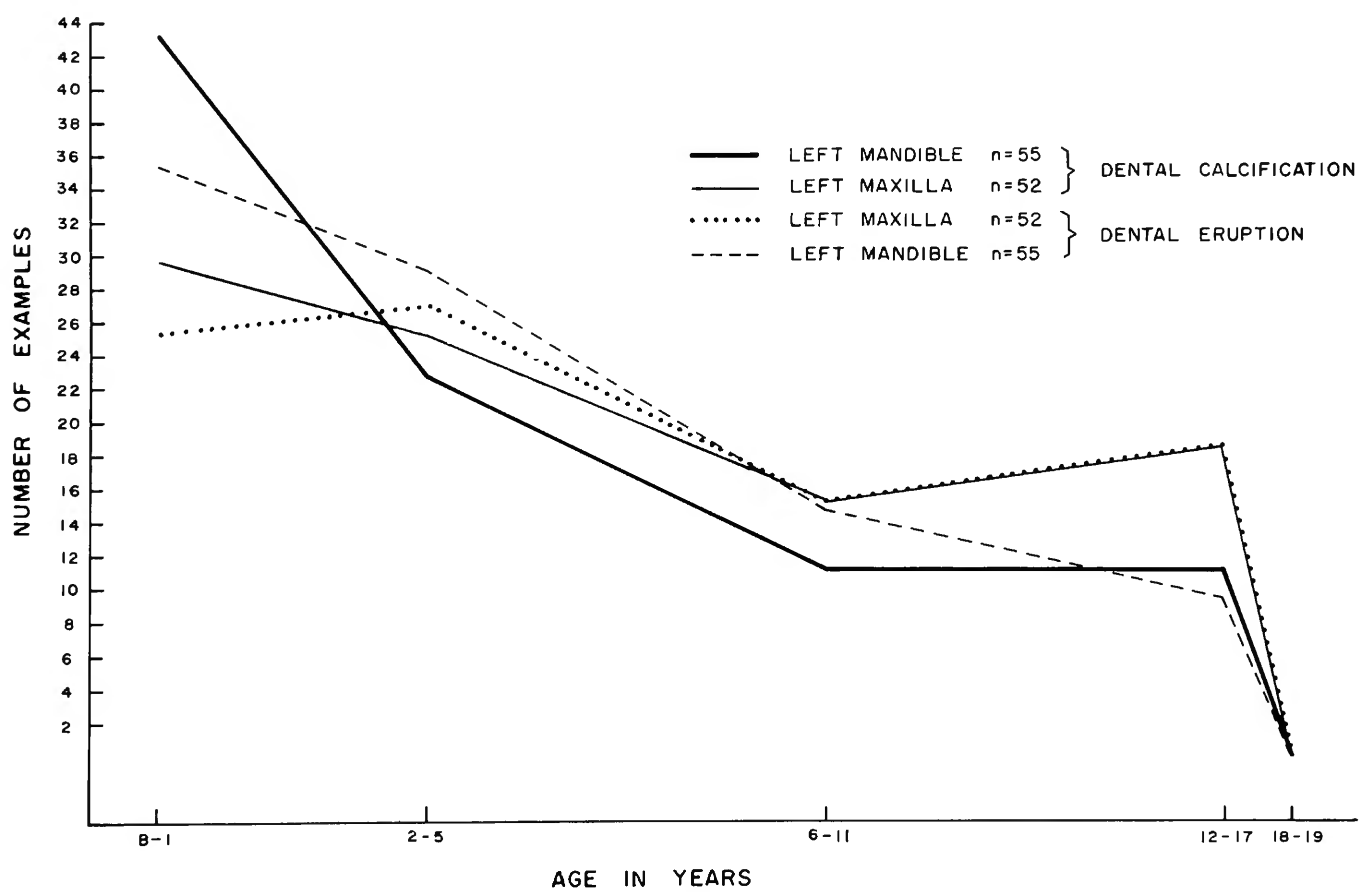


FIGURE 21.—Comparison of age distributions determined from dental eruption and dental calcification in left mandibles and maxillae from Ossuary II. All normalized to n=89.

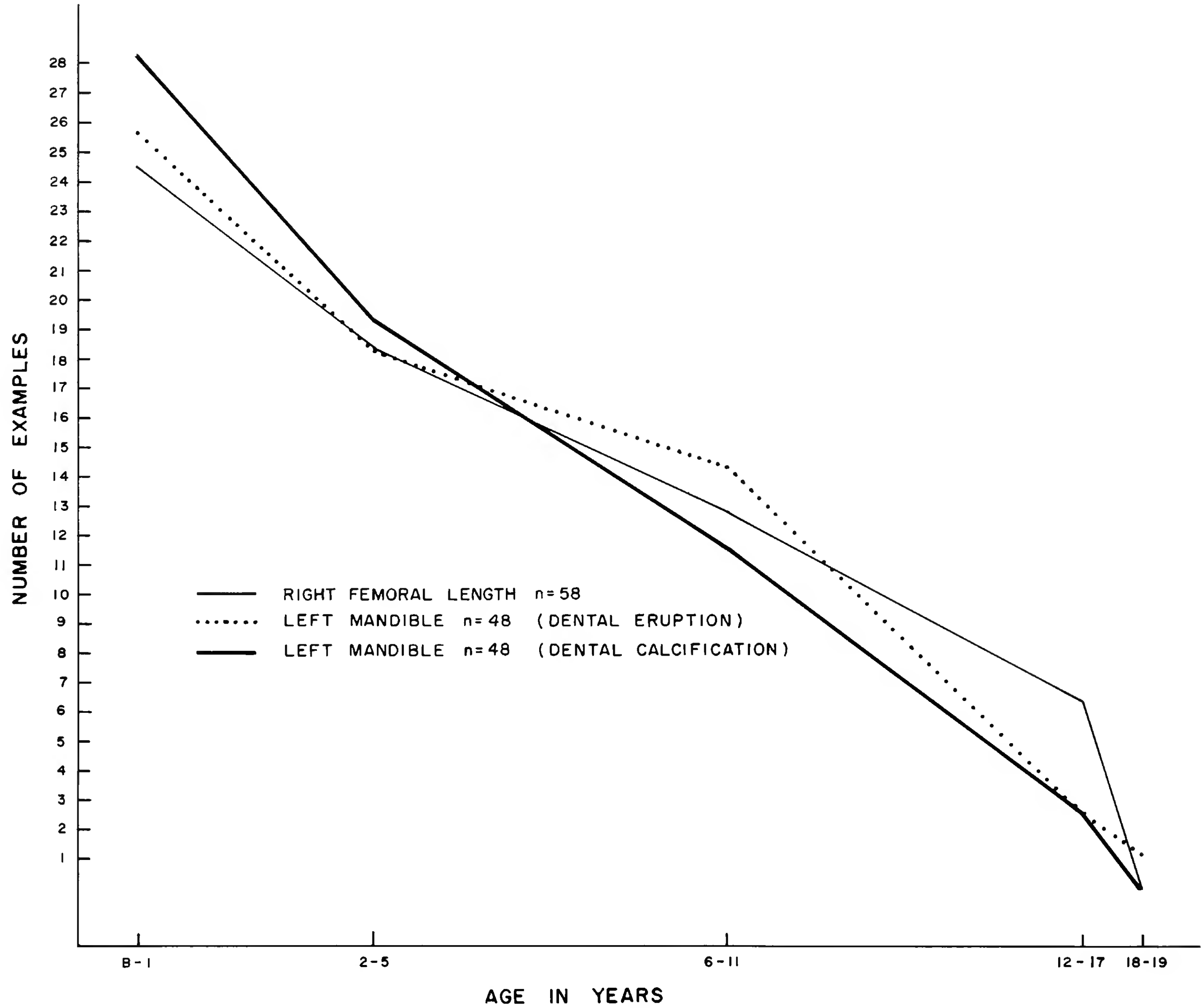


FIGURE 22.—Comparison of age distribution determined from (1) maximum length and epiphyseal union of right femora, (2) dental eruption in left mandibles, and (3) dental calcification in left mandibles from Ossuary I. All normalized to n=62.

edly. Of the three curves, certainly those based on femoral length and tooth calcification are the most accurate.

Any evaluation of the relative accuracy of the femoral and dental calcification curves must consider both the accuracy of the standards and the relative size of the samples. Stewart's study of Eskimo femora was based on ages determined from dental eruption. Consequently, the data not only incorporate the error of correlation between femoral length and stage of dental eruption, but the additional error of the original age assessment from dental eruption. Even though these two independent sources of error may not be additive, they do indicate that age estimates based on femoral length are less reliable than those obtained directly from the dentitions. Even though standards of aging femora may be less accurate, however, the femora are much better represented than mandibles in the ossuaries. In Ossuary I, only four subadults are not represented by femora, while in Ossuary II, the minimum subadult count comes from the femora. In contrast, 14 left mandibles are missing from Ossuary I, and 36 right mandibles are missing from Ossuary II. Although the close agreement of femoral and dental curves suggests that the loss of mandibles was approximately equal for each age category, it appears best to utilize the femoral data for further demographic computations since femoral representation in the ossuaries approaches 100 percent.

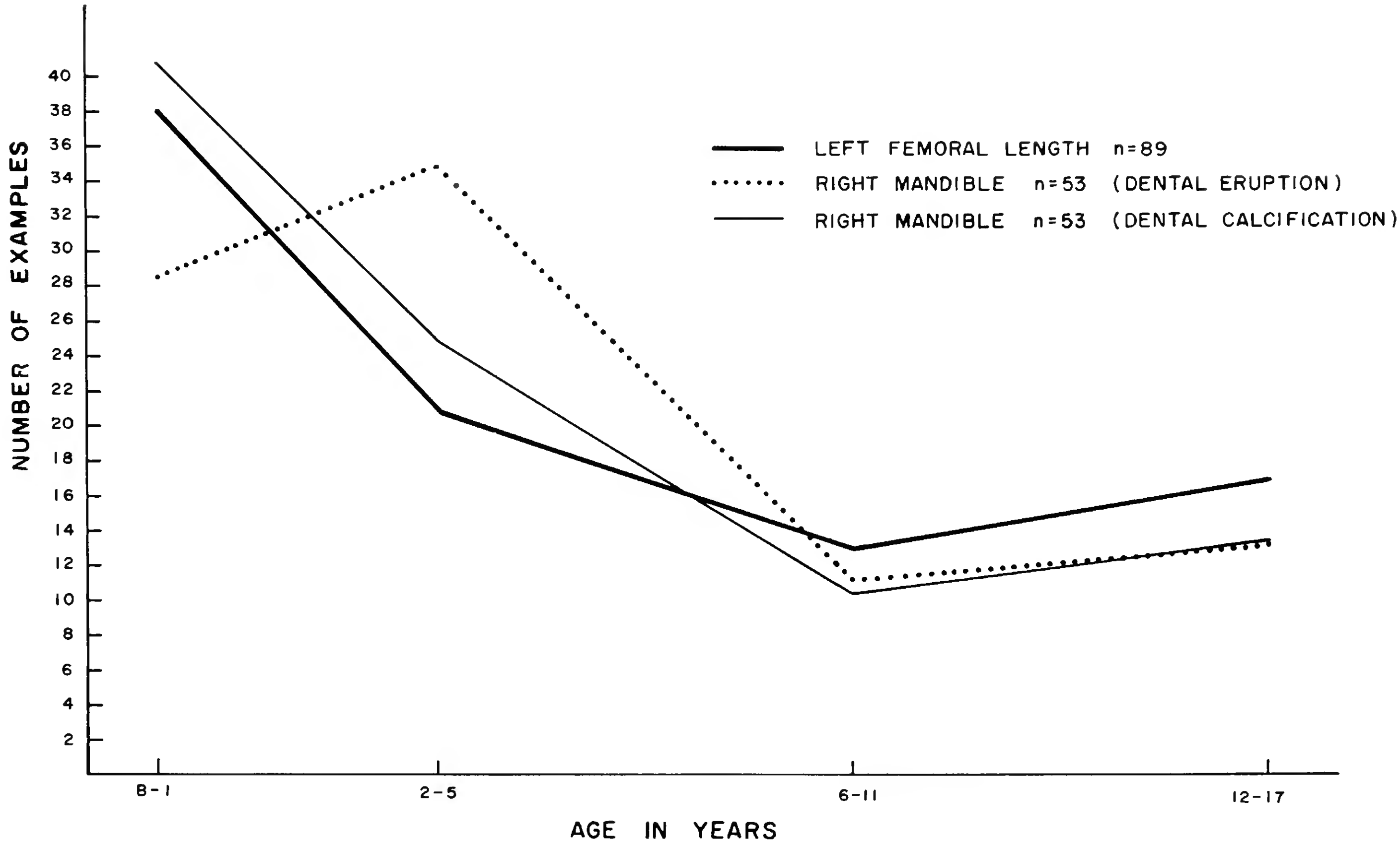


FIGURE 23.—Comparison of age distributions determined from (1) maximum length and epiphyseal union of left femora, (2) dental eruption in right mandibles, and (3) dental calcification in right mandibles from Ossuary II. All normalized to n=89.

DETERMINATION OF AGE OF ADULTS

Adult age at death may be determined in a number of ways. As with subadults, it is best to consider as many criteria as possible from different parts of the skeleton to obtain an overall assessment of skeletal maturity and chronological age. Since few complete skeletons can be assembled from ossuary deposits, however, aging methods applicable to each bone category must be considered independently.

In the past, physical anthropologists relied heavily upon the degree of cranial suture closure and dental attrition for age determination. Age progression in the closure of cranial sutures was described in detail by Todd and Lyon (1924–1925), who noted that endocranial closure progresses more regularly than ectocranial closure, yet the progression is not regular enough for aging purposes. This has been emphasized by Singer (1953) and verified by McKern and Stewart (1957) for North American males. Today suture closure is used in determining age only as a last resort.

The degree of dental attrition is used occasionally for age determination, largely because teeth are frequently all that remains of some poorly preserved skeletons. Hrdlička (1952) related general age categories with stages of dental attrition in American Indians, but Miles (1963) and Moorrees (1957) have demonstrated that the correlation of age with attrition varies considerably within and between populations. Although estimates may be improved by considering the diet of the population and the rate of attrition within each dentition, the method still can provide only very general age estimates.

Kerley (1970) has discussed the ossification of rib cartilage at the costo-chrondral junction as a general aging criterion. With increasing age, the sternal ends of the ribs gradually transform from a billowed appearance to an irregular, often ragged appearance. With advancing age, the ossification extends further out into the cartilage, eventually culminating in complete ossification of the costal cartilage. McKern and Stewart (1957) documented the variability of this feature, showing that the age changes are too erratic to yield reliable age estimates.

Stewart (1958b) described osteophytic outgrowths of vertebral centra as general age indicators. Again, individual variability is so great that the observation can only be applied very generally. Well-developed osteophytes seldom appear at many sites prior to age 40.

Other age changes in bone that yield only very general age determinations are parietal porosity (Todd and Lyon, 1924–1925; Kerley, 1970), lipping of diarthrodial joint margins (Johnson, 1962), and gross resorption of cancellous tissue within long bones (Hansen, 1953–1954; Schranz, 1959). At best, these methods allow age determinations to be made confidently, only within a decade of the real age. Consequently, they do not provide the accuracy needed for demographic analysis.

In 1950, Gustafson published a method of determining age at death from seven features of dental microstructure linked with age changes: cementum apposition, attrition, periodontosis, secondary dentin apposition, root resorption, transparency of the root, and closure of the root orifice. When considered together, these features yield an age estimate containing a standard error of only 3.6 years. The standard curve was determined from a series of 41 teeth taken from individuals of known ages that ranged from 11 to 69 years.

Numerous modifications have been made on the Gustafson method since its formulation in 1950. Nalbandian (1959) and Nalbandian and Sognnaes (1960) reexamined the age correlations and established similar regression coefficients from Swedish and United States Caucasian samples. Dechaume, Dérobert, and Reyen (1960) found that experience was necessary to obtain reliable results, and eventually duplicated Gustafson's findings. All investigators agree that Gustafson's method is accurate when employed by an experienced histologist with the proper sectioning equipment.

Although Gustafson's method is the most reliable of those discussed so far, it was not employed in this study for two reasons: first, many teeth could not be associated with their mandibles or maxillae and second, it was not desirable to destroy adult teeth until they had been studied thoroughly. For these reasons, and because of the lack of reliability of the other methods mentioned, determinations of adult age were made only from the articular surfaces of the pubic symphyses and the anterior cortices of the femora.

Pubic Symphysis

In 1920, Todd defined 10 phases of age-related pubic symphyseal metamorphosis from his examination of 306 adult skeletons of known age (predominately old) from the Todd Collection. A year later (1921) Todd stated that Negro and White pubes showed essentially the same age changes. He noted also that the stages of change in females are basically the same as in males, but proceed more slowly.

McKern and Stewart (1957) provided a new system for aging the male pubis as a result of an analysis of 450 youthful skeletons recovered in "Operation Glory" from the Korean conflict. Their system involves the examination of three "components" of the pubic symphysis: the dorsal plateau, ventral rampart, and symphyseal rim. This has the advantages of (1) being based on a well-defined population of one sex, (2) being easy to use, and (3) allowing different aspects of the symphyseal face to be assessed independently. Gilbert's (1971) study of female pubes now makes the method available for both sexes. Both studies indicate that symphyseal age changes are more variable than Todd's work had indicated. However, the McKern and Stewart's (1957) method still represents a highly accurate, objective method of age determination, especially since plastic models of each stage of symphyseal change are now available for both sexes. These three-dimensional plastic models allow objective comparisons to be made and thereby reduce subjective error.

The application of the McKern and Stewart (1957) and Gilbert (1971) aging methods to adult pubes from Ossuary I and II produced the distributions of ages recorded in Tables 32 and 33. More male than female pubes were present in Ossuary I, while more female than male pubes occurred in Ossuary II. In both ossuaries, more ages could be

TABLE 32.—*Age distribution (in years) of adults as determined from pubes in Ossuary I*

Side	20–24		25–29		30–34		35–39		40–44		45–49		50+		Total no.	Average age
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%		
							MALE									
Right	2	10	3	15	7	35	5	25	1	5	1	5	1	5	20	34
Left	3	12	4	15	10	38	6	23	3	12	0	0	0	0	26	33
							FEMALE									
Right	0	0	1	6	7	44	3	19	3	19	2	12	0	0	16	36
Left	0	0	0	0	5	46	3	27	2	18	1	9	0	0	11	37
							SEXES COMBINED									
Total Right	2	6	4	11	14	39	8	22	4	11	3	8	1	3	36	35
Total Left	3	8	4	11	15	41	9	24	5	14	1	3	0	0	37	34

Table 33.—*Age distribution (in years) of adults as determined from pubes in Ossuary II*

Side	*20–24*		*25–29*		*30–34*		*35–39*		*40–44*		*45–49*		*50+*		*Total no.*	*Average age*
	No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*		
								Male								
Right	0	0	7	33	9	43	4	19	1	5	0	0	0	0	21	32
Left	4	16	6	24	11	44	2	8	2	8	0	0	0	0	25	30
								Female								
Right	4	13	8	27	10	33	7	23	0	0	0	0	1	3	30	31
Left	4	11	9	26	13	37	9	26	0	0	0	0	0	0	35	31
								Sexes Combined								
Total Right	4	8	15	29	19	37	11	22	1	2	0	0	1	2	51	31
Total Left	8	13	15	25	24	40	11	18	2	3	0	0	0	0	60	31

determined from left pubes than rights. Age estimates from the two sides are in general agreement, with minor discrepancies reflecting both the error of the aging method and the unequal sample sizes. The average age at death was higher for Ossuary I than Ossuary II, slightly higher for females than males in Ossuary I, but equal for both sexes in Ossuary II.

