Online Supporting Information

Auerbach BM, "Skeletal variation among early Holocene North American humans: implications for origins and diversity in the Americas"

Section 1. Detailed description of the non-EHAS American archaeological samples used.

This section provides additional details about the sites from which male skeletons were measured for the later Holocene comparative data set. Site numbers, based on national or state systems, are provided where possible. In some instances no site number was provided. References are not intended to be exhaustive, but provide useful additional sources; citations are listed at the end of this section. A map of sampled sites is also provided, along with the locations of the EHAS (Figure S1).

(1) Windover Pond
Site number: 8BR246
Location: Central east coast of the Florida peninsula, near to Cape Canaveral
Dating of site: Multiple radiocarbon dates, with a mean date of 7400 BP
Cultural affiliation: Windover Archaic (Early Archaic)
Subsistence: Hunter-gatherers
Institution curating remains: Florida State University, Gainesville, FL
Excavator: Glen Doran (1982-1986)
References: Doran and Dickel, 1988; Hauswirth et al., 1991; Doran, 2002; Powell, 2005; Stojanowski et al., 2006

(2) Point Hope Tigara
Location: Northwestern Alaska, on the Point Hope peninsula
Dating of site: Relative dating based on artifacts, 800 to 300 years before present
Cultural affiliation: Inuit / Inupiat (argued to be Tigara culture)
Subsistence: Marine hunter-gatherers
Institution curating remains: American Museum of Natural History, New York, NY
Excavator: Helge Larsen and Froeligh Rainey (1939-1941)
References: Larsen and Rainey, 1948; Holliday and Hilton, 2010

(3) Sadlermiut
Location: Native Point, on the southern coast of Southampton Island
Dating of site: Relative dating based on artifacts, likely between 950 and 100 years before present
Cultural affiliation: Sadlermiut Inuit
Subsistence: Marine hunter-gatherers
Institution curating remains: Canadian Museum of Civilization, Gatineau, Quebec, Canada
Excavator: H.B. Collins (1954), and Charles F. Merbs & William Laughlin (1959)
References: Merbs, 1974; Merbs, 1983

(4) Aleut

Location: Throughout the Aleutian Island chain, including the Near Islands (Agattu Island), Rat Islands (Amchitka Island), Adreanof Islands (Adak Island, Kanaga Island, Atka Island), Islands of the Four Mountains (Kagamil), and Fox Islands (Umnak Island, Ship Rock Island, Unalaska Island, Amoknak Island). The majority of skeletons were uncovered at Kagamil Island.
Dating of site: Multiple radiocarbon dates, between 1500 and 1000 BP
Cultural affiliation: Aleut (Unangan)
Subsistence: Marine hunter-gatherers
Institution curating remains: National Museum of Natural History (Smithsonian), Washington, D.C. (skeletons have been repatriated)
Excavator: Ales Hrdlička (early 1930s)
References: Hrdlička, 1945; Hunt, 2002; Coltrain et al., 2006

(5) Ikogmiut

Location: Multiple locations in southwestern Alaska along the Yukon River (Anvik, Bonasila, Holy Cross, Ingrehak, New Hamilton, Paimute, Pilot Station, Shageluk)
Dating of site: Relative dating based on artifacts, between 1000 to 100 years before present
Cultural affiliation: Yup'ik (most likely Inuit)
Subsistence: Hunter-gatherers
Institution curating remains: National Museum of Natural History (Smithsonian), Washington, D.C.
Excavator: Ales Hrdlička (1926-1929)
References: Hrdlička, 1930; de Laguna, 1936; Hrdlička, 1943

(6) Lillooet Salish

Location: Western south-central British Columbia, near Lytton and Lillooet
Dating of site: Relative dating based on artifacts associates the site with the Coast Salish, before European contact
Cultural affiliation: Most likely Coast Salish
Subsistence: Hunter-gatherers
Institution curating remains: American Museum of Natural History, New York, NY
Excavator: Harlan I. Smith (1897-1899)
References: Smith, 1899, 1900; Boas, 1903; Fitzhugh and Krupnik, 2006

