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Dr. Richard L. Jantz,
Major Professor

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SECULAR TRENDS IN STATURE

IN AN

HISTORIC SIOUX POPULATION

A Thesis

Presented for the

Master of Arts

Degree

The University of Tennessee, Knoxville

Joseph M. Prince

May 1989

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FOR MY PARENTS

Sero sed serio.

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ABSTRACT

This study attempts to explore the possibility of the occurrence of secular trends in height in an historic population of Sioux American Indians, and presents the results from an analysis on anthopometric data from two primary sources. One data set was collected in the late 19th century under the direction of Franz Boas. A later early 20th century set was collected by Dr. James R. Walker. A cross sectional design is used to examine an unusually long span of Sioux history; ca. 1820-1880 for the adult (individuals over 20 yrs.) analysis, and ca. 1892-1907 for the children (aged 6 to 11 years). Trends observed in the data are interpreted in light of the insights they provide into the health and nutritional status of this population.

Adult heights (n=1195 tot.) were adjusted for aging effects and regressed on age, sexes being analyzed separately. Tests for differences between the means of age cohorts by decade of birth (1820-1880) were also carried out. The one sample of adults that showed significant differences between age-cohorts in this latter test also showed a significant positive linear secular trend (Walker's adult males). Child heights (n=717 tot.) were used to examine any trend within the 15 yr. interval between original observations (1892 and 1907). A test for equivalence of regression slopes and for means was carried out comparing the two samples of children.

No convincing secular trend could be discerned in the majority of the adult analysis ($p < .05$). Similarly the null hypothesis of equivalence of slopes could not be rejected in the analysis of the child samples. The failure to find any negative secular trend in this population of American Indians is remarkable given the drastic socioeconomic changes that occurred with the coming of the reservation period (1876 on), and the concomitant radical changes in subsistence lifeways. Comparisons with contemporary populations of White Americans also show that the Sioux remained consistently taller than Whites well into the reservation period.

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CHAPTER I

INTRODUCTION

Secular trends in the stature of children and adults have been observed for decades and known for over a century (Tanner, 1966, 1981; Van Wieringen, 1986). It has been generally well established that in developed or industrial countries there has been just such a long term systematic change in height, showing a strong positive trend since World War II (and generally since the end of the 19th century), for increasing height in successive generations of given populations. This secular trend can be observed in all ages, and coincides with the moment that industrialization began to improve socioeconomic conditions. As such changes in height are quite sensitive to fluctuations and variations in economic, cultural and socio-hygienic conditions, changes in secular growth can serve as indicators of the health and nutritional status of a given population. Indeed, this close relationship between changes in exogenous factors and growth pattern has been used to augment standard economic histories for developing western nations during the 18th and 19th centuries (Floud, 1984; Fogel et al., 1983; Fogel, 1986; Komlos, 1987; Sandberg and Steckel, 1987; Steckel, 1986), and has proved useful in deriving improved measures of living standards for these historical populations (Steckel, 1988a).

It is reasonable to assume that the histories of most population groups, when examined in such a manner, will exhibit undulating changes in growth patterns in response to shifting environmental circumstances, such as changes in nutritional status, economic welfare, and morbidity and mortality (Malina, 1979). This thesis will attempt to document just such a trend (or trends) in an historic population of Sioux (Dakota) North American Indians. Any trends observed in the data (adult and child statures) will be interpreted in light of what historians and anthropologists now know about the situation of the historic Sioux tribes during the 19th and early 20th centuries.

The samples utilized in this study are a subset of the larger (ca. 20,000 individuals) Boas North American Indian anthropometric data set. This data set is currently being curated at The University of Tennessee (Knoxville) for the purpose of microfilming and computerizing the original data sheets. The bulk of this data set was generated as part of an anthropometric survey undertaken by the World's Columbian Exposition under the direction of Franz Boas during the years 1891-1892. These data represent the largest and most comprehensive North American Indian data set ever assembled (Jantz and Key, 1987; Jantz, pers. comm.). The samples utilized for this thesis are believed to represent the largest historical American Indian data set ever examined for secular trends.

A working hypothesis was constructed about the possible shape or direction of a secular trend in 19th century Sioux (ca. 1820-1880 by decade of birth for the adult analysis), and late 19th and early 20th century Sioux (children and 6 to 11 years reporting on the 15-year interval 1892-1907). It was conjectured that since the Sioux have usually been reported as being among the tallest of all Indians (Boas, 1894; Schell and Johnston, n.d.; Wissler, 1911), and given that there are ample reports of stress they were subjected to upon their move to the reservations, one might expect a negative secular trend. That is, with worsening living conditions, inadequate nutrition and radical changes in activity and subsistence patterns (from semi-nomadic hunters to sedentary farmers or herders), one might expect individuals born during or after the reservation period to exhibit shorter statures when compared to adults born earlier in the 19th century. (The final phase of establishment of permanent Sioux reservations occurred during the period 1870-1876). In this manner, the reservation period provides a common time horizon as well as a shared experience of universal importance to all the Sioux groups represented in this study.

The significance of this thesis lies in the exploration of several important questions heretofore seldom studied or difficult to address when involving an understanding of American Indian biological variation and adaptation (Jantz and Key, 1987): (1) an examination of an unusually long span of Sioux (Indian) history (about 2/3's of Sioux history on the Great Plains, up to 1907, is represented) for secular trend; and (2) an assessment of Sioux adult and child growth in relation to contemporary white standards of the 19th and early 20th centuries.

CHAPTER II

A GENERAL SKETCH OF SIOUX HISTORY (1820-1900)

The following is a brief survey of Sioux history, intended only to provide a framework of interpretation for the research results reported in this thesis. There are many sources from which a more detailed depiction of Sioux history and life can be gleaned (e.g., Anderson and Hamilton, 1971; Bad Heart Bull, 1967; Bowler, 1944; DeMallie, 1984; Commissioner of Indian Affairs [C.I.A.], 1870-1910; Gerlach, 1970; Hassrick, 1964; Hickerson, 1974; Holder, 1970; Howard, 1966; Hurt, 1974; Hyde, 1967, 1956; Johnston, 1948; MacGregor, 1946; Marken and Hoover, 1980; Nurge, 1970; Olson, 1965; Powers, 1977; Prucha, 1984; Schell, 1975; Seerley, 1965; Standing Bear, 1928; Textor, 1896; Utley, 1963; Walker, 1980, 1982, 1983; Wedel, 1940, 1986; Weist and Sharrock, 1985; Wood, 1986; Wood and Liberty, 1980; Woolworth and Champe, 1974).

Identity and Demography of the Dakota or Sioux Indians

As Howard (1966:1) reminds us:

> Perhaps no tribe of American Indians with the possible exception of the Apache, is as familiar to the general public as the Dakota or "Sioux." Famous for their stubborn resistance to the Whites, the Dakota remain the favorite prototype for Indians in "Western" films, romantic novels, and television sketches.

The term "Sioux" is derived from the French corruption of the Chippewa term for enemy "Nadowe-is-iw," meaning literally "snake" or "adder," and dates to the time when the entire Sioux tribe resided in the western Great Lakes region (Howard, 1966). A common mistake made when referring to these Indians as "Sioux" is the confusion with the linguistic term "Siouan." Although the Dakota language is a member of the Siouan language family, this category also includes many of the historic tribes perennially at war with the Sioux (e.g., the Omaha, Winnebago and Mandan tribes). Therefore, Siouan should not be used as an adjectival form of Sioux, the latter referring to the tribal identity. Both the United States and Canadian governments officially refer to the tribe as Sioux, and the term is now commonly used by both Whites and Indians when speaking English (Howard, 1966).

At the time of first white contact the Sioux were essentially Woodland Indians living in the region near the western margin of the Great Lakes, a territory that now comprises most of the middle and southern portions of Minnesota, and some adjacent areas of Iowa, Wisconsin, and North and South Dakota. At this time (ca. 1640-1700), it is inferred that the tribe was divided into seven bands or "council fires." These were:

Eastern or Santee division:

1. Mdewakantonwan ("Spirit Lake Village");

2. Wahpekute ("Shooters Among the Leaves");

3. Sisseton ("Fish Scale Village");

4. Wahpeton ("Dwellers Among the Leaves").

Middle or Wiciyela/Yankton division:

5. Yankton ("End Village");

6. Yanktonai ("Little End Village").

Western division:

7. Teton ("Dwellers on the Plains").

With the migrations of these groups both south and west there arose three great divisions of the tribe as cultural and dialectic differences emerged. These are the Eastern, Middle, and Western divisions, as noted above. As a further consequence of these migrations, several sub-bands were created. These are most notable among the Western or Teton division, but also exist for the Middle Sioux (Feraca and Howard, 1963) (Figure 1).

Migrations were quite frequent during the first hundred years of Sioux history since white contact. Under constant pressure from their better-armed Algonquin neighbors to the north and east, the Sioux gradually moved out of their territory around the headwaters of the Mississippi (in Minnesota) on into the Minnesota Valley. From this region the Western and Middle divisions of the Sioux began to drift slowly westward, following the buffalo herds, until they reached the open plains of the Missouri Basin, in the present state of South Dakota. By 1775 an Oglala war party

WESTERN SIOUX (Teton Dakota)	MIDDLE SIOUX (Yankton)	EASTERN SIOUX (Santee)
Oglala (Pine Ridge Reservation)	Yankton (Yankton Reservation)	Mdewakanton - (in Minn.) (Flandreau) (Santee, Nebr.)
Brulé (Rosebud) (Lower Brulé)	Upper Yanktonai (Standing Rock, Devil's Lake, N.D.)	
Hunkpapa (Standing Rock)	Lower Yanktonai (Crow Creek, Ft. Peck, Montana)	Wahpeton (Devil's Lake) (Flandreau) (Sisseton)
Blackfoot Sioux (Standing Rock) (Cheyenne River)		Wahpekute (Santee) (Ft. Peck)
Sans Arcs (Cheyenne River)		Sisseton (Sisseton) (Devil's Lake)
Miniconjou (Cheyenne River)		
Two Kettles (Cheyenne River)		
Dialect: Lakota	Nakota	Dakota

Figure 1. Divisions of the Sioux (Dakota) With Their Present Location

Source: Maynard, E., and Twiss, G. (1969) That These People May Live: Conditions among the Oglala Sioux of the Pine Ridge Reservation, Pine Ridge, S.D.: U.S. Public Health Service, p. 39.

Note: Unless otherwise noted the reservations mentioned with the brackets are located in North and South Dakota.

had reached the Black Hills, finding timber, game, and buffalo plentiful there (Hyde, 1967; Schell, 1975). As Schell notes (1975:22), eventually the domain of these Teton and Yankton Sioux came to include not only all of the territory of South Dakota (and portions of North Dakota), but generally ". . . extended from the Republican River in Kansas and Nebraska westward to the Rocky Mountains and northward to the Canadian border." (The historic territory of the three Sioux divisions are indicated in Figure 2.)

For the purposes of this thesis both the Western (Teton) and Middle (Yankton) Sioux will be referred to collectively as "Plains" Sioux when a comparison with the Eastern or Santee Sioux is made. This categorization is made mainly for heuristic ends, with the full realization that only some Yankton or Yanktonai would meet the requirements of a strict interpretation. Most of the 18th and 19th century Yankton domain lay between the Big Sioux River on the east and the Missouri River on the west, occupying much of the eastern part of the present state of South Dakota. The Yanktonai (a Middle division sub-band) domain was situated in much the same manner, only further north, extending from the Red River in the east to the Missouri in the west. With the Red and Big Sioux rivers making up most of the boundary between the Eastern and Middle and Western Sioux, it is sometimes convenient to regard those west of this line as "Plains" Sioux. As noted

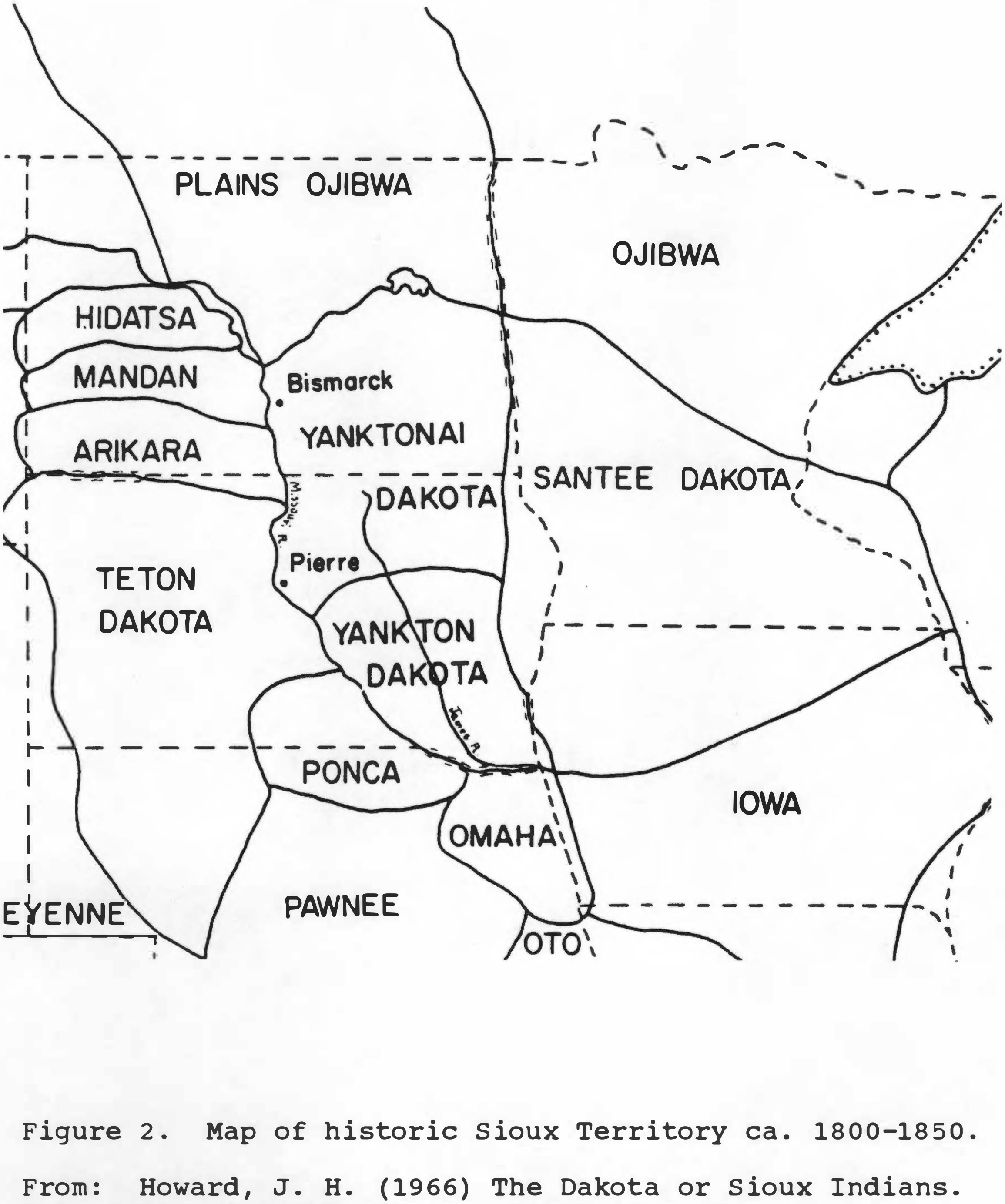

Figure 2. Map of historic Sioux Territory ca. 1800-1850.

From: Howard, J. H. (1966) The Dakota or Sioux Indians. University of South Dakota: Dakota Museum. Anthropological Papers No. 2 (N.P.).

by Howard (1966, 1972, 1976), this is somewhat of a misleading simplification, as most of the Yankton could be found in a "tall grass" or prairie environment, which is easily distinguished from the more arid "short grass" plains country. This latter area was the proper domain of the Teton, who would come to occupy the trans-Missouri lands west of the Missouri and extending over several present day states (notably Nebraska, with smaller portions of Montana and Wyoming). Many early ethnographic reports also utilized a similar scheme, i.e., the Sioux of the Mississippi [River] and the Sioux of the Plains/West (Hurt, 1974).

Subsistence and Diet of the Pre-reservation Sioux

As noted by Hurt (1974:18):

> No single village or economical pattern has characterized all the Dakota Sioux since the time of European contact. In addition, that of a single tribe [band] also varied through time. This variation resulted from the many different ecological zones inhabited by the Sioux in their homeland in the headwaters of the Mississippi, and was compounded by the migrations of many of the Sioux tribes into the northern plains at a later date.

The familiar image of the Sioux as nomadic equestrian bison hunters and tipi-dwellers of the western plains actually represented a life way that gradually developed during the ensuing century since white contact, and only then properly categorized the most western divisions of the tribe (the Tetons and to a lesser extent the Yanktons). The

Eastern or Santee Sioux largely retained their Woodland Indian identity up until the period when conflict with Whites forced them to be removed from their ancestral homeland and scattered widely over the Plains.

A central unifying feature for most of the Middle and Western Sioux bands was their primary or heavy reliance on buffalo as a principal subsistence resource. Although this buffalo economy was not fully organized until after these new migrants crossed and came to occupy the lands to the west of the James and Missouri Rivers (South Dakota), it seems to be firmly established by the period 1790-1800 (Hagen and Schaw, 1960; Holder, 1970; Hurt, 1974; Hyde, 1967).

Of equal importance to these Sioux was the adoption of the horse. Originally horses were variously gifts of or stolen from the then more populous, sedentary riverine Plains tribes (the Mandans and Arikaras), who would be eventually displaced by the westward migration of the Sioux, and driven from their territory. With the introduction of the horse (ca. 1760-1790) the Sioux, formerly semi-sedentary hunter-gatherers, were radically transformed. New ecological opportunities were now possible; with their newly acquired horses the Sioux could range over astonishing distances to hunt the buffalo and came to rely upon this skill to provide an increasing share of their subsistence base. As trade firearms became more readily available, the horse enabled the Sioux to wage war with great effectiveness against their Plains neighbors: the Arikaras, Cheyennes, Crows, Omahas, and Poncas (to name but a few). The Teton Sioux were exemplars of this new adaptation; they became buffalo nomads, and within one generation after crossing the Missouri River (about 1750) they, along with some of their Yankton brethren, had driven the once powerful Arikaras from their stronghold near the Great Bend of the Missouri (ca. 1775-1792) (Holder, 1970; Hyde, 1967).

For the Teton the buffalo provided for virtually all their needs: the buffalo robes were used for garments, bedding, and for trade; tanned hides served in the construction of food containers and the tipi (the main type of Teton dwelling for both summer and winter); bones and horns were made into implements for hide processing and other tools; and the sinews furnished thread, bow strings and rope (Hassrick, 1964; Nurge, 1970; Seerley, 1965).

The location of Teton camps were largely determined by the access they afforded to sizeable buffalo herds. Other accommodations were made in the Teton cultural structure to meet these new circumstances; sub-bands were formed, and bands in general became more fluid entities to better sustain a nomadic way of life. Teton material culture also came to reflect this nomadic imperative, being light, durable, and easily transported. The use of pottery was abandoned, and whatever limited horticulture previously practiced was generally given up. (This latter feature does not entirely apply to the second Plains Sioux division, the Yankton or Middle division, as noted below). The horse quickly became a valuable commodity: a measure of a man's wealth, and a significant contribution to the economic security of the entire band. With the aid of a fast durable horse, a man could with relative ease acquire a surplus of buffalo meat for his family (Hassrick, 1964; Howard, 1966; Hyde, 1967).

In addition to buffalo the Teton were also known to have exploited a number of other animals: deer, elk, antelope, porcupines, beavers, otters, raccoon, bear, bobcats, coyotes, bighorn sheep, squirrels, as well as nearly any other animal available on the plains (Seerley, 1965). A wide variety of plant resources were also known to have been utilized by the Teton Sioux as well as other Plains Indian tribes (Gilmore, 1919). Most notable among these were the timpsina or prairie turnip, wild artichokes, wild onions, choke cherries, gooseberries, buffalo berries, elderberries, wild plums, sand cherries, and nuts of all sorts. Additionally, the inner bark of cottonwood trees was often used to feed hungry horses during the winter, and the soft maple and box elder provided sap for sugar (Hassrick, 1964). The Teton were also known to obtain corn, beans, and squash through trade with the sedentary Missouri river tribes (Arikara or Mandan), or failing this, by plundering these and other neighboring tribes (Hassrick, 1964; Seerley, 1965).

The Yankton or Middle division Sioux subsistence pattern differed somewhat from that of the Teton, the principal distinction being the extent of Yankton involvement with farming or gardening. Ethnographic reports from the period clearly indicate that some Yankton did practice a limited sort of horticulture, with different bands[1] being cited for the custom during much of the pre-reservation period (Woolworth and Champe, 1974). It seems equally clear that this practice was not uniformly observed for all or "most" of the Yankton, or indeed for any one large consistent group for a period much before 1840-1850. The record seems to indicate that horticulture declined in importance after the Yankton had migrated onto the prairies and plains around 1700. Like the Teton, they came to depend more heavily upon the great herds of buffalo to supply most of their needs. It was only with the drastic diminution of these herds within their territory did they again take up horticulture and government sponsored agriculture in any great numbers (Woolworth and Champe, 1974).

As evident from compiled ethnographic reports, part of the problem in assessing the extent of such practices among the Yankton is the diverse and complex relations the Yankton

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[1] Here "band" is utilized in a generic sense, i.e. Drifting Goose's band, indicating the chief of a "band" of Lower Yankton Sioux.

regularly engaged in with both the Santee and Teton bands. Seemingly for any given time horizon (a ten-year span for example), a variety of different circumstances can be revealed: in 1805, for example, the Yankton are reported to be following the buffalo "as chance directs"; but another band of Yankton are reported to be raising corn on the Des Moines River in 1812 (Woolworth and Champe, 1974:183). During this time period several different Yankton bands are reported to have been traveling and hunting with various Teton bands, principally east of the Missouri River. Yet about ten years later (1822) we find ethnographic reports mentioning Yanktons camped with some Sisseton and Wahpekute bands near the Blue Earth River in southwestern Minnesota. By 1836 there is clear evidence that the Yanktons had shifted their hunting grounds from the banks of the Missouri to the Teton territory around the Black Hills (Woolworth and Champe, 1974). It seems reasonably apparent that the Yankton enjoyed decent enough relations with both neighboring Sioux divisions, and were flexible in association with both as mutually beneficial opportunities arose (e.g. cooperative hunts or village sites for cultivation and trading fairs).

Another researcher (Howard, 1966, 1972, 1976) has long argued that Yankton contacts with the semi-sedentary riverine tribes (the Arikara, Hidatsa, Mandan, and Ponca) brought about cultural changes in the Yankton, to the effect that "by the beginning of the reservation era both Yankton and Yanktonai bands had approximated many of the cultural patterns of these riverine tribes to a remarkable degree" (Howard, 1966:1). According to this model, the Yankton, like the riverine tribes, would plant their crops of corn, beans, and squash along the floodplains of the Missouri, James, and Vermillion rivers. Their seasonal pattern would differ from the Teton in that these villages would be semi-permanent, and the Yankton would return from the summer buffalo hunt in order to harvest crops that had been planted the previous spring. After an August harvest the Yankton would remain in these villages until the late fall or winter bison hunt would begin, returning to plant once again in the spring. However, as noted above, it is not entirely clear that this type of horticulture was commonly practiced among the Yankton for most of the pre-reservation period.

Most sources agree that for a majority of Yankton the buffalo remained a primary focus of the subsistence economy of these Middle Sioux. This is not to deny the possibility that some bands of Yankton may have derived a considerable or important part of their subsistence from horticulture, only to again note that such bands seem to have been in the decided minority.

In other aspects the Yankton were quite similar to their Teton neighbors; the horse was of vital importance to them, and for the most part they continued to exhibit the characteristic nomadic hunting economy that is seen for the Western division Sioux. Also in common with the Teton, the tipi was the principal dwelling, and the same basic food stuffs were utilized by both divisions (Warren, 1986). Both bands also shared a passion for "wasna," a particular "mixture of pounded, pulverized meat and choke cherries that had been pounded into a pulp (pits and all) and combined with animal fat" (Seerley, 1965:77). This preparation when tightly wrapped in a hide "parfleche" pouch could last for several years, and sustained the Sioux while traveling or in times of famine. In this manner, a surplus of buffalo meat could be stored for later use, a highly valuable consideration given the Plains Sioux nomadic way of life.