Internal Bone Remodeling

In 1965, Ellis R. Kerley published a method of determining age from the microscopic examination of cortical bone that advanced skeletal aging methodology to a new level of accuracy. His method is based on the fact that during the years of rapid long bone growth (0 to 17) most of the diaphyseal cortex consists of circumferential lamellar bone deposited by the periosteum. Beginning about the fourth year and continuing throughout the life of the individual, this lamellar bone constantly is being remodeled. The remodeling process involves osteoclasts destroying the lamellar bone to form resorption spaces. These spaces are then gradually filled in by material generated by osteoblasts to produce Haversian systems or osteons. Occasionally, the osteoclasts not only destroy unremodeled bone but osteons as well, leaving behind only fragments of the formerly complete osteons (Figure 24). The effect of this process increases the number of new osteons and osteon fragments with increasing age at the expense of the original circumferential lamellar bone (for details of this process see Enlow, 1963; Jowsey, 1960). Utilizing cross-sections through the midshaft, these structures can be objectively examined in four, precisely defined, circular, microscopic fields in the outer third of the long bone cortex. Age determinations are made from counts of these structures using regression formulae developed from Kerley's study of 126 undecalcified ground thin-sections of femora, tibae, and fibulae, taken from individuals of documented age, sex, and clinical history. The regression formulae contain standard errors as low as 9.39 years (femur), 6.69 years (tibia), and 5.27 years (fibula).

In recent years, two important modifications of the Kerley aging method have appeared in the literature. Using thin sections from the mandibles, femora, and tibiae of 59 cadavers of known age, sex, and medical history, Singh and Gunberg (1970) examined in two circular fields the total number of osteons, the average number of concentric lamellae per osteon, and the average diameter of the Haversian canals. From this data, they worked out regression equations with standard errors as low as 2.55 years. Unfortunately, the Singh and Gunberg (1970) study was based on a sample of individuals aged 39 to 87 years and clearly cannot be applied to ossuary material where evidence from the pubes suggests most adults died prior to age 40.

In 1969, Ahlqvist and Damsten pointed out that (1) Kerley's reliance upon several structures for age assessment overly complicated the method while adding little accuracy; (2) that his use of circular visual fields necessitates specimen movement to distinguish structures on the borders of the field; and (3) that one of the visual fields he selected for examination falls directly upon the linea aspera, an area that demonstrates more non-age related osteon variation than other areas. In their modified version of Kerley's method, Ahlqvist and Damsten consider only the total percentage of remodeled bone (osteons and osteon fragments) from four square fields placed just inside the outer surface of the bone. They spaced the fields around the circumference of the bone to fall between Kerley's fields and not on the linea aspera. Using a 100-square ruled ocular micrometer, inserted into the eyepiece so that one side (10 squares) of the grid measured one millimeter at the level of the section, they counted the number of squares more than half-filled with either osteons or osteon-fragments, and repsented the result as a percentage. Finally, by applying this method to 20 unstained, ground sections from midshafts of

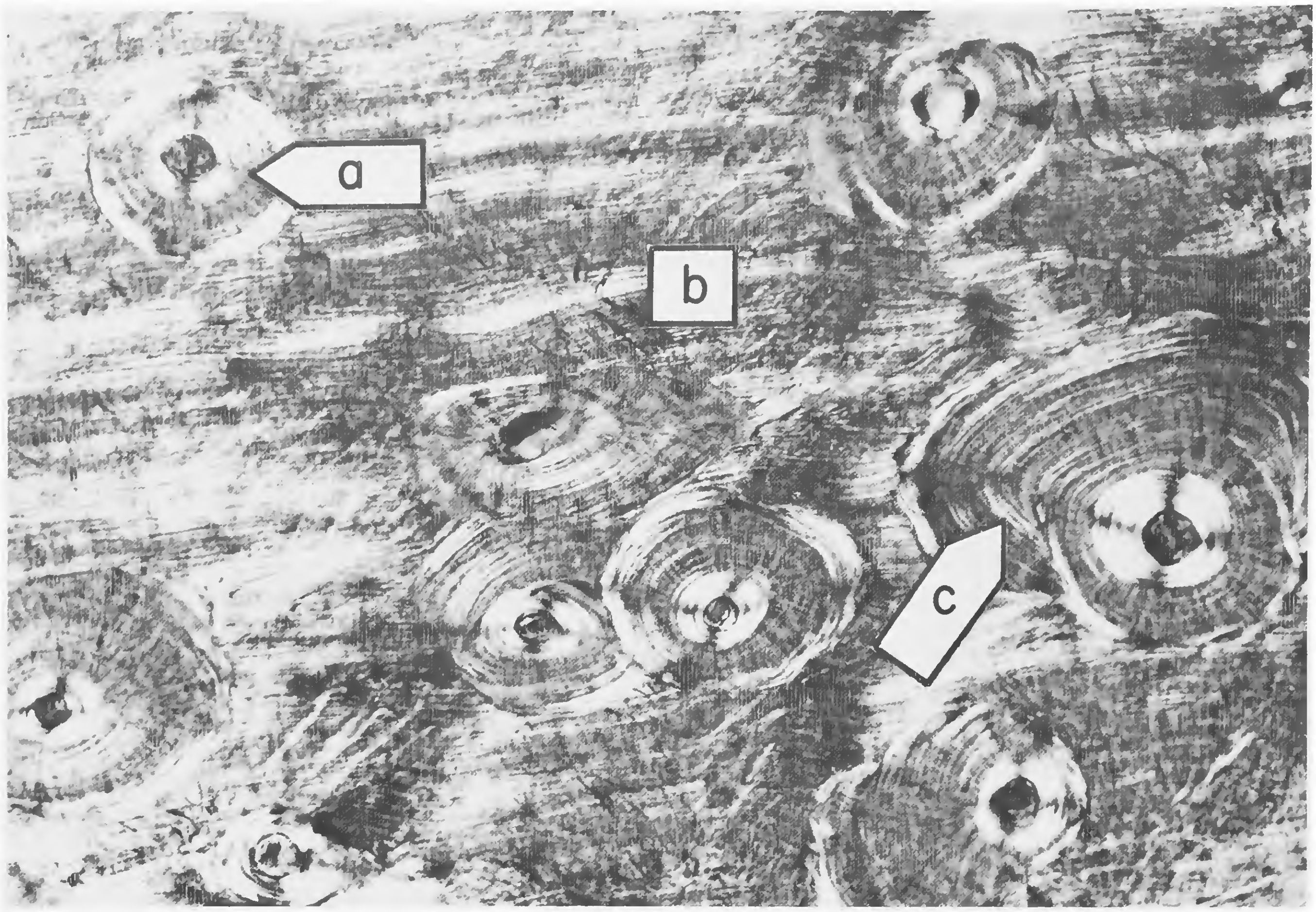


FIGURE 24.—Cross-section of human cortical bone showing (*a*) osteons, (*b*) unremodeled circumferential lamellar bone, and (*c*) osteon fragments.

femora of known age at death, they developed a regression expressing the relation between age and the percentage of remodeled bone. Their linear regression formula contains a standard error of 6.71 years;

Of the Kerley, and Ahlqvist and Damsten studies, Kerley's offers the lower standard error, draws upon the larger sample, and would appear to be the better of the two methods. However, many sections prepared from the possibly 400 year-old ossuary specimens lack the clarity and resolution of sections prepared from fresh anatomical specimens. Although it is possible to readily distinguish remodeled bone from circumferential lamellar bone, often it is difficult to distinguish whole osteons from osteon fragments. Largely because the Ahlqvist and Damsten modification does not require the latter distinction to be made, it was chosen over Kerley's original method for use in this study.

The femora were selected for sectioning since they occurred in great frequency in the ossuaries and femora formed the basis for Ahlqvist and Damsten's (1970) study. The sample was comprised of 151 right femora, 66 from Ossuary I, and 85 from Ossuary II. Right femora were given preference because in both ossuaries they outnumbered the lefts. In each bone two horizontal cuts about 15 mm apart were made three-quarters of the way through the bone just below the anterior midshaft. The remaining quarter which includes the linea aspera was not removed since it was not to be used for the age determination and leaving it intact preserved the original length of the bone for future studies. A standard 10 inch hand saw was used for cutting and a Foredom Model 73 dental drill with a No. 8 round bit was used to disconnect the section from the long bone shaft.

SPECIMEN PREPARATION

Both Ahlqvist and Damsten (1969), and Kerley (1965) utilized ground, undecalcified, unstained thin sections for their age determinations, although the former mentioned that unstained decalcified sections would work as well for fresh bone. Ahlqvist and Damsten recommend cutting the decalcified bone in sections approximately 25 microns thick and grinding the undecalcified sections to a thickness of 30–50 microns.

Unlike fresh bone, archeological bone often has lost mineral constituents due to prolonged exposure to soil chemicals and has been invaded by organic and inorganic substances from the surrounding soil. These changes limit the quality of ground sections and necessitate the introduction of new techniques to reveal their details. Experimentation with bone samples from Ossuary I using several decalcifying solutions for different lengths of time, showed that decalcified stained thin sections could not be used successfully, because they lack enough remaining bone mineral to allow the structures necessary for aging purposes to be distinguished. Accurate age determinations could be made from unstained ground thin sections, but even with these, two major problems were encountered. First, after a dry archeological bone section was mounted on a thick slide, it would absorb water during the preparation process, expand, and crack the nonabsorbant glass slide. Initially, the problem was solved by using specially cut, plastic slides which would bend and not break as the bone section expanded. Unfortunately, several of the plastic slides bent to the point where they would not adhere to the vacuum-supported chuck face of the cutting saw. The problem was eliminated only by infiltrating the bone specimen with an epoxy resin, which prevented the absorption of water and the resultant bone expansion and thus saved the slide from destruction. (The epoxy-resin used is Araldite AY105 with Hardener 935F. These products can be obtained from Chemical and Engineering Company, Inc., 221 Brooke Street, Media, Pennsylvania, 19063. Equal weights of the araldite and hardener were mixed thoroughly on a hot plate until the originally milky mixture became transparent. For infiltration, 5 grams of the araldite mixture were dissolved in 150 ml. of Toluene.)

The second major problem involved the organic and inorganic contaminants mentioned above. Their permeation of the important periosteal third of the cortex obscured the microstructures used in age determination. In some cases, the extraneous material was removed by gently teasing the section surface with a dissection needle under a dissecting microscope. Unfortunately, the araldite, needed to keep the bone from expanding, also firmly held the extraneous material in the bone matrix. Eventually better results were obtained by placing all blocks in an ultrasonic cleaner and infiltrating them with a mild oxidizing agent prior to the araldite infiltration. This somewhat time-consuming modification allowed satisfactory age determinations to be made.

In short, the procedure initially involved the cleaning of the bone block after its removal from the femoral shaft. The block was then infiltrated with araldite and mounted on a glass slide. At that time, a slab of bone with smooth parallel surfaces had to be removed from the block and remounted on a second glass slide for final grinding. This step was necessary since the final thin section had to be of even thickness and consequently be prepared from a bone specimen with parallel surfaces. The parallel-sided bone slab was removed by making two cuts through the original block. The first cut near the outer surface of the bone created one outer smooth surface that was parallel to the glass slide. A second cut, closer to the slide and also parallel, freed the bone slab from the original block. Since the bone slab had two parallel surfaces, it could then be mounted on the final slide and be evenly ground down to a finished specimen. Specifically, the entire process was as follows:

The block was first washed with soap and water in the ultrasonic cleaner for one hour, thoroughly rinsed, and then washed again in distilled water in the ultrasonic cleaner for 30 minutes. This procedure removed much of the soil from both the medullary and outer surfaces and even some loose material from within the cortex. The block was then infiltrated with a mild oxidizing agent to remove as much as possible of the organic and inorganic material that had permeated the outer cortex. Several oxidizing agents were used successfully, but the most effective was a 20 percent by volume solution of household chlorox. After being left overnight under vacuum in a bell jar, the block was washed again in the ultrasonic cleaner for 20 minutes to remove any residues of the oxidizing reaction.

Following cleansing, the bone block was prepared for sectioning by being infiltrated with araldite to limit expansion during the cutting process. Approximately 20 blocks at a time were placed in the toluene-araldite solution under vacuum in the bell jar. About 10 grams of araldite were added each day until the solution became quite thick. The specimens were left under vacuum for a total of five or six days, or until the araldite solution began to gel. At that time, the specimens were removed from the vacuum, cleaned of any adhering araldite and dried overnight in an oven heated to 60° C.

When dry, each block was mounted on a thick glass slide with the araldite-hardener mixture as the mounting medium. The medium was applied to one flat surface of the block and the latter was placed on a clean glass slide. Slight pressure was applied to the block to remove excess air bubbles. The slide and mounted bone block were then dried at room temperature overnight or until the mounting media had hardened.

At that time it was necessary to remove the parallel-sided bone slab from the block for reasons discussed earlier. After the mounting media was thoroughly hardened, the slide with mounted block was held by water vacuum to the chuckface of an Ingram thin section saw. An initial cut was made on the outer edge of the bone (across the long axis) that removed the rough outer edge and created a smooth surface that was parallel to the glass slide. A second cut was then made approximately 3 mm closer to the slide than the first cut, which freed a bone slab from the original rough mount. The free slab had smooth, parallel sides and, of course, still represented a cross-section of the femur. One side of the free slab was then machine-polished. The free slab was moved slowly against the direction of the high speed wheel for 90 seconds, rotated 180° and polished for an additional 90 seconds or until deep scratches and cuts were removed from the bone surface. The second polishing wheel was used to remove all fine scratches and irregularities from the bone surface. With the wheel spinning, the slab slowly was moved against the direction of the wheel for 30 seconds, rotated 180° and again polished for 30 seconds. The laboratory was equipped with an A.B. Buehler polishing apparatus (No. 48–1512) with two polishing wheels; (1) a high speed (550 rpm) wheel covered with an A.B. Texmet cloth (No. 40–7668) and (2) a low speed (168 rpm) wheel covered with an A.B. Microcloth lap (No. 40–7218). The first wheel was coated with A.B. Metadi diamond polishing compound (3 microns) and a mixture of equal parts A.B. mineral spirits (No. 40–8140) and A.B. polishing oil (No. 40–8142). The second wheel had a thin coat of water and Buehler A.B. Bamma micropolish added to the cloth.

The polishing was followed by a thorough washing with a grease-removing detergent, a 30-second rinsing in ether-chloroform to remove any remaining grease, and then a bathing in an oxidizing solution for 15 minutes in the ultrasonic cleaner. The oxidizing agent was used again to insure removal of all extraneous material from near the bone surface, and was followed by a final 15 minute wash in distilled water. The bone slab was then dried overnight in an oven at 60° C. The dry slab was mounted to a clean slide of uniform thickness, again using the araldite-hardener mixture as the mounting medium. The mounting medium, slide, and bone slab had been uniformly heated to 200° C to obtain uniform expansion, and thus to avoid slide breakage. Following this, the mount was placed in a "C" clamp between two flat sections of 3 mm cork. With the clamp tightened, the media was allowed to set overnight or until it hardened.

Once the mount was firmly fixed, the slide was attached to the chuckface of the cut-off saw. A final cut was made approximately 500 microns from the slide surface. The remaining mounted specimen was then attached to an Ingram thin-section grinder and ground down to a thickness of about 80 microns. The polishing procedures outlined earlier were repeated to remove all scratches from the bone surface. After a detergent wash, and a rinse in distilled water, the section was dried, and covered with a cover glass, mounted with Permount or Canada Basalm. If the finished thin section still displayed an excessive amount of foreign material, the cover slip was removed with xylene, and the surface of the specimen was brushed with the oxidizing agent.

Osteon Counts

Having produced satisfactory thin sections using the above procedure, all observations were made in the manner defined by Ahlqvist and Damsten (1969). An ocular square-ruled reticule was inserted into the left eyepiece of a Leitz Ortholux microscope. A square reticule containing 100 squares was especially prepared by Bunton Instrument Company, Washington, D.C., to meet the specifications of this project. One side of the reticule (10 small squares) measured exactly 1 mm at the level of the section. Four visual fields were examined along the periosteal surface of the bone sections. In each field, the small squares more than half-filled with either osteons or osteon fragments were counted. The numbers for the four fields were averaged and the age at death computed by the linear regression formula $y=0.991x-4.96\pm6.71$, where y equals age at death and x equals the percentage of osteons and osteon fragments in the four fields.

An analysis of the data is presented in Table 34 for femora from Ossuary I and in Table 35 for femora from Ossuary II. Both tables present the average number of microscopic grid squares more than half-filled with osteons or osteon fragments (percentage remodeled) and the corresponding estimated age at death for each specimen. Table

TABLE 34.—*Percentages of remodeled bone and corresponding age estimates for 66 right femora from Ossuary I*

*Specimen number**	*Percentage remodeled*	*Estimated age*	*Specimen number**	*Percentage remodeled*	*Estimated age*
46+	42	36.7	12–15	41	35.7
39B	31	25.8	E. 109	47	41.6
113	36	30.8	42	32	26.8
27	34	28.8	111–112	41	35.7
Bt 112–113	44	38.7	114	51	45.6
2–17B	29	23.8	110	43	37.7
8	42	36.7	102	28	22.8
30	51	45.6	W119	27	21.8
NR128(A)	43	37.7	39C	47	41.6
2–17C	27	21.8	112–113	38	32.7
20–28A	50	44.6	38B	35	29.7
61B	60	54.5	126–112B	54	48.6
34	54	48.6	103	52	46.6
46+A	38	32.7	128D	31	25.8
18A	38	32.7	121	54	48.6
39A	42	36.7	38A	38	32.7
111?	45	39.6	7	51	45.6
20–38	31	25.8	101-120	50	44.6
18B	36	30.7	108	39	33.7
46+D	48	42.6	SE Cor.	48	42.6
2-17A	36	30.8	40–56–57	41	35.7
61A	33	27.7	TR	42	36.7
46+C	47	41.6	24	31	25.8
10–13B	38	32.7	45	40	34.7
10–13A	32	26.8	29	36	30.7
37	42	38.6	126–112A	36	30.7
46+B	31	25.8	2–17D	37	31.7
20–38B	37	31.7	NR61	37	31.7
105	31	25.8	10–13C	48	42.6
50–60?	33	27.7	128C	31	25.8
115	56	50.5	W117–118	53	47.6
23A	45	39.6	15	36	30.7
23B	33	27.7	128B	30	24.8

*Number refers to location of nearby crania.