(7) Grasshopper Pueblo

Site Number: AZ P:14:1
Location: East-central Arizona, in the Salt River drainage
Dating of site: Radiocarbon dates, approximately 675 to 550 BP
Cultural affiliation: Mogollon (Pueblo)
Subsistence: Agriculturalists
Institution curating remains: Arizona State Museum, University of Arizona, Tucson, AZ
Excavator: Walter Hough (1919-1920) & Raymond H. Thompson (1963-1993)
References: Berry, 1985; Ezzo, 1993; Riggs, 2001

(8) Mobridge Arikara I
Site Number: 39WW1
Location: North-central South Dakota, near to the city of Mobridge (site has been inundated)
Dating of site: Radiocarbon and relative dating based on artifacts, between 350 and 250 years before present
Cultural affiliation: Arikara (Plains Village 2)
Subsistence: Village hunter-horticulturalists
Institution curating remains: National Museum of Natural History (Smithsonian), Washington, D.C. (skeletons have been repatriated)
Excavator: William Bass (1968-1970) and Douglas Ubelaker (1971)
References: Owsley et al., 1982; Owsley and Jantz, 1994

(9) Polley-Secrest Fremont
Site Number: 42GR3576
Location: Central eastern Utah in the town of Moab
Dating of site: Radiocarbon dating, approximately 1300 years before present
Cultural affiliation: Fremont
Subsistence: Horticulturalists
Institution curating remains: Utah Museum of Natural History, University of Utah, Salt Lake City, UT
Excavator: Lloyd Pierson (1959, 1976)
References: Kopp, 2006

(10) Montague Delaware
Location: Northwestern New Jersey, just south of the city of Montague
Dating of site: Relative dating based on artifacts, estimated to be between 500 and 400 years before present
Cultural affiliation: Lenape (Munsee tribe)
Subsistence: Agriculturalists
Institution curating remains: National Museum of Natural History (Smithsonian), Washington, D.C. (skeletons have been repatriated)
Excavator: George G. Heye (1914)
References: Hrdlička, 1916

(11) Ledford Island Mississippian
Site Number: 40BY13
Location: Southeastern Tennessee, at the confluence of Candy Creek and the Tennessee River
Dating of site: Relative dating based on artifacts, between 500 and 300 years before present
Cultural affiliation: Late Mississippian (Mouse Creek phase)
Subsistence: Agriculturalists
Institution curating remains: Frank H. McClung Museum, The University of Tennessee, Knoxville, Tennessee
Excavator: George A. Lindberg (1938-1939)
References: Boyd and Boyd, 1989; Lidberg et al., 1995

(12) Ryan Mound
Site Number: CA-ALA-329
Location: Central west California, on the southeastern shore of San Francisco Bay
Dating of site: Multiple radiocarbon dates, between 1400 and 500 BP
Cultural affiliation: Late Period (possibly pre-Yokut)
Subsistence: Hunter-gatherers
Institution curating remains: San Jose State University, San Jose, CA
Excavator: Wedel (1935), C.E. Smith (1948), Bert A. Gerow (1959), and J. Hester & D. Pritchard (1962-1968)
References: Coberly, 1973; Leventhal, 1993; Bartelink, 2001

(13) Santa Cruz Island
Site Number: SCRI-100
Location: Located off the southwestern coast of California, on the southwestern coast of Santa Cruz Island
Dating of site: Relative dating based on artifacts, between 400 and 200 years before present
Cultural affiliation: Canaliño (possibly pre-Chumash)
Subsistence: Marine hunter-gatherers
Institution curating remains: Natural History Museum (British Museum), London, England, and Phoebe Hearst Museum of Anthropology, University of California, Berkeley, CA
Excavator: Ronald L. Olson & Richard van Valkenburg (1930's)
References: Olson, 1930; Walker, 1989; King, 1990; Lambert, 1993

(14) Ayalán
Location: Punta Anllulla, southern central western Ecuador, along the Estero Salado
Dating of site: Radiocarbon dating, approximately 1200 years before present
Cultural affiliation: Late Integration Period (Milagro phase)
Subsistence: Agriculturalists
Institution curating remains: National Museum of Natural History (Smithsonian), Washington, D.C.
Excavator: Earl H. Lubensky (1972) and Douglas H. Ubelaker (1973)
References: Ubelaker, 1981

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Section 2. Climate data for later Holocene American sites

While climate was not examined as a variable in the analyses of this paper, the climates of locations used for comparative data were taken into account in their selection. The following tables provide mean monthly and annual climatic data for weather stations geographically proximate to the sites chosen. The National Oceanographic and Atmospheric Administration (NOAA) maintains publicly available databases for climatic data. Modern instrumental data gathered by direct measurements at weather stations have been accumulated over the last fifty or more years from hundreds of global locations, and have been made available in World Wide Web online databases (located at http://lwf.ncdc.noaa.gov/oa/climate/climatedata.html). Only climate data dating to before 1990 are used to minimize the possible effects of climate change.