The Santee or Eastern division Sioux had a subsistence economy that most closely resembled their Central Algonquin woodland neighbors (the Ojibwa, Menominee, Sauk, and Winnebago). Although the Santee are known to have hunted the buffalo, this animal did not represent the same economic focus for the Santee as it did for the Plains Sioux. The more common game species of the eastern forests were more important to most Santee; deer, moose, and a wide variety of fish being the most prominent of these. Wild rice was also known to have been gathered, and along with other wild foods like the timpsina (prairie or wild turnip) and maple sugar, provided an important share of the diet for most Santee. Extensive gardens were also maintained by most

Santee in which corn, beans, squash, pumpkins, and tobacco were grown (Howard, 1966; Woolworth and Champe, 1974).

In general most Santee traditionally hunted on foot, but several different bands are known to have occasionally hunted with the Yankton for buffalo. It seems likely that during these periods when they hunted on the prairie, the Santee utilized horses extensively. It is also apparent that horses were gradually incorporated within the Santee lifeway and became more popular sometime after 1800. It is also fairly certain that horses were never as prevalent among the Santee as they were among the Plains Sioux. At the time of the Minnesota uprising (1862) Bowler (1944) makes mention of several bands of mounted "hostile" Santee and the troubles involved in capturing these roving bands.

Ethnographic reports also indicate that for considerable periods of time some Santee bands were known to have camped and traveled with various Yankton bands in the Missouri River basin. As Woolworth noted (1974:84), "we have unmistakable evidence that a sizable body of Santee Sioux had moved from southern Minnesota or northwest Iowa to the Missouri and had joined the Yankton . . ." in 1830. It should be mentioned that this band seems to be identifiable, and continued to be associated with these particular Yanktons (from the Upper Missouri Agency) for nearly a decade. Other bands of Santee are known to have frequented Yankton territory during the late 1830s and the

1840s, principally because game was growing scarce in Minnesota and northwestern Iowa.

The Santee subsistence pattern was substantially different from the Plains division Sioux. Most Santee bands concentrated on a different spectrum of food resources that were not available on the prairie or plains of the Dakota territory. They utilized different house types, and in their dress and economy more closely approximated their Central Algonquin neighbors than the Sioux of the Plains. In these traits the Santee division seemed to have retained the "ancestral" type of economy that is postulated for all pre-migration Sioux (i.e. before 1700) (Howard, 1966; Hurt, 1974). Although extensive conflicts and wars with Algonquin tribes (Sauk, Fox, and Chippewa among others), forced the Santee to retreat to southwestern Minnesota and northwest Iowa after about 1800, they never fully migrated onto the plains as did the Teton and the Yankton Sioux (Hickerson, 1974; Woolworth and Champe, 1974). Up until the Minnesota uprising of 1862, most Santee could be found within a territory bounded on the west by the Red and Big Sioux Rivers, and on the northeast by the Mississippi River; the furthest extent north being about the present city of St. Cloud (Minnesota); the southern extent being not much beyond the present city of Sioux City, Iowa.

A Brief Sketch of Sioux History: 1820-1900

By the year 1800 the Sioux of the Plains were beginning to consolidate their position and settle into the territories that would come to be identified with them throughout the pre-reservation period. French trading expeditions at the time clearly note that the Plains Sioux were "all migratory" and those residing near the Minnesota River (the Santee), were mainly "tillers of the soil" (Hurt, 1974:130). Also at this early date (1802-1804), the particular pattern of endemic warfare that would come to be associated with the Plains Sioux was readily apparent. An unequal trading relationship between the Sioux and the Arikara was also noted, this latter tribe having been decimated by several great epidemics of smallpox (1750 and 1780-1782) (Hyde, 1967; Taylor, 1977) and recurrent depredations by the Sioux, who would come to appropriate Arikara hunting lands on the Missouri. Most of the bands contacted by these White traders were situated on both banks of the Missouri, and did not seem to occupy the lands far into the plains west of the Missouri in great numbers.

The Lewis and Clark Expedition of 1804-1806 made note of the fact that annual trading encampments were held at the head of the James River, and that this area of present day eastern South and North Dakota was repeatedly traversed by all the Sioux divisions: the Tetons, Yankton, and Santee (in particular the Sisseton and Wahpekute bands representing this latter Eastern division). The Wahpekute and Sisseton were known to hunt only on the margins of this territory, however.

By this time French traders from St. Louis had established a trading post on the Missouri near the Great Bend. The Tetons soon developed a seasonal cycle that came to include an eastward trek to the Missouri for trading. There are reports that indicate that Teton Oglala bands were regularly wintering on the eastern edge of the Black Hills at this time. In spring these bands would hunt along the Bad River, reaching the Missouri to join with other Teton bands (notably the Brulé, Sans Arc, Hunkpapa, Two Kettles and Blackfeet bands) and settle in large camps to conduct the Sun Dance and make war on the Arikaras and Mandans (Hagen and Schaw, 1960; Hyde, 1967). They were also known to attack traders going north to trade with these enemy tribes. It is also apparent that by this time the Teton Sioux were gradually encroaching upon the traditional hunting territories of several Plains Indian tribes: the Ponca (to the immediate south), the Arapaho (further south), and the Crow (to the west) (Hurt, 1974).

By 1817 American fur traders had penetrated to the area occupied by the Sioux, and went on to establish several trading posts along the Missouri. From this time on, competition between these various commercial interests became fairly intense. As inducement to trade, liquor was made available to the Sioux in quantity for the first time. The first two decades of American occupation of the Central and Northern Plains (1805-1825) also brought an increasing number of European and American explorers into the area, as well as the first major American military expeditions (by Pike and Leavenworth among others). During this time period the Sioux mainly traded with the British and French. This caused problems for the Americans, who had recently acquired the territory as part of the Louisiana Purchase (1803) and desired to explore the region and exploit its natural resources. It was within this context of trade wars between various factions that the Teton and Yankton Sioux entered into a military alliance with the American army (represented by a force led by Colonel Henry Leavenworth), to punish the Arikara for attacking and killing several members of a party of trappers in 1823. Although this campaign was not successful, the Teton Sioux would eventually succeed in defeating the Arikaras, who were forced to retreat to the Upper Missouri sometime after 1825. Also during this time period the Teton were coming into the Black Hills in force, pressuring the Kiowa, Arapaho, Cheyenne, Crow, and Apache tribes southward and westward. By about 1825 on, these older hunting tribes were being rapidly displaced by the Teton west of the Missouri (Hagen and Schaw, 1960; Hurt, 1974; Hyde, 1967).

In 1825 the first treaties of peace and friendship were made with the Plains Sioux and neighboring Plains tribes, and the Eastern Sioux and their Algonquin neighbors. On making these treaties with the Indians,the U.S. Government hoped to quell the increasing level of hostilities in both regions, which by now were growing in economic and political importance. Unlike most of the Plains Sioux, the Santee Sioux (as well as those Yankton remaining in Minnesota and northwest Iowa) were facing severe pressures from the Algonquin tribes (in particular the Chippewa, Sauk, and Fox), during most of the 1820s. These Sioux were themselves being displaced south and westward as a result of conflicts along a broad front with these neighboring tribes over resource areas (Hagen and Schaw, 1960; Hickerson, 1974; Hyde, 1967). Despite numerous peace councils between the Chippewa and the Sioux, these conflicts would continue off and on for at least a decade after 1825.

It was also during this time that the first United States Indian agents were sent among the Sioux (1819). These men were mainly responsible for regulating the fur trade with the Indians (i.e. to issue and recall the licenses of traders), maintaining the peace with recent settlers on the frontier, administering the payment of annuity (treaty) goods for lands ceded by the Indians, and keeping records on the situation and conditions of the Indians and the surrounding territory (Prucha, 1984). These agents lived within the Indian territory, and it is from these reports that a great deal of ethnographic detail about American Indians has come to light. Indian agents were first sent to the Santee Sioux in Minnesota, and later to the Dakota territory.

The period of 1825-1845 saw a marked increase in trading posts, as well as an influx of travelers to the Central and Northern Plains. Additionally, it is obvious that the buffalo were continuing to gradually retreat from their former ranges east of Missouri (Hickerson, 1974; Hurt, 1974; Hyde, 1967). This period also coincided with the heyday of the fur trade on the Upper Missouri. This trade concentrated on buffalo pelts and was certainly a major contributing factor to the disappearance and near extinction of these animals. The Sioux gradually became more enmeshed in this trading economy to the point of dependency by the end of this period. Previously largely self-sufficient, the Sioux came to rely heavily upon the manufactured goods they received in exchange for the pelts they could supply. This development is seen as an important indication of the economic and political decline of the Sioux. While it would eventually require the direct application of military force (e.g. wars with the U.S. 1861-1876), the seeds for the dissolution of the Sioux as an autonomous culture were already sown (Hagen and Schaw, 1960; Schell, 1975).

Increasingly, immigrants traveling west to California or Oregon passed through Teton Sioux Territory by way of the Platte River. Besides presenting new opportunities for conflicts and disputes of all kinds, this new influx of Euro-Americans represented a significant new disease vector for the Sioux (Hurt, 1974; Hyde, 1967; Taylor, 1977).

During this time period the Western Sioux were still actively expanding their territory in all directions to encompass much of the former territory of the Crows;

> the area of the Black Hills of South Dakota and the Little Missouri and . . . the section of the North Platte eastward from a line extending from Red Buttes beyond the Laramie Fork to the Little Missouri (Hurt, 1974:222).

They regularly made raids to the mouth of the Yellowstone River (North Dakota) to assail the Assiniboine, and drove the Pawnees from their territory on the North Platte River (Nebraska). The 1830s are generally considered to be the zenith of Teton Sioux political, economic, and military power and influence. The Teton dominated the Plains from just below the Knife River (North Dakota) to the Niobrara (Nebraska); never again would the game be as plentiful, their lands as free from White settlers, their horse stealing or war forays go unpunished by the government, or their dominance of the Northern and Central Plains go unquestioned (Hagen and Schaw, 1960; Hyde, 1967).

The situation for the Missouri River Sioux (Yankton) and the Santee was already becoming fairly desperate in some instances, due to the lack of game and the gradual disappearance of the buffalo herds east of the Missouri during the 1830s. Although most Sioux seem to have regularly undergone a feast and famine regime (Nurge, 1970; Seerley, 1965), both winter counts[2] and ethnographic reports mention an increasing frequency of starvation and famine among these groups beginning in the mid-late 1830s. By the end of 1845 there are consistent reports of starvation facing thousands of Sioux on the Missouri River (some Sisseton included in this number) (Hickerson, 1974; Hyde, 1967; Woolworth and Champe, 1974). This increasing scarcity of game would come to force the Yankton to range west of the Missouri in search of food, and to attempt to slowly revive past horticultural practices from about the mid 1830s on. The extent of this phenomenon is also indicated by the fact that the Yankton were expanding their territory at this time, helping to force the Pawnees from the Platte River in order to secure access to larger hunting lands. In general, this scarcity was first seen in the eastern portions of the Sioux territory and gradually spread westward. By the mid-late 1840s buffalo became scarce west of the Missouri,

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[2] A type of tribal history, kept by the Sioux themselves, to record the most significant event occurring during the previous year. Originally these were recorded just as pictographs painted on tanned hides. As the Sioux gained an orthography of their language (by the mid 1850s), brief descriptions were written beneath the pictographs. This was also done retrospectively, as the historians were required to memorize the explanatory phrase indicating the significance of the pictograph (Howard, 1976).

forcing the Teton further afield to reach sizable herds (Hyde, 1967; Woolworth and Champe, 1974).

To the east the Santee were faced with a new influx of settlers to the Minnesota territory; this only further exacerbated the disappearance of game in this territory and would reignite intertribal conflicts over the rights to hunting grounds (Hickerson, 1974). In a pattern that would become quite familiar to the Sioux in later years, the pressure from these settlers forced the acceptance of the first major land cessions by the Sioux. In 1837 the Mdewakanton Sioux signed a treaty ceding all possessions east of the Mississippi for specified annuities for twenty years; these included a provision that these funds be spent to purchase medicines, agricultural implements, and for the support of a physician, government farmers, and blacksmiths (Bowler, 1944).

The period of 1845-1876 was characterized by an intense period of Indian-White hostilities throughout the entire Sioux territory. The causes behind this period's heightened tension are fairly unambiguous: immigrants started to reach Indian Territory in great numbers, buffalo and other game became scarce, the break-up of Indian lands forming new territories or states, and most certainly the fact that the military was called on to occupy the Sioux territory to protect White interests (Hurt, 1974; Schell, 1975).

This latter feature was an important ingredient that kept a deadly cycle of costly murderous blunders and equally devastating reprisals between the Sioux and Whites maintained. The Army's presence tended to aggravate many a small dispute into major confrontations with the government, something that was not easily controlled and would inevitably lead to a new cycle of hostilities as the Army failed to discern "hostile" from "friendly" Indians; or conversely, the Sioux tried fruitlessly to run off more settlers or surveyors from what they considered to be their territory. This is the era of Sioux history that is more familiar to most people (if only in fairly cursory detail).

This period is often presented as the climax of Sioux culture and power. However, most popular accounts fail to note that while direct military conquest or force certainly played an important part in the "subjugation" of the Sioux, the more important role was that of the loss of the buffalo, the basis of their economy. As noted above, in this light the Sioux were in decline long before the brunt of governmental military force was ever applied. The dealings with Whites within the context of the new economy of barter and trading for buffalo hides certainly helped cause the dramatic reduction in buffalo during this period. This was probably more responsible for the decline of the Sioux than any of the more obvious (and costly) military campaigns that are a central part of the popular lore of this period (Hagen and Schaw, 1960; Hyde, 1967; Schell, 1975).

The beginning of this strife-filled period for the Teton Sioux probably can be traced directly to the swelling number of migrants that appeared along the Platte River Valley traveling towards the California gold fields (from 1849 on). The Teton blamed these travelers for driving the buffalo away from the North Platte, forcing them to hunt beyond the Black Hills. The migrants loudly complained of Sioux depredations, primarily the theft of livestock and horses. Already by 1845, the first company of U.S. dragoons was sent against the Indians in a show of force. In 1849, Fort Laramie was purchased by the government in order to better protect these migrants traveling along the Oregon Trail.

The first settlers came to present day Nebraska and South Dakota during the 1850s. The Nebraska Territory was formally created in 1855, and at this time settlements started springing up on the Iowa side of the Missouri (Hurt, 1974). After a brief military campaign, General Harney negotiated with the Teton in 1856 to have the right of free travel over the Oregon Trail recognized. Although this treaty was never ratified by the Senate, it was considered that the Teton had consented to immigrant traffic through their territory along the Platte, and over a trail following the White River from Fort Laramie to Fort Pierre (Hurt, 1974; Schell, 1975). It is conjectured that Harney's defeat of the Brulé in 1855 generally suppressed the Teton until the panic from the Minnesota Santee outbreak of 1862 spread across the Plains, eventually involving many Plains Sioux in the hostilities. By the end of the 1850s several forts had been established by the government, Fort Laramie (Wyoming) on the Upper Platte being principal among these, with several others also scattered throughout Sioux territory. From 1852 to 1860 the Plains Sioux consequently experienced firsthand the effectiveness of the military in responding with punitive measures to outbreaks of lawlessness or violence by the Sioux.

The Santee Sioux of Minnesota were the first Sioux to be forced on a permanent reserve, this by treaties ratified in 1851. Minnesota was declared a territory in 1849, and the Santee had faced increasing pressures from settlers, miners, and lumbermen who were already encroaching upon their lands. In these treaties the Santee ceded all their lands in the territory of Minnesota and Iowa east of the Red and Big Sioux Rivers (Bowler, 1944). Although the Santee were promised specified annuities, most of these monies were never received. In general, the condition of these Sioux during most of the first decade of reservation life is reported to have been quite poor (Bowler, 1944; Textor, 1896). By 1860 some progress was noted in advancing government-sponsored agriculture on this reserve, but seemingly the policy of acculturation, by which instruction in agriculture was supposed to turn these Indians into self-sufficient sedentary subsistence farmers, was largely a failure. This was to become a common approach to "civilizing" the Sioux; it would enjoy a modicum of success only at those few reservations situated on suitable lands (Hoover, 1983; Textor, 1896).

By 1850 the Yanktons, having realized that game was quickly disappearing from their territory, were variously trespassing on Brulé hunting lands to the west, and starting to make serious attempts at farming on several eastern river basins. Hunger and starvation among these Missouri River bands is mentioned in the ethnographic literature for the years 1848 and 1849 (Woolworth and Champe, 1974). The fur trade also having all but been extinguished, the Yanktons were now more dependent upon the annuities from land cessions they made in 1830 and 1837.

By 1850 it was also noted that the Yanktonai sub-bands generally enjoyed better hunting opportunities in their territory than did the Yankton sub-bands proper. (It should be remembered that these latter bands ranged lower down on the Missouri and James Rivers in present day South Dakota.) As a result of this, the Yanktonai bands generally traveled with and came to be associated with the northern Teton sub-bands ranging west of the Missouri. The Yankton sub-bands were soon forced into negotiations with the government as game became more scarce and the advancing line of White settlements approached their territory from the south and east. In accounts of the day, the Yanktonai would soon come to be associated with the hostile Teton bands that would not be entirely subdued and placed on reservations for more than two decades (Schell, 1975; Woolworth and Champe, 1974).

As Minnesota became a state in 1857, there was a clamor for land for prospective townsites along the eastern boundaries of Yankton territory. Under this pressure, and facing periodic bouts of disease and a general scarcity of all types of game, the Yankton sub-bands agreed to cede their territories east of the Missouri River and withdraw to a reservation. By a treaty signed in 1858 this reservation was created along the east bank of the Missouri River within the present confines of Charles Mix County, South Dakota. Soon after this site was occupied in 1859 a census of these Lower Yankton bands showed a population of just over 2,000 individuals (Schell, 1975; Woolworth and Champe, 1974). A small amount of annuities were included in this treaty along with hunting rights; however--and importantly--no specified rations were written into this treaty. Attempts at making a treaty with the Upper Yankton sub-bands (the Yanktonai) at this time were largely fruitless.

The central event that would in some sense come to predetermine the fate of all the Sioux on the Plains was the Minnesota Sioux uprising or the Santee outbreak of 1862.

Most sources agree that treaty non-compliance by the government over promises made to the Santee led to the outbreak of hostilities. For several years annuity payments were late or not paid at all; many Santee were destitute and hungry, and hundreds of Indians are said to have died of starvation (Bowler, 1944). The hostilities, mostly involving the Santee sub-bands proper, soon came to encompass most of southern Minnesota, only ending when the Minnesota militia chased large parties of Santee across the Big Sioux River and into the Dakota Territory.[3] As the Santee fled towards the Missouri, they communicated these hostilities across the Northern Plains, inciting widespread panic among the White settlers. The Yanktonais in particular were almost immediately drawn into the conflict. Federal troops were sent to the Dakota Territory to protect settlers and to operate against the fugitive Santees in the Upper Missouri Valley during 1863-1864 (Schell, 1975). With the presence of these additional troops occupying the Dakota Territory and Sioux lands, a new cycle of raids and reprisals began once again. These grew in intensity over the next fourteen years, and this period of severe hostilities is commonly referred to as the Indian Wars on the Great Plains (Hyde, 1967).

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[3] The Dakota Territory was formally organized in 1861. Although definitive numbers are hard to come by, Bowler (1944) estimates that possibly 1000 whites and an unknown but much lower number of Indians were killed during the outbreak.

The Santees remaining in Minnesota (including those who had stayed neutral or who had supported the government throughout the hostilities) were subsequently quickly removed from their reserves within the state to the Dakota Territory. Most of these Santee, about 1,300 in number, were transported to the Crow Creek Reservation in 1863. There are numerous reports that mention starvation and hunger among these Sioux while at Crow Creek (Hyde, 1967; Nurge, 1970; Prucha, 1984). These Indians were later moved to the Niobrara Reservation in northern Nebraska in 1866. Here they were gradually reunited with most of their kinsmen who had fled from the Army, or who had been captured during the uprising and subsequently released. However, there is a strong indication that at least a few Santee remained hostile up until the time the remaining Plains Sioux were forced to surrender to the Army in 1876. As all prior treaties with the Santee bands were annulled as a result of the uprising, these Eastern division bands were allowed to become party to the treaty of 1868, which was made mainly with the Teton bands of the Plains Sioux (Bowler, 1944; Hyde, 1967; Schell, 1975; Textor, 1896).

The Sisseton and Wahpeton sub-bands of the Santee had not been directly involved in these hostilities, and yet many of these bands had fled with the approach of the advancing troops. In 1867, a separate treaty was made with these groups of Eastern Sioux, providing them with two reservations: Fort Totten or Devil's Lake in present day North Dakota, and the Lake Traverse or Sisseton Reservation in North and South Dakota. Some Cuthead or Upper Yanktonai were also included in with the Sisseton at Devil's Lake. Importantly, all of the Santee groups mentioned above started receiving allotments of land in severalty (generally 80-160 acres) soon after 1868, two decades before a similar agreement would be reached for the Teton Sioux (1888). It should also be noted that no explicit amount of rations was specified in the treaties made with the Santee, and in general the annuities they received (much like the Yanktons that preceded them) were much less than would be offered the Teton groups when they came to parley for peace with the agents of the government (Bowler, 1944; Textor, 1896).

By the mid 1860s, the Teton Sioux, along with seemingly most of the Yanktonai bands, were ranging far beyond the Black Hills proper in search of sufficient game and buffalo. Having successfully driven the Crow from the Powder River and Big Horn countries (bounded on the south by the North Platte River [Wyoming] and extending north to the mouths of the Big Horn, Tounge, and Powder Rivers at the Yellowstone River [Montana]), these hostile Sioux could handily elude most of the troops that were sent against them by simply withdrawing to this mountainous region. From these mountain sanctuaries, the Sioux continued to raid immigrant wagon trains, road survey teams, and the line of forts established to protect the Bozeman Trail. This was the type of war the Sioux excelled at; they soon acquired many of the mules and horses that were formerly picketed at these government forts, and would occasionally trade robes and pelts for shot and powder from the very same forts they may have raided earlier in the season (Hyde, 1967). It was from this relative position of strength that these Sioux finally agreed to make a peace treaty with the U.S. Government, after several peace commissions had been sent to them. This treaty, the Fort Laramie Treaty of 1868, was a product of the Grant Peace Policy of the time, and was successful in abating general hostilities for several years.

The Fort Laramie Treaty created the Great Sioux Reservation (Figure 3), which encompassed essentially all of the area covered by the present state of South Dakota west of the Missouri River. This area was set aside for the exclusive use of the Sioux, who were to receive certain annuities and rations for a period of four years, in return for land cessions and the right of the Union Pacific Railroad to cross their territory. Additionally, the Bozeman Road was closed, and with troops withdrawn and forts abandoned, the Powder and Big Horn River country (Wyoming-Montana) was recognized as unceded Sioux hunting lands, as were the Black Hills. With this treaty the reservation period began for about 1/2 to 1/3 of the Teton and other hostile bands that had continued to rove the Plains. A much

REDUCTION OF THE GREAT SIOUX RESERVATION
1868 to 1890

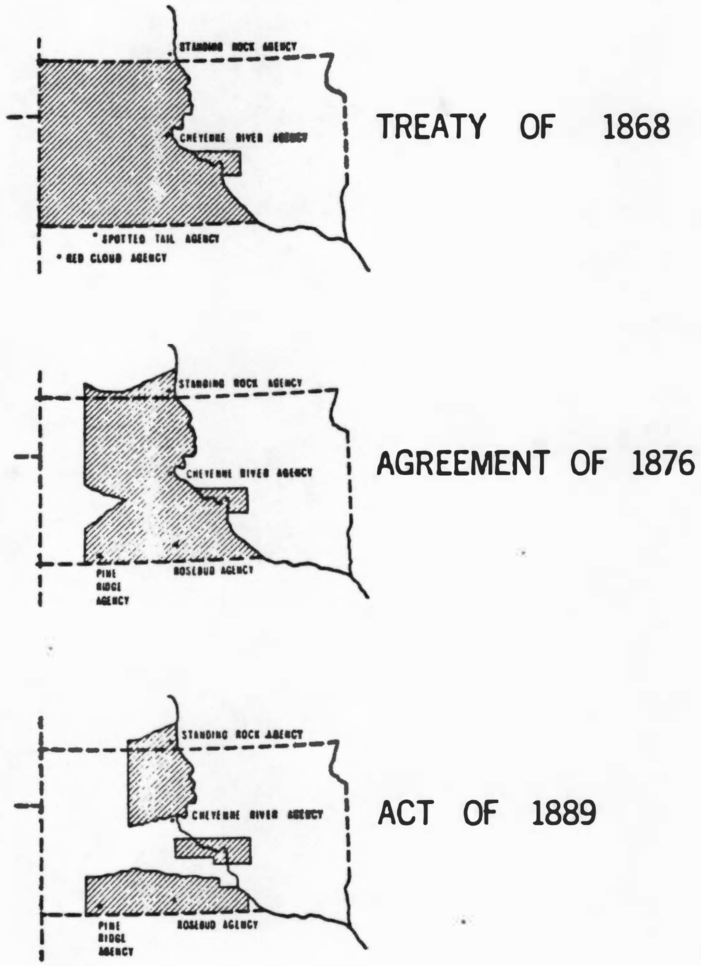

Figure 3. Map of Great Sioux Reservation.