TABLE 35.—*Percentages of remodeled bone and corresponding age estimates for 84 right femora from Ossuary II*

*Specimen number**	*Percentage remodeled*	*Estimated age*	*Specimen number**	*Percentage remodeled*	*Estimated age*
AL1-1	35	29. 5	ER1-1	66	60. 0
AL1-2	38	33. 0	ER1-2	63	55. 2
AL1-3	44	38. 6	FR1-1	55	50. 0
AL1-4	28	22. 5	FR1-2	56	50. 5
BL1-1	30	24. 8	FR1-3	55	50. 0
BL1-3	60	54. 0	FR1-4	34	28. 7
BL1-4	47	41. 9	CC-1	34	28. 2
CL1-1	48	42. 1	CC-2	55	49. 1
CL1-2	54	48. 3	DC-1	37	31. 7
DL1-1	48	42. 1	DC-2	29	24. 0
DL1-2	44	38. 6	DC-3	45	39. 4
DL1-3	45	40. 0	DC-4	38	33. 0
DL1-4	56	50. 0	EC-1	45	39. 1
DL1-5	54	48. 6	EC-2	44	38. 6
EL1-1	28	22. 3	EC-3	34	29. 0
EL1-2	39	33. 4	EC-4	45	39. 1
EL1-3	54	48. 6	EC-5	40	34. 7
EL1-4	48	43. 5	EC-6	27	22. 0
EL1-5	41	35. 7	EC-7	47	41. 4
EL1-6	37	31. 2	FC-1	44	38. 6
EL1-7	36	30. 2	FC-2	33	27. 3
FL1-1	34	28. 5	FC-3	39	33. 9
FL1-3	27	21. 6	FC-4	33	27. 7
GL1-1	38	32. 2	FC-5	38	33. 0
GL1-2	48	42. 9	FC-6	60	54. 8
GL1-3	41	35. 1	FC-7	37	31. 2
GL1-4	30	24. 8	FC-8	46	40. 6
GL1-5	56	50. 5	FC-9	44	38. 3
HL1-1	62	56. 5	AL-BL-1	40	34. 4
AR1-1	43	37. 9	AL-BL-2	46	40. 1
AR1-2	42	36. 7	BL-CL-1	58	52. 3
AR1-3	37	32. 0	BL-CL-2	48	43. 1
BR1-1	49	43. 4	DL-EL-1	57	51. 0
BR1-2	42	36. 2	DL-EL-2	43	37. 2
BR1-3	51	45. 1	DR-ER-1	39	33. 4
BR1-4	62	56. 0	DR-ER-2	52	46. 1
BR1-5	46	40. 9	DR-ER-3	38	32. 7
BR1-6	71	65. 7	B-1-1	44	38. 6
CR1-1	32	26. 8	B-2-1	36	28 2
CR1-2	36	31. 0	B-2-2	37	31. 2
CR1-3	40	34. 2	B-4-1	27	21. 9
DR1-1	44	38. 9	B-5-1	56	50. 0

*Number refers to either the grid square or distinct bundles (B) with which the femora were associated.

TABLE 36.—*Age distribution (in years) of adults in Ossuaries I and II as estimated from femoral microscopic remodeling*

Age group	*Ossuary I*		*Ossuary II*	
	No.	*%*	*No.*	*%*
20–25	5	8	8	10
26–30	14	21	10	12
31–35	16	24	18	21
36–40	13	20	17	20
41–45	9	14	11	13
46–50	7	11	9	11
51–55	2	3	7	8
56–60	0	0	3	4
61–65	0	0	0	0
66–70	0	0	1	1
Totals	66		84	

36 compares the data from the two ossuaries when the age estimates are grouped into 5-year intervals.

Age estimates from the femoral osteon counts are markedly different from those determined from the symphyseal face of the pubis. Figure 25 demonstrates this fact by means of separate adult mortality curves calculated from each ossuary, using the data yielded by each method. The curves express the percentages of age determinations in 5-year age categories that range from 20.0 years to 69.9 years. Although all curves demonstrate an increase in the percentage of deaths between 30 and 35 years and a decline in the percentage of deaths after age 35, they differ in the relative frequencies for each age category. The pubis indicates nearly 20 percent more individuals were dying in the 30.0–34.9 age category than suggested by femoral osteons. After age 35, the pubes indicate a rapid decline in the percentage of deaths with no one living after age 50 in Ossuary II or after age 60 in Ossuary I. In contrast, femoral osteon counts indicate a slow decline in numbers of deaths after age 40 with some individuals living to nearly 60 years in Ossuary I and to 70 years in Ossuary II. Whereas the pubis suggests an average adult age at death of 34 years for Ossuary I and of 31 years for Ossuary II, femoral osteon counts indicate average adult ages of about 36 and 38 years for Ossuaries I and II, respectively. These differences are great enough that they would produce quite different demographic profiles and could lead to contrasting interpretations.

The differences between the death curves described above result largely from two factors: differences in the accuracy of the aging methods, and differences in sample size of the bones selected for determining age. The second factor is probably the larger contributor to the discrepancy, but the first does warrant some discussion.

Pubis metamorphosis is probably the less accurate of the two methods of aging used in this study. A major problem in determining age from the symphyseal face of the pubis involves distinguishing a ventral rampart that is building up in the early part of the fourth decade from one that is breaking down in the sixth. The problem is greater in females where scars of parturition may further alter the appearance of the symphyseal face. Consequently, it is possible that some of the fragmentary pubes judged to be in the 30 to 35 year interval were actually much older.

The femoral osteon method is relatively straight-forward and presents few interpretational problems as long as reasonably clear histological sections are available for examina-

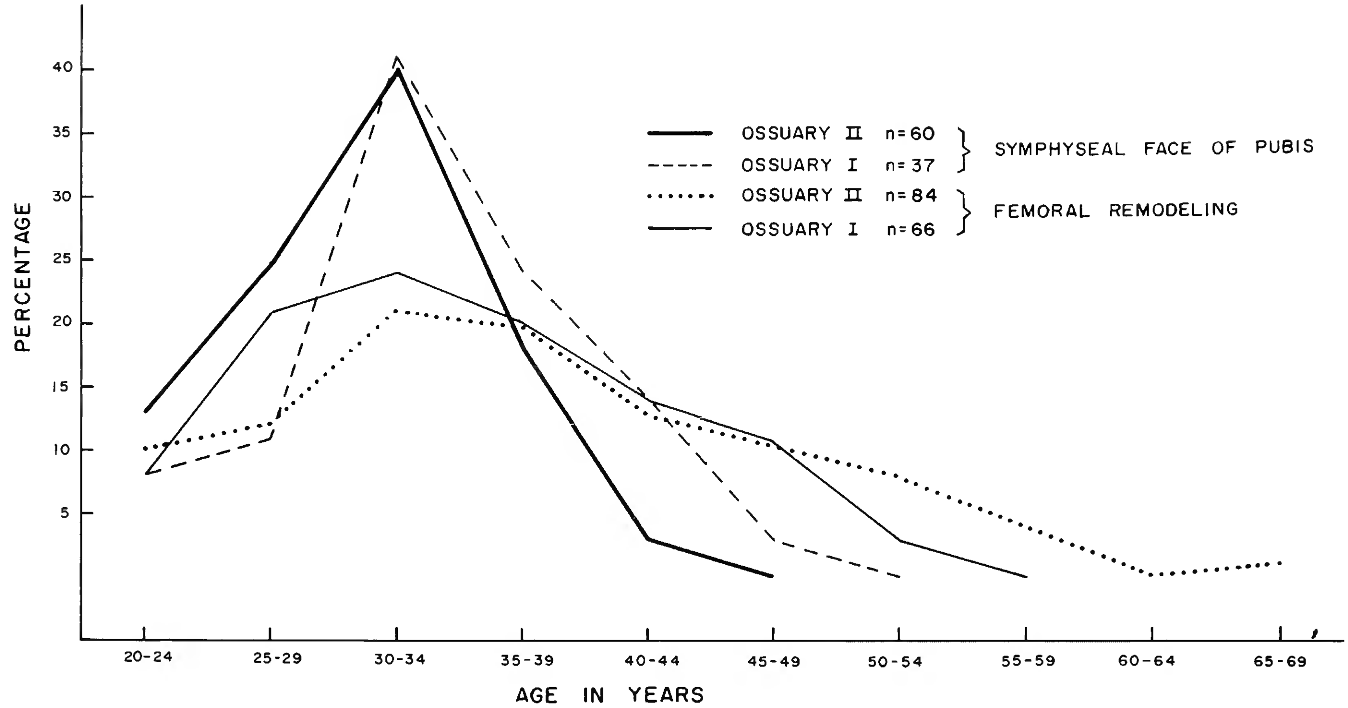


FIGURE 25.—Comparison of adult mortality curves from Ossuaries I and II as determined from the appearance of the symphyseal faces of the pubes and the degree of microscopic cortical remodeling in the femora.

tion. As discussed earlier, the presence of extraneous substances in the bone cortex presented time-consuming methodological problems in specimen preparation. However, additional sections for each specimen were prepared and subjected to more thorough cleaning until accurate evaluations could be made.

Both aging methods assume that the standards developed from modern populations are applicable to prehistoric populations from different cultural and environmental areas. Todd (1921) found that little difference exists between Whites and Negroes in the rate of symphyseal metamorphosis. Probably, therefore, if the prehistoric population represented in the ossuaries is different in this respect, the difference is minimal. The possibility is greater that the osteon remodeling rates are different between populations, since remodeling is strongly influenced by physical activity. If the Indians represented in the ossuaries were more active than the populations represented in Ahlqvist's and Damsten's sample, and had faster osteon turnover rates, then the regression formula might overestimate the age at death. However, Ahlqvist (pers. comm.) has indicated that the samples used in the Ahlqvist and Damsten study were taken from routine autopsies, and probably represent predominantly lower economic class individuals, who may have approached the Indians in physical activity. Even though such factors as alcoholism, arteriosclerosis, and cardiovascular disease may affect osteon turnover rates (Ortner, 1970), there is no indication that these diseases were more prevalent in the Ahlqvist and Damsten sample than in the Indians from the ossuaries. In the absence of any further such adverse evidence, the femoral osteon method appears to be the more accurate method for the present purpose.

An additional justification for relying upon age estimates calculated from femoral osteon counts involves the relative representation of femora and pubes in the ossuaries. Whereas age estimates from the pubes represent only 54 percent and 61 percent of adults in Ossuaries I and II, respectively, those from the femora represent 96 percent and 85 percent, respectively. Consequently, most of the difference between death curves can be explained by the absence of older pubes from the ossuary samples. This explanation is logical since the older, fragile, osteoporotic pubes would probably be damaged easier than the younger ones.

Reconstruction of Demographic Profiles and Population Size

The ethnohistorical and archeological information presented earlier suggests that the ossuaries contain nearly a complete representation of all individuals who died in the contributing populations during a culturally prescribed number of years. Although some individuals who died away from their villages or whose bones were lost prior to ossuary burial may not be represented, the skeletal samples still offer a relatively unique opportunity to reconstruct demographic profiles for the formerly living populations. The procedure used in these reconstructions assumes that (1) the skeletal samples are complete, (2) the ages at death can be accurately determined, and (3) the size of the living populations and their death rates remained constant during the time interval represented by the ossuaries. The completeness of the sample and the accuracy of the age determinations have already been discussed and validated. In regards to the third assumption, there is little doubt that fluctuations in population size and mortality occurred. However, since only a few years are represented by each ossuary, the demographic effect of these fluctuations would have been negligible.

In this chapter, the ages at death of the individuals in the two ossuaries are used to construct mortality curves, survivorship curves and life tables for the populations represented. These statistics offer important demographic data on longevity, age-specific mortality, and life expectancy at all ages. Crude mortality rates (i.e., numbers of individuals dying annually for every 1000 of the living population) are calculated from the life tables. Archeological data then provide clues as to the length of time represented by each ossuary. Finally, all of these data are considered in estimating the total population size. The terms Population I and II are introduced in this chapter to refer to the living populations represented by each ossuary.

Table 37 shows the frequency of deaths by 5-year age intervals in the two ossuaries. As discussed in the last chapter, age estimates below 20 years were determined from femoral length and stages of epiphyseal union, while ages 20 years and over were calculated from femoral microscopic cortical remodeling. Only 5 and 8 percent of the total individuals in Ossuaries I and II, respectively, are not represented by femora.

TABLE 37.—*Age distribution of subadults and adults from Ossuaries I and II as estimated from femoral length and epiphyseal union (0–20 years) and femoral microscopic remodeling (20 + years)*

Age interval	Ossuary I		Ossuary II	
	No.	*%*	*No.*	*%*
0. 0– 4. 9	36	29. 03	56	32. 37
5. 0– 9. 9	14	11. 29	12	6. 94
10. 0–14. 9	6	4. 84	7	4. 05
15. 0–19. 9	2	1. 61	14	8. 09
20. 0–24. 9	5	4. 03	8	4. 62
25. 0–29. 9	14	11. 29	10	5. 78
30. 0–34. 9	16	12. 90	18	10. 40
35. 0–39. 9	13	10. 48	17	9. 83
40. 0–44. 9	9	7. 26	11	6. 36
45. 0–49. 9	7	5. 65	9	5. 20
50. 0–54. 9	2	1. 61	7	4. 05
55. 0–59. 9	0	0	3	1. 73
60. 0–64. 9	0	0	0	0
65. 0–69. 9	0	0	1	0. 58
Totals	124		173	

Mortality Curves

Figure 26 converts the percentages contained in Table 37 to mortality curves for the living populations represented by the ossuaries. The curves for the two populations are generally similar. They both show the highest frequency of deaths in the first five years of life, a dramatic decline through childhood into adolescence, a steady increase during early adulthood to a maximum adult death frequency between 30 and 35 years, followed by a steady decline after age 35.

Perhaps the most significant difference between the two curves is in the period of adolescence. The curve for Population I reached a low of 2 percent between 15 and 20 years, whereas that for Population II is 8 percent, an actual increase of 4 percent over the previous interval. Although there are only two individuals in Ossuary I between ages 15 and 20, Ossuary II contains 14 in that interval. Several of the 15 to 20 year-olds in Ossuary II had femora with small head

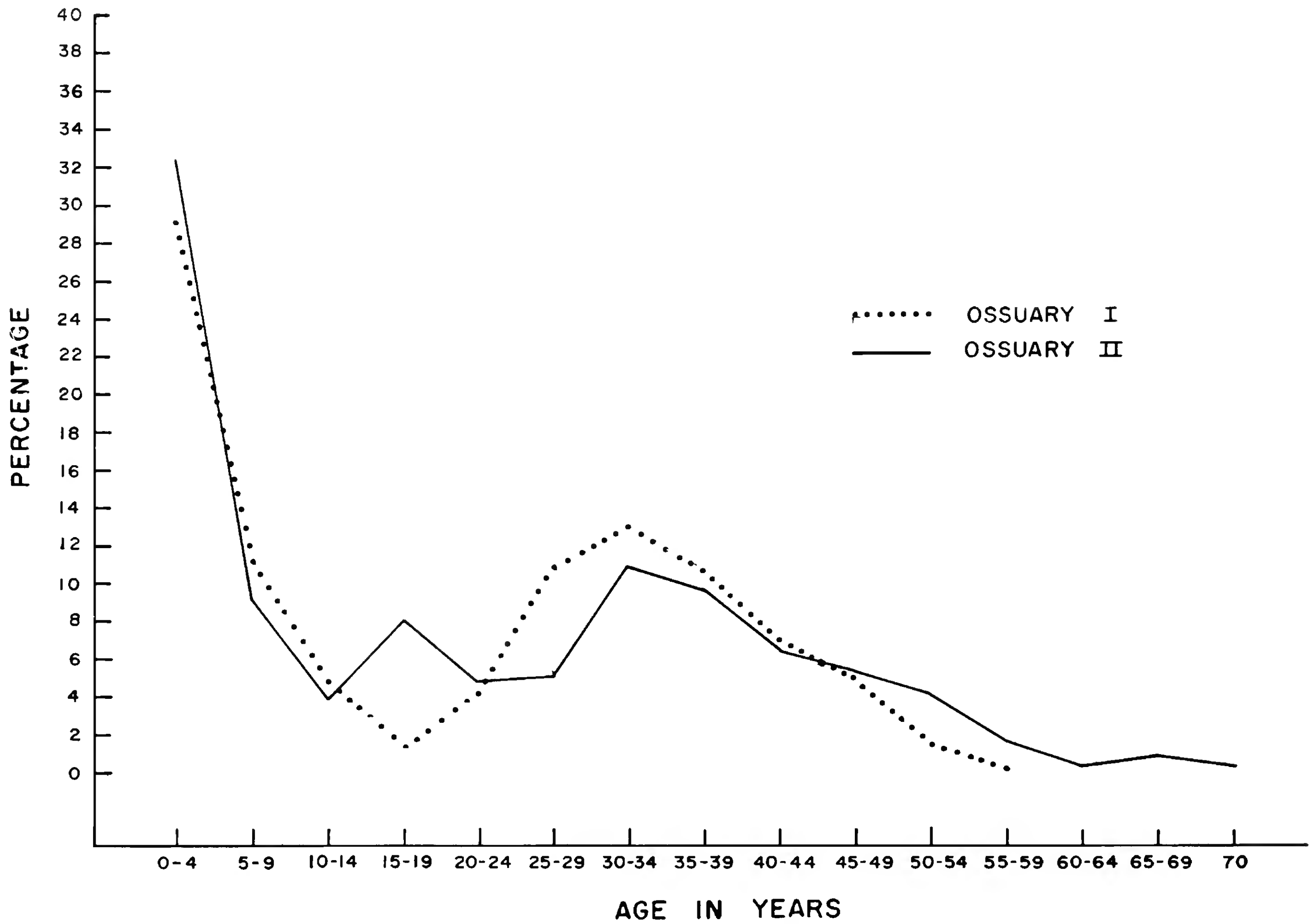


FIGURE 26.—Comparison of mortality curves calculated from Ossuaries I and II.

diameters suggesting they probably were females, whose deaths perhaps reflect problems resulting from childbirth.