While using modern climate data is not ideal, it is employed here to provide a broad model of the climatic variation represented in the sample. In the case of the Fremont and Pueblo samples, data was restricted to extreme drought years to match paleoclimate data for those sites derived from tree ring data. Additional discussion of the climate data and the models employed here may be found in Auerbach (2007).

Station numbers for locations within the United States are National Weather Service Cooperative Station Network identifications. These station six-digit identification numbers are provided below with climate data. Weather data for Canada and Ecuador are gathered from world-wide weather station network (which have eleven-digit identification codes). All data are available from the National Oceanic and Atmospheric Administration's (NOAA) National Climate Data Center (www.ncdc.noaa.gov).

Data collected at Cooperative Stations are recorded in Imperial units (inches, degrees Fahrenheit); data presented in this appendix have been converted to centimeters for precipitation and degrees Celsius. World-wide station data are in SI Units.

Months are abbreviated to single letters in order from January to December. Variables: MXT, mean highest temperature of the warmest month; MNT, mean lowest temperature of the coolest month; MAT, mean annual temperature; MTP, mean total annual precipitation. Note that the "Annual" column reports the unweighted mean temperature and the *total annual* precipitation for each site.

Sample: Windover Pond
Station: 044876

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
MXT	6.94	9.17	15.28	20.94	25.33	28.94	30.56	29.83	26.22	20.56	14.61	8.94	19.78
MNT	-5.22	-3.94	0.56	4.94	10.06	14.44	17.00	16.56	12.78	6.11	1.39	-3.00	6.00
MAT	0.89	2.61	7.94	12.94	17.72	21.72	23.78	23.22	19.50	13.39	8.00	2.94	12.89
MTP	6.45	7.16	8.46	7.29	9.27	8.08	9.30	8.05	8.03	9.02	7.67	7.39	96.16

Sample: Point Hope Tigara
Station: 509739

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
MXT	-12.17	-16.56	-14.39	-8.89	0.17	6.22	10.83	10.67	6.78	0.28	-5.44	-11.67	-2.83
MNT	-20.11	-24.00	-22.11	-16.33	-5.33	0.67	5.72	6.11	2.67	-4.22	-11.61	-18.94	-8.94
MAT	-16.17	-20.28	-18.22	-12.56	-2.56	3.44	8.28	8.39	4.72	-1.94	-8.50	-15.33	-5.89
MTP	1.24	0.79	0.94	0.86	1.50	2.21	4.17	6.45	5.69	3.63	1.83	1.22	30.53

Sample: Sadlermiut
Station: 40371915000

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
MXT	-26.01	-25.27	-20.34	-11.15	-2.49	5.57	13.18	11.34	3.88	-4.14	-12.92	-21.18	-7.46
MNT	-34.16	-33.77	-30.21	-21.98	-10.91	-1.15	4.20	3.25	-2.01	-11.16	-21.52	-29.36	-15.73
MAT	-30.09	-29.52	-25.28	-16.57	-6.70	2.21	8.69	7.30	0.94	-7.65	-17.22	-25.27	-11.60
MTP	0.77	0.88	1.08	1.44	1.66	2.79	4.00	4.73	3.52	3.48	1.87	1.16	27.37

Sample: Aleut
Station: 500026

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
MXT	2.72	2.67	3.94	5.39	7.56	9.78	12.39	13.28	11.33	8.56	5.44	3.56	7.22
MNT	-2.11	-2.28	-0.94	0.61	2.61	4.94	7.17	8.17	6.39	3.50	0.67	-0.89	2.33
MAT	0.33	0.22	1.50	3.00	5.11	7.39	9.78	10.72	8.89	6.06	3.11	1.33	4.78
MTP	13.11	9.80	12.01	9.98	7.44	6.20	6.88	10.34	12.60	14.78	18.03	16.94	138.13