From: Utley, R. M. (1963). The Last Days of The Sioux Nation. New Haven: Yale University Press, p. 43.

larger group of Teton and Yanktonai bands never signed this treaty, and continued to roam in the Powder River country (Bowler, 1944; Hyde, 1967; Schell, 1975). Under this treaty, agency sites were chosen for the several bands party to the treaty, the locations of which would not be finalized for several years (in some cases as late as 1878-1888).

The next outbreak of widespread hostilities between Whites and Sioux Indians occurred as a direct result of the breach of the Fort Laramie Treaty. In 1874 General George A. Custer led a 1,200-men expedition force into the Black Hills with the specific (if not explicit) intention to survey the mineral and natural resources of the region. Such actions were specifically prohibited by the Treaty of 1868; worse, it led to Sioux lands being inundated by hordes of White settlers once gold was announced to be present in these hills. The government's promise to exclude all Whites from Sioux lands could eventually not be kept, and once again negotiations with the Sioux were initiated to attempt to buy the Black Hills outright. This was largely a moot point, as the entire area soon flooded with prospectors. The Sioux at the agencies refused to cede the Black Hills and the Wyoming Powder River country as requested by the government, realizing that the remaining hostile or non-treaty Sioux occupying the region needed to at least be consulted, and in any case would not agree to such a cession. Soon after negotiations were broken off, the Army withdrew from the Black Hills, tacitly allowing White trespass on recognized unceded Sioux lands; thus, technically abrogating the Laramie Treaty of 1868--and taking the necessary steps that led to the last and most memorable Sioux War (Hyde, 1867; Olson, 1965; Schell, 1975).

Up until this time (1875-1876) the government's peace policy had been a modest success at the various Teton agencies. This was achieved in no small measure by a liberal feeding policy, intended to keep the Sioux well-disposed and within the reservation boundaries. Thus, the scarcity of game in all but the remotest hunting lands was an asset to the government's policy of keeping the Sioux content in an area where their agent could keep a watchful eye over them (Hyde, 1967; Textor, 1896). Indeed, the relative success of this policy can be seen in the fact that only a few of the hostile Sioux that would regularly raid immigrants or who fought the Army in 1876 were drawn from the permanent residents of these agencies. Most of the Sioux that were involved in subsequent hostilities were drawn from the non-treaty Sioux, and even a number of these "wild" Indians would regularly winter at the agencies due to this liberal treatment (Hyde, 1967).

With an ever increasing population of White settlers encroaching upon their hunting lands, the Sioux were making desperate attempts to drive these immigrants from their territory all during the early 1870s. During this time several military expeditions were sent into the Powder River country (1872 and 1873) and yet failed to subdue the mainly non-treaty Sioux. Open hostilities began once again when a renewed concerted effort was made by the government to force these non-treaty Sioux from their strongholds in the Big Horn and Powder River country in Montana and Wyoming. It was highly unfortunate that the Army decided to wait until summer to march against the Sioux. This was a time when several bands usually concentrated in one or two main camps, and their number would be augmented by some agency bands joining up with these Sioux to hunt or conduct the Sun Dance. The main camp that General Custer stumbled upon on June 25, 1876 probably contained 2,000 to 3,000 warriors, and was also probably the largest concentration of Indians ever faced by the Army (Schell, 1975). With results that are still familiar to most Americans (and are still utilized by stand-up comics to this day), the Sioux quickly withdrew from this engagement, breaking up into smaller bands, and resuming their normal seasonal rounds (Hyde, 1967). The rest of the nation was informed of the Custer disaster on the day after Independence Day (the centenary celebration), July 5, 1876, as the survivors (from Major Reno's command) reached Bismark. As the Army regrouped from this and an earlier (June 17th) defeat, they attempted to redeem themselves by chasing after the more elusive small bands of

Sioux who were by now attempting to peaceably return to winter at the various agencies. The Sioux had no desire to continue to fight the Army, and incredibly believed that they could simply return to the agencies after a "normal" summer of hunting and fighting--a cycle they had long become familiar with, either with the Crow Indian tribe or the U.S. Army of late. The troops from the Army succeeded in overtaking one or two scattered bands of Sioux before they reached the agencies, scattering these Sioux handily without much effort. Upon arriving at the various agencies the Army immediately assumed control, and disarmed and dismounted those Sioux at the Cheyenne River, Standing Rock and Red Cloud (Pine Ridge) Agencies. It was some months later that Spotted Tail, a leading Brulé chief, convinced most of the remaining hostiles to come into the agencies and surrender. By May 1877, about 4,500 did so, surrendering at the Red Cloud (Pine Ridge) and Spotted Tail (Rosebud) Agencies. A smaller band of hostiles under Sitting Bull retreated to the Canadian border and would not come in to surrender until 1881. Soon after the Custer tragedy the military occupied all the large Sioux agencies (including those mentioned above as well as Spotted Tail), marking an effective end to the Teton Sioux as an autonomous independent people (Hyde, 1967; Schell, 1975).

The Teton were soon forced to relinquish any claim to the Black Hills as well as the hunting rights to their territory in Montana and Wyoming. Instead of the usual annuities accruing from such a cession, the Sioux were promised certain specified rations until they were able to support themselves. This provision within the 1876 Treaty was unique to the Sioux signing this treaty (all the Teton sub-bands as well as most Yanktonai); seemingly no other Indian treaty provided this specific assurance of rations for such an indefinite period of time (C.I.A., 1900). As late as 1906 a majority of Teton Sioux on some reservations were still receiving government rations.[4]

These rations are specified for each individual as follows: "1 1/2 pounds (lbs.) of beef (or 1/2 lb. of bacon in lieu of), 1/2 lb. corn, 1/2 lb. flour; and for every 100 rations--4 lbs. of coffee, 8 lbs. sugar, 3 lbs. of beans" (C.I.A., 1900:6-7). As late as 1900, the Commissioner of Indian Affairs figured the value of a full ration at $50.00 per capita per annum,[5] showing that for the year 1900 most Teton Sioux received the equivalent of a 70% ration. Of the principal items on this list, beef and flour, the target provision of these items should ". . . give over 1 pound of net beef and over 5 3/4 ounces of flour to every man, woman and child on the reservations (outside of school children)

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[4] Here I speak of the Oglala Sioux at the Pine Ridge Reservation and the Brulé Sioux at the Rosebud Reservation. (Commissioner of Indian Affairs [C.I.A.] Report, 1906).

[5] It does not appear that this figure is indexed to any year (viz., 1876 or 1880).

every day in the year" (C.I.A., 1900:7), this for the year 1900. School children were similarly provided for, the composition of the rations differing somewhat, the quantity remaining essentially the same, however. We shall return to a more detailed discussion of the importance of these rations in a later section of this chapter.

The Early Reservation Period: (1876-1900)

The early reservation period for the Sioux was a period of radical adjustments. With their loss of economic independence came a total dependence upon the government for subsistence. A great and complicated administrative structure soon evolved at the Indian Office (Schmekebier, 1927), mainly as a result of the effort needed to distribute and contract for vast amounts of annuity goods and other items to feed and clothe the Indians, who were now recognized as wards of the government. The government's policy was to initially foster this dependence in order to better control the Indians on the reservations. The "feed them or fight them" peace policy soon gave way to the unduly optimistic expectation that the Sioux (as well as other Indians) would quickly make the transition from their traditional life-way to full acculturation; from nomadic buffalo hunters to sedentary small farmers in but a few years. The government was inclined to supply plows, seed, oxen teams, and other benefits to willing Indians; yet after many decades it became quite apparent that most of the Sioux had not become self-supporting, self-reliant farmers. For a few years many Teton achieved an appreciable success at cattle raising, building from the mid 1880s and reaching a climax at about 1905-1910 (Gerlach, 1970; Hoover, 1983; Prucha, 1984; Schell, 1975). Indeed, some researchers have regarded this period of involvement in a grazing economy as representing a period of relative prosperity for the Teton that has not been seen since (Macgregor, 1946).

The government's assimilation policy had as its specific ends the destruction of various component elements of Sioux culture in order to "civilize" these Indians. The authority of tribal chiefs or head men was consistently undermined, most religious ceremonies were vigorously suppressed (e.g. the Sun Dance), children were occasionally kidnapped and sent to far off boarding schools, communal lands were broken up, and extended kin groups weakened in favor of nuclear families, all in the name of progress (C.I.A., 1880-1900; Hagen and Schaw, 1960; Hyde, 1956, 1967; Prucha, 1984). Conformity to regulations and reservation policies was regularly sanctioned with the threat and actual withdrawal of vital government rations. Status roles consequently shifted and were undermined as men no longer could fulfill the role of warrior and hunter (Seerley, 1965; Utley, 1963). Within the confined reservation boundaries, food practices were forced to change radically; the hunt was replaced with the issue, unfamiliar foods were introduced (flour, mess pork, green coffee beans), and the availability of gathered foods decreased. In general, the traditional knowledge and belief system of the Sioux was of little use in adapting to reservation life, and almost always conflicted with the Western assumptions and attitudes held by the White Indian agents governing the reservations (Hagen and Schaw, 1960; Seerley, 1965).

The broad outline supplied above conforms to the shared experiences of most of the Sioux on the reservations, especially the six agencies assigned to the Teton and Yanktonai[6] in the Dakota territory after 1876: the Standing Rock Agency (N.D.) for the Yanktonai, Hunkpapa, and Blackfeet Sioux; Crow Creek (S.D.) for the Lower Yanktonai Sioux; Cheyenne River (S.D.) for the Blackfeet, Sans Arcs, Miniconjou, and Two Kettle Sioux; Lower Brulé (S.D.) for the Lower Brulé Sioux; Pine Ridge (S.D.) for the Oglala Sioux; and the Rosebud Agency (S.D.) mainly for the Brulé Sioux (but with some Two Kettle, Wajiaziah, and Loafer bands also represented). These agencies would become separate reservations with the Allotment Act of 1889.

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[6] This summary does not include those Yanktonai Sioux that had surrendered at Fort Peck, Montana, as these do not appear to be included within Boas' sample. The population of these Yanktonai were estimated at about 4,700 in 1880 (C.I.A., 1880; Textor, 1896) and about 1,200 in 1900 (C.I.A., 1900). It should also be noted that for several years up until the mid-1890s, several bands of Northern Cheyenne stayed with the Oglalas at Pine Ridge; their number usually did not exceed 500, though.

By 1880 a clear dichotomy could be seen between the relative development of the Sioux reservations east of the Missouri River (the Santee, Sisseton, Devil's Lake and Yankton) and those agencies west of the Missouri, represented within the Great Sioux Reservation on the Plains of South Dakota. As reported within the Commissioner of Indian Affairs (C.I.A.) Report for this year; 65% of the Santee, 75% of the Sisseton, 75% of the Sioux at Devil's Lake, and about 65% of the Yankton Sioux were described as self-supporting (mainly by agriculture and some ranching). None of the Sioux west of the Missouri would reach this level of officially recognized self-sufficiency before the turn of the century. By the mid-late 1880s the Sioux at the Devil's Lake, Sisseton, and Santee reservations were considered to be sufficiently "advanced" to a point where the government withdrew most rations, except for the elderly and infirm. These rations had been continued despite the fact that they generally were not stipulated by treaty, a not uncommon occurrence for the period. The Yankton for example, continued to receive partial rations (generally 1/2-1/3 of the full Teton ration) up until 1900.

The reasons for this disparity are not difficult to grasp: those Sioux settled east of the Missouri and not subject to the Treaty of 1876 had more experience with the reservation culture, occupied better quality farmland (good prairie soil, more favorable climate), and had a more salient history and tradition of horticulture (Santee and Yankton) than did their counterparts west of the Missouri (Textor, 1896). However, this was a gradual process to be sure; for example, the Santee were wholly dependent upon the government from the time they came to their Nebraska reservation (1866) until about 1873, and were in quite a wretched state during the early years on their reserve (C.I.A., 1873; Textor, 1896). In general, the much more numerous Plains Sioux, west of the Missouri and beyond the 100th meridian, could not avail themselves of this opportunity as they were much more affected by the vagaries of climate (frequent drought, low annual rain fall, frequent hail storms); insect infestation; and poor, tough, fibrous soil (Schell, 1975; Textor, 1896; Wedel, 1986). The Plains Sioux who did succeed in achieving similar levels of self-sufficiency did so with ranching as the principle mode of support. Here the most notable reservation band were the Oglala Sioux at Pine Ridge, who in 1901 were running 31,000 head of cattle for a population of about 6,600 people (C.I.A., 1901). The Cheyenne River Reservation and the Rosebud Reservation were running similar sized herds at the time, but only the Oglala were now judged to be 75% self-supporting (50% of the Sioux at these other reservations were cited as being dependent on government rations for subsistence). It should be mentioned that despite this initial measure of success for some groups of Sioux, events and circumstances would later manage to reverse these modest gains in self-support (Hagen and Schaw, 1960; Hoover, 1983; Maynard and Twiss, 1969; U.S. Public Health Service, 1959).

In 1880 the population of Sioux on the various reservations and agencies were (for the Sioux east of the Missouri and not party to the Treaty of 1876): Devil's Lake, 1,089; Sisseton, 1,500; Santee, 1,271; Yankton, 2,019. For the Sioux residing generally west of the Missouri within the confines of the Great Sioux Reservation (S.D.), the populations were: Cheyenne River, 1,764; Crow Creek, 969; Lower Brulé, 1,300; Pine Ridge, 7,200; Rosebud, 7,314; and Standing Rock, 2,611 (C.I.A., 1880). The extent and location of the various Sioux reservations at this time are indicated in Figure 4.

By the early to mid-1880s pressure from White settlers was growing once again, giving a major impetus behind the next major land agreement between the Sioux on the Great Sioux Reservation and the government. This agreement would also coincide well with the objectives of the Indian Office at the time. Ever confident in its vision for the Sioux to become enlightened, frugal, citizen farmers, the Indian Office had decided to break up Indian lands into individual allotments in order to advance self-sufficiency. By the late 1880s it was also stated that the ration system was "pauperizing" the Indians and that Indians were being demoralized by this system, which was seen as a great

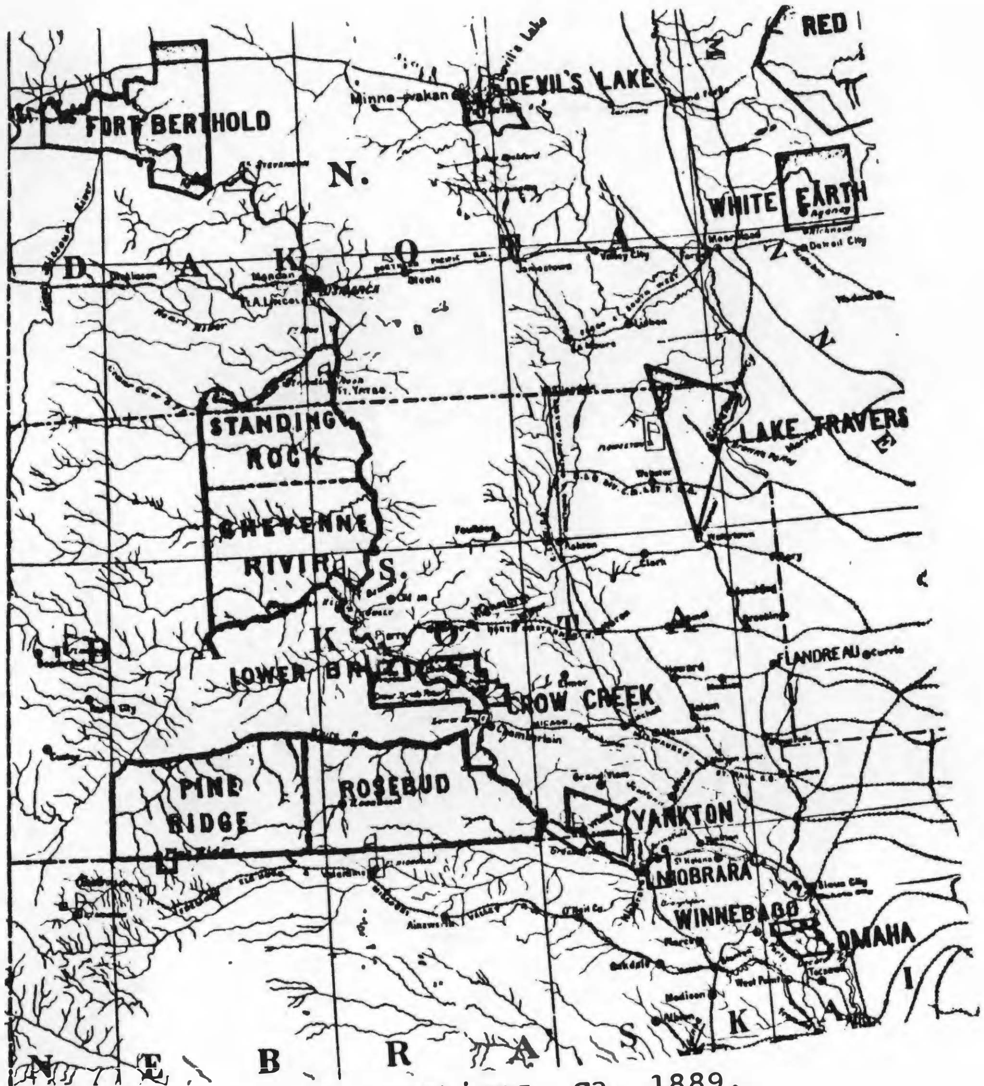

Figure 4. Map of historic reservations, ca. 1889.

From: Commissioner of Indian Affairs (C.I.A.) Annual Report (1889). End papers.

disincentive to work (C.I.A., 1885-1888). After negotiations over several years, the Sioux of the Great Sioux Reservation agreed in 1888 to receive land in severalty in allotments of 320 acres (for families) and 160 acres (for individuals), plus certain benefits: two cows, one pair of oxen; farming tools, including one plow, one hoe, one harrow, one wagon, one axe, and one pitch fork; and $50.00 to be held in trust. This became known as the Allotment Act of 1889, and its immediate effect was to throw open 9 million acres of land, formerly held within the Great Sioux Reservation, to White settlement. This Act reduced the amount of Sioux lands by about half, and yet it would be several years before many of the Sioux at the newly created separate reservations would apply for their patents on individual parcels. This Act preceded the creation of the states of North and South Dakota (1889) and allowed for the construction of railroads through this territory, as well as providing for farming and grazing lands for land-hungry White settlers. Amendments to this Act also allowed Whites to lease lands that Indians were "unable" to utilize, allowing for much exploitation of Indian and Sioux lands for decades after 1890. After a period of trust ended (after 1905), many Indians were cajoled into disposing of their individual allotments for ready cash. This further broke up the reservations, and did not increase the self-sufficiency of the Indians in the long run, signalling the failure of this policy, once considered a panacea for solving the "Indian Question" (Gerlach, 1970; Johnston, 1948; Schell, 1975; Utley, 1963). Ironically, the loss of large tracts of Sioux corporate lands is also partly responsible for the dramatic decline in ranching after 1910.

The mid-1880s also saw a gradual reduction in rations on the reservations as a more careful census of Sioux was taken at each agency or reservation. This feature has been mentioned by Hyde (1967, 1956), and Olson (1965), who notes that the rations were reduced in order to better reflect the number of Sioux actually at the various agencies, and that for years several groups had been drawing more than the stipulated treaty amounts. This surplus of rations (at least for the main issue of beef) also seems to be reflected in the official accounting of beef contracts let for the various agencies (C.I.A., 1877, 1878, 1880, 1882). Only infrequently is the arrival of the beef issue noted in an agent's annual report, so these contract orders are the only consistent basis of comparison for a given span of years and between various agencies. Such comparisons become useful when there is a serious discrepancy for any one or two years between the description of contracts let and ethnographic accounts of severe deprivation and hunger.

Such a disparity is evident for the events leading up to the Wounded Knee disaster of 1890 at Pine Ridge. This tragedy was the culmination of the messianic Ghost Dance revitalization movement that swept through several western

Sioux reservations in the years 1889 and 1890 (Prucha, 1984; Utley, 1963). Growing out of the increasing sense of disaffection and despair the Sioux felt on the reservations, especially after the great land cession of 1888 (the Allotment Act), the Sioux became influenced by a messiah who promoted a message that seemed to promise to restore the Sioux to their glory days of old. This new paradise foreseen for the Sioux (and other Indians) would be possible if the Indians remained at peace with the Whites, lived honest and industrious lives, and performed a holy ghost dance. The Sioux modified the original message of this messiah towards a more antagonistic stance towards Whites, who were held directly responsible for the misery of the Sioux tribe (Prucha, 1984). There is much ethnographic documentation to suggest that a confluence of several factors led to the ready acceptance of this messianic message among the Sioux, where unlike other reservations, the Ghost Dance and its adherents would not fade away. These factors are now frequently cited by researchers as contributing causes of the subsequent sudden outbreak of hostilities which led to the tragic deaths of more than 150 Sioux men, women, and children and 25 White soldiers, marking the last major confrontation involving serious fatalities between the Sioux (Teton) and the government. These causes were realized by the government soon after the 'outbreak' (C.I.A., 1891; Mooney, 1892-1893) and have not been significantly augmented over the years (Prucha, 1984).

The most prominent among these posited causes has been the issue of semi-starvation and hunger on the Sioux reservations during the year 1889-1890. Hyde (1956) in particular has championed this cause in later years. Rations to the Sioux had been steadily declining since the census of 1886 and were reduced by about one third to one half for the fiscal year 1890. This reduction came at a most unfortunate time, as the Sioux Commission had not long departed the reservation after finally gaining the signatures needed for final approval of the land cession included within the Allotment Act of 1889. The Sioux had repeatedly asked for and received assurances that by signing the document proffered by the Commission, rations would not be reduced, and yet the reductions came two weeks after the government had left the Sioux (Hyde, 1956; Mooney, 1892-1893; Utley, 1963). Although the Commission was seen as responsible for these reductions in the eyes of the Sioux, a new separate census of the Sioux was the real motivation behind these cutbacks. Complicating matters as well was the fact that the appropriations for fiscal year 1890 were delayed by several months (until mid-August), causing a rationing of the supplies on hand at the various agencies. Further exasperating this stressful situation were repeated crop failures in the years 1888, 1889, and 1890 (due mainly to drought), reducing the small but important Indian crop yield. These same years also saw the Sioux visited by several severe epidemics of influenza, measles, and whooping cough, which swept through the Pine Ridge and other reservations causing a great number of deaths. One source placed the estimated mortality rate for children at about 25 to 45 deaths per month in a population of 5,600 Oglala Sioux at Pine Ridge during the winter of 1889-1890 (C.I.A., 1889; Mooney, 1892-1893).