The remaining differences between the two curves are largely products of greater longevity in Population II. More individuals were dying in Population I during the early adult years 20 to 35. Death frequencies were the same between ages 35 and 45, but after age 45, more individuals were dying in Population II than in Population I. No one lived past age 55 in Population I, whereas three percent of Population II exceeded that age, with one individual living to nearly 66 years.

Survivorship Curves

Differences in mortality between populations are more clearly revealed through survivorship curves (Figure 27). A curve of survivorship is merely the reverse of the mortality curve and plots the percentage of the original population surviving after each five-year interval. According to Figure 27 for example, 71 percent of all individuals born in Population I were still alive after five years, while only 68 percent of Population II were living. Survivors were approximately equal by ages 10 and 15 years. Then the higher mortality of adolescent females discussed earlier for Population II, created a higher survivorship for Population I by ages 20 and 25. The higher death rate between ages 25 and 30 in Population I restored an equality of survivors by age 30. After age 30, greater longevity in Population II was reflected by a proportionately greater number of survivors in each successive age category, until 70 years when there were no survivors remaining in either population. In short, the curve of survivorship accentuates the differences between the two populations, documenting that Population II exhibited a higher infant and adolescent mortality, but greater adult longevity.

Life Tables

Perhaps the most informative of all statistical presentations of demographic data is the life table. The procedure of life table construction has been summarized by several in-

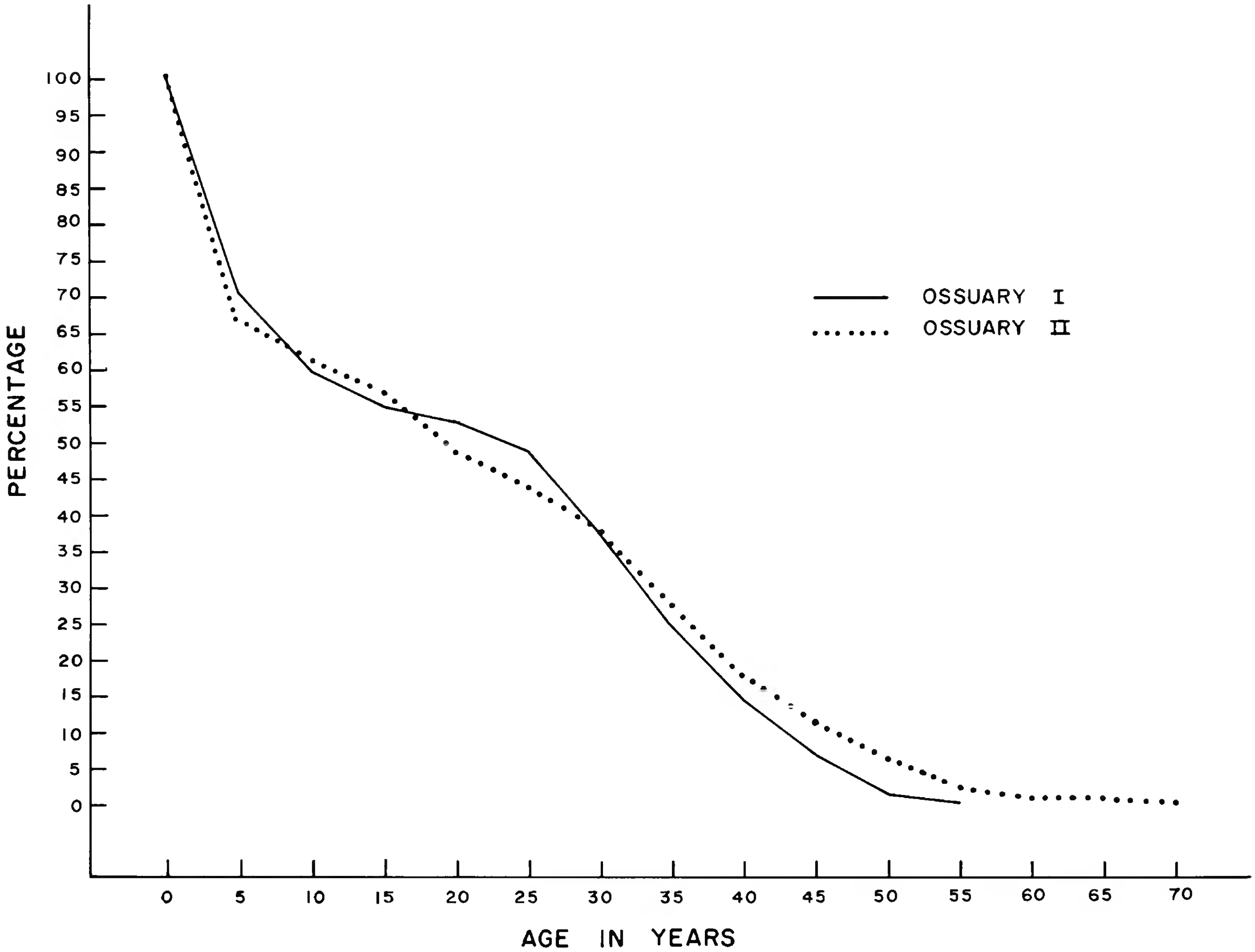


FIGURE 27.—Comparison of survivorship curves calculated from Ossuaries I and II.

vestigators (Swedlund and Armelagos, 1969; Acsádi and Nemeskéri, 1970) and will not be discussed in detail here. Essentially, it involves computing a number of attributes that characterize the demographic structure of the living population and that can be compared with data taken from both living and skeletal populations. The life table contains calculations for x, the age interval; Dx, the total number of deaths occurring in age interval x; dx, the percentage of total deaths occurring in age interval x; lx, the number of survivors of age interval x; qx, the probability of dying at age interval x; Lx, the total number of years lived between age interval x and the following age interval; Tx, the total number of years lived after a lifetime of all individuals who reach the age interval x; and e^0x, the life expectancy of an individual of age x.

Two types of life tables are usually employed by demographers studying modern populations: generation life tables and current life tables (Dublin and Spiegleman, 1941). Although both types are organized in the manner previously described, they differ in the type of population sample they draw upon. Generation life tables are constructed from data obtained by following a generation of people from birth until death, recording age at death for each individual in the population. Obviously, such tables must be recorded in retrospect, using well-documented death records.

Usually the records necessary for generation life table construction are not available and demographers must construct current life tables instead. These tables are constructed from age distributions within living populations, and assume that the mortality rates suggested by the population composition will remain constant throughout the lives of the individuals in the population examined. Of course, in modern human populations, this assumption is not valid. For example, changing medical practices markedly affect mortality rates over periods of 50 to 70 years. In fact, Dublin and Spiegelman (1941) have shown that the difference between current and generation life tables can be an effective measure of improvement in public health. Although some demographers (Fisher, 1923; Dublin and Lotka, 1963) have attempted to modify current life tables to compensate for this effect, their tables remain only approximations for the populations described.

The basic concepts underlying current life table reconstruction have been applied by biologists and ecologists to the study of demography in wild animal populations. Nonhuman populations in natural environments display relatively stable mortality as long as the environment remains generally unchanged. Using various methods to determine age at death, biologists have constructed life tables, survivorship curves, and other demographic statistics for Dall mountain sheep (Murie, 1944), rotifers (Edmondson, 1945), herring gulls (H. Marshall, 1947), robins, blackbirds, song thrushes, starlings, and lapwings (Lack, 1943), barnacles (Hatton, 1938), rabbits (Green and Evans, 1940a, 1940b, 1940c), sunfish (Ricker, 1945), lizards (Tinkle, 1961, 1967; Tinkle, Wilbur, Tilley, 1970), mosquitos (Crovello and Hacker, 1972), and many other species (Deevey, 1947). All of these studies demand adequate samples and accurate age determinations and assume that demographic features remain relatively stable throughout the lifespan of the population.

Angel (1947), and Swedlund and Armelagos (1969) have suggested that the approach to life table construction utilized by biologists can be applied successfully to prehistoric human populations as well. Since most archeological populations did not experience the rapid nutritional and medical advances of modern populations, they approach the demographic stability documented for nonhuman populations in natural environments. The similarity of aging techniques available to both the biologist and physical anthropologist and the homogeneity of archeological populations further validate the use of the current life table in prehistoric demographic reconstruction. It should be noted that Angel (1969a) now avoids using the life table for demographic reconstruction, feeling that population instability and the loss of infants during the period of cemetery use might introduce error. However, population instability should affect all demographic data, not just the life table, and should be negligible for the short periods of time represented by ossuaries.

The life tables for Populations I and II presented in Tables 38 and 39 were computed as follows: the symbol "x" represents the total span of years contained in each age interval. Although modern life tables utilize age intervals of single years, a five-year age interval is used in this study since aging criteria for adults contain approximately a five-year standard error. A smaller interval would be misleading due to aging errors and a larger interval would limit the information gained from the analysis.

The total number of deaths (Dx) for each age interval is weighted so that the total deaths in the life tables equal the total number of individuals in the ossuaries. The weighting assumes that the missing femora are evenly distributed among all age intervals in the group considered. Although there is no assurance that the missing femora are evenly distributed, the assumption must be made since a complete representation is needed. Adults and subadults were weighted separately to equal the minimum adult and subadult representation as determined from individual bone counts. Weighting factors of 1.07, 1.05, and 1.18 were applied to the femoral counts of Ossuary I subadults, Ossuary I adults, and Ossuary II adults, respectively. A weighting factor is not needed for Ossuary II subadults since the minimum count actually came from the femora.

The number of survivors at each age interval (lx) is calculated by subtracting the percentage of deaths (dx) in the age interval from the number of survivors entering that interval, beginning with an initial number of 100

TABLE 38.—*Life table reconstructed from Ossuary I age distribution*

Age interval (*x*)	*No. of deaths* (*Dx*)	*% of deaths* (*dx*)	*Survivors* (*lx*)	*Probability of death* (*qx*)	*Total no. yrs. lived between x and x + 5* (*Lx*)	*Total no. yrs. lived after lifetime* (*Tx*)	*Life expectancy* (e^ox)
0	0	0	100.00	.0000	426.125	2105.600	21.06
5	39	29.55	70.45	.2955	323.850	1679.475	23.84
10	15	11.36	60.09	.1612	284.075	1335.625	22.60
15	6	4.55	54.54	.0770	268.900	1071.550	19.65
20	2	1.52	53.02	.0279	255.625	802.650	15.14
25	5	3.79	49.23	.0715	217.750	547.025	11.11
30	15	11.36	37.87	.0308	157.150	329.275	8.69
35	17	12.88	24.99	.3401	98.425	172.125	6.89
40	14	10.61	14.39	.4246	51.075	73.700	5.13
45	11	8.33	6.05	.5793	18.875	22.625	3.74
50	6	4.55	1.50	.7521	3.750	5.750	[illegible].50
55	2	1.52	0.00	1.0000	0.000	0.000	0.00
60	0	0	0.00	0.0000	0.000	0.000	0.00

TABLE 39.—*Life table reconstructed from Ossuary II age distribution*

Age interval (*x*)	*No. of deaths* (*Dx*)	*% of deaths* (*dx*)	*Survivors* (*lx*)	*Probability of death* (*qx*)	*Total no. yrs. lived between x and x + 5* (*Lx*)	*Total no. yrs. lived after lifetime* (*Tx*)	*Life expectancy* (*e°x*)
0	0	0	100. 00	. 0000	425. 525	2297. 900	22. 98
5	56	29. 79	70. 21	. 2979	335. 100	1872. 375	26. 67
10	12	6. 38	63. 83	. 0909	309. 850	1537. 275	24. 08
15	7	3. 72	60. 11	. 0583	281. 925	1227. 425	20. 42
20	14	7. 45	52. 66	. 1239	251. 325	945. 500	17. 95
25	9	4. 79	47. 87	. 0910	223. 400	694. 175	14. 50
30	12	6. 38	41. 49	. 1333	179. 525	470. 775	11. 35
35	21	11. 17	30. 32	. 2692	125. 000	291. 250	9. 61
40	20	10. 64	19. 68	. 3509	81. 125	166. 250	8. 45
45	13	6. 91	12. 77	. 3511	49. 225	85. 125	6. 67
50	11	5. 85	6. 92	. 4581	23. 950	35. 900	5. 19
55	8	4. 26	2. 66	. 6156	7. 975	11. 950	4. 49
60	4	2. 13	0. 53	. 8008	2. 650	3. 975	7. 50
65	0	0. 00	0. 53	. 0000	1. 325	1. 325	2. 50
70	1	0. 53	0. 00	1. 0000	0. 000	0. 000	0. 00
75	0	0. 00	0. 00	. 0000	0. 000	0. 000	0. 00

survivors. Survivorship values in the life table directly reflect mortality and correspond to the survivorship curves discussed earlier.

The probability of death (qx) for each age interval is computed by dividing the percentage of deaths in the age interval by the number of survivors of that interval. The figure represents the probability of individual death in each age category and provides a valuable index of age-specific mortality.

Calculations of life expectancy values (e°x) necessitate initial determinations of (1) the total number of years (Lx) lived between age interval x and the following interval, and (2) the total number of years (Tx) lived by all survivors of age interval x. The value of Lx is determined from the formula

$$Lx=\frac{5\,(lx+lo)}{2}$$

where lo is the number of survivors of the age interval following interval x. The factor of 5 is introduced, since the life table is abridged to a 5-year age interval.

The value of Tx is derived from the Lx value by the formula

$$Tx=\sum_{x}^{w-1} Lx.$$

The value expresses the total number of years that can be lived by the survivors of each interval. The Tx value has no demographic significance in itself, but is used to calculate life expectancy by the formula

$$e_x{}^{o}=\frac{Tx}{lx}.$$

Consequently life expectancy at birth is computed by the formula

$$e_0{}^{0}=\frac{To}{lo}.$$

A comparison of life tables for the two populations reveals important demographic information. The percentage of deaths (dx) and the number of survivors (lx) have already been discussed. A comparison of qx for each population reveals differences in age-specific mortality. The probability of dying in Population I is greater than in Population II for all ages except 15–20 and 20–25 years. In both of these age intervals, the probability of dying was greater in Population II, reflecting the high incidence of adolescent and young adult deaths expressed in the mortality curve.

Life expectancy for Population II was greater than for Population I in all age intervals. A newborn entering Population I could expect to live only 21 years. However, if the child was one of the 71 percent that survived the first five years, it could expect to live another 24 years. After age 10, life expectancy diminished with age until by age 50 only 1.5 percent of the original population was still alive and their life expectancy was a mere 2.5 years. Similarly, the average newborn entering Population II could expect to live about 23 years, an 8 percent increase over life expectancy at birth in Population I. If the child in Population II was among the 70 percent living to age five, it could expect to live an average of 27 more years. Life expectancy declined steadily thereafter until age 65, when the surviving 0.53 percent of the original population could expect to live only 2.5 more years. In Population I, the age intervals with the lowest probabilities of death are 15–19 and 20–24 years. In Population II, they are 10–15 and 5–10 years, reflecting the higher mortality of adolescents and young adults in the latter population.

Table 40 lists life expectancy figures at birth for several populations. While the figures for archeological populations are practically all that are available, they have little comparative value, due to sample inadequacies and differences in methods of age determination. For example, the high life expectancy for Pecos Pueblo was calculated by Goldstein (1953) on ages published by Hooton (1930), and originally determined by Todd (1927:494), who admits that "the very young children are represented by such scattered remnants that, as usual, they must be discarded." In the absence of the probable high number of infant skeletons, Goldstein's calculation of life expectancy at 42.9 years has little meaning.

Stewart (1962) has shown that the data on the Archaic Indian Knoll population from Kentucky (see Table 40) are of limited value since only part of the sample was considered and questionable criteria were used to determine age.

The data from Nubia (Swedlund and Armelagos, 1969; Table 40) are derived from 328 skelctons excavated from a Meinarti cemetery. Although the archeologists intensively excavated the major portion of the cemetery, part of it had eroded away prior to excavation. In addition, most of the skeletons excavated had been disturbed, leaving the overall completeness of the sample somewhat questionable. Swedlund and Armelagos estimated the ages at death from a combination of stages of dental eruption and changes in the pubic symphyses.

The remainder of the comparisons in Table 40 suggest that life expectancy at Nanjemoy was very close to that of Ancient Greece, but substantially lower than that of 11–16th century England, 19th century United States Whites, 20th century United States Negroes and modern populations of India and England.

In addition to the foregoing Churcher and Kenyon (1960) studied two Huron ossuaries which unfortunately had been disturbed prior to excavation, first by construction equipment and then by local looters. Their analysis revealed that of 90 recorded skeletal ages, only five were under 10 years, while 29 were between ages 16 and 20. Such an unusual preadolescent death rate probably means that a considerable number of preadolescent skeletons were lost from the sample prior to analysis.

Anderson's (1964) analysis of another Iroquois ossuary indicates that his sample was probably complete. His selection of age intervals and his uncertain criteria for determining adult age, however, do not permit close comparison. He found that 28 percent of his sample was between birth and 12 years, 14 percent was between 13 and 16 years and 58 percent was "adults" over 17 years. By comparison, 36 to 41 percent of the individuals from the Nanjemoy ossuaries was between birth and 10 years, 4 to 5 percent was between 10 and 15 years and 56 to 60 percent was over 15 years of age. This crude comparison generally shows that the mortality rate in the Nanjemoy populations was higher in infancy, but lower in adolescence than that in the Huron population.

Unquestionably, data on life expectancy and age specific mortality provide an evaluation of overall population fitness and health status. However, until reliable aging techniques are applied rigorously to complete samples of carefully excavated skeletons, sound comparisons of earlier populations will not be possible. Of all skeletal samples previously reported for aboriginal North American Indian populations, only the Huron ossuary described by Anderson (1964) offers a sample suitable for meaningful demographic comparison. As we have seen, Anderson's Huron population displayed a lower infant mortality and greater adult longevity than the

TABLE 40.—*Life expectancy at birth in 15 world-wide populations, arranged in order of increasing magnitude*

Population	*Dates*	*Life expectancy (years)*	*Source*
Indian Knoll, Kentucky	3000 B.C	18.6	Johnston and Snow, 1961: 241
Nubia, Egypt	A.D. 1050–1600	19.2	Swedlund and Armelagos, 1969: 1293
Nanjemoy, Ossuary I	A.D. 1500–1600	20.9	
Nanjemoy, Ossuary II	A.D. 1500–1600	22.9	
Ancient Greeks	670 B.C.–A.D. 600	23.0	Goldstein, 1953: 4
Texas Indians	A.D. 850–1700	30.5	Goldstein, 1953: 4
European ruling families	A.D. 1480-1579	33.7	Goldstein, 1953: 4
U.S. Caucasian	A.D. 1800	30.0–35.0	Goldstein, 1953: 4
U.S. Negro	A.D. 1900	33.8	Goldstein, 1953: 4
English	A.D. 1000-1100	35.3	Goldstein, 1953: 4
India (Females)	A.D. 1951–1960	40.6	Klebba, 1971: 2
India (Males)	A.D. 1951–1960	41.9	Klebba, 1971: 2
Pecos Pueblo	A.D. 800–1700	42.9	Goldstein, 1953: 4
England and Wales (Males)	A.D. 1965–1967	68.7	Klebba, 1971: 2
England and Wales (Females)	A.D. 1965-1967	74.9	Klebba, 1971: 2

Nanjemoy populations, but his choice of age intervals eliminates more detailed life table comparisons.