Sample: Ikogmiut
Station: 500754

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
MXT	-10.61	-10.67	-6.06	-0.39	9.00	14.89	16.83	15.28	11.11	1.67	-5.22	-9.61	2.17
MNT	-17.56	-18.22	-14.78	-9.06	-0.17	5.72	8.72	7.94	3.50	-4.56	-11.72	-16.56	-5.56
MAT	-14.06	-14.44	-10.39	-4.67	4.39	10.28	12.78	11.61	7.33	-1.44	-8.44	-13.06	-1.67
MTP	1.47	1.09	1.50	1.78	1.98	3.66	5.03	7.39	5.18	3.68	2.72	2.59	38.07

Sample: Lillooet Salish
Station: 40371891001

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
MXT	3.98	6.87	10.43	14.53	18.73	21.63	24.57	24.15	20.18	14.79	8.99	5.20	14.50
MNT	-2.28	-0.80	1.56	4.34	7.65	10.87	12.85	12.59	9.55	5.46	1.64	-0.86	5.21
MAT	0.85	3.03	6.00	9.43	13.19	16.25	18.71	18.37	14.87	10.12	5.32	2.17	9.86
MTP	4.11	2.55	1.66	1.33	1.89	2.67	2.35	2.69	3.03	3.25	3.36	4.96	33.84

Sample: Grasshopper Pueblo
Station: 026653 (1950-1956 data used, reflecting similar drought-like conditions)

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
MXT	12.39	14.33	16.11	20.61	25.28	30.89	32.50	30.83	28.28	23.61	17.22	12.83	22.06
MNT	-6.50	-5.28	-3.56	-1.33	1.89	6.33	12.61	11.94	7.78	1.72	-3.39	-6.39	1.33
MAT	2.94	4.56	6.28	9.61	13.61	18.61	22.61	21.39	18.06	12.72	6.89	3.22	11.72
MTP	5.64	2.49	4.88	3.16	0.82	1.52	11.54	8.51	2.45	1.21	3.56	3.00	48.79

Sample: Mobridge I Arikara
Station: 395691

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
MXT	-4.89	-1.33	5.11	13.72	20.56	25.72	29.78	28.67	22.17	15.61	5.28	-2.89	13.11
MNT	-16.44	-13.06	-6.78	0.56	7.28	12.89	16.33	15.00	9.00	2.50	-5.61	-13.50	0.67
MAT	-10.67	-7.17	-0.83	7.17	13.89	19.33	23.06	21.83	15.61	9.06	-0.17	-8.17	6.89
MTP	0.86	1.07	2.90	5.31	6.60	7.75	5.18	4.47	3.61	2.74	1.35	1.19	43.03

Sample: Polley-Secrest Fremont
Station: 425733 (1950-1956 data used, reflecting similar drought-like conditions)

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
MXT	8.06	11.36	15.88	23.35	27.92	34.31	38.13	36.08	32.95	26.27	13.81	7.36	23.56
MNT	-6.09	-4.44	-0.69	5.31	8.78	13.40	17.53	15.82	10.75	4.46	-2.92	-6.31	5.11
MAT	1.00	3.47	7.61	14.34	18.36	23.88	27.84	25.96	21.87	15.39	5.45	0.54	14.35
MTP	1.55	0.79	1.34	2.21	1.23	0.26	0.79	1.83	1.64	1.56	1.75	1.36	14.80

Sample: Montague Delaware
Station: 288644

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
MXT	0.83	2.44	8.11	14.83	21.11	25.61	28.28	27.28	23.28	17.28	10.61	3.44	15.28
MNT	-11.00	-10.00	-4.17	1.33	6.72	11.89	14.61	13.61	9.11	2.67	-1.39	-7.17	2.17
MAT	-5.06	-3.78	2.00	8.11	13.94	18.78	21.44	20.44	16.22	10.00	4.61	-1.89	8.72
MTP	8.51	7.57	8.92	10.19	11.23	11.28	11.35	10.67	9.65	8.66	10.01	8.94	116.97

Sample: Ledford Island Mississippian
Station: 401808

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
MXT	8.39	11.39	16.61	21.83	25.72	29.56	31.11	30.72	27.44	22.00	16.11	10.56	20.94
MNT	-3.44	-1.72	2.61	6.72	11.44	16.06	18.39	18.00	14.44	7.00	2.39	-1.39	7.56
MAT	2.50	4.83	9.61	14.28	18.56	22.83	24.78	24.39	20.94	14.50	9.28	4.56	14.28
MTP	12.34	11.94	15.24	11.13	12.42	10.29	12.32	8.89	10.57	8.81	11.40	13.46	138.81