As Utley (1963) notes, the evidence that shortened rations were the principle cause behind the numerous reports of hunger and semi-starvation is far from conclusive. Official reports for 1890 state that the primary ration, the beef issue, was reduced by 1 million pounds at Pine Ridge and by 2 million pounds at the Rosebud Reservation (Mooney, 1892-1893). These reports also put this issue (essentially delivered as cattle on the hoof), at 4 million pounds for the Oglala at Pine Ridge in 1890 (Mooney, 1892-1893: 833). This then is the genesis behind the Commissioner of Indian Affairs' (Thomas J. Morgan's) claim that these Sioux at Pine Ridge (where the hostilities were concentrated) should have received the normal ration of about 1 1/2 lbs. of beef per capita (in a population now calculated at 5,600) per day, for every day of the year (Utley, 1963: 57). Allowances for cattle weight shrinkage of 15% yields about 1.6 lbs. of beef per capita per day; a 35% expectation of shrinkage (seemingly not uncommon on the northern Plains) would yield about 1.3 lbs. of beef per capita, per day. Hyde (1956) claims it was not all that unusual that steers would lose 50% of their weight by spring, having wintered on the open range. Hyde (1956: 237), citing Agent Gallagher at Pine Ridge, also states that in the spring of 1890 the monthly issue of beef was at 205,000 lbs., whereas a full treaty issue for the same period would have been 470,400 lbs. This researcher further states that it is unclear if shrinkage was taken into account in this former figure (Hyde, 1956: 237-238). Taking this actual ration outlay at face value and annualizing it over the entire year (1890), we arrive at a figure of 2,460,000 lbs. of beef, or 1.2 lbs. of beef per capita, per day. An additional allowance for a reduction of 35% and 50% (shrinkage) would yield respectively, 284.7 and 219.0 lbs. of beef per capita, per year as the beef ration the Oglala Sioux would have received for the entire year of 1890. Assuming a worse case scenario that 50% of the <u>entire</u> beef issue was lost due to shrinkage, waste, or other losses, the figure of 219 lbs. of beef per year probably exceeds by at least 20% recent estimates calculated for the per capita annual meat consumption in the United States as a whole (Komlos, 1987: Table 9: 913) during roughly the same time period. Komlos (1987) gives a calculation for the total annual per capita meat consumption for the U.S. for the year 1879 as 161 lbs. per capita. Utley (1963) also cites another estimate of beef rations for 1890, this for the Rosebud Reservation--10 ounces of beef per capita per day. A quick calculation will show that this works out to about 228 lbs. of beef per capita, per year, which still would seem to compare quite favorably with both the estimates provided by Komlos (1987) and Hyde's incorporation of Agent Gallagher's outlays for Pine Ridge during 1890.[7]

Seemingly then, despite the prospect that full "treaty" rations may not have been available to many Sioux, it would appear that for at least the beef issue, an adequate amount was contracted for. (It should also be remembered that the Sioux also received rations of flour, bacon, coffee, sugar, corn, and other items--but the beef issue was the primary focus of attention, and hence easiest to track.) Table 1 provides a view of the standard items included in the subsistence ration to various Sioux (mainly Teton) agencies. The supplies listed were delivered during the calendar year of 1890 (C.I.A., 1891). This said, one cannot ignore the fact that ostensibly a significant portion of these regular

[7] It should be noted that Komlos (1987) found that the trend in meat consumption was one of general decline during most of the 19th century in the U.S. The highest annual per capita consumption appears for the year 1839 (213 lbs.). McMahon (1981) also provides an estimate of average meat allowances (roughly equivalent to consumption) for New England during 1808-1830 as being just above 200 lbs. per capita, per year (209.7 lbs.). Importantly, Komlos (1987) does not provide any estimate for meat consumption during the period 1880-1900. However, it seems unlikely that the figures for consumption could exceed or approach a 200 lbs. per capita, per year level, as the value for 1909 (154 lbs.) and subsequent years (to 1939) are well below this average.

Table 1. A Tabulation of All Subsistence Supplies Delivered During the Calendar Year 1890 at Various Sioux Agencies According to the Commissioner of Indian Affairs.[a]

Articles	Pine Ridge[b]	Rosebud	Standing Rock	Cheyenne River	Crow Creek	Lower Brulé
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Bacon.............	225,000	274,231	126,170	28,553	17,714	17,420
Beef (gross)......	4,926,860	4,579,820	2,483,270	586,175	241,960	387,232
Coffee............	62,574	58,024	55,127	30,278	14,015	12,279
Corn..............	61,830	64,682	27,900	16,968	....	31,551
Flour.............	402,300	545,000	663,651	451,670	....	214,780
Hominy............	3,000	30,000	....	....	....	....
Lard..............	4,000	....	500	....	600	786
Pork..............	....	....	60,000	10,900	....	....
Salt..............	....	....	18,845	15,654	....	....
Sugar.............	117,101	114,901	108,138	62,086	23,034	22,192
Tea...............	383	238	384	137	190	252
Wheat.............	....	20,000	30,000	....	318,342	42,027
Rice..............	3,000	....	....	....	3,000	....

[a]Table is taken from the Annual Report to the Commissioner of Indian Affairs (1891), Appendix C:p197

[b]Population figures for the close of 1890 (presented in the 1891 C.I.A. Report) are as follows: Pine Ridge, 5701; Rosebud, 5345; Standing Rock, 4096; Cheyenne River, 2823; Crow Creek, 1058; Lower Brulé, 1026.

rations were delayed due to inaction on an appropriation bill in Congress. It should be remembered that the Teton Sioux were almost wholly dependent on government rations during this time, and disruptions in supplies would have had an immediate and serious effect upon their material well being. The appropriation bill was signed on August 19, 1890, with the fiscal year having begun on July 1; therefore, we may assume it took several months for the supply of treaty mandated rations and annuities to arrive at the various reservations. Given that we have a reasonable figure for actual monthly outlays of the beef issue for spring of 1890 at Pine Ridge, it seems temperate to suggest that it was the delay in these rations rather than the newly adjusted absolute amounts that contributed to the deprivation and hunger of the Teton Sioux at this time. Such a delay in these goods would certainly have been interpreted by the Sioux as bad faith on the part of the government, something that was sure to have only increased their sense of disaffection and despair which led ultimately to the catastrophe played out over the last days of 1890, and now known as the Wounded Knee Massacre.

Another factor that should be recognized as confounding simple explanations involving hunger and semi-starvation is the fact that the Pine Ridge population was already facing a considerable amount of stress due to several recurring epidemics at this time (Hyde, 1956). The synergistic interaction between these disease states and even a moderate level of malnutrition should now be obvious (Carmichael, 1983; Scrimshaw, 1983; Taylor, 1983). Particularly important in this regard is the acknowledgement that acute infectious episodes can also bring about malnutrition through a variety of mechanisms (principally nutrient absorption and utilization) (Martorell, 1980). Also, a massive community infection of the kind suggested as having prevailed during the winter of 1889-1890 at Pine Ridge would have severely taxed the social network of the Oglala and led to further secondary infections accentuating mortality over this short period (1888-1890) of time (Carmichael, 1983). Accordingly, I tend to agree with Utley (1963) in conceding that there was probably widespread hunger among the Sioux for a portion of this strife-filled period (1889-1890). Starvation was possibly seen in some instances; however, the evidence is much too conflicting to be able to conclusively decide this issue.

It does seem to be reasonably apparent, though, that if the beef issue is a good indicator (i.e. contracts let minus very liberal allowances for shrinkage, waste, and loss) of the general diet of the Sioux, they should have been quite adequately maintained on government rations up until the time when the 1890 issue was delayed. This new insight is possible now given the estimates provided by Komlos (1987) for per capita annual total meat consumption for the White population in the U.S. during the 19th century. In most instances where comparisons are possible, the beef issue to the Sioux is absolutely higher than any of the estimates provided by Komlos (1987), even given a 50%-75% allowance for shrinkage, loss, waste, fraud or abuse (C.I.A. 1877, 1878, 1880, 1882, 1883, 1884, 1885, 1889). As noted in Table 2, this is especially consistently true for the Pine Ridge Oglala. Komlos' (1987) observations on 19th century American meat consumption can also be compared to the case of Britain where Howe (1972) notes that consumption, as measured by carcass weight, rarely exceeded 130 lbs. per capita before the 1950s.

However, it should be acknowledged that the figures provided in Table 2 may not be exactly compatible to Komlos' figures (1987) even given a 50%+ allowance for wastage and loss, simply because typical white consumption patterns differed markedly from those known ethnographically for the Sioux. Both Nurge (1970) and Seerley (1965), as well as numerous C.I.A. reports throughout the early (1870-1893) reservation period, often mention that the Sioux typically utilized their beef issue much in the same way they had the buffalo previously; i.e. making good use of the fats, blood and offal that would normally be lost during the rendering process, and hence usually unavailable to the non-farming White population. That American farmers and agricultural sector workers are known to exhibit taller mean statures

Table 2. Annual Outlays of Gross Beef By The Indian Office For Some Sioux Agencies

	Sioux Agencies									
	Pine Ridge		Rosebud		Standing Rock		Cheyenne River		Crow Creek	
Year[a]	Gross	Per Capita[c]	Gross	Per Cap.	Gross	Per Cap.	Gross	Per Cap.	Gross	Per Cap.
	- - - - - - - -		- - - - - -		- - - -	Pounds	- - - - - - - -		- - - - -	
1874	5.37×10^6[b]	584.0	(Not Avail.)		N.	A.	N.	A.	N.	A.
1877	5×10^6	833.3	5.5×10^6	626.8	2×10^6	795.2	2.19×10^6	1118.5	1×10^6	817.7
1878	6×10^6	1000[b]	6.5×10^6	921.2	2.2×10^6	900.2	9×10^5	476.0	9×10^5	979.3
1880	6.5×10^6	902.8	6×10^6	820.3	2.5×10^6	957.5	N.	A.	N.	A.
1882	6.5×10^6	800.8	6.5×10^6	837.4[d]	2.0×10^6	532.6	2.3×10^6	721.5	1.75×10^6[e]	1700[d]
1883	6.5×10^6	812.5	6.5×10^6	841.0	3.09×10^6	670.8	2.3×10^6	715.4	7.5×10^5	766.1
1884	7×10^6	843.4	6×10^6	754.9	4×10^6	847.3	2.0×10^6	636.1	8×10^5	728.6
1885	7×10^6	915.1	6×10^6	723.6	4×10^6	898.9	2.0×10^6	688.0	8×10^5	754.0
1889	4×10^6	712.9	6×10^6	780[d]	4×10^6	975.6	1.5×10^6	527.1	8×10^5	724.6
1890[f]	4.93×10^6	864.2	4.56×10^6	856.8	2.48×10^6	606.3	5.86×10^5	207.6	2.42×10^5	228.6
1892	6×10^6	985.5	3.8×10^6	822	3.5×10^6	883.8	N.	A.	1×10^6	909.9
1893	3.5×10^6	572.6	1.85×10^6	432.6	2.75×10^6	N.A.	N.	A.	1×10^6	N.A.

[a] Year calculated as following: 1874-1875, starting with same year contract was let.
[b] Rounded.
[c] Calculated from the start of the year (1874 ...) for the entire population, as reported in the Annual Commissioner of Indian Affairs (C.I.A.) Report for the year contract was let. Used as an indication of gross availability.
[d] Population figures taken as the immediate previous calendar year or the finalized census reported at the end of the same calendar year.
[e] Possible printers error. Assuming 1.25×10^6 lbs., a conservative estimate would yield 1265.2 lbs. per capita.
[f] Actual accounting of all supplies delivered during the calendar year 1890 as reported in the 1891 C.I.A. report. Compare with figures for 1889-90. Cheyenne River's agent was authorized to buy 1 million lbs. of gross beef from his Indians, the Agent at Standing Rock 750,000 lbs. The same arrangement is claimed for Crow Creek.

during the early 19th century is thought to be connected to their special access to such "extra-edibles" (Komlos, 1987) or higher quality food (Margo and Steckel, 1983) when compared to their more urban contemporaries. Also significant in this regard are reports (Nurge, 1970) and even photographs (Anderson and Hamilton, 1971) that show that the Sioux also dried and prepared their beef issue as they would have buffalo meat. This indicates that the Sioux would have avoided the adverse effects of salting (Fogel, 1986), and may have been able to safely store a greater portion of the meat available to them than would be possible for their rural White neighbors (Higgs, 1973). It is the present author's contention that if anything, such comparisons with White consumption patterns would tend to underestimate actual Sioux consumption of meat from all sources. Even given liberal allowances of 50-60% wastage from all sources, it would seem that many of the Sioux at the larger agencies (Teton) may have been able to sustain a level of per capital annual total meat consumption that exceeded the estimated White average by 20% for several years prior to 1893. A greater disparity is probable for comparisons with the Pine Ridge and Rosebud reservations. It should be remembered that the government issue rations did not supply a broad spectrum diet for the Sioux, and various nutritional deficiencies are certainly possible within this framework.

Wounded Knee marked the culmination of enforced acculturation for the Teton Sioux (Satterlee and Malan, 1968). Soon afterwards, most Sioux on the reservations became grudgingly reconciled with the status quo, and to the fact that their old way of life had gone forever. Government day and nearby boarding schools grew more popular and attendance swelled. Although tipis were still fairly common on the reservations well into the 1890s (Anderson and Hamilton, 1971), these were gradually being replaced by simple one room plank houses. Many Teton were also beginning to realize that they could easily augment their government rations by entering into the cash economy, usually by hauling freight for the Indian Office, working for the railroads, or for the Agency itself, and were encouraged to do so. Many Wild West Shows (Buffalo Bill's among these) also employed these Sioux, who would then travel to Europe and return home relatively wealthy and speaking good English. This latter practice was strongly discouraged by the Indian agents as being disruptive, however.

For the remainder of the century calm prevailed on the Sioux reservations. Although the Army would continue to be concerned over possible hostile outbreaks up until 1898 (Wooster, 1985), the period of confrontation with regular troops had by now long passed. Conflicts with White ranchers over trespass on Sioux lands would become prevalent during the 1880s and 1890s, but no serious incidents of violence were noted (Gerlach, 1970). By the mid-1890s several reservations were supplying their own beef rations by selling the stock they raised back to the government (C.I.A., 1896). By 1897 the Oglala at Pine Ridge were running over 40,000 head of cattle for a population of 6,386 individuals (C.I.A., 1897). By 1896 the Sioux on the reserves east of the Missouri were making respectable progress in agricultural pursuits, with the Yankton raising over 100,000 bushels of wheat and 90,000 bushels of corn for the year (C.I.A., 1896). By the turn of the century the Teton Sioux were realizing sizable returns from ranching, with the Oglala's able to sell over 2 million pounds of beef annually (C.I.A., 1898; Gerlach, 1970). By 1905 the Pine Ridge Oglala's were considered to have made a successful transition to a cattle economy (Gerlach, 1970).

The cattle economy allowed the Sioux to retain some traditional aspects of their former buffalo economy, and established the possibility of self-sufficiency without resorting to the more unfamiliar and precarious agricultural pursuits that were consistently advanced by the Indian Office as a model for self-support. For the Oglala men who considered farming women's work (Hoover, 1983; Hyde, 1956, 1967), to again rove the plains by horse and to move about independently with their cattle herds provided them a sense of satisfaction and incorporated many of the horsemanship and marksmanship skills that were formerly associated with a Teton warrior-hunter (Gerlach, 1970; Satterlee and Malan, 1968).

Throughout the reservation period the Indian Offices's avowed policy was one of rapid assimilation. All the treaties made with the Sioux from the Yankton Treaty of 1858 on had some stipulation for the expenditure of funds for education. Day schools became increasingly popular with the Sioux after their introduction in the mid-1880s, this despite perennial problems with poor equipment, under-staffing and poor staffing, and poor and often dangerously toxic (infectious) sanitary conditions (Hyde, 1956; Putney, 1980; Schell, 1975). The other main feature of this assimilation policy was of course the push for individual allotments of land. Allotments were generally completed on the eastern Sioux reservations (Santee, Sisseton, Yankton and Devil's Lake) by the early 1890s, if not earlier, at which time very few of the Sioux on reserves west of the Missouri had even begun this process. These latter Sioux would not fully involve themselves with the allotment process until after 1900. As a result of these allotments, 'surplus' land was created for White settlers, effectively breaking up the reserves into checkerboard patterns of Indian and White holdings--slowly whittling away the size of these reserves for many years. The Allotment policy in and of itself signaled an end to tribal authority; the Sioux were compelled to accept allotments or the government would assign them to the Sioux, and the Congress saw fit to only offer a veneer of protection against unscrupulous White land dealers. The main achievements of this policy are now recognized as the separation of the Indians from tribal lands, the destruction of existing tribal organization, and the inordinate increase in governmental responsibility for Indian lands and financial affairs (Priest, 1942; Prucha, 1984; Schell, 1975).

CHAPTER III

RATIONALE AND METHODOLOGY

Secular Trends in Heights as an Indicator of Net Nutritional and General Health Status

Anthropometric measures have long been utilized as indicators of general economic welfare and nutritional and health status. Of these measures, height--either reported for given ages, the age at which growth ceases, attained adult stature, or the rate of change or increase in height during childhood--has enjoyed the longest tradition of use, stretching back over 150 years (Tanner, 1981, 1982). Anthropometric measures of weight and height are thus said to ". . . reflect accurately the state of a nation's public health and the average nutritional status of its citizens" (Eveleth and Tanner, 1976: 1), and are utilized by agencies like the World Health Organization to regularly assess the nutritional status of the population of less-developed countries.

There is ample documentary and clinical evidence of a variety of environmental conditions having a negative effect upon growth. In general, past studies have associated low economic status; poor living or sanitary conditions; numerous disease states; poor access to health care; psychological stress; and above all, malnutrition; with shorter statures, delayed growth velocities, slower maturation, and reduced muscle and skeletal mass (Bielicki, 1986; Bogin, 1988; Frisancho, 1978; Tanner, 1988). However, it should be remembered that human growth is the result of a complex interplay of not only various environmental factors but hereditary determinants as well:

> Two genotypes which produce the same adult heights under optimal environmental circumstances may produce different heights under circumstances of privation. Thus two children who would be the same height in a well-off community may not only be smaller under poor economic conditions, but one may be significantly smaller than the other. This type of interaction, called non-additivity of genotype and environment, may be quite detailed and specific in its effects. If a particular environmental stimulus is lacking at a time when it is essential for the child (times known as 'sensitive periods'), then the child's development may be shunted, as it were, from one line to another. We know, as yet, little of the details of such interactions, but quite enough to make overly-simplified models scientifically suspect (Eveleth and Tanner, 1976: 222).

In this regard it has long been observed that American Black children, when matched for socioeconomic status variables with White children, show a consistent advancement over these Whites in skeletal maturation and in the formation and emergence of permanent teeth (Garn and Bailey, 1978). While African Black children seem to be similarly advanced over European Whites at birth (Masse and Hunt, 1963), by two or three years of age the Africans fall behind the Europeans in these developmental measures, probably due to the adverse nutritional, disease, and socioeconomic factors that could not be corrected for--representing greater detriments to growth in the African population

(Bogin, 1988; Garn and Bailey, 1978). While well off American Blacks will attain adult statures similar to or above comparable American Whites, few African Blacks are afforded this opportunity. This example also illustrates the importance of critical periods of growth; growth retardation during the first few years of life largely determines the later achievement of shorter adult stature (Martorell and Habicht, 1986).

While the relative primacy of malnutrition among the many environmental factors affecting growth has been often suggested (Eveleth, 1986), it must be remembered that such nutritional influences are usually seen in conjunction with changes in morbidity and mortality, and are inevitably almost always associated with synergistic interactions with infections and numerous disease states (Chen and Scrimshaw, 1983; Kielmann et al., 1983; Martorell, 1980; Martorell and Habicht, 1986; Van Wieringen, 1986). As stated by Taylor (1983: 228):

> Synergism between common infections and malnutrition probably accounts for more mortality, morbidity, and reduced growth and development than any other combination of factors. Infections such as diarrhea and measles, which would be self limited in normally nourished children, continue to be major causes of mortality in children who are malnourished. In addition, common infections precipitate overt malnutrition where nutritional status is borderline.

Currently there seems to be agreement on the assessment that the variation in height (and in other anthropometric measures) attributed to environmental factors far outweighs that which can be ascribed to hereditary influences, especially when considering populations in developing countries usually experiencing poverty and/or other sub-optimal conditions (Eveleth, 1986; Martorell and Habicht, 1986).

As a measure of nutritional status, stature is said to be a cumulative one, presenting in some sense a record of an individual's nutritional history of how effectively he or she has coped with past episodes of stress that may have led to stunting or reduced growth rates. Stunting or growth delay need not be a permanent condition if the given environmental insult is experienced for a short duration of time. In such an instance catch up growth (Tanner, 1978) is usually successful in compensating for this delay by accelerating "normal" growth velocities during periods of more favorable circumstances. However, if this period of nutritional stress is prolonged (yet not severe), maturation and growth will be delayed, and will continue beyond the age at which the growth of well-fed adolescents ceases. Final achieved height may also consequently be depressed in such an instance. Not infrequently, an individual's response can combine these two reactions in order to achieve an adequate level of catch up growth. In general it is the periods of prolonged and severe undernutrition that are typically associated with truncated growth patterns and permanent substantial stunting (Bogin, 1988; Frisancho, 1978; Kielmann et al., 1983; Martorell and Habicht, 1986). It is also important to note that a mortality risk gradient from mild to severe malnutrition has been demonstrated (Martorell, 1980), and that even the poor in the U.S. who experience moderate, chronic undernutrition have demonstrated resultant cumulative growth deficits (Garn and Clark, 1975).

Nutritional adequacy in and of itself is not a simple concept. Nutritional requirements can vary according to a number of conditions, but can be thought of in terms of an energy or nutrient balance between the intake of essential nutrients and the physiological claims upon the body in order to maintain basal metabolic rates, the support of normal growth and maturation in children, the repair and replacement of tissues, and necessary levels of physical activity (Malina, 1987). Recommendations for energy and nutrient intakes must typically consider age, sex, body size, level of physical activity, stage of growth and maturation, and various physiological states, eg. infection and/or illness, pregnancy and lactation (Greene and Johnston, 1980; Malina, 1987). Additionally, nutritional adequacy can be influenced by a number of culturally mediated dietary practices and activity patterns such as food preferences or taboos, food preparation, health practices and sanitary conditions, and time of weaning and choice of supplemental foods for infants (Martorell and Habicht, 1986; Scrimshaw and Young, 1976; Taylor, 1983).

Accordingly, it is useful to think of nutritional status as a measure of the net nutritional balance between food consumption and the various claims on that consumption (Fogel, 1986). Malnutrition defined within this framework is the consequence of a deficit in food energy relative to need or an inadequate intake of any essential nutrient (amino acids and protein, vitamins, essential fatty acids, and minerals) (Scrimshaw and Young, 1976). Malnutrition, no matter how provoked, affects growth in that this condition ultimately determines nutrient availability at the cellular level, with the attendant results of reduced rates of cell accumulation and the size of cells (Winick and Brasel, 1980). The further consequent results of these deficits are body wasting, and growth delay or retardation during the developmental years, which if not later made up by catch up growth will result in permanent stunting and shorter mean statures. Accordingly, it is generally agreed that mean heights provide the best indication of a population's cumulative nutritional status over time (Greene, 1980).

As noted above, the causes of malnutrition are frequently complex, involving multidimensional interactions with many disease states, and particularly infection. The particular virulence of this synergistic interaction is indicated by the assessment of researchers that malnutrition should be regarded as one of the world's most prevalent immunodeficiency diseases (Cunningham-Rundles, 1984;

Martorell, 1980). A particularly deadly combination between infection and malnutrition is seen in the diarrheal diseases, which are easily the principle cause of death from infections in children in developing countries (Chen and Scrimshaw, 1983). While a clear association can be seen between childhood illnesses (in particular, diarrheal diseases) and depressed physical growth in developing countries, this relationship is often not found in developed nations (Martorell and Habicht, 1986). This further highlights the different environmental contexts in which these two disparate populations are found. Children (and adults) in the developing world experience a greater disease load (more exposure to infectious agents due to the contamination of food and water, poor personal or group hygiene and sanitation in regards to food handling, and incomplete cooking), and generally endure infectious illnesses which are more frequent, of longer duration, and of greater severity than do their counterparts in the industrialized world (Martorell, 1980).

However, it is important to note that all infections have the capacity to worsen the nutritional status of any individual or population, regardless of the infectious agent responsible. This effect can be derived by a number of mechanisms: reduced appetite, decreased nutrient absorption when the gastrointestinal tract is affected, increased metabolic loss or poor utilization of energy and nutrients, and cultural practices that may dictate dietary restrictions during illnesses (Martorell, 1980; Rotberg and Rabb, 1983). It should be remembered that such episodes of infection divert nutrients from growth, and cause the body to draw heavily upon nutrient reserves, which in turn may cause growth to cease for the duration of the infectious event (Fogel, 1986; Martorell and Habicht, 1986). This then would provide a good rationale of how malnutrition can be brought about with a disease state as a primary cause, illustrating the point that simple inadequate nutrient intake, in any context, cannot be said to explain all of the variation seen in the nutritional status of a population--or the mean height series that is the principle measure of this status.