Life expectancy in both the Huron and Nanjemoy populations was markedly lower than among the 16th century European ruling families (Table 40). Sigerist (1965) has suggested however, that life expectancy at birth was as low as 20 to 25 years among European general populations during the 15th century. If his calculations are correct, they would indicate that overall life expectancy and mortality may have been approximately the same for the general populations in both Europe and North America during the 16th century. Recent medical advances of course, have led to markedly higher life expectancy in many countries, and even to a current peak of over 70 years in the United States. Most of this recent nearly 50-year increase in life expectancy can be accounted for by the remarkable reduction in infant mortality, following the introduction of antibiotics and other medical aids.

Crude Mortality Rates

Another statistic that not only provides information about mortality and longevity, but that can also lead to the reconstruction of population size is the crude mortality rate. This rate is usually expressed as the number of individuals dying per thousand per year, or less commonly as the number per hundred per year. The figure is a direct reflection of overall life expectancy and can present evidence for population decline, equilibrium, or expansion when considered in relation to the birth rate.

In the past, crude mortality rates have been derived by comparing age distributions within skeletal samples with age distributions documented for populations with known mortality rates. For example, Hooton (1920) compared the distributions of deaths determined from his Madisonville, Ohio skeletal material with documented deaths for a number of European populations (Table 41). His skeletal sample closely matched the Switzerland sample for the years 1873–1877 which had a recorded death rate of 2.38 per hundred per year. Hooton then extended the death rate at Madisonville to 3.0 per hundred to allow for infants that may have been overlooked during the excavation.

Churcher and Kenyon (1960) used Hooton's 1920 table for a comparison of their skeletal sample from the Tabor Hill ossuaries. The distribution of ages at death from their ossuary material matched that recorded for France during the period 1866–1877, when the documented death rate was 2.46 per hundred. Allowing for a few missing infants, they rounded the figure to 3.0 per 100 and calculated the size of the population contributing to the ossuary.

Assuming a constant rate of deaths, the crude mortality rate can be calculated directly from the life table by the formula

$$M=\frac{1}{e^{o}}$$

where M is the crude mortality rate and e^{o} is life expectancy at birth (Acsádi and Nemeskéri, 1970:67). The application of this formula to the ossuary data produces a crude death rate of 47.8 per thousand for Population I and 43.5 per thousand for Population II. Table 42 compares these death rates with those calculated from other skeletal populations. The table shows that Nanjemoy death rates were lower than those of the protohistoric Arikara populations, the archaic Indian Knoll sample, and Angel's Middle Bronze age populations from Lerna, Greece, but higher than Hooton's Madisonville, Ohio, sample and Churcher and Kenyon's Huron population. Again the comparisons are of limited value since much of the variation probably reflects differences in the completeness of the samples. Certainly the low death rate offered for the Tabor Hill ossuaries is influenced by the loss of infants. Consequently, perhaps the only really meaningful comparisons are those between the two ossuaries from Nanjemoy Creek.

Population Reconstruction

The calculation of the crude death rate not only permits comparison of mortality rates, but also provides data that can be utilized to reconstruct population size. Since the mortality rate equals the number of individuals dying per thousand per annum, a knowledge of the total number

TABLE 41.—*Correlation of ages at death with known annual death rates* (after Hooton, 1920:21)

Place	*Period*	*Age 0–10* %	*10–20* %	*20+* %	*Period*	*Aver. annual death rate*
Italy	1872–77	52. 37	4. 22	43. 41	1865–78	2. 99
France	1866–77	32. 28	4. 25	63. 47	1865–77	2. 46
England	1860–70	44. 23	4. 56	51. 21	1865–78	2. 20
Prussia	1875–77	52. 43	3. 51	44. 06	1865–78	2. 72
Bavaria	1871–77	52. 61	2. 22	45. 17	1865–78	3. 09
Austria	1865–77	52. 38	4. 05	43. 57	1865–78	3. 18
Spain	1865–70	51. 86	4. 37	43. 77	1865–70	3. 12
Russia	1870–74	62. 33	4. 13	33. 54	1865–75	3. 67
Switzerland	1873–77	36. 94	3. 72	59. 33	1870–78	2. 38

525-413 O - 74 - 6

TABLE 42.—*Death rate estimates from eight skeletal populations*

Site	*Location*	*Death rate*
Madisonville	Ohio	30
Tabor Hill	Ontario	30
Nanjemoy, Ossuary II	Maryland	44
Nanjemoy, Ossuary I	Maryland	48
Sully	South Dakota	54
Lerna	Greece	56
Indian Knoll	Kentucky	59
Leavenworth	South Dakota	63

of dead in the ossuary and the length of time represented by the ossuary can lead to an accurate determination of the size of the contributing population. This calculation may be represented by the formula

$$P=\frac{1000\ N}{M\ T}$$

where P is population size, N is the number of individuals in the ossuary, M is the mortality rate expressed in the number of deaths per annum per 1000 of the population, and T is the number of years represented by each ossuary. The values of all of these figures except T have been determined for the ossuaries.

The length of time represented by a single mid-Atlantic ossuary can be estimated from the different degrees of bone articulation, observed during excavation. A discussion of the three stages of articulation that were observed during the excavation of Ossuary II is given in detail on pp. 28–30: (1) completely disarticulated bones; (2) partially-articulated skeletal parts; and (3) completely-articulated skeletons. Undoubtably, the degree of articulation directly reflects the length of time the skeleton remained in the primary repository between the time of death and time of ossuary burial. Consequently, the ratio of individuals represented by disarticulated bones to individuals represented by partially articulated skeletal parts should increase as the length of time between ossuary deposits increases. Of course, the ratio of partially articulated individuals to completely articulated individuals would remain constant as long as the death rate and decomposition rate remains the same.

Table 6 summarizes the number of adults represented by partially articulated skeletal parts in Ossuary II. At least 23 adults had articulated foot bones, followed by 20 adults with articulated tibiae and fibulae. These data indicate that approximately 20 percent of the 99 adults in the ossuary had died soon enough before the ossuary burial that their lower leg bones were still held together by ligaments. Consequently, if both the death rate and decomposition rate remained constant, then the length of time represented by the partially articulated bones would be approximately 20 percent of the length of time represented by the entire ossuary. This relationship can be expressed by the formula $T = .42\ t$, where T is the length of time (in years) represented by the entire ossuary and t is the length of time (in months) represented by the partially articulated lower leg bones.

Table 43 presents a series of ossuary time intervals as calculated from different rates of decomposition using this formula. The table shows that if total decomposition of all soft parts was accomplished within one month after death, then the entire ossuary would represent less than a six month period of accumulation. At the other extreme, if two years were required for the decomposition of soft parts, then the ossuary would represent about a 10-year accumulation.

Unfortunately, there are few data on the rate of body tissue decomposition, especially for a prehistoric scaffold situation. T. K. Marshall (1968) notes that decomposition rates can be quite variable depending upon such factors as climate, protection of clothing, and accessibility to scavengers, rodents, and insects. Marshall claims that in a very dry environment, a body may become partially mummified and remain in that state for years. In contrast, a body left on the ground surface in damp climates may be reduced to bones in several weeks. Both T. D. Stewart and J. L. Angel (pers. comm.) have observed medical-legal cases where a body left exposed on the ground was reduced to bone in less than one month, especially when it was accessible to scavenging birds and mammals. Bodies placed by the mid-Atlantic Indians in death houses or scaffolds may have been protected from many scavengers, but bacteria, maggots, and perhaps birds would insure that decomposition and defleshing would proceed rapidly. Thus, even allowing for deaths during the winter months, it is doubtful that lower-leg bone

TABLE 43.—*A comparison of possible time intervals* (T) *represented by Ossuary II, assuming different rates of decomposition* (t), *as calculated by the formula* $T=.42\ t$

Decomposition rate "t" (possible no. of months required for lower leg bones to become disarticulated)	*Time interval "T" (corresponding no. of years represented by total accumulation)*
1	4
2	.8
3	1.3
4	1.7
5	2.1
6	2.5
7	2.9
8	3.4
9	3.8
10	4.2
11	4.6
12	5.0
18	7.6
24	10.0

articulation could have been maintained longer than eight months after death. This figure implies that the entire ossuary represents approximately a 3-year accumulation. Of course, this is only an approximation and the exact intervals cannot be determined until more data on decomposition rates are available for the mid-Atlantic area. However, the actual interval was certainly less than the 10-year interval documented for the Huron of Canada. The 20 individuals in Ossuary II with articulated lower legs would have to reflect a 2-year accumulation of the dead for the entire ossuary to represent a Huron-like interval of 10 years. It seems unlikely that the bones of the feet and lower legs could remain articulated after two years of exposure on a scaffold or in a death house above ground. More probably, articulation was maintained only about 8 months, suggesting the time interval of only 3 years.

Although this suggested 3-year interval is considerably less than that documented for the Huron, it is compatible with intervals suggested for Algonquian groups in the Great Lakes region. In 1709, Raudot (1940: 368) mentioned that the Algonquian feast of the dead was held every 3 years. In contrast, Hickerson (1960: 88) believed that the event was annual with seven or eight distinct groups participating. He interpreted the accounts of Perrot (Blair, 1911: 88), Radisson (Scull, 1943: 199), and Beschefer (Thwaites, 1896–1901, LXII: 201) to indicate that the seven or eight Algonquian groups communally buried their dead, and rotated the place of ossuary burial so that a particular group would host the ceremony once every 7 or 8 years.

Table 44 gives a series of population estimates for each of the two Nanjemoy ossuaries, calculated from different theoretical time intervals by the formula

$$P=\frac{1000\ N}{MT}.$$

Those from Ossuary I range from 5481, assuming a time interval of 6 months, to 183, assuming a time interval of 15 years; whereas those for Ossuary II range from 8644, for a 6-month interval to 288 for a 15-year interval. The time interval of about 3-years suggested by the partial-articulation data from Ossuary II indicates a size of 914 for Population I and 1441 for Population II.

TABLE 44.—*A comparison of possible population sizes assuming different time intervals, as calculated from Ossuary II by the formula* $P=\frac{1000\ N}{M\ T}$

Time interval (T) (years)	*Population size (P)*	
	Ossuary I	*Ossuary II*
.5	5481	8644
1.0	2741	4322
2.0	1370	2161
3.0	914	1441
4.0	685	1080
5.0	548	864
6.0	460	720
7.0	392	617
8.0	343	540
9.0	305	480
10.0	274	432
15.0	183	288

TABLE 45.—*A comparison of possible population sizes assuming different time intervals, as calculated from Ossuary II by the formula* $P=K+\frac{De_0^o}{T}$

Time interval (T) (years)	*Population size (P)*	
	Ossuary I	*Ossuary II*
0.5	5518	8641
1.0	2759	4320
2.0	1380	2160
3.0	920	1440
4.0	690	1080
5.0	552	865
6.0	460	721
7.0	397	618
8.0	346	541
9.0	307	481
10.0	277	433
15.0	185	290

Population size can be estimated also by the formula

$$P=K+\frac{De_0^o}{T}$$

where P is the average population size, D is the total number of dead, e_0^o is life expectancy at birth, T is the time interval, and K is a correction factor equal to 10 percent of the value of T (Acsádi and Nemeskéri, 1970: 65). The application of this formula to the ossuary material produced the population estimates in Table 45 for different values of T. A comparison of Table 44 with Table 45 shows that population estimates calculated from the two formulae are nearly the same.

It appears unlikely that the entire population contributing to either of the Nanjemoy ossuaries could have occupied the habitation site adjacent thereto. Preliminary testing by T. D. Stewart revealed that cultural debris (pottery, shell, animal bone, and lithic material) was concentrated within an area of approximately 106 square meters (1000 ft^2), extending 50 meters (150 ft) west from the Juhle residence (Figure 4). If all of the population contributing to Ossuary II resided in that area, a population density of over eleven persons per square meter (1.2 per ft^2) would be suggested. Obviously, such overcrowding was unlikely, and hence much of the population must have lived elsewhere. It is possible that the occupation area is actually much larger than revealed by Stewart's testing; however, only exhaustive excavation can determine the actual extent. At this time, it appears more probable that several settlements in addition to the village at 18CH89 buried their dead in the ossuaries.

John Smith's map of 1612 (Arber, 1884:384–385) lists 28 villages in the area occupied historically by the Conoy.

This area consists of the part of southwestern Maryland, south of the present city of Washington, D.C., that is bordered on the west by the Potomac River and on the east by the Chesapeake Bay (Figure 1). On Smith's map, 5 of these 28 villages (each hereafter referred to as a "chief's village") are accompanied by a symbol which indicates they contained the house of a chief, in addition to the houses of common people. The remaining 23 villages (each hereafter referred to as a "common village") lack such symbols and therefore contained only houses of common people. The map suggests a ratio of approximately one chief for five to six villages. Consequently, if we assume that the Nanjemoy ossuaries represent the communal dead of the five or six villages governed by a single chief, then each village would contain an average of about 235 people. Such population estimates compare favorably with Smith's counts of 20 to 100 warriors for the villages in that area. The occurrences of ossuaries associated with many of the villages in the area may reflect a Huron-like practice of rotating the site of ossuary burial from village to village.

Regardless of whether a number of villages were represented by the ossuaries, a comparison of the population estimates derived from Ossuaries I and II suggests the existence of temporal demographic oscillations. Unfortunately, the associated cultural artifacts are not sufficiently diagnostic to establish which of the ossuaries is the older. The ceramics indicate only that both ossuaries date from just prior to European contact. Whatever the temporal ordering, the population represented by Ossuary II was 58 percent larger than that of Ossuary I. Also, it exhibited a greater life expectancy at birth, a greater longevity, a lower over-all mortality rate, and a higher adolescent mortality rate. If Ossuary I preceded Ossuary II, then the data indicate a rapidly expanding population with increases in longevity, adolescent mortality, life expectancy at birth and decreases in over-all mortality. If Ossuary II is older, then the evidence would suggest the opposite situation, namely, a rapidly declining population, with decreases in longevity, adolescent mortality and life expectancy, and an increase in over-all mortality. Be this as it may, Charles MacNett of American University (pers. comm.) indicates in his archeological study of Late Woodland settlement patterns that prior to 17th-century European contact aboriginal mid-Atlantic populations were expanding rapidly in response to improved agricultural techniques and more efficient food procurement systems. Of course, with the advent of cultural conflict and the introduction of new diseases following initial European contact, aboriginal populations decreased markedly in numbers. Since the Nanjemoy ossuaries lack European-manufactured trade materials, however, they probably represent pre-contact populations. I think it is reasonable to believe therefore, that they were enjoying the population expansion and increased longevity indicated when Ossuary I is assumed to be earlier than Ossuary II. Of course, the size difference between ossuaries also could reflect a change in the size of the social-political unit contributing to the ossuaries.

Regional Population Estimates

The question may now be asked: What bearing do these local population estimates have on the population estimates of the total tidewater Potomac area at the time of European contact? Most of the frequently quoted figures for the latter area can be traced to James Mooney. Although he used figures on the tidewater Potomac area as part of the basis of his total North American Indian population estimate (Mooney, 1910), his more detailed account was not published until after his death (Mooney, 1928). In the preface, John R. Swanton cautioned that the figures had not been arranged in final tabulation at the time of Mooney's death, but he expressed confidence in their accuracy because "it is known that, in some cases, he [Mooney] carried his investigations back to the original census rolls" (Mooney, 1928:2). Kroeber (1939) likewise showed confidence in Mooney's estimates by using them almost without alteration for his own purpose.

Mooney estimated the total aboriginal population of Virginia to be 15,100, but that of Maryland and Delaware to be only 4700, with the Conoy or Piscataway of southwestern Maryland contributing a mere 2000. Although the exact methods employed by Mooney to produce these figures have never been published, Mook (1944) detected a proportional relationship between Smith's Virginia warrior counts and Mooney's total Virginia population estimates. This suggested to him that Mooney's Virginia estimates might have been produced by multiplying Smith's warrior counts for each village by a factor of about 4.5 to account for the number of nonwarriors in the total population. The factor of 4.5 was derived by Mook by dividing Mooney's total population estimates by Smith's total warrior counts.

Following Mooney's death, all of his unpublished manuscripts, notes, and miscellaneous data became a part of the Bureau of American Ethnology Archives and recently were transferred to the National Anthropological Archives in the National Museum of Natural History. Among these records are several scraps of paper which contain Mooney's original population calculations for Maryland. These documents demonstrate that Mooney's estimates for the Conoy were derived by considering John Smith's warrior counts for villages within the area occupied by the Conoy historically. The following warrior counts per village were listed by Mooney: Cecomocomoco, 40; Potapaco, 20; Pamacocack, 60; Moyaons, 100; and Nacotchtank, 80. He then added 200 more warriors from the villages Mattpament, Pawtuxnet, and Acquintanactuck to obtain a total of 500 warriors. All of these figures agree with Smith's estimates. The warrior counts were then multiplied by 4 producing a total population of 2000 for the Conoy. Mooney's original figures show an addition of 400 more individuals, apparently to account for numerous other villages shown on Smith's map, but not mentioned in his discussion of warrior counts. Subsequently, Mooney must have ignored these other villages, since his published estimate for the Conoy is only 2000.

If Mooney's estimates are incorrect, then the error probably originates from two sources: (1) his use of the 1:4 ratio of warriors to the entire population, or (2) his failure to include estimates of all of the villages on Smith's map. Mooney's notes do not disclose the source of his 1:4 ratio. It approaches, however, the ratio implied by John Smith (in Arber, 1884:65), who wrote, "the land is not populous, for the men be fewe; their far greater number is of women and children. Within 60 miles of *James Towne* there are about some 5000 people, but of able men fit for their warres scarse 1500." Smith's estimate of 1500 warriors in a population of 5000 represents a ratio of 3 to 10. Others have offered such ratios as 1:10 (McKenney, in Graham, 1935:4), 3:10 (Jefferson, 1787:139), and 1:5 (Proud, 1797–1798, II:297).