Sample: Ryan Mound
Station: 047767

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
MXT	14.54	15.01	14.75	15.46	16.46	17.10	17.69	18.57	18.63	19.03	17.15	14.90	16.61
MNT	5.38	6.47	7.33	7.26	8.99	10.35	11.69	12.60	12.08	10.83	8.31	6.78	9.01
MAT	9.97	10.75	11.06	11.38	12.74	13.74	14.71	15.60	15.36	14.94	12.75	10.85	12.82
MTP	8.53	8.30	9.74	8.37	9.95	10.31	11.06	11.55	11.71	11.41	11.31	10.09	17.04

Sample: Santa Cruz Island
Station: 042516 (temperature data) / 047953 (precipitation data)

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
MXT	17.67	18.72	19.83	22.72	25.83	30.28	34.61	34.78	32.17	27.67	21.72	17.94	25.33
MNT	1.78	2.56	3.11	4.83	7.50	10.00	12.61	12.89	10.89	7.61	4.11	1.72	6.61
MAT	9.72	10.67	11.50	13.78	16.67	20.11	23.67	23.83	21.50	17.67	12.94	9.83	16.00
MTP	6.76	7.52	5.77	2.08	0.36	0.03	0.05	0.43	0.58	0.66	4.60	4.72	33.55

Sample: Ayalán
Station: 30684203000

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
MXT	31.00	31.00	31.00	32.00	31.00	31.00	29.00	30.00	31.00	30.00	31.00	31.00	30.75
MNT	21.00	22.00	22.00	22.00	20.00	20.00	19.00	18.00	19.00	20.00	20.00	21.00	20.33
MAT	26.15	26.27	26.57	26.69	25.97	24.78	23.98	23.93	24.25	24.39	24.83	25.91	25.31
MTP	23.24	28.63	29.51	17.93	5.53	0.43	0.03	0.04	0.08	0.23	0.16	3.01	108.82

Section 3. Regression formula for estimating bi-iliac breadth from femoral head diameter and stature.

As explained in Ruff (1994) and Auerbach and Ruff (2004), body mass may be estimated from bi-iliac breadth and stature when modeling the human body as a cylindrical solid. As also summarized in Auerbach and Ruff (2004), femoral head diameter may be used to estimate body mass based on mechanical properties of body mass support at the hip joint. It is therefore reasonable to propose that, when stature and femoral head diameters are known, it is possible to estimate bi-iliac breadth.

A multiple linear ordinary least squares regression method was used to estimate bi-iliac breadth (the criterion) from individual statures and femoral head diameters. A global sample (Auerbach and Ruff, 2004) and a large sample of North American indigenous groups (Auerbach and Ruff, 2010) were used. A total of 1128 male skeletons with measurable bi-iliac breadths (mean = 269.10mm, Std. Dev. = 16.21 mm) were used in estimating bi-iliac breadths.

The resulting equation to estimate bi-iliac breadth (BIB) in millimeters is presented here. Femoral head diameters (FHD) and statures (STAT) are measured in millimeters:

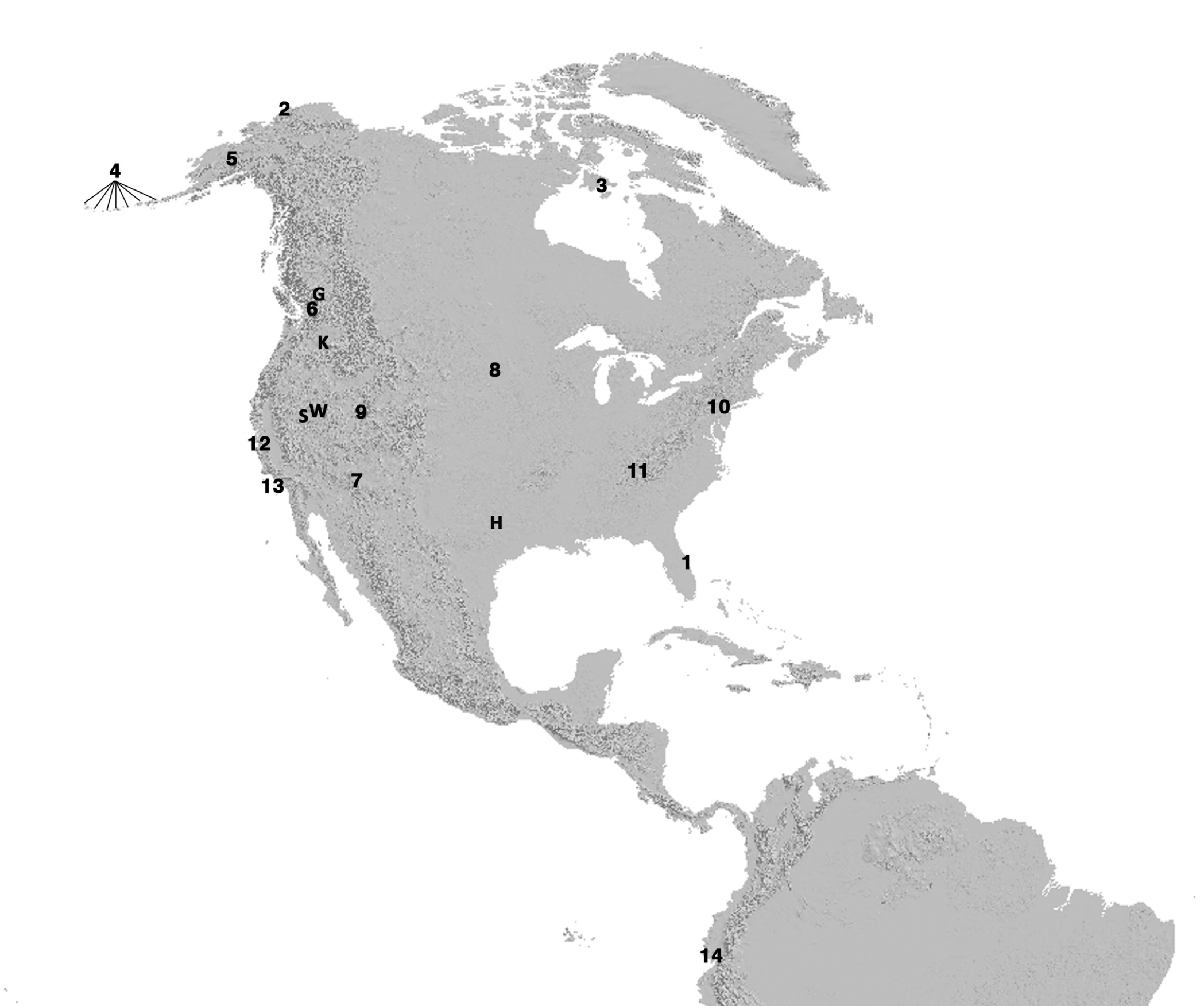
$$BIB = 2.739 \times FHD + 0.0389 \times STAT + 85.45 \qquad (S1)$$

This equation has a standard error of the estimate of $\pm$ 13.41 mm (4.95% SEE) and the multivariate Pearson's $R = 0.58$. The 95% confidence limits of the mean estimate are $\pm$26.28 mm. Based on the high amount of imprecision in this estimate, this equation does not perform well as an estimator of bi-iliac breadths, which have an intra-observer measurement error of under 1% for the entire sample. It therefore is not recommended that researchers use this equation to estimate body breadths.

As body breadth has great potential importance in understanding population history and the migration of humans in the Americas, this equation is utilized to provide broad estimates of the possible bi-iliac breadths of Horn Shelter 2 and Wizard's Beach. However, it should be noted that the statures of both of these individuals were estimated using the equations provided in Auerbach and Ruff (2010). This may result in compound error, so the body breadths reported for these individuals should be regarded as illustrative and not absolute.

FIGURE LEGEND

Figure S1. Approximate locations of American samples used in the analysis. Later Holocene cemetery samples are designated using numbers corresponding with the numbers before site names in Section 1 of the Supplementary Information. Early Holocene skeletons are designated using the same letters used in the main text: G, Gore Creek; H, Horn Shelter 2; K, Kennewick; S, Spirit Cave; W, Wizard's Beach.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H
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