As mentioned previously, an already depressed nutritional status within an individual or a population generally is capable of reducing resistance to infection, consequently increasing the frequency and severity of many infections. These effects are mediated through a variety of mechanisms: depressed immunocompetence, reduced production of antibodies, less effective phagocytosis, weakened epithelial barriers, and lower lysozyme production (Cunningham-Rundles, 1984; Martorell, 1980; Rotberg and Rabb, 1983). As not all infections are nutritionally sensitive (the reverse is true), and the body's resistance to sufficiently virulent pathogens incidental in any which case, there is a range of infections that can be identified in which the nutritional status of subjects often plays a deciding role in the outcome of such episodes and in possible subsequent mortality. These infections need to be both nutritionally sensitive and of an intermediate degree of virulence. These are apt to include the same common childhood ailments (measles, chicken pox, mumps, and rubella) that are familiar to most people even within industrialized countries. That well-nourished children in the developed world usually manage to avoid the sequelae of stunting in association with these familiar conditions further indicates the importance of nutritional status in interceding in such contexts and allowing for catch up growth, which would quickly make up the losses seen from the more infrequent episodes of these illnesses (Fogel, 1986; Martorell, 1980; Rotberg and Rabb, 1983). Other illnesses that are known to be definitely influenced by nutritional status are tuberculosis, pertussis (whooping cough), most respiratory infections, most intestinal parasites, cholera, herpes, malaria, the diarrheal diseases, as well as many other illnesses caused by viruses, mycobacteria, protozoa, and fungi (Cunningham-Rundles, 1984; Martorell, 1980).

It is within this context that mean heights can be utilized as an indicator of the general health status of a population (Van Wieringen, 1986). While acknowledging that this relationship can be quite complex, and that the effect of growth delay will vary from one disease state to another and within different contexts, health status is still inevitably reflected in a mean height series in a generalized manner. It is recognized that

> an oversimplified approach which assumes strict proportionality or some other simple relationship between stunting or its absence will miss or greatly underestimate . . . much of the range of diseases occurring among well-fed populations (Fogel, 1986: 116)

including most chronic diseases. The interactions between many disease states (particularly infections) and mal-nutrition have definite consequences for nutritional status, particularly in developing situations, namely an increased risk of infection and mortality as well as physical growth retardation. Again, we are reminded by Fogel (1986: 33)

> although mean height is a good measure of nutritional status, it does not by itself indicate whether fluctuations in net nutrition are due to fluctuations in the consumption of food, in the claims on the food intake, or in the efficiency with which food is converted into outputs.

It remains difficult to decompose the effects of these various factors on growth and mortality, and no direct attempt will be made in this thesis in this regard.

Secular trends or changes in growth refer to long-term alterations in the pattern of growth and development in a given population. Generally these changes do not occur uninterruptedly in any one direction, but exhibit cycles of changes in growth (here mean heights) in response to shifting environmental circumstances, as described above.

These fluctuations are described with the adjective 'positive,' denoting greater growth velocity, increased adult (or child) heights, and earlier maturation; and the adjective 'negative,' designating the reverse situation, depressed heights over time or delayed growth. In general, an increase in height (over time) or earlier maturation can be regarded as a favorable indicator of a population's nutritional and health status, as these changes are strongly associated with better living conditions, reduced morbidity and mortality, and improved socioeconomic status (Bielicki, 1986; Eveleth, 1986; Van Wieringen, 1986).

However, it should be mentioned that a tall stature as such is not 'better' than a smaller one, only that given adverse conditions (undernutrition, poor living standards) a population may not be able to express the maximum size permitted by the genes, an outcome that has only recently been realized throughout the industrialized world (Eveleth and Tanner, 1976; Tanner, 1981). While severe malnutrition and accompanying poor social and living conditions do seem to be associated with certain motor coordination and cognitive deficits during early childhood (Balazs et al., 1986), this does not necessarily imply that our 19th century European or American ancestors, who would fall into the 25th percentile of a modern height distribution (at age 18) never came to express their 'full' normal intellectual or cultural potential (Komlos, 1987; Steckel, 1986).

While it is noted that positive secular changes are usually concomitant with favorable trends in a variety of indices of economic well-being and improved living standards, these growth changes are entirely reversible given periods of economic or living standard deterioration. Indeed, such a cycle in heights can be seen for native-born white males within the United States during the later 19th century. Fogel (1986) reports that the mean heights of these Americans declined after 1830 and only recovered this statural loss after about 1890.

Materials and Methods

The Composition and Derivation of Samples Utilized

The standing height data that were analyzed for secular trends for this study originate from two main sources. One source, identified as the "Boas" set, consists of anthropometric measurements from most of the prominent Sioux bands and sub-bands, mainly carried out by students of Franz Boas or observers trained by Boas or these students. These data were collected for (or as an adjunct to) the World's Columbian Exposition, chiefly during the years 1891-1892, as part of the larger North American anthropometric survey undertaken at this time (Jantz and Key, 1987; Sullivan, 1920). Although collected under similar circumstances (as all the Sioux were on reservations or under government "agency" oversight at the time), it can be shown that within this heterogenous grouping of Sioux bands discernibly different contexts did exist. As the data utilized for the Boas set of Sioux were unusual in that most of the original data sheets are missing and unavailable, it is presently impossible to disaggregate this sample into the original different constituent bands of Sioux represented within the data set. The groups of Sioux Indians that are known to be represented within this sub-sample of the larger Boas North American Indian anthropometric data set can be gleaned from the original data sheets that are available for Sioux children, and from a listing supplied by Sullivan (1920). From these sources it is apparent that the Boas data set includes samples taken from every Sioux reservation in North and South Dakota, as well as Nebraska. Some Sioux children were also measured at distant boarding schools, Haskell (Kansas) and Grant (Nebraska) among these. According to the summary presented by Sullivan (1920), all three divisions of the Sioux tribe are included within the present sample. The Western or Teton Sioux represent just over half of this total, with these Sioux seemingly the only division for which most of the individual bands and sub-bands were identified separately. While it is difficult to be certain, it appears that the samples cited by Sullivan (1920) would roughly reflect the actual historic (ca. 1891) proportion of the various major band populations within the Sioux tribe as a whole. It is from Sullivan's tally sheets for the Sioux that most of the individuals comprising the Boas data set, used herein, are drawn.

The second source of height data is a primary one, and is derived from anthropometric measurements taken and collected by Dr. James R. Walker on the Pine Ridge reservation, South Dakota, in the years 1905-1907 (Walker, 1980; Wissler, 1911). These Sioux were all identified as Oglalas; however, it is possible that a few Cheyennes were included in this sample, though probably not representing more than 5% of the total. Dr. Walker was the full-time agency physician at Pine Ridge for eighteen years (1896-1914), and came to be well acquainted with traditional Sioux customs and beliefs during his tenure at the reservation. Dr. Walker's relationship with the Sioux was one of mutual trust and respect, which afforded him unusual access to Oglala informants and holy men from whom he drew upon to undertake various anthropological studies apart from his work as a physician (Walker, 1980, 1982, 1983). Walker's interest in the disappearing elements of traditional Sioux culture first came to the attention of Clark Wissler, from the American Museum of Natural History in New York, in 1902 when Wissler visited Pine Ridge to collect anthropological material for the museum. Noting Walker's interests, Wissler proposed that Walker carry out anthropological investigations on behalf of the American Museum. This was a common method of the day, whereby field research was carried out with the help of interested Whites and Indians alike, who would then send their notes and manuscripts to the museum where the staff would edit them for publication (Walker, 1980). Wissler would continue to personally instruct and encourage Walker's efforts, even after the former became the head of the anthropology department and director of scientific research at the American Museum in 1905, and Walker had long since retired from the Indian Service (1914). Indeed, their professional correspondence only ceased the year before Walker's death in 1926. It is mainly through this correspondence and a few visits to Pine Ridge that Wissler was able to instruct Walker on anthropological methods in the field, although no record survives on the exact methodology suggested or utilized to measure stature or other anthropometric dimensions.

Only the Walker set of measurements are wholly available from the original data sheets, showing various measures made on each individual, who are identified by number and name. For the Boas data set, the adults comprising the sample were taken from Sullivan's tally sheets, from which he published an early summary on the anthropometry of the Siouan tribes (1920). These latter individuals are also identified by number and name but lack specific band or divisional determinations. The Sioux children represented within the Boas data set were largely available from original data sheets. All measurements were taken in centimeters and were entered as millimeters (i.e. 147.1 cm becomes 1471 mm).

While the Walker data set is not part of the Boas North American Indian anthropometric data set proper, it is generally comparable to this larger data set for several basic measures, and eventually will be incorporated into the (corporate) Boas data set. As previously mentioned, the present sub-sample of the larger Boas data set and the Walker data set are currently being curated at the University of Tennessee, Knoxville, after being housed at the American Museum of Natural History for several decades. Both data sets were kindly made available to me by Dr. R. L. Jantz, Professor of Anthropology at The University of Tennessee, Knoxville.

Problems of Samples Used and General Assumptions

As alluded to above, there are a series of issues pertaining to the nature of both data sets that need to be addressed. Among other topics, when a comparison of the Walker data sheets that were retrieved from the American Museum of Natural History was made with a previously published description of this collection (Wissler, 1911), it was noted that seemingly a substantial portion of the original data sheets were missing.

Wissler notes that Walker took measurements on 1,770 "full blood" Sioux and 1,193 "half blood" Sioux Indians at

Pine Ridge. There is little information available to discern exactly how these groups were differentiated, though Wissler's (1911) analysis proceeds by partitioning these groups from the whole. As both parents are scored for "blood" relationships on the data sheets, it may be possible to reconstruct how these categories were created (e.g., does an individual with a father identified as being of "mixed" blood and an "Indian" mother classify as a full blood or half blood, etc.). However, this determination was not deemed necessary for the present analysis of secular trends, and all individuals were combined into a single category (Sioux Indian) for the analysis. (There is a strong indication that Wissler's tendency was to rigorously apply the standards of "Indian-ness" in his partition of the sample.)

This said, the available Walker data set presently comprises 1,710 individuals, of which 1,051 are used in the present analysis. This would indicate that about 42% of the original collection is missing. An exact accounting may be quite difficult to obtain, however, since it was Walker's practice to count "each child separately each year he or she was measured" (Walker, 1980: 19). Thus, each child is identified with a new I.D. number for each year, and would be counted as a separate individual in different years. This practice seems to have been known to Wissler, and he may have excluded these individuals from his 1911 analysis.

A few adults were remeasured also. For purposes of continuity and clarity, Walker's practice is continued in the present analysis, and it is not thought to affect an examination of secular trend (Jantz, pers. comm., 1987). Wissler (1911) reported a grand total of 2738 Sioux children from Pine Ridge, and it is thought that Walker originally measured about 1,000 children with 457 remeasurements (Walker, 1980: 19). The samples utilized in the present analysis of Walker's data comprise 638 children (aged 6-11 years, combined sexes) and 413 adults (aged 20 and above).

However, if Wissler's (1911) accounting of totals can be relied upon, a much greater proportion of the children originally measured by Walker are missing from the present Walker data set. Wissler (1911: 357) gives the following totals: 635 adults and 2,738 children (both "pure" bloods and "mixed") for a grand total of 3,373 Oglala Sioux at Pine Ridge that were measured by Walker. Seemingly then, to obtain his total of 2963 Sioux (1,770 "full" bloods and 1,193 "mixed" bloods) Wissler seems to have disregarded 410 individuals--possibly those that were remeasured. Significantly, for the calculation of stature (1911: Table 1: 357) Wissler utilizes the entire sample of 3,373 Sioux, indicating that the present sub-sample represents just under 51% of the total number of measurements or individuals (including remeasures) taken by Dr. Walker.

It is not thought that the remaining children or adults represent a biased or a non-random sample of the original measurements obtained by Walker. As the height by age profile for children comprising the present Walker data set agrees very substantially with one that is supplied by Wissler (1911: 35), as do the two respective figures for adult height, this assumption was not tested explicitly.

With the Boas data set the largest concern can be seen to be the composite nature of the Sioux sample. As noted in the history section, discernibly different contexts (i.e. environmental, historical, geographical, etc.) did exist between the three Sioux tribal divisions. It would then be important to ascertain if these putative differences would be reflected within this corporate sample of Sioux from all divisions and most major bands. As noted above, it is not presently possible to test this proposition directly, as there is no band or division identified for each individual on Sullivan's (1920) tally sheets. However, Sullivan himself carried out Z-tests on the different band population height averages represented within this sample.[8] He

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[8] The bands that are listed in Sullivan's (1920) summary and upon which he performed statistical tests are: Santee, Wahpeton, Sisseton, Yankton, Yanktonai, Cut Head, Brulé, Loafer, Oglala, Waziahziah [sic], Sans Arc, Blackfoot, Minneconjou, Two Kettle, Hunkpapa, and Assiniboin. These latter Indians were not included as Sioux within the corporate Boas data set or the present sub-sample of Boas data. The Assiniboin split off from the Yanktonai band of Sioux sometime before the major migrations onto the Plains occurred, possibly before 1700 (Feraca and Howard, 1963; Hyde, 1967).

reported on these constituent Sioux bands, finding no statistical differences between the average heights of the Sioux bands comprising the present sample. These tests were made on a total of 538 "pure [blood]" adult Sioux males, representing more than one third of the original Boas data sample for the Sioux (1,405 individuals including "half bloods") according to Sullivan (1920: Table V:101). The totals of Sioux within the present corporate Boas data set currently are 993 total, with 745 males and 248 females (Jantz and Key, 1987). Of these, the present sub-sample utilized herein comprises a combined total of 895, with 816 adults and 79 children (aged 6-11 years).

The comparability of results and measures is also an important concern. As the Boas data are essentially a composite set of measures taken by several observers, interobserver error in measurements and observations may be a problem. This question also concerned Boas himself, and he took several actions to attempt to deal with this problem, including carefully instructing all observers on the East Coast, and having observers on the West Coast practice with their instructors (Jantz and Key, 1987). Sullivan (1920) also was concerned about this issue, and noted that for the Sioux there did not seem to be significant differences between the height averages reported from the eight different observers who measured the tribe. This said, it must be noted that since each observer essentially reported on a different band or group of Sioux, a true error analysis can not be undertaken (Jantz and Key, 1987).

As Walker is known to be the only observer for his data set, the problem of interobserver error does not arise. However, the exact method by which Walker measured his subjects is not known. Presumably, the measurement of stature did not differ from the standards set by Boas, as Walker was instructed by Wissler, and Wissler was trained by Boas. Sullivan (1920: 93) notes an essential (if obvious) point, that stature should be taken without shoes. This should also have been obvious to Dr. Walker, whose sophistication and diligence is reflected in the fact that he reports on weights for each individual, certainly an unusual and difficult undertaking for field measurements of the period. However, as noted by Sullivan (1920: 98) the height averages of Walker's collection of Oglala Sioux, as reported by Wissler (1911), are higher than those found in the Boas data set. This can also be observed within the present sample of Walker's data, and this difference appears to be consistent throughout the entire height series. The disparity between heights can range as high as 3-4 cm, but generally Walker's Sioux are at least 1-2 cm taller than the Sioux represented within the present Boas data set. This can be seen in the series of heights reported on in Appendix A; Figure A-1 for the Boas data set children and adults; and Figure A-2 for the listing of all the individuals within the Walker data set. A means procedure of SAS (SAS Institute, Inc., 1985) was utilized to calculate the sample sizes, mean heights, standard deviations, variances, and minimum and maximum values for each age and sex.

The origin of this consistent difference within the Walker data set is unknown. A test of the "shoe" hypothesis was carried out, utilizing the month recorded on the data sheets and partitioning the sample of children into "winter" and "summer" seasons. It was conjectured that during the summer the children would be more likely to go barefoot; however, no significant differences were found in the heights of children between the winter or summer months.

From a look at the comparable standard deviations of the two different data sets (Boas v. Walker) in Appendix A, it can be noted that the magnitude of these deviations are quite similar for both sets and are certainly reasonable given the sample sizes involved. This again is a good indication of the internal consistency of this possible systemic bias in Walker's data. Possible sources of this putative bias are several: (a) Walker could have measured his group of Sioux consistently in a manner different than the Boas group of Sioux, (b) secular trend could be responsible for the difference, (c) the small sample (n=39) utilized by Sullivan (1920) to illustrate a typical Oglala population height mean[9] may not be an accurate reflection of the "true" population mean for the Oglala Sioux males included within the Walker data set, and hence the Walker Oglala sample might simply display a higher height mean than the average Sioux male (as reported on by the "composite" Boas data set). It should also be mentioned that differences of this order (3.2-3.3 cm) can be noted in modern developed societies between the extremes of socioeconomic levels (unskilled laborers vs. managerial classes) (Bielicki, 1986; Tanner, 1981). Much larger differentials between socioeconomic classes in underdeveloped situations are certainly possible, with India having a differential greater than 6.4 cm between groups of high and low socioeconomic class children (Martorell and Habicht, 1986). Fogel (1986) reports on a historic differential of 4 cm between farmers (being taller) and urban laborers that accurately reflects the start of a deterioration in the final adult heights of native-born U.S. White males in an 1840 birth cohort.

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[9] Sullivan (1920: 95-96) gives "averages" for height; it is assumed that this is equivalent to an arithmetic mean. The calculated mean of the Walker data set for all adult males (1753.26 mm) is reported on in the next Chapter (IV). Sullivan gives an Oglala "pure blood" male average of 1728, with a standard deviation (S.D.) of 49.1. These means were found to be significantly different ($p<.01$) when a T-test was utilized. It should be mentioned that Sullivan does allude to the fact that he had access to other Oglala samples for height (possibly for women and children) besides the males he reports on.

This said, such a systematic differential or "bias," even if credible, should not seriously distort secular trends as long as it can be shown that the distribution of individual or mean heights retains an approximate normal distribution (Fogel et al., 1983; Jantz, pers. comm., 1987; Steckel, pers. comm., 1988). This can be shown graphically for the Walker data set with an examination of the composite growth curves obtained from the Walker data set as well as the height profiles for each sex. These can be seen in Figures 5 through 8, which were generated utilizing Walker means for height by age and sex and calculated with the MEANS procedure of SAS (SAS Institute, Inc., 1985). An inspection of the graphs shows that Walker children show a fairly normal cross-sectional curve or pattern of height attainment (Eveleth and Tanner, 1976; Tanner, 1978). The fluctuations seen within the adult ages are due to the differences in final attained heights over a span of decades (minus some statural loss due to aging). As previously discussed, these fluctuations are seen as mainly as a response to shifting environmental circumstances during the developmental periods of the individuals represented within an age group. These are the secular trends over time that this thesis reports on and will attempt to interpret. Thus, for the three females and four males aged 30 within the Walker data set, the final heights would be reporting on the environmental conditions experienced from a period of 1876

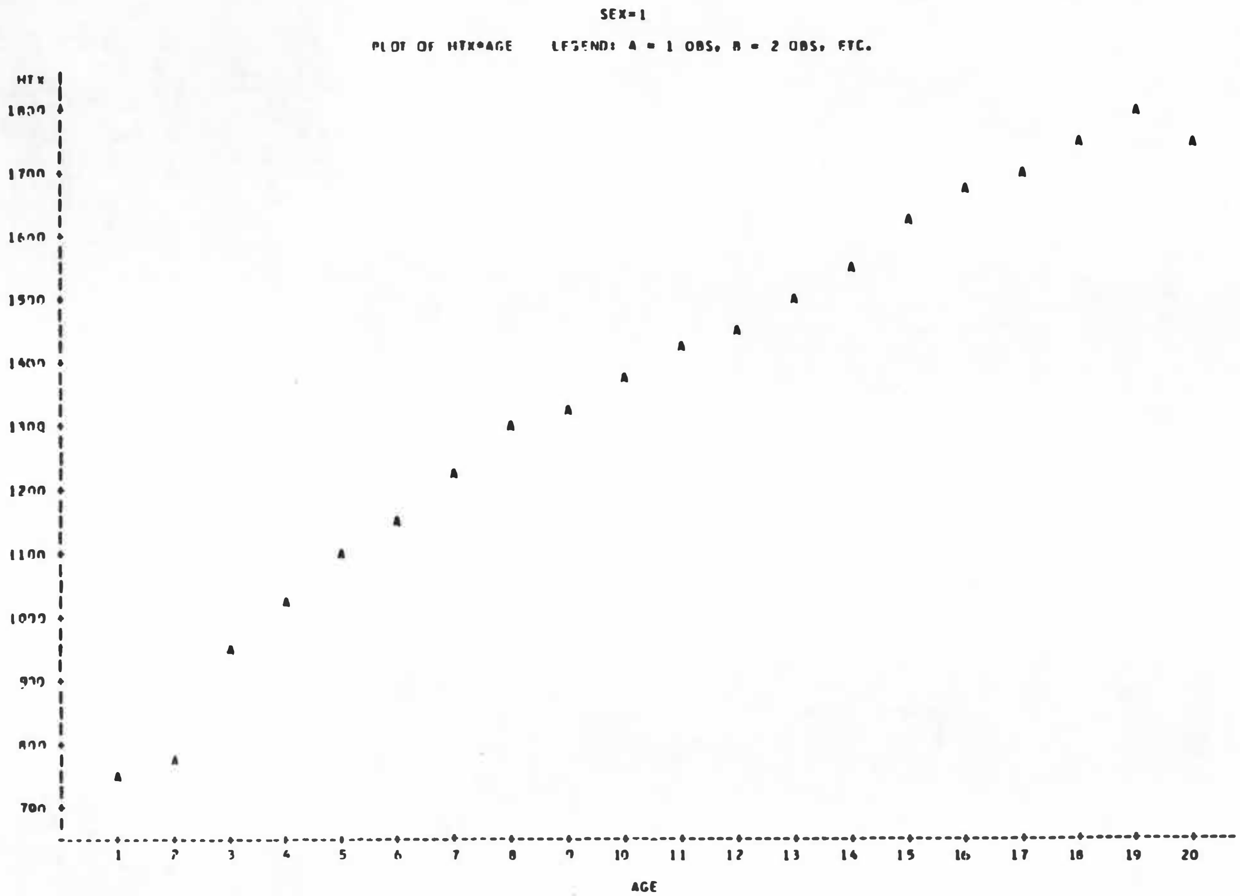

Figure 5. Male composite growth curve of heights by age for Walker sample, age ≤ 20.