The most accurate determination of the ratio of warriors to overall population can be made directly from the skeletons. The life tables reconstructed from the Nanjemoy ossuaries specify the number of survivors entering each age category. The number of warriors would equal approximately one-half of the number of survivors between ages 15 and 40. Age 15 would approximate the lower age limit since at about that age, boys underwent "huskanaw," the rite of passage from boyhood to manhood. According to Beverly (1705:ch. 6:41) at that time they "unlive their former lives, and commence Men, by forgetting that they ever have been Boys." The upper age limit of 40 indicates the approximate age at which most men would terminate active warrior activities, although the age could have been even lower and certainly varied with each individual. An acceptance of these age boundaries, would place the percentage of potential "warriors" at approximately 24 percent of Population I and 23 percent of Population II. The ratio of warriors to overall population would then be 1:4.12 for Ossuary I and 1:4.38 for Ossuary II, suggesting that Mooney's ratios were the most precise of all. The substitution of either of the calculated values of 4.12 or 4.38 for Mooney's factor of 4.0 would not significantly alter his overall population estimate.

Although Mooney's 1:4 ratio appears to be nearly correct, his population estimate for the Conoy is overly conservative because he did not include all of the villages in the area. Mooney's estimates were derived directly from John Smith's warrior counts for only eight villages, although Smith's map of 1612 (Arber, 1884:384–385) shows 20 additional villages in that same area. Since none of these 20 additional villages was a "chief's village," Mooney may have felt that they were too small to add significantly to the overall estimate. Smith lists 60 warriors for the "common village" of Pamacocack, however, whereas as few as 40 warriors were recorded for the "chief's village" of Cecomocomoco. Clearly therefore, all of the villages on the map need to be considered.

Warrior estimates are available for only two of the 23 "common villages," Pamacocack with 60 and Potapaco with 20. This suggests an average of 40 warriors per "common village." The application of Mooney's own factor of 4 produces an average population size of 160 for the "common villages" and indicates that the 20 "common villages" not included in Mooney's estimate represent about 3200 people. Consequently, the inclusion of these villages raises Mooney's estimate to 8400.

A comparable crude regional population estimate can be generated from the ossuary data. If the length of time between ossuary deposits was approximately 3 years, as suggested by the partial-articulation data, then a population of about 1440 would have contributed to Ossuary II. If the hypothesis discussed earlier is correct, Ossuary II represents the collective dead from five or six villages governed by a single "chief." If these political units were approximately of equal size, then the presence on Smith's map of five villages with "chiefs" would suggest a total of prehistoric Conoy population of 7200.

In conclusion, the ossuary analysis and John Smith's map both suggest that Mooney's population estimate of 2000 for the Conoy was much too conservative. The actual number must have been at least 7000 and perhaps much higher. A total population size of 8400 (suggested by Smith's map) implies a population density of over 1.2 persons per square kilometer. Kroeber, using Mooney's population estimates, suggested a density of 0.13 person per square kilometer. Not only is Kroeber's population estimate for the Conoy (2700) too conservative, however, but he considers the area inhabited by the Conoy to be 20,100 km^2 My calculations indicate that the area was closer to 6750 km^2. The higher population density of 1.2 persons per square kilometer is substantially higher than that calculated by Kroeber for either the east coast (.07 person per km^2) or for all of North America north of Mexico (.05 person per km^2), but below the figure offered by Dobyns (1966a) for the entire western hemisphere (2.1 persons per km^2). Although such figures do not necessarily mean that Mooney's tribal estimates for all of North America were too conservative, they do indicate the need for further review of his estimates, through similar detailed studies in local areas.

Within the mid-Atlantic area, future ossuary excavations should aim to discover (1) whether the length of time between ossuaries was constant in all areas; (2) whether the population size differences documented in this study represent population expansion or merely changes in the organization of the social unit contributing to the ossuary; (3)

the extent that European contact affected the demographic profiles of the aboriginal population; and (4) whether the bone distributions observed within Ossuary II were unique or represent a cultural pattern. Given this additional information, such investigations should fill many gaps in our knowledge about prehistoric mortuary practices, social systems, and demographic-environmental adaptation in the mid-Atlantic region.

Literature Cited

Acsádi, Gy, and T. Nemeskéri

1957a. Palaodemographische Probleme am Beispiel des Frümittelalterlichen Graberfeldes von Halimba—Cseres. *Homo,* 8:133–148.

1957b. Contributions à la Reconstruction de la Population de Veszprém, X[e] et XI[e] Siècles. *Annales Historico-Naturales Musei Nationalis Hungarici,* 8:435–467.

1958. La Population de la Transdanubie Nord—Est, X[e] et XI[e] Siècles. *Annales Historico-Naturales Musei Nationalis Hungarici,* 50:359–415.

1959. Analyses des Trouvailles Anthropologiques du Cimetière de Kérpuszta (XI[e] Siècle) sous L'aspect de L'age. *Acta Archaeologica Academiae Scientiarum Hungaricae,* 11:419–455. Budapest.

1960. Le Population de Székesfehérvár X[e] et XI[e] Siècles. *Annales Historico-Naturales Musei Nationalis Hungarici,* 52:481–495.

1970. *History of Human Life Span and Mortality.* Budapest: Akademiai Kiado.

Adams, R. G.

1890. *Notes on the Delaware Indians: Report on Indians Taxed and Not Taxed.* Washington: U.S. Census.

Ahlqvist, J., and O. Damsten

1969. A Modification of Kerley's Method for the Microscopic Determination of Age in Human Bones. *Journal of Forensic Sciences,* 14:205–212.

Allan, W.

1965. *The African Husbandman.* New York: Barnes and Noble.

Anderson, J. E.

1964. The People of Fairty. *National Museum of Canada Bulletin,* 193. Ottawa.

Anderson, M., and W. T. Green

1948. Lengths of the Femur and Tibia. *American Journal of Diseases of Children,* 75:279–290.

Angel, J. L.

1947. The Length of Life in Ancient Greece. *Journal of Gerontology,* 2:18–24.

1948. Health and the Course of Civilization. *Interne,* 15–18. New York.

1951a. Population Size and Microevolution in Greece. *Cold Spring Harbor Symposium on Quantitative Biology,* 15:343–351. Long Island Biological Association.

1951b. *Troy: The Human Remains.* Supplementary Monograph I. Princeton: Princeton University Press for University of Cincinnati.

1953. The Human Remains from Khirokitia. Appendix 2 *in* P. Dikaios, editor, *Khirokitia.* London: Oxford University Press.

1954. Human Biology: Health and History in Greece from First Settlement until Now. *Yearbook of the American Philosophical Society,* 98:168–174.

1957. Human Biological Changes in Ancient Greece. In *Yearbook of the American Philosophical Society,* 98:266–270.

1959. Early Helladic Skulls from Aghios Kosmas. Appendix *in Aghios Kosmas.* G. E. Mylonas, Princeton: Princeton University Press.

1968. Ecological Aspects of Paleodemography. Pages 263–270 in D. R. Brothwell, editor, The Skeletal Biology of Earlier Human Populations. *Symposium for the Study of Human Biology VIII.* London: Oxford University Press.

1969a. The Bases of Paleodemography. *American Journal of Physical Anthropology,* 30(3):427–437.

1969b. Paleodemography and Evolution. *American Journal of Physical Anthropology,* 31(3):343–353.

Arber, E., editor

1884. Capt. John Smith, Works, 1608–1631. *The English Scholar's Library,* 16. Birmingham.

1910. *Travels and Works of Captain John Smith, 1580–1631.* Edinburgh: J. Grant.

Archives of Maryland

1887. *Proceedings of the Council of Maryland, 1667–1687/8.* Baltimore: Maryland Historical Society.

1896. *Proceedings of the Council of Maryland, 1676–1678.* Baltimore: Maryland Historical Society.

Ascher, R.

1959. A Prehistoric Population Estimate using Midden Analysis and Two Population Models. *Southwestern Journal of Anthropology,* 15:168–178.

Aschman, H.

1959. The Central Desert of Baja, California: Demography and Ecology. *Ibero-Americana,* 42. Berkeley.

Bailit, H., and E. E. Hunt, Jr.

1964. The Sexing of Children's Skeletons from Teeth Alone and its Genetic Implications. *American Journal of Physical Anthropology,* 22(2):171–173.

Bass, W. M., D. R. Evans, and R. L. Jantz

1971. The Leavenworth Site Cemetery: Archaeology and Physical Anthropology. *University of Kansas Publications in Anthropology,* 2. Lawrence.

Baudin, L.

1961. *A Socialist Empire: The Incas of Peru.* Translated by Katherine Woods, edited by A. Goddard. Princeton: D. Van Nostrand Co. [Originally published 1928 under the title *L'Empire socialiste des Inka.* Paris.]

Bauer, W. H.

1944. Tooth Buds and Jaws in Patients with Congenital Syphilis: Correlation Between Distribution of Treponema Pallidum and Tissue Reaction. *American Journal of Pathology,* 20:297–314.

Beloch, K. J.

1886. *Die Bevölkerung der Griechischrömischen Welt.* Leipzig.

Bennett, J. W.

1966. Comment on Estimating Aboriginal American Population. *Current Anthropology,* 7(4):425–426.

Bernal, I.

1966. Comment on Estimating Aboriginal American Population. *Current Anthropology,* 7(4):426.

Beverly, R.
1705. *The History and Present State of Virginia*. London.

Biggar, H. P.
1929. *The Works of Samuel de Champlain*. Volume 3. Toronto: The Champlain Society.

Blair, E. H.
1911. *The Indian Tribes of the Upper Mississippi Valley and Region of the Great Lakes as Described by Nicolas Perrot, French Commandant in the Northwest*. 2 volumes. Cleveland: The Arthur H. Clark Co.

Blakely, R. L.
1971. Comparison of the Mortality Profiles of Archaic, Middle Woodland, and Middle Mississippian Skeletal Populations. *American Journal of Physical Anthropology*, 34(1): 43–53.

Blakely, R. L., and P. L. Walker
1968. Mortality Profile of the Middle Mississippian Population of Dickson Mound, Fulton County, Illinois. *Proceedings of the Indiana Academy of Science, 1967*, 77:102–108.

Blasi, O.
1966. Comment on Estimating Aboriginal American Population. *Current Anthropology*, 7(4):426–427.

Borah, W.
1962a. Population Decline and the Social and Institutional Changes of New Spain in the Middle Decades of the Sixteenth Century. *Internationalom Amerikanisten-Kongresses*, 34:172–178.
1962b. America Como Modelo ? El Impacto Demografico de la Expansioń Europeå Sobre el Mundo no Europeo. *Cuadernos Americanos*, 6:176–185. [Reprinted in English in *Actasy Memorias, XXXV Congreso Internacional de Americanistas, Mexico, 1962*, 3:379–387.]

Borah, W., and S. F. Cook
1963. The Aboriginal Population of Central Mexico on the Eve of the Spanish Conquest. *Ibero-Americana*, 45. Berkeley.

Boucher, B. F.
1955. Sex Differences in the Foetal Sciatic Notch. *Journal of Forensic Medicine*, 2:51–54.
1957. Sex Differences in the Foetal Pelvis. *American Journal of Physical Anthropology*, 15(4):581–600.

Bozman, J. L.
1837. *The History of Maryland*. Volume 1. Baltimore: James Lucas and E. K. Deaver.

Brainerd, G. S.
1956. *The Ancient Maya*. Palo Alto: Stanford University Press.

Brinton, D. G.
1885. *The Lenape and Their Legends*. Philadelphia: Brinton's Library of Aboriginal American Literature, 5.

Bröste, K., and J. B. Jörgensen
1956. *Prehistoric Man in Denmark: A Study in Physical Anthropology: I, Stone and Bronze Ages*. Copenhagen: E. Munksgaard.

Bullard, W. R. Jr.
1960. Maya Settlement Pattern in Northeastern Peten, Guatemala. *American Antiquity*, 25:355–372.

Bushnell, D. I
1920. Native Cemeteries and Forms of Burial East of the Mississippi. *Bureau of American Ethnology Bulletin*, 71. Washington, D.C.

Churcher, C. S., and W. A. Kenyon
1960. The Tabor Hill Ossuaries: A Study in Iroquois Demography. *Human Biology*, 32:249–273.

Coe, M. D., and K. V. Flannery
1967. Early Cultures and Human Ecology in South Coastal Guatemala. *Smithsonian Contributions to Anthropology*, 3. Washington, D.C.

Colton, H. S.
1936. The Rise and Fall of the Prehistoric Population of Northern Arizona. *Science*, 84 (2181):337–343.
1939. Prehistoric Culture Units and Their Relationships in Northern Arizona. *Museum of Northern Arizona Bulletin*, 22. Flagstaff.

Cook, S. F.
1937. The Extent and Significance of Disease Among the Indians of Baja California, 1697–1773. *Ibero-Americana*, 12. Berkeley.
1939. Smallpox in Spanish and Mexican California, 1770–1845. *Bulletin of the History of Medicine*, 7:153–191.
1940. Population Trends Among the California Mission Indians. *Ibero-Americana*, 17. Berkeley.
1943. The Conflict Between the California Indians and the White Civilization: 1, The Indian Versus the Spanish Mission. *Ibero-Americana*, 21. Berkeley.
1946a. A Reconsideration of Shellmounds with Respect to Population and Nutrition. *American Antiquity*, 12:51–53.
1946b. Human Sacrifice and Warfare as Factors in the Demography of Precolonial Mexico. *Human Biology*, 18:81–102.
1955a. The Epidemic of 1830–1833 in California and Oregon. *University of California Publications in American Archaeology and Ethnology*, 43:303–326. Berkeley.
1955b. The Aboriginal Population of the San Joaquin Valley, California. *Anthropological Records*, 16(2):31–78.
1956. The Aboriginal Population of the North Coast of California. *Anthropological Records*, 16(3):81–129.
1958. Santa Maria Ixcatlán Habitat, Population, Subsistence. *Ibero-Americana*, 41. Berkeley.
1966. Comments on Estimating Aboriginal American Population. *Current Anthropology*, 7(4):427–429.

Cook, S. F., and W. Borah
1957. The Rate of Population Change in Central Mexico, 1550–1570. *Hispanic American Historical Review*, 37:463–470.

Cook, S. F., and L. B. Simpson
1948. The Population of Central Mexico in the Sixteenth Century. *Ibero-Americana*, 31. Berkeley.
1950. The Quantitative Investigation of Indian Mounds with Special Reference to the Relation of the Physical Components to the Probable Material Culture. *University of California Publications in American Archaeology and Ethnology*, 40:223–262. Berkeley.

Cowgill, U. M.
1962. An Agricultural Study of the Southern Maya Lowlands. *American Anthropologist*, 64:273–286.

Crovello, T. J., and C. S. Hacker
1972. Evolutionary Strategies in Life Table Characteristics Among Feral and Urban Strains of *Aedes aegypti* (L). *Evolution*, 26(2):185–196.

Cunha, A. X.
1956. Contribuicâo para a Antropologia dos povos de Cultura Campaniforme em Portugal. *Estudios Anthropologia Portugal*, 123–137.

Dahlberg, A. A., and R. M. Menegaz-Bock
1958. Emergence of the Permanent Teeth in Pima Indian Children: A Critical Analysis of Method and an Estimate of Population Parameters. *Journal of Dental Research*, 37:1123–1140.

Davidson, D. S.
1935. Burial Customs in the Delmarva Peninsula and the Question of their Chronology. *American Antiquity,* 1(1):84–97.

Dechaume, M., L. Dérobert, and J. Payen
1960. De la valeur de la détermination de l'âge par l'examen des dents en coupes minces. *Annales de Médecine Légale,* 40:165–167. Paris.

Deevey, E. S.
1947. Life Tables for Natural Populations of Animals. *Quarterly Review of Biology,* 22(4):283–314. Baltimore.

Denevan, W. M.
1966. Comment on Estimating Aboriginal American Population. *Current Anthropology,* 7(4):429.

Dobyns, H. F.
1962. *Pioneering Christians Among the Perishing Indians of Tucson.* Lima: Editorial Estudios Andinos.
1963a. Indian Extinction in the Middle Santa Cruz River Valley, Arizona. *New Mexico Historical Review,* 38:163–181.
1963b. An Outline of Andean Epidemic History to 1720. *Bulletin of the History of Medicine,* 37:493–515.
1966a. Estimating Aboriginal American Population: An Appraisal of Techniques with a New Hemispheric Estimate. *Current Anthropology,* 7(4):395–416.
1966b. Reply to Comments on Estimating Aboriginal Population Numbers. *Current Anthropology,* 7(4):440–444.

Dublin, L. I., and A. J. Lotka
1963. *Length of Life: A Study of the Life Table.* New York: Ronald Press.

Dublin, L. I., and M. Spiegelman
1941. Current Versus Generation Life Tables. *Human Biology,* 13:439–458.

Dumond, D. E.
1972. Demographic Aspects of the Classic Period in Puebla-Tlaxcala. *Southwestern Journal of Anthropology,* 28(2):101–130.

Dwight, T.
1904. The Size of the Articular Surfaces of the Long Bones as Characteristic of Sex: An Anthropological Study. *American Journal of Anatomy,* 4:19–31.

Edmondson, W. T.
1945. Ecological Studies of Sessile Rotatoria, Part II: Dynamics of Populations and Social Structures. *Ecological Monographs,* 15:141–172. Durham.

Enlow, D. H.
1963. *Principles of Bone Remodeling: An Account of Post-natal Growth and Remodeling Processes in Long Bones and the Mandible.* Springfield: Charles C. Thomas.

Etienne, R.
1955. A propos de la démographie de Bordeaux aux trois premiers siècles de notre ère. *Revue Historique de Bordeaux et du Department de la Gironde,* 4:189–200.

Evans, C.
1955. A Ceramic Study of Virginia Archaeology. *Bureau of American Ethnology Bulletin,* 160. Washington, D.C.

Fanning, E. A.
1961. A Longitudinal Study of Tooth Formation and Root Resorption. *New Zealand Dental Journal,* 57:292–217.
1962a. Effect of Extraction of Deciduous Molars on the Formation and Eruption of Their Successors. *Angle Orthodontist,* 32:44–53.
1962b. The Relationship of Dental Caries and Root Resorption of Deciduous Molars. *Archives of Oral Biology,* 7:595–601.

Fenton, W., and G. Kurath
1951. The Feast of the Dead or Ghost Dance at Six Nations. Reserve, Canada. Pages 139–165 *In* Symposium on local Diversity in Iroquois Culture. *Bureau of American Ethnology Bulletin,* 149. Washington, D.C.