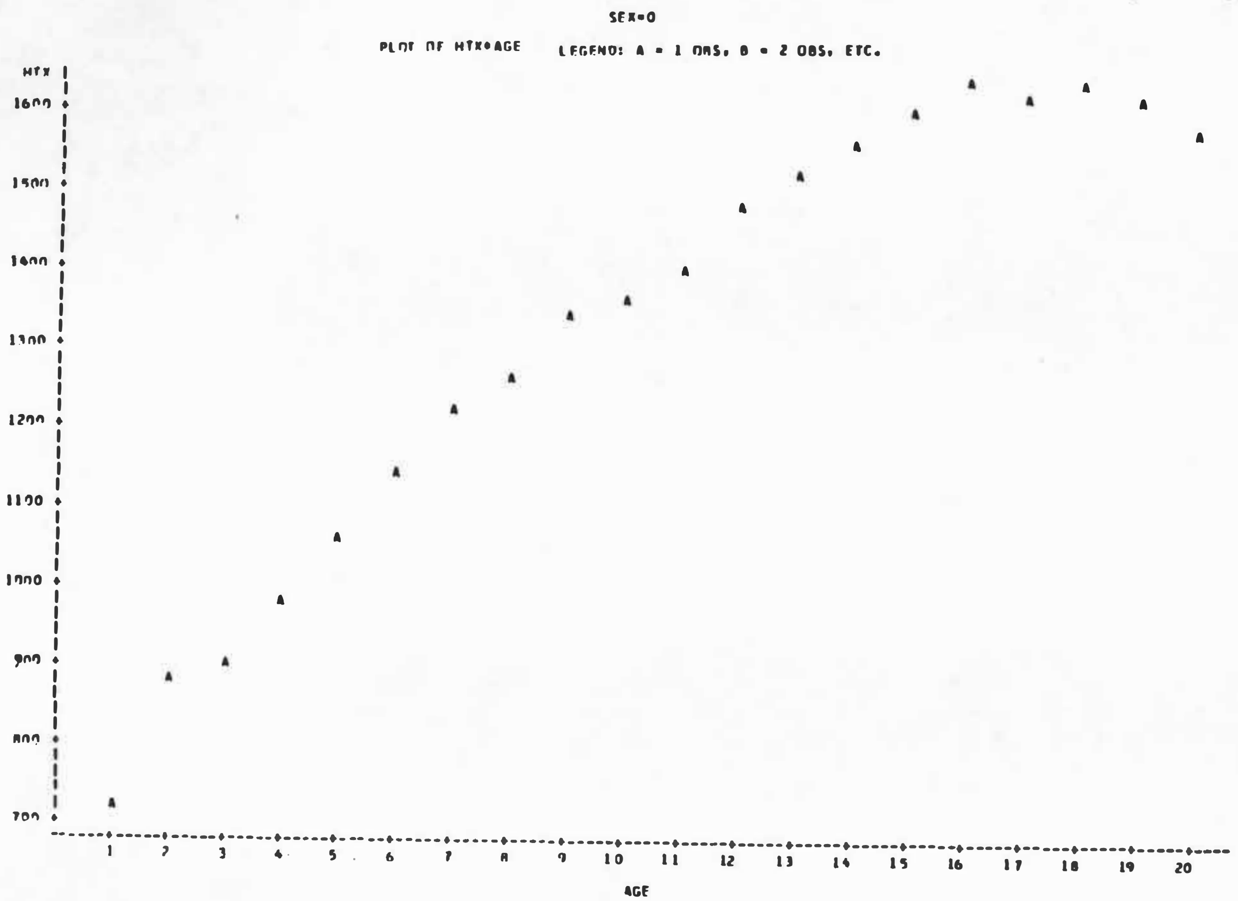

Figure 6. Female composite growth curve of heights by age for Walker sample, age ≤20.

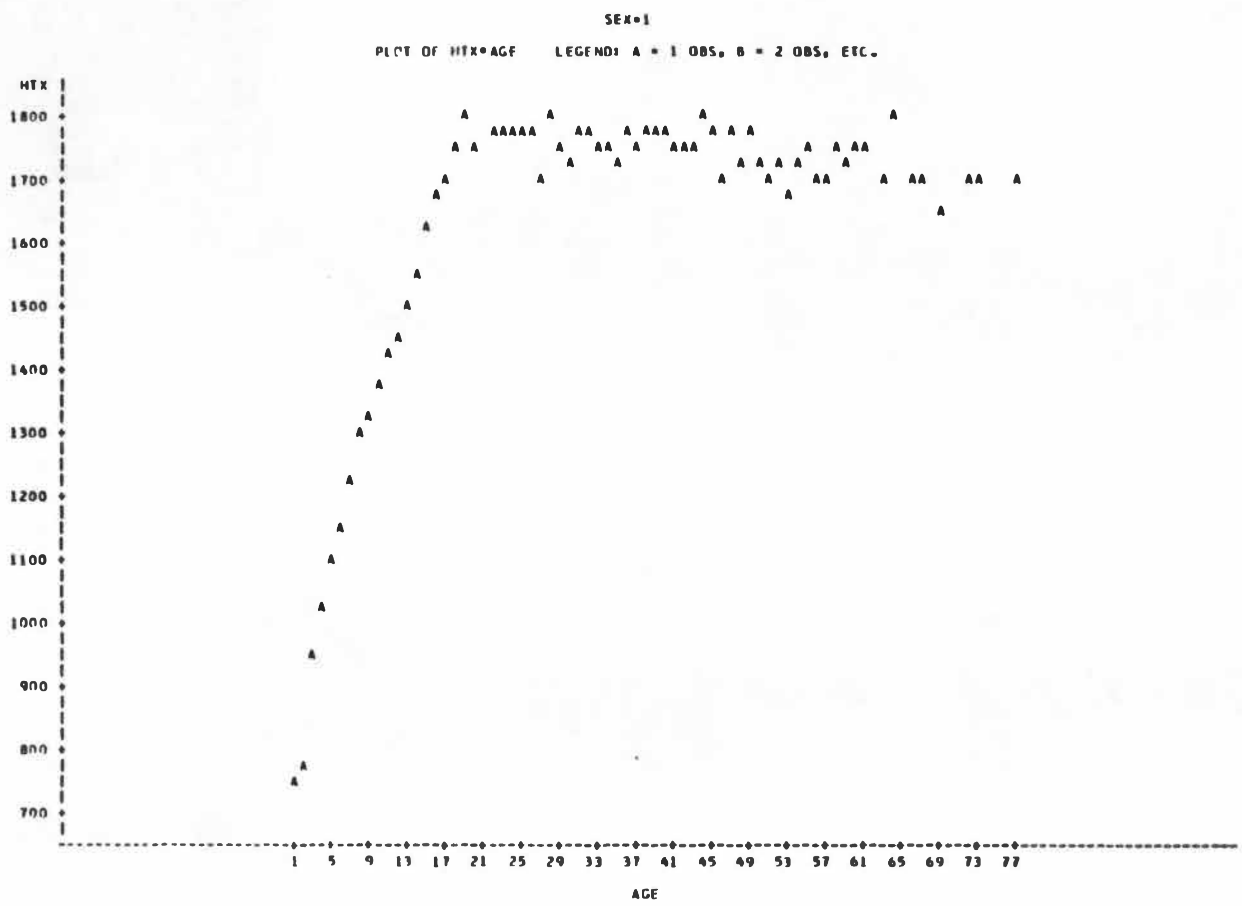

Figure 7. Male complete height by age profile (uncorrected) for Walker sample.

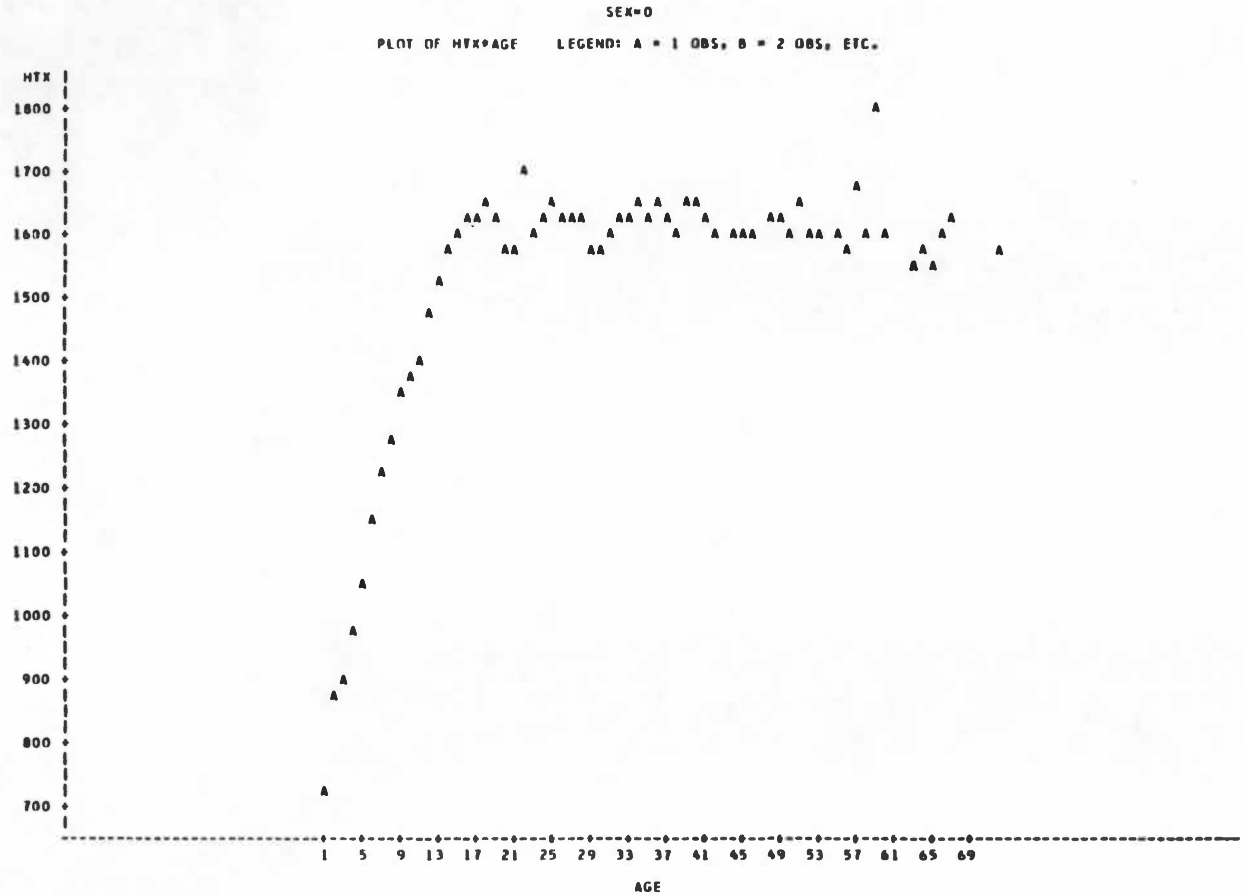

Figure 8. Female complete height by age profile (uncorrected) for Walker sample.

1877 through 1896-1897, while these individuals were growing and maturing to adulthood. We shall return to the issue of this possible bias in the discussion of Chapter IV.

From the above, one can get a sense of the number of individuals available for each age within the data sets. The Boas and Walker data sets are not well matched in this regard, with the Boas set having many fewer children than the Walker set, and the Walker set having many fewer adult males than does the Boas data set. (Both sets have roughly equivalent total numbers of adult females.) Because of the small sample sizes for many of the individual age groups involved, it was not thought advisable or particularly useful to compare the mean heights of the two groups of Sioux at successive ages with a string of students' t-tests. While one can be reasonably confident that larger age classes (i.e. 20-30 years of age by decade of birth) have approximate normal distributions of heights, reliable results might be difficult to obtain for some individual age groups (age 21, 22, 23, . . .) owing to small sample sizes. In such instances, height distributions may be truncated in a manner that might render a t-test suspect (Fogel et al., 1983). In the next chapter (IV) we will be able to explicitly test for differences between the means of several age classes.

Another issue of concern is the comparability of the ages given for individuals within the two data sets. Both

Boas (1894) and Walker (Walker, 1980; Wissler, 1911) were also aware of this possible source of bias. However, as noted by Fogel et al. (1983), accuracy in age would have only minor effects on the determination of a secular trend in final heights (as growth has ceased by this time and errors on the order of $\pm$ 2 years can be tolerated), but would be of some importance during the growing years. Boas (1894) noted that his observers would attempt to accurately determine a child's age by questioning parents or other people familiar with the Indian families. Wissler (1911) noted that Walker would carefully question parents, utilizing the winter-count calendar by which most of the Sioux reckoned their age and other important yearly events. Given Walker's familiarity with the Sioux under his charge, it can be assumed that his age determinations should be slightly more accurate (on average) than those represented within the Boas data set (compiled from 8 different observers). In this regard it can be noted that there does not appear to be glaring differences in the variability of the height measures given in Appendix A between the two data sets; if anything, the Boas data set shows slightly less variation for the height means for these childhood ages.

Analyses Performed

Two basic analyses were performed on both the Walker and Boas data sets. One involved the examination of the series of final attained heights in adults for the effects of a secular trend (or trends), and is the primary analysis reported on in this thesis. A second analysis was undertaken to augment the primary series of adult heights, with a smaller series reporting on the 15-year interval between original observations (taken as 1892 for the Boas data set and 1907 for the Walker set). This latter analysis was performed utilizing children aged 6-11 years of age. The methods utilized to test for a secular trend in the adult series will be described first, with the methodology employed for the analysis of child heights reported on afterwards. A comparison with available contemporary White standards (Fogel 1986; Steckel, 1986, 1987) will be made in a later Results section (Chapter IV), as will a comparison with a modern Sioux population (Ship, 1964).

Methods for the Analysis of the Adult Series of Heights

As noted by Relethford and Lees (1981) and Himes and Mueller (1977), change in adult height over time can be due to two main factors: (a) the effects of aging on height with the compression of intervertebral discs and loss of muscle tone tending to decrease stature; and (b)discernable secular trends, where final attained stature may be seen to increase over time with the improving nutritional and health status of a population (to give an obvious example). These relationships can also be influenced by differential migration and survival (Malina, 1979; Relethford and Lees, 1981). These two main factors might be easily separated out if one were conducting a comparison of longitudinal studies, but as we are dealing here with cross-sectional data (i.e most individuals were measured only once or over a very limited span of time), a way of partitioning the effects of aging and secular trend on changes in adult stature is required. Since aging primarily affects stature through changes in the spinal column (Susanne, 1980), a way of isolating these changes has been suggested (Relethford and Lees, 1981). By using subischial length (here computed as the difference between standing and sitting height), as a reference presumably largely unaffected by aging factors (at least for its contribution to overall stature), one can regress stature on subischial length, and then regress the residuals on age. In such a manner it is possible to arrive at an estimate of statural loss due to aging, and using this estimate (the coefficients from the latter regression), adjust the stature in each case for the effects of aging. A more accurate assessment of secular trends can then be made.

Since Walker's measurement battery did not include sitting heights, the Boas data set was used to compute the aging coefficients for both samples. This would assume that the rate of statural loss would be the same or quite similar for the two populations. Using a SAS program (SAS Institute, Inc., 1985), subischial length was calculated as the difference between stature and sitting height for each sex taken separately. When then used to adjust stature, subischial length will reflect the effects of secular trend alone on any changes seen in adult stature over time.

Two regressions were performed on the adults within the Boas sample to arrive at an estimate of the aging effect on stature for both samples. First, stature was regressed on subischial length for all adults (sexes again being treated separately). The residuals from this procedure were saved and regressed on age to arrive at coefficients estimating the statural loss per year expected due to aging effects. The results of this latter regression are shown in Figure 9 (males) and Figure 10 (females). As can be seen in the figures, the expected loss per year (in units of mm/year) is .63100 for the males and .61425 for females. These coefficients are then used to adjust stature to account for the effects of aging. This is done by creating the variable "adjusted stature":

Adjusted stature = observed stature + b (age-30)

where b is the expected rate of statural loss per year due to aging (as estimated above). This equation essentially standardizes each individual to age 30, to predict maximum stature for all individuals throughout the age range.

A final (third) regression is then performed for each analysis where the adjusted values of stature (now corrected for aging effects) are regressed on age to assess the

DEPENDENT VARIABLE: RESID

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	1	55153.05453557	55153.05453557	40.81	0.0001	0.059508	99999.9999
ERROR	645	871667.54685762	1351.42255327		ROOT MSE		RESID MEAN
CORRECTED TOTAL	646	926820.60139519			36.76169954		-0.00228083

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
AGE	1	55153.05453557	40.81	0.0001	1	55153.05453557	40.81	0.0001

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	23.84223526	5.96	0.0001	4.00253366
AGE	-0.63100339	-6.39	0.0001	0.09877397

Figure 9. Derivation of Aging Correction: Regression Coefficient (mm/yr) and Standard Error of Estimate for Males.

DEPENDENT VARIABLE: RESID

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	1	21992.84646908	21992.84646908	15.19	0.0001	0.066869	99999.9999
ERROR	212	306900.37880132	1447.64329623		ROOT MSE		RESID MEAN
CORRECTED TOTAL	213	328893.22527040			38.04790791		-0.00000000

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
AGE	1	21992.84646908	15.19	0.0001	1	21992.84646908	15.19	0.0001

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	22.98302829	3.57	0.0004	6.44467861
AGE	-0.61425853	-3.90	0.0001	0.15759457

Figure 10. Derivation of Aging Correction: Regression Coefficient (mm/yr) and Standard Error of Estimate for Females.

effects of secular trend over the reported age range (Relethford and Lees, 1981).

It should be mentioned that for the first two regressions above, used to estimate the aging effect on stature, the regressions utilized 646 adult males (here aged 18 years and above) and 214 adult females (aged 18 years and above) form the Boas sample. While elsewhere in this thesis adults will be defined as individuals at or above 20 years of age, because of the small sample size of females over the age of 20 within the Boas sample (n=181), it was thought advisable to expand this category to attempt to produce more reliable estimates for aging in females. It was noted that by excluding individuals under 30 years of age, Relethford and Lees (1981) obtained optimal results in their analyses. However, their results for a finding of secular trend were not essentially changed when all males (aged 16 and older) within their sample were utilized to obtain a correction for aging. An explicit test of this proposition was carried out on the 420 adult males from the Boas sample that were 30 years of age or older. The coefficient arrived at in this test regression was substantially different than the one derived above; an estimate of 1.065 mm/yr loss due to aging. However, subsequent analyses failed to discern a statistically significant secular trend for Boas males when utilizing this larger correction factor. That the two aging coefficients for Boas males were notably different would suggest that in the younger ages (18-30) there may have been some continued growth as younger adults. This inclusion of younger adults may then introduce a curvilinear relationship of stature with age, where the relatively shorter statures of these young adults would act to pull the regression line downward. Again, this does not affect the results of the assessment of secular trends in this analysis, similar to an outcome reported by Relethford and Lees (1981).

To attempt to alleviate some of the problems of continued growth after age 18, most subsequent analyses for secular trend will define adults as ages 20 or above. The exception was for an analysis of Boas females, where it was feared that a distribution may have been truncated if the adult age was taken as 20 rather than 18.

It should be remembered that the above regressions assume linear relationships. Heterogeneity in the data for the secular trend (involving the last regression) was tested by creating a variable called "decade of birth." This was meant to track, in a coarse manner, secular changes over the reported time span (chiefly 1820-1880) that might not be linear, for each birth cohort. Tests of significant differences between the reported decades of birth were then performed for each sex and each data set just as for the regressions for secular trend, utilizing an ANOVA model (analysis of variance) with each decade as a treatment class. Decade of birth was created by subtracting age from the respective date of observations (again either 1892 or 1907) to arrive at a date of birth. From each individual date of birth 5 years were subtracted and then this number was rounded to the nearest decade. For example, a 21 year old Oglala Sioux Indian in the Walker sample would be placed within the 1880 decade of birth, a 58 year old within the decade 1840, etc.

All of the above regressions were performed using Statistical Analysis Systems (SAS) packaged programs (SAS Institute, Inc., 1985), principally utilizing the PROC GLM (General Linear Models) procedure.

Sample sizes for the adult analysis are as follows: for the initial regression of adjusted heights by age: Walker males, 222; Walker females, 190; Boas males, 602; Boas females, 214. (Again, the latter group of females is taken as 18 or older.) For the analysis of secular trend by decade of birth (age cohorts), the samples are mostly the same, but may vary slightly due to computed corrected totals, and Boas females are taken at age 20 and above (n=181).

Methods for the Analysis of the Child Series of Heights

The sample of the Boas data set utilized in the analysis of child heights consists of measurements on 79 children aged 6-11 years of age. This age range was chosen in order to make comparisons between the two historical data sets more tractable, as this span in considered a time when the height attainment curve can best be described by a straight line for both sexes (Tanner, 1978). The sexes were pooled for this analysis primarily in order to obtain an adequate sample size for the Boas sample. This was necessary to ensure that a robust test for secular trend (viz. Walker's Sioux children) could be made. It is recognized that such a procedure will increase the variance within the age categories (Tanner, 1986), but this is unavoidable and could not be corrected for due to the fact that the Boas sample for children is not large enough to provide robust estimates otherwise. Again, as in the adult analysis, each child's recorded stature was employed in the analysis, with height as measured (cm) being converted to the nearest millimeter.

The sample of children from the Walker data set utilized 638 children, aged 6-11 years of age. Again, most of these children would be identified as Oglala Sioux, with a number of these "measures" being actually remeasures of the same children taken a year apart. As noted elsewhere, this is not seen as affecting the results reported on in the next chapter. (It should be noted that most of the measurements recorded within the Walker data base bear the date of 1906 or 1907, indicating that few individuals were measured in 1905.)

Both data sets (Boas and Walker) were combined in order to perform the analysis. As with the statistical operations performed on the data, this concatenation was achieved utilizing SAS statistical programs (SAS Institute, Inc., 1985), with the principal procedure being PROC GLM (General Linear Models). Two regressions were performed on this combined data set. In order to discern if a secular trend had occurred within the roughly 15-year interval between the dates when the two original data sets were measured (1892 for the Boas set and 1907 for the Walker set), a test for the equivalence of slopes and for means was carried out--comparing the Boas children with the Walker children. Using a GLM procedure with a model of:

Model: Standing Height = Age Group Age x Group

a test of slopes was first executed, and then a test for equivalence of means between the two groups. The removal of the interaction term from the regression enables this test of means to be performed with a Least Squared Means statement.

CHAPTER IV

RESULTS AND DISCUSSION

In keeping with the format established in the previous section, I shall first discuss the results of the adult analyses for secular trend, with a consideration of the analysis of the child series of heights following this. Finally, some comparisons will be made utilizing available 19th century White American and European standards for height attainment, with a mention of seemingly the only accessible data for "modern" Sioux heights (for children).

Results of the Analyses of Adult Sioux Heights for Secular Trends

In considering the results of the two sets of analyses performed on the two adult height series (Boas and Walker), the results of the basic regression test for a secular trend will be discussed first, with comment about the second set of tests of significance utilizing age classes of birth cohorts (by decade of birth) in an analysis of variance (ANOVA) following this initial examination.

The results of these initial regressions will be presented with the outcome of the statistical tests for the significance of the regressions displayed preceding the scatter plots for each regression. These tests are essentially reproduced directly from the output of the SAS

(SAS Institute, Inc., 1985) PROC GLM procedure, which displays the results of each regression in an ANOVA format. PROC GLM was utilized, as was the F test statistic for Type III sums of squares, due to an unbalanced design (although it should be recognized that Type I and III sums of squares are the same with only 1 effect in the model). Again, all regressions were performed using adjusted heights, which corrects each reported height for the expected rate of statural loss per year by adjusting each individual to age 30, to predict maximum stature. It should also be noted that a total of 12 outliers were removed from the entire sample of adults utilized in the present analysis.

In the basic test for a long term linear secular trend of any kind (negative or positive), only one sample of Sioux, Walker males, showed any significant trend. As the ANOVA table in Figure 11 shows, the Walker male Sioux sample shows a slope of $^{-}.857$ mm./yr ($p<0.001$), which as shown in the plot supplied in Figure 12, gives this group a positive secular trend (remembering that a negative slope in this instance is due to greater adjusted heights at younger ages). This would indicate that Oglala males born in later years (roughly 1860-1880) tended to be taller than individuals born earlier in the century, something one might expect from a typical "Western" industrial situation (for White Europeans). This rate of 8.57 mm per decade is comparable with other estimates of secular changes in

DEPENDENT VARIABLE: ADJUST

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	1	24298.55738658	24298.55738658	8.54	0.0038	0.037191	3.04
ERROR	221	629044.60896832	2846.35569658		ROOT MSE		ADJUST MEAN
CORRECTED TOTAL	222	653343.16635297			53.35124831		1753.265165

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR >
AGE	1	24298.55738658	8.54	0.0038	1	24298.55738658	8.54	0.00

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	1789.64866439	138.14	0.0	12.95493294
AGE	-0.85748669	-2.92	0.0039	0.29348169

Figure 11. Statistical test for the significance of the regression of adjusted stature on age for Walker adult males.