Ferembach, D.
1960. Les hommes du mésolithique d'Afrique du Nort et le problème des isolats. *Sociedade Portuguesa de Ciencias Naturais,* 8(2a). Lisbon.
1961. Quelques Facteurs de Formation et de Développement d'un Isolat. *Population,* 16:71–90.
1962. *La Nécropole Épipaléolithique de Taforalt: Étude des Squelettes Humains.* Centre National de la Recherche Scientifique et de la Mission Universitaire et Culturelle Française au Maroc, oriental.

Ferguson, A. L. L.
1937. Burial Area in Moyaone. *Journal of the Washington Academy of Sciences,* 27(1):261–267.

Fisher, I.
1923. *Report on National Vitality.* National Conservation Commission, Washington, D.C.

Forbis, R. G.
1966. Comment on Estimating Aboriginal American Population. *Current Anthropology,* 7 (4):431.

Fowke, G.
1894. Archeological Investigations in James and Potomac Valleys. *Bureau of American Ethnology Bulletin,* 23 Washington, D.C.

Franz, L., and W. Wingler
1936. Die Sterblichkeit in der fruhen Bronze zeit Niederosterreichs. *Zeitschrift für Rassenkunde,* 4:157–163.

Fusté, M.
1954. La Duracioń de la Vida en la Poblacioń Espânola Desde de la Prehistoria Hasta Nuestros Dias. *Trabajo del Inst. Bernardino de Sahagún de Anthropologia y Ethnologia,* 14:81–104. Barcelona.
1955. La Duracioń de la Vide en las Poblaciones Humanas del Levante Espânol Durante el Periodo Neo-eneolítico. Pages 325–333, in D. Francisco Pardillo Vaguer, *Homenaje Postumo.* Barcelona.

Garn, S. M., A. B. Lewis, and R. M. Blizzard
1965. Endocrine Factors in Dental Development. *Journal of Dental Research,* 43:243–258.

Garn, S. M., A. B. Lewis, and R. S. Kerewsky
1964. Sex Differences in Tooth Size. Volume 12: 125–126 in S. T. Genoves, editor, *Yearbook of Physical Anthropology.* Cordoba, Mexico: Instituto Nacional de Anthropoliga Historia.

Garn, S. M., A. B. Lewis, and D. L. Polacheck
1959. Variability of Tooth Formation. *Journal of Dental Research,* 38:135.

Garn, S. M., and C. F. A. Moorees
1951. Stature, Body Build and Tooth Emergence in Aleutian Aleut Children. *Child Development,* 22:261–270.

Gejvall, N. G.
1960. *Westerhus: Mediaeval Population and Church in the Light of Skeletal Remains.* Lund: H. Ohlssons Boktr.

Genovés, S.
1963. Estimation of Age and Mortality. Pages 353–364 *in* D. R. Brothwell, editor, *Science and Archaelogy.* New York: Basic Books, Inc.

Gerhardt, K.
1953. *Die Glockenbeckerleute in Mittel- und Westdeutschland.* Stuttgart: E. Schweizerbart.

Gilbert, B. M.
1971. A Method for Aging the Female Os Pubis. PhD thesis, Department of Anthropology, University of Kansas, Lawrence, Kansas.

Giles, E.
1964. Sex Determination by Discriminant Function Analysis of the Mandible. *American Journal of Physical Anthropology,* 22:129–135.
1970a. Sexing Crania by Discriminant Function Analysis: Effects of Age and Number of Variables. *Proceedings, VIIIth International Congress of Anthropological and Ethnological Sciences,* 1:59–61. Tokyo.
1970b. Discriminant Function Sexing of the Human Skeleton. Pages 99–109 *in* T. D. Stewart, editor, *Personal Identification in Mass Disasters.* Washington, D.C.

Giles, E., and O. Elliott
1963. Sex Determination by Discriminant Function Analysis of Crania. *American Journal of Physical Anthropology,* 21:53–68.

Giot, P. R.
1951. Armoricains et Bretons, étude Anthropologiques. *Travaux de l'Institut d'Anthropologie Generale de la Faculté des Sciences de Rennes,* 1.

Glasstone, S.
1938. A Comparative Study of the Development *in vivo* and *in vitro* of Rat and Rabbit Molars. *Proceedings of the Royal Society of London,* series B., 126:315–330.
1963. Regulative Changes in Tooth Germs Grown in Tissue Culture. Conference on Genetic Aspects of Oral Structures, Denver, Colorado, 1961. *Journal of Dental Research,* 42(6):1364–1368.
1964. Cultivation of Mouse Tooth Germs in a Chemically Defined Protein-free Medium. *Archives of Oral Biology,* 9:27–30.

Glover, T.
1676. *An Account of Virginia, Its Situation, Temperature, Productions, Inhabitants, and Their Manner of Planting and Ordering Tobacco.* Oxford: B. H. Blackwell.

Goldstein, M. S.
1953. Some Vital Statistics Based on Skeletal Material. *Human Biology,* 25:3–12.

Gomme, A. W.
1933. *The Population of Athens in the Fifth and Fourth Centuries B.C.* Oxford: Basil Blackwood.

Graham, W. J.
1935. *The Indians of Port Tobacco River, Maryland, and Their Burial Places.* Washington: Private printing.

Green, R. G., and C. A. Evans
1940a. Studies on a Population Cycle of Snowshoe Hares on the Lake Alexander Area, I: Gross Annual Censuses, 1932–1939. *Journal of Wildlife Management,* 4:220–238.
1940b. II. Mortality According to Age Groups and Seasons. *Journal of Wildlife Management,* 4:267–278.
1940c. III. Effect of Reproduction and Mortality of Young Hares on the Cycle. *Journal of Wildlife Management,* 4:347–358.

Griffin, J. B.
1956. Prehistoric Settlement Patterns in the Northern Mississippi Valley and the Upper Great Lakes. *Viking Fund Publications in Anthropology,* 23:63–71.

Gustafson, G.
1950. Age Determinations on Teeth. *Journal of the American Dental Association,* 41:45–54.

Hall, E. T. Jr.
1942. Archeological Survey of the Walhalla Glades. *Museum of Northern Arizona Bulletin,* 20. Flagstaff.

Hansen, G.
1953–1954. Die Altersbestimmung am Proximale Humerus- und Femurende in Rahmen der Identifizierung menschlichen Skelettreste. Wissenschaftliche Zeitschrift der Humboldt-Universitat zu Berlin. *Mathematish- Naturwissenschaftliche Reihe,* 3(1):1–73.

Hariot, T.
1590. *Narrative of the First English Plantation of Virginia.* London.

Harkness, A. G.
1896. Age at Marriage and at Death in the Roman Empire. *Transactions of the American Philological Association,* 27:35–72. Boston.

Harrington, M. R.
1921. Religion and Ceremonies of the Lenape. *Indian Notes and Monographs,* 19. New York: Museum of the American Indian.

Hatton, H.
1938. Essais de bionomie explicative sur quelques espèces intercotidales d'algues et d'animaux. *Annales Institut Oceanographique,* 17:241–348. Paris.

Häusler, A.
1966. Comment on Estimating Aboriginal American Population. *Current Anthropology,* 7(4):433.

Havilland, W. A.
1965. Prehistoric Settlement at Tikal, Guatemala. *Expedition,* 7:15–23.
1966. Maya Settlement Patterns: A Critical Review. *Middle American Research Institute, Tulane University Publications,* 26:21–47.
1970. Family Size, Prehistoric Population Estimates and the Ancient Maya. *American Antiquity,* 37(1):135–139.

Heckewelder, J.
1819. *An account of the History, Manners and Customs of the Indian Nations Who Once Inhabited Pennsylvania and the Neighboring States.* Philadelphia. [Reprinted in *Memoires of the Historical Society of Pennsylvania,* 12. Philadelphia, 1876.]

Heizer, R. F., and M. A. Baumhoff
1956. California Settlement Patterns. Pages 32–44 *in* G. W. Wiley, editor, Prehistoric Settlement Patterns in the New World. *Viking Fund Publications in Anthropology,* 23. New York.

Hickerson, H.
1960. The Feast of the Dead among the Seventeenth Century Algonkians of the Upper Great Lakes. *American Anthropologist,* 6(1):81–107.

Hombert, M. and C. Préaux
1945. Note sur la durée de la vie dans l'Egypte Gréco-Romaine. *Chronique d'Egypt,* 20:139–146.

Hooten, E. A.
1920. Indian Village Site and Cemetery near Madisonville, Ohio. *Papers of the Peabody Museum, American Archaeology and Ethnology,* 8. Cambridge.
1930. *The Indians of Pecos Pueblo: A Study of their Skeletal Remains.* New Haven: Yale University Press.

Howells, W. W.
1960. Estimating Population Numbers through Archaeological and Skeletal Remains. Pages 158–185 *in* R. Heizer and and S. Cook, editors, The Application of Quantitative Methods in Archeology. *Viking Fund Publications in Anthropology,* 28. Chicago: Quadrangle Books.

Hrdlička, A.
1908. Physiological and Medical Observations among the Indians of Southwestern U.S. and Northern Mexico. *Bureau of American Ethnology Bulletin,* 34. Washington, D.C.
1952. *Practical Anthropometry.* 4th edition, T. D. Stewart, editor. Philadelphia: The Wistar Institute of Anatomy and Biology.

Huffiington, W.
1838. *The Delaware Register.* Dover.

Hulbert, A. B., and W. N. Schwarze
1910. Zeisberger's History of Northern American Indians. *Ohio Archaeological and Historical Quarterly,* 19

Hunt, E. E. Jr., and I. Gleiser.
1955. The Estimation of Age and Sex of Preadolescent Children from Bones and Teeth. *American Journal of Physical Anthropology,* 13(3):479–487.

Hurme, V. O.
1948. Standards of Variation in the Eruption of the First Six Permanent Teeth. *Child Development,* 19:213–231.

Ivanicek, F.
1951. Staroslavenska Nekropola u Ptunu. Rezultati antropoloskish Istrazivanja, Ljubljana. *Slovenska Akademija Znanosti in Umetnosti, Razredza Zgodouino in druzbene vede Dela,* 5.

Jefferson, T.
1787. *Notes on the State of Virginia.* London.

Johnson, L. C.
1962. Joint Remodeling as the Basis for Osteoarthritis. *Journal of the American Veterinary Medicine Association,* 141: 1237–1241.

Johnston, F. E.
1962. Growth of the Long Bones of Infants and Young Children at Indian Knoll. *American Journal of Physical Anthropology,* 20(3):249–254.

Johnston, F. E., and C. E. Snow
1961. The Reassessment of the Age and Sex of the Indian Knoll Skeletal Population: Demographic and Methodological Aspects. *American Journal of Physical Anthropology,* 19(3):237–244.

Jowsey, J.
1960. Age Changes in Human Bone. *Clinical Orthopedics,* 17:210–17.

Kehoe, T. F., and A. B. Kehoe
1966. Comment on Estimating Aboriginal American Population. *Current Anthropology,* 7(4):434–435.

Kerley, E. R.
1965. The Microscopic Determination of Age in Human Bone. *American Journal of Physical Anthropology,* 23(2):149–163.
1969. Age Determination of Bone Fragments. *Journal of Forensic Sciences,* 14(1):59–67.
1970. Estimation of Skeletal Age after about Age 30. Pages 57–70 *in* T. D. Stewart editor, *Personal Identification in Mass Disasters.* Washington, D.C.: Smithsonian Institution.

Kidd, K. E.
1952. Sixty Years of Ontario Archeology. Pages 71–82 *in* J. R. Griffin, *Archaeology of Eastern United States.* Chicago: University of Chicago Press.
1953. The Excavation and Historical Identification of a Huron Ossuary. *American Antiquity,* 18:359–379.

Kidder, A. V.
1958. Pecos, New Mexico: Archaeological Notes. *Papers of the R. S. Peabody Foundation for Archaeology,* 5. Cambridge.

Kivett, M. F.
1953. The Woodruff Ossuary: A Prehistoric Burial Site in Phillips County, Kansas. *Bureau of American Ethnology Bulletin,* 154:109–142. Washington, D.C.

Klebba, A. J.
1971. Leading Components of Upturn in Mortality for Men. *Vital and Health Statistics,* series 20, number 11. Washington, D.C.: U.S. Department of Health, Education, and Welfare.

Kraus, B. S.
1959. Calcification of the Human Deciduous Teeth. *Journal of the American Dental Association,* 59:1128.

Kroeber, A. L.
1939. Cultural and Natural Areas of Native North America. *University of California Publications in American Archaeology and Ethnology,* 38. Berkeley.

Krogman, W. M.
1939. A Guide to the Identification of Human Skeletal Material. *FBI Law Enforcement Bulletin,* 8(8):1–29.
1955. The Skeleton in Forensic Medicine. *Graduate Medicine,* 17 (2 and 3).
1962. *The Human Skeleton in Forensic Medicine.* Springfield, Illinois: Charles C. Thomas.

Kronfeld, R.
1935. Development and Calcification of the Human Deciduous and Permanent Dentition. *The Bur,* 35:18.

Kubler, G.
1942. Population Movements in Mexico, 1520–1600. *Hispanic American Historical Review,* 22:606–643.
1946. The Quechua in the Colonial World. Volume 2:331–410 *in* Julian H. Steward, editor, Handbook of South American Indians. *Bureau of American Ethnology Bulletin,* 143. Washington, D.C.
1948. *Mexican Architecture of the Sixteenth Century.* New Haven: Yale University Press.

Kunstadter, P.
1966. Comments on Estimating Aboriginal American Population. *Current Anthropology,* 7(4):436–437.

Kurth, G.
1955. Vorbericht Uber Anthropologische Beo Bachtungen Bei der Jericho-Grabung. *Homo,* 4:145–156.

Lack, D.
1943. The Age of Some More British Birds. *British Birds,* 36: 193–197, 214–221.

Lefroy, J. H.
1853. On the Probable Number of the Native Indian Population of British America. 1832–33. *Toronto Canadian Journal,* 1:1832–1833. Toronto.

Lewis, A. D., and S. M. Garn
1960. The Relationship between Tooth Formation and Other Maturational Factors. *Angle Orthodontist,* 30:70–77.

Logan, W. H. C., and R. Kronfeld
1933. Development of the Human Jaws and Surrounding Structures from Birth to Age of Fifteen Years. *Journal of the American Dental Association,* 20:379.

Macgowan, K., and J. A. Hester, Jr.
1965. *Early Man in the New World.* New York: Doubleday and Co. Inc.

MacLeod, W. C.
1928. *The American Indian Frontier.* New York: Alfred A. Knopf.

MacNutt, F. A., editor
1909. *Bartholomew de las Casas: His Life, His Apostolate and His Writings.* New York: A. H. Clarke.

Maltby, J. R. D.
1917–1918. Some Indices and Measurements of the Modern Femur. *Journal of Anatomy,* 52:363–382.

Maresh, M. M.
1955. Linear Growth of Long Bones of Extremities from Infancy through Adolescence. *American Journal of Diseases of Children,* 89:725–742.

Marshall, H.
1947. Longevity of the American Herring Gull. *Auk,* 64:188–198.

Marshall, T. K.
1968. Changes After Death. Chapter 8 in F. E. Camps, editor, *Gradwohl's Legal Medicine.* Second edition. Bristol: John Wright & Sons, Ltd.

Marye, W. B.
1936. Former Indian Sites in Maryland as Located by Early Colonial Records. *American Antiquity,* 2:40–46.
1937. Burial Methods in Maryland and Adjacent States. *American Antiquity,* 2:209–214.

Mason, J. A.
1957. *The Ancient Civilizations of the Andes.* Baltimore: Penguin Books.

McKern, T. W., and T. D. Stewart
1957. *Skeletal Age Changes in Young American Males.* Technical Report EP-45, Quartermaster Research and Development Center, Environmental Protection Research Division, Natick.

Means, P. A.
1931. *Ancient Civilizations of the Andes.* New York: Charles C. Scribner's, Sons.

Meigs, P.
1935. The Dominican Mission Frontier of Lower California. *University of California Publications in Geography,* 7. Berkeley.

Mercer, H. C.
1897. Exploration of an Indian Ossuary on the Choptank River, Dorchester County, Maryland: Researches upon the Antiquity of Man in the Delaware Valley and the Eastern U.S. *University of Pennsylvania Publication Series in Philology, Literature, and Archaeology,* 6:87–98.

Meredith, A. V.
1946. Order and Age of Eruption for the Deciduous Dentition. *Journal of Dental Research,* 25:43–66.

Merriam, C. H.
1905. The Indian Population of California. *American Anthropologist,* 7:594–606.

Miles, A. E. W.
1963. The Dentition in the Assessment of Individual Age. Pages 191–209 *in* D. R. Brothwell, editor, *Dental Anthropology.* New York.

Mook, M.
1944. The Aboriginal Population of Tidewater Virginia. *American Anthropologist,* 46(2):193–208.

Mooney, J.
1910. Population. Pages 286–287 *in* F. W. Hodge II, editor, Handbook of American Indians North of Mexico. *Bureau of American Ethnology Bulletin,* 30. Washington, D.C.
1928. The Aboriginal Population of America North of Mexico. *Smithsonian Miscellaneous Collections,* 80(7): 1–40. Washington, D.C.

Moorrees, C. F. A.
1957. *The Aleut Dentition: A Correlative Study of Dental Characteristics in an Eskimoid People.* Cambridge.

Moorrees, C. F. A., E. A. Fanning, and E. E. Hunt, Jr.
1963a. Formation and Resorption of Three Deciduous Teeth in Children. *American Journal of Physical Anthropology,* 21:205–213.
1963b. Age Variation of Formation Stages for Ten Permanent Teeth. *Journal of Dental Research,* 42:1490–1502.

Morley, S. G.
1947. *The Ancient Maya.* Palo Alto: Stanford University Press.

Motta, E.
1891. Morti in Milano del 1452 al 1552. *Archivo Storico Lombardo,* 18:241–286. Milan.

Murie, A.
1944. The Wolves of Mount McKinley. *Fauna of the National Parks of the U.S.,* Fauna Series 5. Washington, D.C.: U.S. Department of Interior, National Park Service.

Nalbandian, J.
1959. Age Changes in Human Teeth. *Journal of Dental Research,* 38:681–682.

Nalbandian, J., and R. F. Sognnaes
1960. Structural Age Changes in Human Teeth. *In* Nathan W. Shock, editor, Aging. *American Association for the Advancement of Science,* 65:367–382. Washington, D.C.

Nelson, N. C.
1909. Shellmounds of the San Francisco Bay Region. *University of California Publications in American Archaeology and Ethnology,* 7(4):309–356. Berkeley.

Niswander, J. D., and C. Sujaku
1960. Dental Eruption, Stature, and Weight of Hiroshima Children. *Journal of Dental Research,* 39:959–963.
1964. Dental Caries, Retained Primary Tooth Fragments and the Eruption of Permanent Teeth. *Journal of Dentistry for Children,* 31:139–145.
1965. Permanent Tooth Eruption in Children with Major Physical Defect and Disease. *Journal of Dentistry for Children,* 32: 266–268.

Nougier, L. R.
1949. Densité humaine et population au Néolithique. *Société Préhistorique Française Bulletin,* 46:126–127. Paris.
1950. *Le peuplement préhistorique, ses étapes entre Seine-et-Loire. Société Préhistorique Française Bulletin,* 47: 210. Paris.
1954. Essai sur le peuplement préhistoriques de la France. *Population,* 9:241–274.
1959. *Géographie humaine préhistorique.* Paris.

Ortner, D. J.
1970. The Effects of Aging and Disease on the Micromorphology of Human Compact Bone. PhD thesis, Department of Anthropolgy, The University of Kansas, Lawrence.

Parsons, F. G.
1913–1914. The Characters of the English Thigh Bone, Part I. *Journal of Anatomy and Physiology,* 48:238–267.
1914–1915. The Characters of the English Thigh Bone, Part II: The Difficulty of Sexing. *Journal of Anatomy and Physiology,* 49:335–361.

Paynter, K. J., and R. M. Grainger
1961. Influence of Nutrition and Genetics on Morphology and and Caries Susceptibility. *Journal of the American Medical Association,* 177:306–309.
1962. Relationships of Morphology and Size of Teeth to Caries. *International Dental Journal,* 12:147–160.

Pearson, K.
1901–1902. On the Change in Expectation of Life in Man during a Period of Circa 2000 Years. *Biometrika,* 1:261–264.

Phenice, T. W.
1969. A Newly Developed Visual Method of Sexing the Os Pubis. *American Journal of Physical Anthropology,* 30 (2):297–302.
Proud, R.
1797–1798. *The History of Pennsylvania.* Philadelphia.
Raudot, A. D.
1940. Memoir Concerning the Different Indian Nations of North America. Appendix to the Indians of the Western Great Lakes, 1615–1760. Edited by W. Vernon Kinietz. *Occasional Contributions from the Museum of Anthropology of the University of Michigan,* 10. Ann Arbor.
Reynolds, E. L.
1945. The Bony Pelvic Girdle in Early Infancy. *American Journal of Physical Anthropology,* 3(4):321–354.
1947. The Bony Pelvis in Prepuberal Childhood. *American Journal of Physical Anthropology,* 5(2):165–200.
Reynolds, E. R.
1883. Ossuary at Accotink, Va. Pages 92–94 *in* Abstract of Transactions of the Anthropological Society of Washington, D.C. (1881). *Smithsonian Miscellaneous Collections,* 25. Washington, D.C.
Richardson, B. E.
1933. Old Age among the Ancient Greeks. . *Johns Hopkins University Studies in Archaeology,* 16. Baltimore: The Johns Hopkins Press.
Ricker, W. E.
1945. Natural Mortality among Indiana Blue-gill Sunfish. *Ecology,* 26:111–121.
Ricketson, O. G., Jr., and E. B. Ricketson
1937. Uaxactun, Guatemala, Group E, 1926–1931. Carnegie Institution of Washington, 477. Washington, D.C.. Press of W. F. Roberts, Co.
Ridley, F.
1961. *Archaeology of the Neutral Indians.* Ontario: Etobicoke Historical Society.
Riquet, R.
1953. La population des Grottes de Baye. *Bulletins et Memoires Société d'Anthropologie de Paris,* 4:45–67.
Rivet, P.
1924. Langues americaines. Pages 597–712 *in* A. Meillet and Marcel Cohen, editors, Les langues du monde. Paris: Collection Linguistique, Société de Linguistique.
Robinow, M., T. W. Richards, and M. Anderson
1942. The Eruption of Deciduous Teeth. *Growth,* 6:127–133.
Roman, B.
1775. *Natural History of East and West Florida.* New York.
Rosenblat, A.
1935. El desarrollo de la poblacioń indigena de Americana. *Tierra Firmé,* 1(1):115–133.
1945. La población indígena de America desde 1492 hasta la actualidad. *Cuadernos de la Serie Stirps Quaestionis.* Buenos Aires: Institution Cultural Espânola.
1954. *La población indígena y el Mestizaje en America, I.* Buenos Aires: Editorial Nova, Biblioteca Americanista.
Rouse, I.
1952. Porto Rican Prehistory. *The New York Academy of Sciences Scientific Survey of Porto Rico and the Virgin Islands,* 18(4):463–518.
Sanders, W.
1953. The Anthrogeography of Central Veracruz. Pages 27–78 in Bernal and Hurtado, editors, *Huastecos, Totonacos y Sus Vecinos.* Mexico: Sociedad Mexicana de Antropologiá.
1956. The Central Mexican Symbiotic Region in Prehistoric Settlement Patterns in the New World. G. Willey, editor. *Viking Fund Publications in Anthropology* 23:115–127.
1960. Prehistoric Ceramics and Settlement Patterns in Quintana Rao, Mexico. *Carnegie Institution of Washington Publications* 606 [Contributions to American Anthropology and History 60.]
1963. Cultural Ecology of the Maya Lowlands, II. *Estudios de Cultura Maya,* 3:203–241.
Sapper, K.
1924. Die Zohl und die Vlksdichte der Indianischer Bevolkerung in Amerika von de Conguista und in der Gegenwart. Pages 95–104 in *Proceedings of the 21st International Congress of Americanists, I.* Leiden: The Hague.
Sauer, C.
1935. Aboriginal Population of Northwestern Mexico. *Ibero-Americana,* 10. Berkeley.
1966. *The Early Spanish Main.* Berkeley.
Schoolcraft, H. R.
1851. *Historical and Statistical Information Respecting the History, Condition, and Prospects of the Indian Tribes of the United States.* 6 volumes. Philadelphia: Lippincott, Grambo and Co.
Schour, I., and M. Massler
1941. The Development of the Human Dentition. *Journal of the American Dental Association,* 28:1153–1160.
Schranz, D.
1959. Age Determination from the Internal Structure of the Humerus. *American Journal of Physical Anthropology,* 17(4):273–278.
Schwartz, D. W.
1956. Demographic Changes in the Early Periods of Cohonina Pre-history. *Viking Fund Publications in Anthropology,* 23:26–31.
Scull, G. D., editor
1943. *Voyages of Peter Esprit Radisson, Being an Account of His Travels and Experiences among the North American Indians, From 1652 to 1684.* New York: The Prince Society.
Sigerist, H. E.
1965. *Civilization and Disease.* Chicago: The University of Chicago Press.
Singer, R.
1953. Estimation of Age from Cranial Suture Closure: A Report on Its Unreliability. *Journal of Forensic Medicine,* 1(1): 52–59.
Singh, I. J. and D. L. Gunberg.
1970. Estimation of Age at Death in Human Males from Quantitative Histology of Bone Fragments. *American Journal of Physical Anthropolgy,* 33(3):373–382.
Snow, C. E.
1948. Indian Knoll Skeletons of Site Oh2, Ohio County, Kentucky. *University of Kentucky Reports in Anthropology,* 4(3/2):371–554.
Speck, F. G.
1927. *The Nanticoke and Conoy Indians.* Wilmington: Historical Society of Delaware.
1937. Oklahoma Delaware Ceremonies, Feasts and Dances. *Memoirs of the American Philosophical Society,* 7. Philaphia.
Steggerda, M., and T. J. Hill
1942. Eruption Time of Teeth among Whites, Negroes and Indians. *American Journal of Orthodontics and Oral Surgery,* 28(b): 361–370.

Stephenson, R. L., and A. L. L. Ferguson

1963. The Accokeek Creek Site. A Middle Atlantic Seaboard Cultural Sequence. *Anthropological Papers Museum of Anthropology University of Michigan,* 20. Ann Arbor.

Stevenson, P. H.

1924. Age Order of Epiphyseal Union in Man. *American Journal of Physical Anthropology,* 7(1):53–93.

Steward, J. H.

1949. The Native Population of South America. Volume 5(3): 655–668 of Handbook of South American Indians. *Bureau of American Ethnology Bulletin,* 143. Washington, D.C.

Stewart, T. D.

1934. Sequence of Epiphyseal Union, Third Molar Eruption and Suture Closure in Eskimos and American Indians. *American Journal of Physical Anthropology,* 19:433–52.

1940a. Further Excavations of the Indian Village Site of Patawomeke (Potomac) *Explorations and Fieldwork of the Smithsonian Institution in 1939,* pages 79–82.

1940b. The Finding of an Indian Ossuary on the York River in Virginia. *Journal of the Washington Academy of Sciences,* 30(8):356–364.

1940c. A Report on the Skeletal Remains from the Piscataway Creek Ossuary. *American Antiquity,* 6(1):4–18.

1958a. Further Notes on the Melton Mask. *Quarterly Bulletin of the Archeological Society of Virginia,* 13(2).

1958b. The Rate of Development of Vertebral Osteoarthritis in American Whites and its Significance in Skeletal Age Identification. *The Leech,* 28(3,4,5):144–151.

1962. Comments on the Reassessment of the Indian Knoll Skeletons. *American Journal of Physical Anthoropology,* 20(2): 143–148.

1968. Identification by the Skeletal Structures. Chapter II *in* F. E. Camps, editor, *Gradwohl's Legal Medicine.* Second edition. Bristol: John Wright & Sons, Ltd.

Stewart T. D., and W. R. Wedel

1937. The Finding of Two Ossuaries on the Site of the Indian Village of Nacotchtanke (Anacostia). *Journal of the Washington Academy of Sciences,* 27(5):213–219.

Stloukal, M.

1962. Heidnische Elemente de Bevölkerung des grossmährischen Mikulcice auf Grund der Befund in Begräbnisstäten. *Homo,* 13:145–152.

1966. Comment on Estimating Aboriginal American Population. *Current Anthropology,* 7(4):438–439.

Strong, W. D.

1935. An Introduction to Nebraska Archaeology. *Smithsonian Miscellaneous Collections,* 93(10). Washington, D.C.

Sundick, R. I.

1972. A New Method for Assigning Ages to Immature Skeletons. *American Journal of Physical Anthropology,* 37(3): 452.

Swedlund, A. C., and G. J. Armelagos

1969. Une recherche en paléo-démographie: la Nubie Soudanaise. *Annales Economies Sociétés Civilizations Extrait,* 6:1287–1298. Paris: Librairie Armand Colin.

Szilagyi, J.

1959. A datok Az Atlagos Elettartam Kérdéseihez Aquincumban és Pannónia más Részeiben. *Antik Tanulmányok,* 6:31–80, 221–243.

Termer, F.

1951. The Density of Population in the Southern and Northern Maya Empires as an Archaeological and Geographical Problem. Pages 101–107 *in* Sol Tax, editor, The Civilization of Ancient America. *Selected Papers of the 29th International Congress of Americanists.* Chicago: University of Chicago Press.

Thompson, A.

1899. Sexual Differences of the Foetal Pelvis. *Journal of Anatomy and Physiology,* 33:359–380.

Thompson, H. P.

1966. Estimating Aboriginal American Population: A Technique Using Anthropological and Biological Data. *Current Anthropology,* 7(1):417–424.

Thompson, J. E. S.

1951. The Itza of Tayasal, Peten. Pages 389–400 in *Homenaje al Doctor Afonso Caso.* Mexico City.

Thwaites, R. G.

1896–1901. *The Jesuit Relations and Allied Documents: Travels and Explorations of the Jesuit Missionaries in New France, 1610–1791.* 73 volumes. Cleveland: The Burrows Bros. Company.

Tinkle, D. W.

1961. Geographic Variation in Reproduction, Size, Sex Ratio and Maturity of *Sternothaerus odorata* (Testudinata: Chelydridae). *Ecology,* 42:68–76.

1967. The Life and Demography of the Side-Blotched Lizard, *Uta stansburiana. University of Michigan Miscellaneous Publication,* 132. Ann Arbor.

Tinkle, D. W., H. M. Wilbur, and S. G. Tilley

1970. Evolutionary Strategies in Lizard Reproduction. *Evolution,* 24:55–74.

Todd, T. W.

1920. Age Changes in the Pubic Bone, Part I. *American Journal of Physical Anthropology,* 3:285–334.

1921. Age Changes in the Pubic Bone, Parts II–IV. *American Journal of Physical Anthropology,* 4:1–70.

1927. Skeletal Records of Mortality. *Scientific Monthly,* 24: 481–496.

1929. Entrenched Negro Physical Features. *Human Biology,* 1:57–69.

1930a. Age Changes in the Pubic Bone, VIII: Roentgenographic Differentiation. *American Journal of Physical Anthropology,* 14(2):255–271.

1930b. The Roentgenographic Appraisement of Skeletal Differentiation. *Child Development,* 1:298–310.

1931. Differential Skeletal Maturation in Relation to Sex, Race, Variability and Disease. *Child Development,* 2:49–65.

Todd, T. W., and D. W. Lyon

1924. Endocranial Suture Closure, Its Progress and Age Relationship, Part I: Adult Males of White Stock. *American Journal of Physical Anthropology,* 7(3):325–384.

1925. Cranial Suture Closure, Its Progress and Age Relationship, Part II: Ectocranial Closure in Adult Males of White Stock. *American Journal of Physical Anthropology,* 8(1):23–71.

Valaoras, V. G.

1938. The Expectation of Life in Ancient Greece. *Pratika de l'Académié d'Athenes,* 13.

Vallois, H. V.

1937. La durée de la vie chez l'homme fossile. *Anthropologie,* 47:499–532.

1960. Vital Statistics in Prehistoric Population as Determined from Archaeological Data. Pages 186–222 in R. Heizer and S. Cook, editors, *The Application of Quantitative Methods in Archaeology.* Chicago: Quadrangle Books.

Van Vark, G. N.

1970. *Some Statistical Procedures for the Investigation of Prehistoric Human Material.* Groningen: Rijksuniversiteit te Groningen.

Washburn, S. L.
1948. Sex Differences in the Pubic Bone. *American Journal of Physical Anthropology,* 6:199–208.

Weidenreich, F.
1939. The Duration of Life of Fossil Man in China and the Pathological Lesions Found in His Skeleton. *Chinese Medical Journal,* 55:34–44.

Weiss, K. M.
1973. Demographic Models for Anthropology. *Memoirs of the Society for American Archaeology,* no. 27 [*American Antiquity,* 38(2)].

Welte, C. R.
1966. *Mapa de las localidades del Valle de Oaxaca.* Oaxaca Oficina de Estudios de Humanidad del Valle de Oaxaca.

Weslager, C. A.
1942. Ossuaries on the Delmarva Peninsula and Exotic Influences in the Coastal Aspect of the Woodland Period. *American Antiquity,* 8(2):141–151.

Wigglesworth, J.
1933. Excavations at Rehoboth. *Bulletin of the Archaeological Society of Delaware,* 3:2–6.

Wilcox. W. F.
1938. The Length of Life in the Early Roman Empire. Volume 3:14–22 in *Congrès International de la Population.* Paris: Herman.

Willey, G. R., W. R. Bullard, Jr., J. B. Glass, and J. C. Gifford
1965. Prehistoric Maya Settlement in the Belize Valley. *Papers of the Peabody Museum of Archaeology and Ethnology,* 54. Cambridge.

Wood, W. R.
1967. An Interpretation of Mandan Culture History. *Bureau of American Ethnology Bulletin,* 198. Washington, D.C.

Wrong, G. W., editor
1939. *The Long Journey to the Country of the Hurons by Gabriel Sagard.* Toronto: The Champlain Society.

Yarrow, H. C.
1880. *Introduction to the Study of Mortuary Customs among the North American Indians.* Washington, D.C.: Smithsonian Institution Bureau of American Ethnology.

U. S. GOVERNMENT PRINTING OFFICE : 1974 O - 525-413

Publication in *Smithsonian Contributions to Anthropology*

Manuscripts for serial publications are accepted by the Smithsonian Institution Press, subject to substantive review, only through departments of the various Smithsonian museums. Non-Smithsonian authors should address inquiries to the appropriate department. If submission is invited, the following format requirements of the Press will govern the preparation of copy. (An instruction sheet for the preparation of illustrations is available from the Press on request.)

Copy must be typewritten, double-spaced, on one side of standard white bond paper, with 1½" top left margins, submitted in ribbon copy with a carbon or duplicate, and accompanied by the original artwork. Duplicate copies of all material, including illustrations, should be retained by the author. There may be several paragraphs to a page, but each page should begin with a new paragraph. Number consecutively all pages, including title page, abstract, text, literature cited, legends, and tables. The minimum length is 30 pages of typescript and illustrations.

The *title* should be complete and clear for easy indexing by abstracting services. Include an *abstract* as an introductory part of the text. Identify the *author* on the first page of text with an unnumbered footnote that includes his professional mailing address. An *index*, if required, may be supplied by the author when he returns page proof.

For *references within the text,* use the author-date system: "(Jones 1910)" or "Jones (1910)." If the reference is expanded, abbreviate the data: "Jones (1910:122, pl. 20: fig. 1)."

Simple *tabulations* in the text (e.g., columns of data) may carry headings or not, but they should not contain rules. Formal *tables* must be submitted as pages separate from the text, and each table, no matter how large, should be pasted up as a single sheet of copy.

Use the *metric system* instead of (or in addition to) the English system.

Illustrations (line drawings, maps, photographs, shaded drawings) can be intermixed throughout the printed text. They will be termed *Figures* and should be numbered consecutively; however, if a group of figures is treated as a single figure, the individual components should be indicated by lowercase italic letters on the illustration, in the legend, and in text references: "Figure 9*b*." If illustrations (usually tone photographs) are printed separately from the text as full pages on a different stock of paper, they will be termed *Plates,* and individual components should be lettered (Plate 9*b*) but may be numbered (Plate 9: figure 2). Never combine the numbering system of text illustrations with that of plate illustrations. Submit all legends on pages separate from the text and not attached to the artwork.

In the *bibliography* (usually called "Literature Cited"), spell out book, journal, and article titles, using initial caps with all words except minor terms such as "and, of, the." (For capitalization of titles in foreign languages, follow the national practice of each language.) Underscore (for italics) book and journal titles. Use the colon-parentheses system for volume, number, and page citations: "10(2):5–9." Spell out such words as "figures" and "plates" (or "pages" when used alone).

For *free copies* of his own paper, a Smithsonian author should indicate his requirements on "Form 36" (submitted to the Press with the manuscript). A non-Smithsonian author will receive 50 free copies; order forms for quantities above this amount with instructions for payment will be supplied when page proof is forwarded.