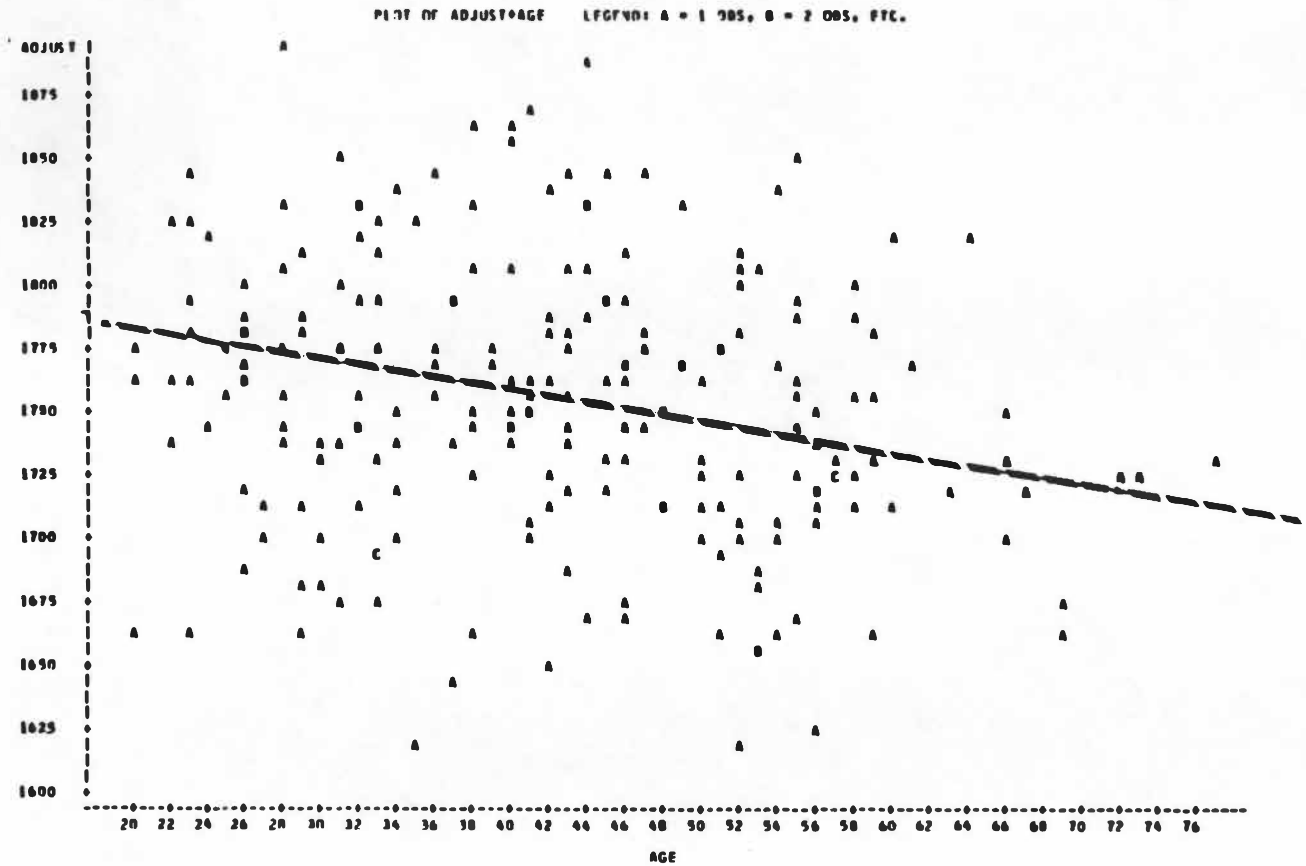

Figure 12. Plot of basic regression of adjusted stature on age for Walker adult males showing significant regression line.

growth, noting height increases of 1-2 cm per decade for several Western nations since the late 19th century (Tanner, 1981; Van Wieringen, 1986).

All other regressions failed to find any significant (again at a probability level of $p<0.05$) secular trends. The results of these tests can be seen in Figures 13 and 14 (for Walker's sample of adult females), Figures 15 and 16 (for Boas adult males) and Figures 17 and 18 (for Boas adult females). No regression lines are drawn for the scatter plots that proved to be non significant (all samples except Walker's adult males).

Again, it should be noted that for this test only, Boas' adult females are taken from 18 years of age due to the small sample size and the fear that the distribution of heights might have been truncated otherwise. However, an earlier independent analysis has shown that the results for the regression analysis is unchanged utilizing either age 18 or 20 as the benchmark for adult status. All plots were generated using a PROC PLOT procedure in SAS (SAS Institute, Inc., 1985), and if examined as they appear in the text (with the Y axis "Adjust" facing towards you), they show the height distributions for the various samples so that a better assessment of normality can be made. While it is true that only the sample with the largest sample size (Boas adult males) produces an immediate impression of a

DEPENDENT VARIABLE: ADJUST

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.
MODEL	1	82.30810315	82.30810315	0.03	0.8590	0.000167	3.14
ERROR	189	491851.63150636	2602.30958522		ROOT MSE		ADJUST ME
CORRECTED TOTAL	190	491933.93970949			51.01362157		1623.764791

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR >
AGE	1	82.30810315	0.03	0.8590	1	82.30810315	0.03	0.85

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	1621.68743777	132.38	0.0	12.25022157
AGE	0.05493211	0.18	0.8590	0.30888097

Figure 13. Statistical test for the significance of the regression of adjusted stature on age for Walker adult females.

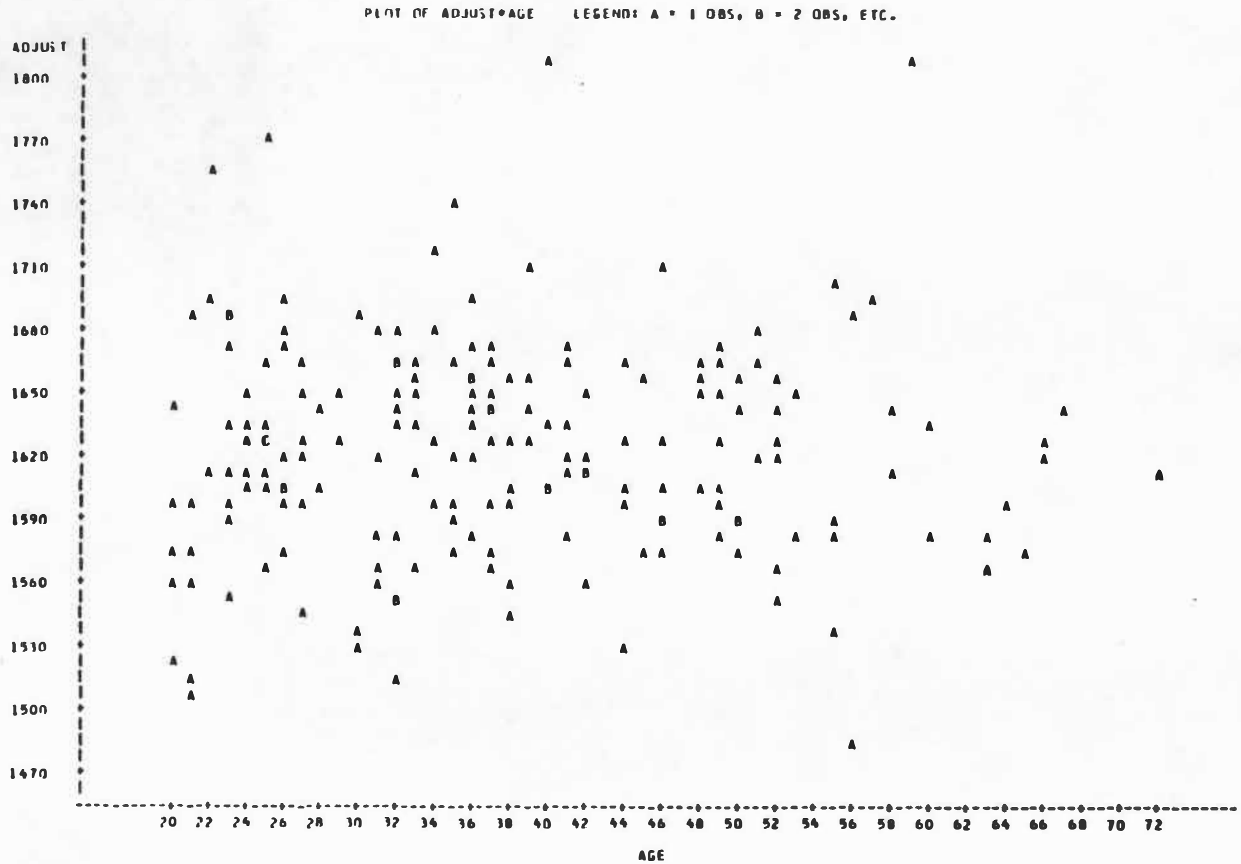

Figure 14. Scatter plot of adjusted stature on age for Walker adult females.

DEPENDENT VARIABLE: ADJUST

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	1	528.34993847	528.34993847	0.17	0.6817	0.000280	3.24
ERROR	601	1885870.64964683	3137.88793618		ROOT MSE		ADJUST MEAN
CORRECTED TOTAL	602	1886398.99958530			56.01685404		1728.024089

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR >
AGE	1	528.34993847	0.17	0.6817	1	528.34993847	0.17	0.68

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	1730.61529368	257.75	0.0	6.71419965
AGE	-0.06610662	-0.41	0.6817	0.16110271

Figure 15. Statistical test for the significance of the regression of adjusted stature on age for Boas adult males.

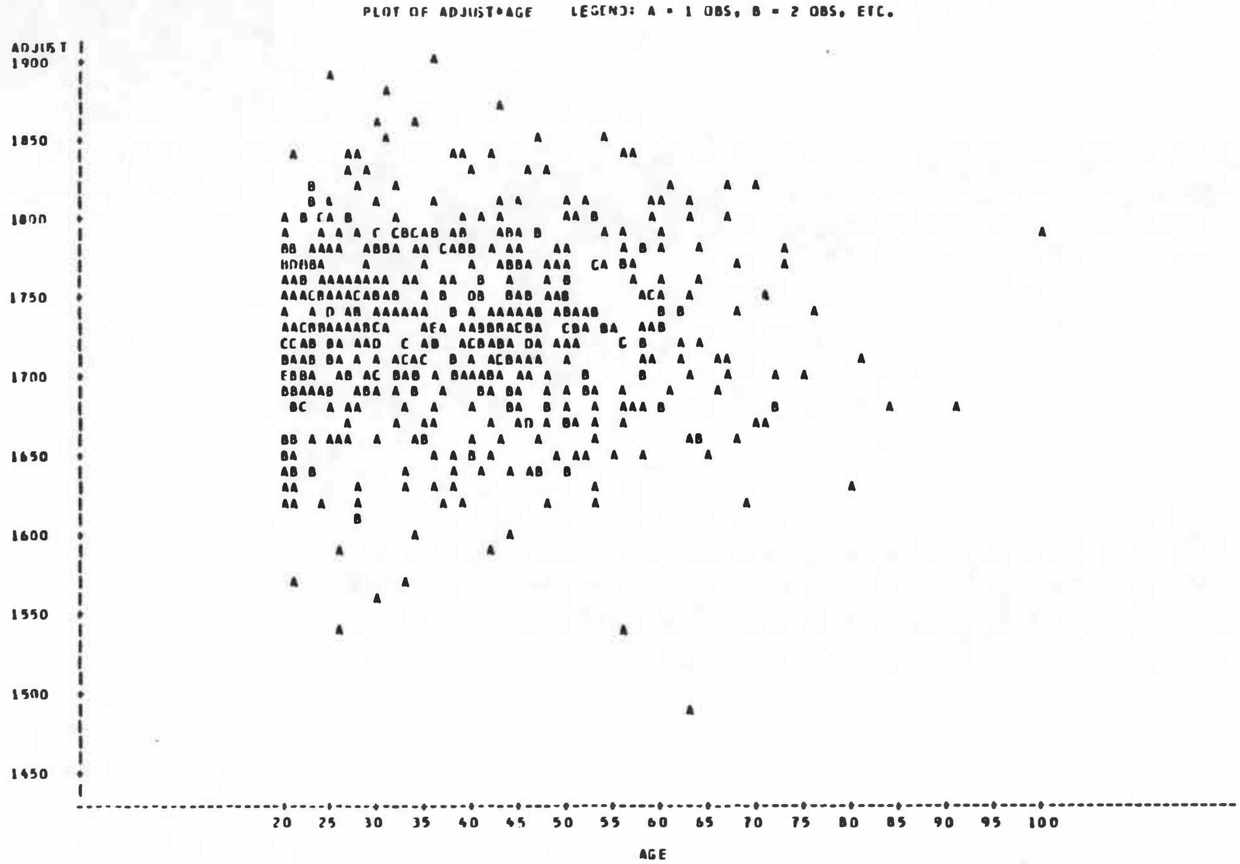

Figure 16. Scatter plot of adjusted stature on age for Boas adult males.

DEPENDENT VARIABLE: ADJUST

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	1	2628.70507151	2628.70507151	0.95	0.3298	0.004458	3.27
ERROR	213	587005.99827458	2755.89670551		ROOT MSE		ADJUST MEAN
CORRECTED TOTAL	214	589634.70334639			52.49663518		1601.603122

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR >
AGE	1	2628.70507151	0.95	0.3298	1	2628.70507151	0.95	0.32

PARAMETER	ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT	1593.53446900	179.22	0.0	8.89135840
AGE	0.21216142	0.98	0.3298	0.21723357

Figure 17. Statistical test of the significance of the regression of adjusted stature on age for Boas adult females.

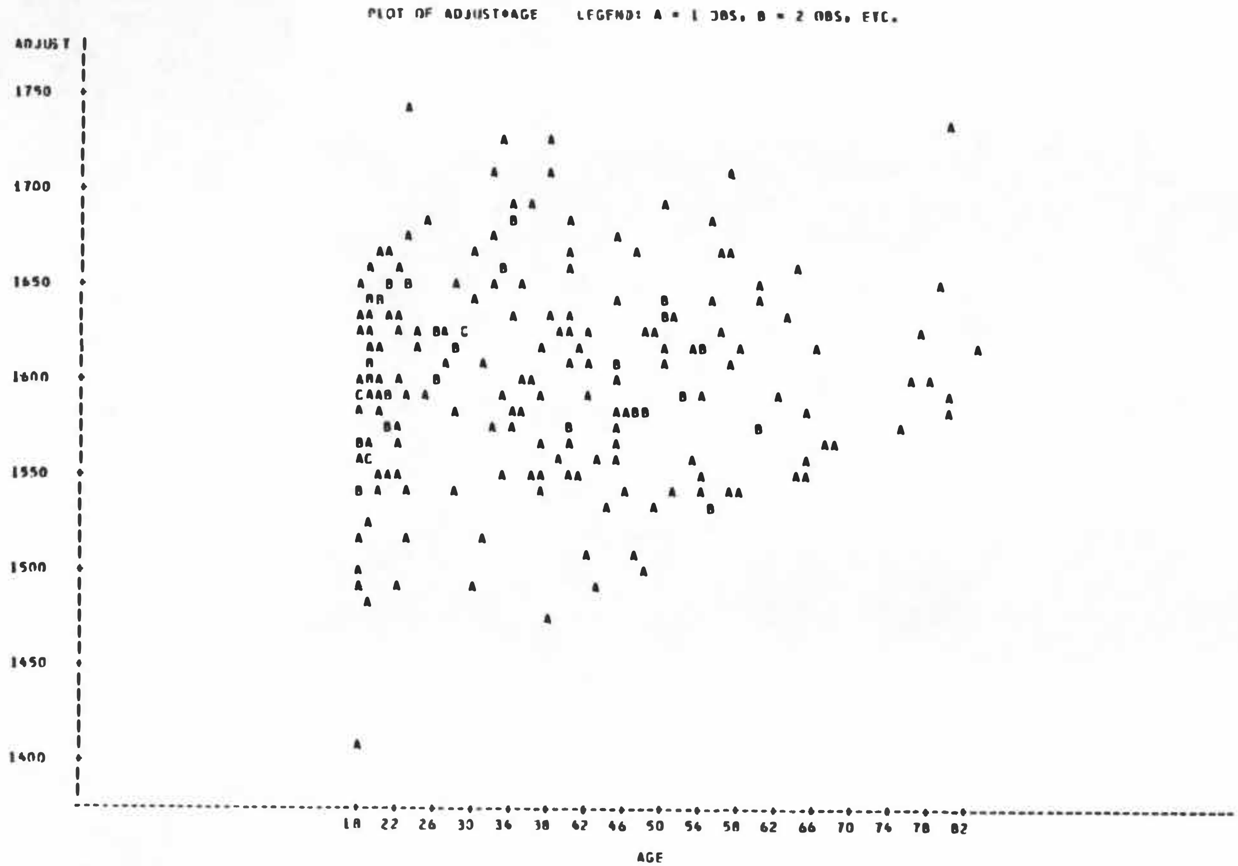

Figure 18. Scatter plot of adjusted stature on age for Boas adult females.

satisfyingly normal distribution, it can be seen that all the samples utilized do approximate normality.

The second examination of the adult height series for secular trends involves the creation and use of 10 year age cohorts (by decade of birth) and tests of significance to see if the means of any cohort differs significantly from others, within each sample. Again, as with the basic regressions for secular trend there are four tests made (one for each sample), here utilizing an ANOVA from the regression of adjusted stature on decade of birth. It was hoped that these tests (and the plots resulting from them) would reveal some possible non linear trends within the height samples. The results will be presented in a slightly different manner than those seen above. As in the above analysis, the outcome of the statistical tests of significance will be shown first. Again the null hypothesis tested was that there were no differences ($p<0.05$) among the means of the various decades, within each sample. Following the display of the results of these statistical tests (much in the same manner as above), a tabular display of the adjusted mean heights ("ADJUST"), the actual mean (unadjusted) standing heights ("STDHT"), as well as the mean age ("AGE"), and mean date of birth ("DOB") within each age cohort (by decade of birth, "DECB") can be found for each sample or test. Variances and standard deviations for each cohort mean are also shown. Following these, plots showing the trends resulting from the use of these age cohorts will be shown. However, when tested, the trends displayed for most samples were not found to be statistically significant. For all the present tests all adults were taken at age 20 or above.

In only one sample of Sioux were significant differences found between the adjusted mean heights by decade of birth. As in the previous analysis it was the Walker adult males. This can be seen from Figure 19, which shows that the probability that the F value is due to chance is $p<0.001$. Figure 20 gives the data from which this test on Walker's Oglala males and the following plot (Figure 21) were constructed. The regression line as well as the plot in Figure 21 (and subsequent plots) were generated using a SAS Graph program (SAS Institute, Inc., 1985). All subsequent plots showing non statistically significant differences are shown with a spline connecting the means by decade of birth for each sample. Although no other sample displays statistically significant results, the graphs for these other samples may nevertheless reveal some consistent tendencies that might prove useful for later interpretation when considering the historical record. The results of these latter tests can be seen in Figures 22, 23 and 24 (for Walker adult females), Figures 25, 26, and 27 (for Boas adult males), and Figures 28, 29, and 30 (for Boas adult females).

DEPENDENT VARIABLE: ADJUST

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.
MODEL	6	50844.31169073	10168.86233815	3.66	0.0033	0.077822	3.00
ERROR	217	602498.85466212	2776.49241780		ROOT MSE		ADJUST ME
CORRECTED TOTAL	222	653343.16635285			52.69243226		1753.265165

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR >
DECB	5	50844.31169073	3.66	0.0033	5	50844.31169073	3.66	0.00

Figure 19. Statistical test for significant differences between the means of adjusted stature by decade of birth for Walker adult males.

VARIABLE	MEAN	N	STANDARD DEVIATION	VARIANCE	MINIMUM VALUE	MAXIMUM VALUE
DECB=1830						
ID	253.00000000	5	253.77918634	64378.5000000	108.00000000	702.00000000
CODE	4.00000000	1	.	.	4.00000000	4.00000000
SEX	1.00000000	5	0.00000000	0.0000000	1.00000000	1.00000000
AGE	72.00000000	5	3.31662479	11.0000000	69.00000000	77.00000000
STDHT	1677.00000000	5	30.55323223	933.5000000	1637.00000000	1700.00000000
DOB	1835.00000000	5	3.31662479	11.0000000	1830.00000000	1838.00000000
ADJUST	1703.50200000	5	32.30925210	1043.8877710	1661.60900000	1729.65700000
DECB=1840						
ID	304.94444444	18	275.33967732	75811.9379085	62.00000000	930.00000000
CODE	4.00000000	2	0.00000000	0.0000000	4.00000000	4.00000000
SEX	1.00000000	18	0.00000000	0.0000000	1.00000000	1.00000000
AGE	61.05555556	18	3.31613209	10.9967320	58.00000000	67.00000000
STDHT	1727.83333333	18	43.10759453	1858.2647059	1645.00000000	1801.00000000
DOB	1845.94444444	18	3.31613209	10.9967320	1840.00000000	1849.00000000
ADJUST	1747.42938889	18	42.71762573	1824.7955483	1663.29900000	1819.93000000
DECB=1850						
ID	478.29629630	54	362.32423870	131278.853948	1.00000000	956.00000000
CODE	4.16000000	25	0.80000000	0.640000	4.00000000	8.00000000
SEX	1.00000000	54	0.00000000	0.000000	1.00000000	1.00000000
AGE	52.87037037	54	2.69203084	7.247030	48.00000000	57.00000000
STDHT	1719.24074074	54	52.18144512	2722.903215	1603.00000000	1834.00000000
DOB	1854.12962963	54	2.69203084	7.247030	1850.00000000	1859.00000000
ADJUST	1733.67194444	54	51.98597267	2702.541354	1616.88200000	1849.77500000
DECB=1860						
ID	521.81538462	65	347.35059254	120652.434135	9.00000000	975.00000000
CODE	4.00000000	37	0.00000000	0.000000	4.00000000	4.00000000
SEX	1.00000000	65	0.00000000	0.000000	1.00000000	1.00000000
AGE	42.58461538	65	2.73228560	7.465385	38.00000000	47.00000000
STDHT	1760.16923077	65	53.55708672	2868.361538	1645.00000000	1877.00000000
DOB	1864.41538462	65	2.73228560	7.465385	1860.00000000	1869.00000000
ADJUST	1768.11012308	65	53.50704773	2863.004157	1652.57200000	1885.83400000
DECB=1870						
ID	441.66666667	54	322.82643272	104216.905660	11.00000000	958.00000000
CODE	4.23529412	17	0.66421116	0.441176	4.00000000	6.00000000
SEX	1.00000000	54	0.00000000	0.000000	1.00000000	1.00000000
AGE	32.33703704	54	2.74007962	7.508036	28.00000000	37.00000000
STDHT	1756.07407407	54	58.83294285	3461.315164	1617.00000000	1894.00000000
DOB	1874.96296296	54	2.74007962	7.508036	1870.00000000	1879.00000000
ADJUST	1757.35944444	54	58.68044567	3443.394704	1620.15500000	1892.73800000
DECB=1880						
ID	412.70370370	27	324.22190881	105119.846154	49.00000000	996.00000000
CODE	5.00000000	5	1.00000000	1.000000	4.00000000	6.00000000
SEX	1.00000000	27	0.00000000	0.000000	1.00000000	1.00000000
AGE	24.07407407	27	2.16485789	4.686610	20.00000000	27.00000000
STDHT	1765.37037037	27	47.47480963	2253.857550	1644.00000000	1850.00000000
DOB	1882.92592593	27	2.16485789	4.686610	1880.00000000	1887.00000000
ADJUST	1761.63111111	27	47.36718360	2243.650082	1659.58300000	1845.58300000

Figure 20. Walker adult male means by decade of birth.

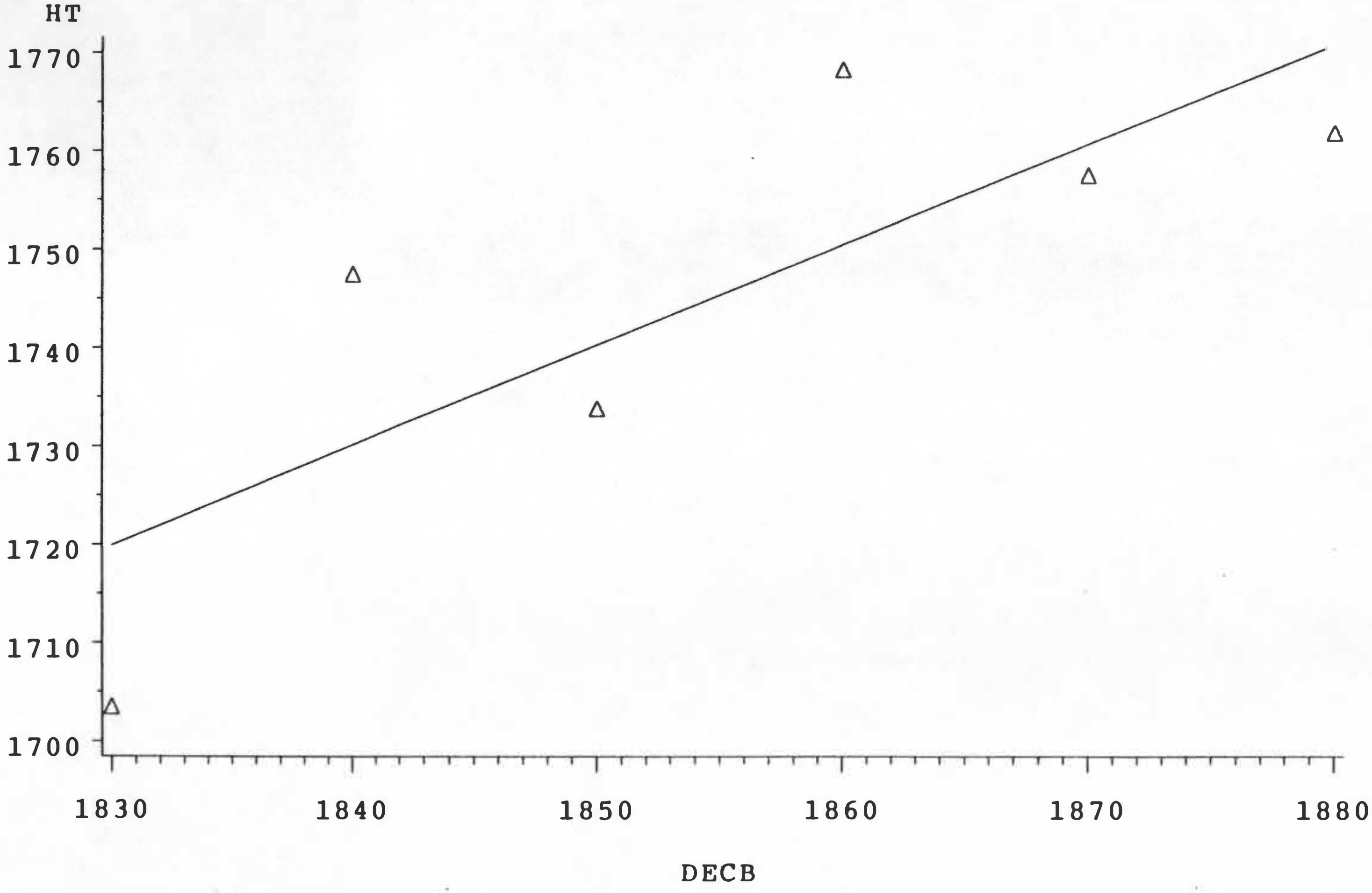

Figure 21. Plot of male adjusted mean heights by decade of birth for the Walker sample.

DEPENDENT VARIABLE: ADJUST

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.
MODEL	5	969.34925601	193.86985120	0.07	0.9962	0.001970	3.17
ERROR	185	490964.59045153	2653.86265110		ROOT MSE		ADJUST ME
CORRECTED TOTAL	190	491933.93970954			51.51565443		1623.764791

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR >
DECA	5	969.34925601	0.07	0.9962	5	969.34925601	0.07	0.99

Figure 22. Statistical test for significant differences between the means of adjusted stature by decade of birth for Walker adult females.

VARIABLE	MEAN	N	STANDARD DEVIATION	VARIANCE	MINIMUM VALUE	MAXIMUM VALUE
DECB=1830						
ID	164.00000000	1	.	.	164.00000000	164.00000000
CODE	.	0	.	.	.	.
SEX	0.00000000	1	.	.	0.00000000	0.00000000
AGE	72.00000000	1	.	.	72.00000000	72.00000000
STDHT	1583.00000000	1	.	.	1583.00000000	1583.00000000
DOB	1835.00000000	1	.	.	1835.00000000	1835.00000000
ADJUST	1608.79850000	1	.	.	1608.79850000	1608.79850000
DECB=1840						
ID	397.58333333	12	293.45820775	86117.7196970	92.00000000	827.00000000
CODE	4.00000000	3	0.00000000	0.0000000	4.00000000	4.00000000
SEX	0.00000000	12	0.00000000	0.0000000	0.00000000	0.00000000
AGE	62.41666667	12	3.28794861	10.8106061	58.00000000	67.00000000
STDHT	1605.08333333	12	64.52266456	4163.1742424	1550.00000000	1790.00000000
DOB	1844.58333333	12	3.28794861	10.8106061	1840.00000000	1849.00000000
ADJUST	1624.99527083	12	63.85638390	4077.6377649	1570.27025000	1807.81325000
DECB=1850						
ID	454.97058824	34	355.79117857	126587.362745	29.00000000	915.00000000
CODE	4.00000000	18	0.00000000	0.000000	4.00000000	4.00000000
SEX	0.00000000	34	0.00000000	0.000000	0.00000000	0.00000000
AGE	51.32352941	34	2.63680923	6.952763	48.00000000	57.00000000
STDHT	1610.41176471	34	48.54183928	2356.310160	1470.00000000	1687.00000000
DOB	1855.67647059	34	2.63680923	6.952763	1850.00000000	1859.00000000
ADJUST	1623.50974265	34	48.28691499	2331.626160	1485.97050000	1702.35625000
DECB=1860						
ID	528.00000000	38	345.03998985	119052.594595	2.00000000	935.00000000
CODE	4.00000000	27	0.00000000	0.000000	4.00000000	4.00000000
SEX	0.00000000	38	0.00000000	0.000000	0.00000000	0.00000000
AGE	41.73684211	38	2.77716763	7.712660	38.00000000	46.00000000
STDHT	1615.86842105	38	50.92770236	2593.630868	1518.00000000	1800.00000000
DOB	1865.26315789	38	2.77716763	7.712660	1861.00000000	1869.00000000
ADJUST	1623.97777632	38	50.67323606	2567.776052	1526.59950000	1806.14250000
DECB=1870						
ID	465.00000000	56	360.73546087	130130.072727	8.00000000	961.00000000
CODE	4.19354839	31	0.79241737	0.627951	4.00000000	8.00000000
SEX	0.00000000	56	0.00000000	0.000000	0.00000000	0.00000000
AGE	31.57142857	56	2.60668471	6.794805	28.00000000	37.00000000
STDHT	1624.37142857	56	48.12903382	2316.403896	1513.00000000	1737.00000000
DOB	1873.42857143	56	2.60668471	6.794805	1870.00000000	1879.00000000
ADJUST	1626.51517857	56	48.43107139	2345.563824	1514.22850000	1740.07125000
DECB=1880						
ID	352.22000000	50	353.04860566	124643.317959	3.00000000	981.00000000
CODE	5.31818182	22	1.12911106	1.274892	4.00000000	8.00000000
SEX	0.00000000	50	0.00000000	0.000000	0.00000000	0.00000000
AGE	23.82000000	50	2.24690263	5.048571	20.00000000	27.00000000
STDHT	1625.18000000	50	54.11050296	2927.946531	1515.00000000	1773.00000000
DOB	1883.18000000	50	2.24690263	5.048571	1880.00000000	1887.00000000
ADJUST	1621.38393500	50	54.42710120	2962.309345	1509.47175000	1769.92875000

Figure 23. Walker adult female means by decade of birth.

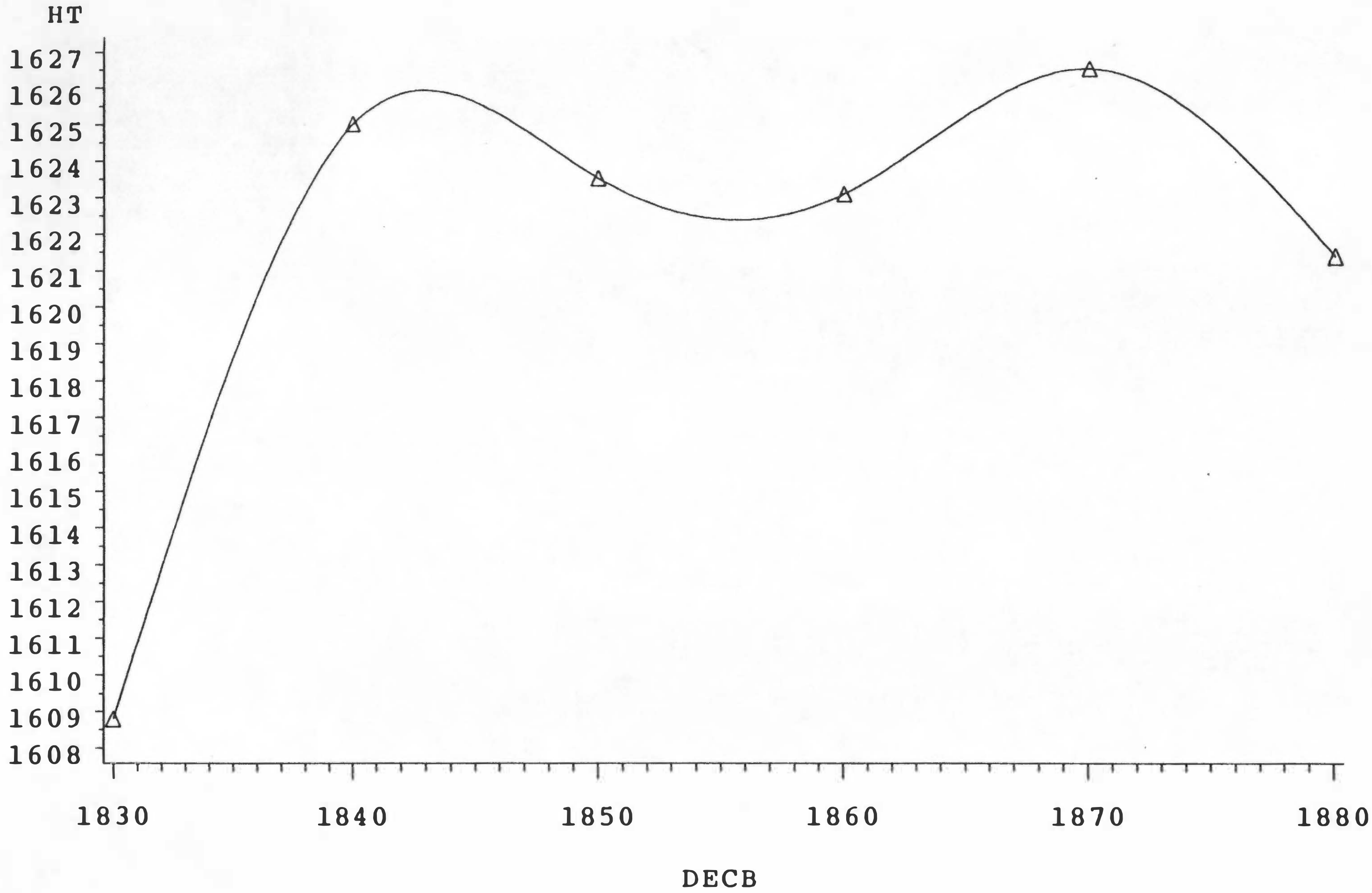

Figure 24. Plot of female adjusted mean heights by decade of birth for Walker Sample.

DEPENDENT VARIABLE: ADJUST

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	8	41469.22273461	5183.65284183	1.72	0.0911	0.022660	3.1774
ERROR	593	1788571.95757909	3016.14158108		ROOT MSE		ADJUST MEAN
CORRECTED TOTAL	601	1830041.18031371			54.91940988		1728.41811130

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
DECA	8	41469.22273461	1.72	0.0911	8	41469.22273461	1.72	0.0911

Figure 25. Statistical test for significant differences between the means of adjusted stature by decade of birth for Boas adult males.

VARIABLE	MEAN	N	STANDARD DEVIATION	VARIANCE	MINIMUM VALUE	MAXIMUM VALUE
DECB=1790						
AGE	100.00000000	1	.	.	100.00000000	100.00000000
STDHT	1742.00000000	1	.	.	1742.00000000	1742.00000000
STHT	876.00000000	1	.	.	876.00000000	876.00000000
DOB	1792.00000000	1	.	.	1792.00000000	1792.00000000
ADJUST	1786.17000000	1	.	.	1786.17000000	1786.17000000
DECB=1800						
AGE	87.50000000	2	4.94974747	24.50000000	84.00000000	91.00000000
STDHT	1643.00000000	2	0.00000000	0.00000000	1643.00000000	1643.00000000
STHT	814.50000000	2	12.02081528	144.50000000	806.00000000	823.00000000
DOB	1804.50000000	2	4.94974747	24.50000000	1801.00000000	1808.00000000
ADJUST	1679.28250000	2	3.12329065	9.75494450	1677.07400000	1681.49100000
DECB=1810						
AGE	76.33333333	6	3.44480285	11.86666667	73.00000000	81.00000000
STDHT	1691.66666667	6	55.06965286	3032.66666667	1600.00000000	1754.00000000
STHT	848.50000000	6	38.05128119	1447.90000000	787.00000000	893.00000000
DOB	1815.66666667	6	3.44480285	11.86666667	1811.00000000	1819.00000000
ADJUST	1720.90300000	6	53.41163710	2852.80297720	1631.55000000	1781.13300000
DECB=1820						
AGE	66.82142857	28	3.11571372	9.70767196	63.00000000	72.00000000
STDHT	1695.75000000	28	57.30918419	3284.34259259	1592.00000000	1792.00000000
STHT	855.57142857	28	51.63219536	2665.88359788	655.00000000	916.00000000
DOB	1825.17857143	28	3.11571372	9.70767196	1820.00000000	1829.00000000
ADJUST	1718.98432143	28	56.91284218	3239.07160526	1616.60900000	1817.24000000
DECB=1830						
AGE	57.04225352	71	2.78483967	7.75533199	53.00000000	62.00000000
STDHT	1716.81690141	71	54.42539057	2962.12313883	1527.00000000	1832.00000000
STHT	866.88732394	71	40.37203746	1629.90140845	695.00000000	965.00000000
DOB	1834.95774648	71	2.78483967	7.75533199	1830.00000000	1839.00000000
ADJUST	1733.88056338	71	54.58446193	2979.46348402	1543.40600000	1847.14400000
DECB=1840						
AGE	46.90769231	130	2.81591863	7.92939773	43.00000000	52.00000000
STDHT	1716.05384615	130	50.42798404	2542.98157424	1591.00000000	1866.00000000
STHT	877.53076923	130	34.52000621	1191.63082886	735.00000000	948.00000000
DOB	1845.09230769	130	2.81591863	7.92939773	1840.00000000	1849.00000000
ADJUST	1726.72260000	130	50.24026801	2524.08452982	1599.83400000	1874.20300000
DECB=1850						
AGE	37.46666667	135	2.94425826	8.66865672	33.00000000	42.00000000
STDHT	1771.85925926	135	56.72138807	3217.31586512	1565.00000000	1899.00000000
STHT	888.48148148	135	41.88948713	1754.72913212	695.00000000	997.00000000
DOB	1854.53333333	135	2.94425826	8.66865672	1850.00000000	1859.00000000
ADJUST	1776.57072593	135	56.74316406	3219.78666774	1566.89300000	1902.78600000
DECB=1860						
AGE	27.26623377	154	2.92619945	8.56264324	23.00000000	32.00000000
STDHT	1739.56493506	154	58.00731589	3364.84869705	1541.00000000	1890.00000000
STHT	871.81168831	154	32.45968228	1053.63097360	817.00000000	972.00000000
DOB	1864.73376623	154	2.92619945	8.56264324	1860.00000000	1869.00000000
ADJUST	1737.83992857	154	58.10706325	3376.43079935	1538.47600000	1886.84500000
DECB=1870						
AGE	20.85333333	75	0.78315601	0.61333333	20.00000000	22.00000000
STDHT	1720.60000000	75	52.51897984	2758.24324324	1574.00000000	1849.00000000
STHT	889.64000000	75	26.16508918	684.61189189	829.00000000	933.00000000
DOB	1871.14666667	75	0.78315601	0.61333333	1870.00000000	1872.00000000
ADJUST	1714.82845333	75	52.58565476	2765.25108649	1568.32100000	1843.32100000

Figure 26. Boas adult male means by decade of birth.

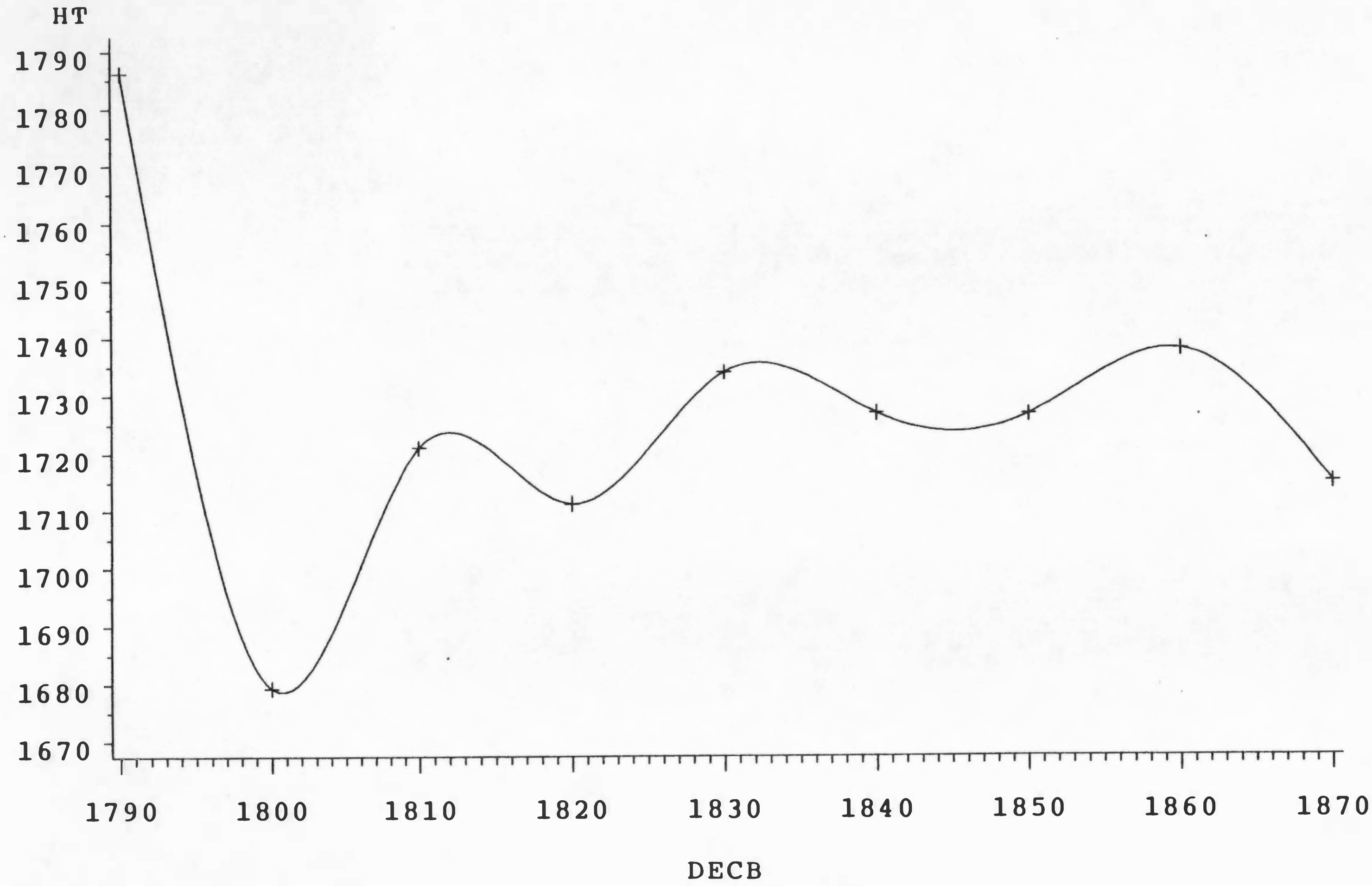

Figure 27. Plot of male adjusted mean heights by decade of birth for Boas Sample.

DEPENDENT VARIABLE: ADJUST

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.
MODEL	7	17361.56797572	2480.22399653	0.95	0.4713	0.036933	3.18
ERROR	173	452727.00157310	2616.91908424		ROOT MSE		ADJUST ME
CORRECTED TOTAL	180	470088.56954882			51.15583138		1605.884215

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR >
DECA	7	17361.56797572	0.95	0.4713	7	17361.56797572	0.95	0.47

Figure 28. Statistical test for significant differences between the means of adjusted stature by decade of birth for Boas adult females.

VARIABLE	MEAN	N	STANDARD DEVIATION	VARIANCE	MINIMUM VALUE	MAXIMUM VALUE
DECB=1800						
AGE	83.00000000	1	.	.	83.00000000	83.00000000
STDHT	1586.00000000	1	.	.	1586.00000000	1586.00000000
STHT	830.00000000	1	.	.	830.00000000	830.00000000
DOB	1809.00000000	1	.	.	1809.00000000	1809.00000000
ADJUST	1618.55525000	1	.	.	1618.55525000	1618.55525000
DECB=1810						
AGE	78.12500000	8	1.95940953	3.83928571	75.00000000	80.00000000
STDHT	1591.12500000	8	49.98410462	2498.41071429	1547.00000000	1699.00000000
STHT	782.00000000	8	38.59200913	1488.57142857	721.00000000	828.00000000
DOB	1813.87500000	8	1.95940953	3.83928571	1812.00000000	1817.00000000
ADJUST	1620.68578125	8	50.48044523	2548.27535104	1574.64125000	1729.71250000
DECB=1820						
AGE	65.22222222	9	1.56347192	2.44444444	63.00000000	68.00000000
STDHT	1566.33333333	9	38.72660584	1499.75000000	1526.00000000	1635.00000000
STHT	786.55555556	9	26.84730485	720.77777778	754.00000000	833.00000000
DOB	1826.77777778	9	1.56347192	2.44444444	1824.00000000	1829.00000000
ADJUST	1587.96858333	9	38.37875286	1472.92867138	1547.49875000	1655.88450000
DECB=1830						
AGE	56.41666667	24	2.55235044	6.51449275	53.00000000	62.00000000
STDHT	1588.04166667	24	50.77356310	2577.95471014	1517.00000000	1688.00000000
STHT	808.58333333	24	34.08801481	1161.99275362	707.00000000	852.00000000
DOB	1835.58333333	24	2.55235044	6.51449275	1830.00000000	1839.00000000
ADJUST	1674.26810417	24	50.92566323	2593.42317539	1532.35625000	1704.58475000
DECB=1840						
AGE	47.45714286	35	2.59346302	6.7260504	43.00000000	52.00000000
STDHT	1582.25714286	35	47.56131823	2262.0789916	1485.00000000	1682.00000000
STHT	788.37142857	35	140.55396404	19755.4168067	0.00000000	870.00000000
DOB	1844.54285714	35	2.59346302	6.7260504	1840.00000000	1849.00000000
ADJUST	1592.98019286	35	48.06503702	2310.2477834	1492.98525000	1694.28500000
DECB=1850						
AGE	37.43181818	44	2.95231661	8.71617336	33.00000000	42.00000000
STDHT	1608.22727273	44	57.96424866	3359.85412262	1468.00000000	1721.00000000
STHT	818.52272727	44	33.21283629	1103.09249471	745.00000000	897.00000000
DOB	1856.56818182	44	2.95231661	8.71617336	1850.00000000	1859.00000000
ADJUST	1612.79226705	44	57.52137224	3308.70826417	1472.91400000	1724.91400000
DECB=1860						
AGE	27.17647059	34	3.09907697	9.60427807	23.00000000	32.00000000
STDHT	1618.17647059	34	53.46053236	2858.02852050	1489.00000000	1742.00000000
STHT	817.64705882	34	64.38232505	4145.08377897	519.00000000	886.00000000
DOB	1866.82352941	34	3.09907697	9.60427807	1860.00000000	1869.00000000
ADJUST	1616.64211765	34	53.36479653	2847.80150874	1489.00000000	1737.70025000
DECB=1870						
AGE	20.96153846	26	0.82368777	0.67846154	20.00000000	22.00000000
STDHT	1605.96153846	26	44.19817260	1953.47846154	1497.00000000	1672.00000000
STHT	837.84615385	26	35.23372510	1241.41538462	773.00000000	938.00000000
DOB	1871.03846154	26	0.82368777	0.67846154	1870.00000000	1872.00000000
ADJUST	1600.40966346	26	44.11647399	1946.26327715	1492.08600000	1666.47175000

Figure 29. Boas adult female means by decade of birth.

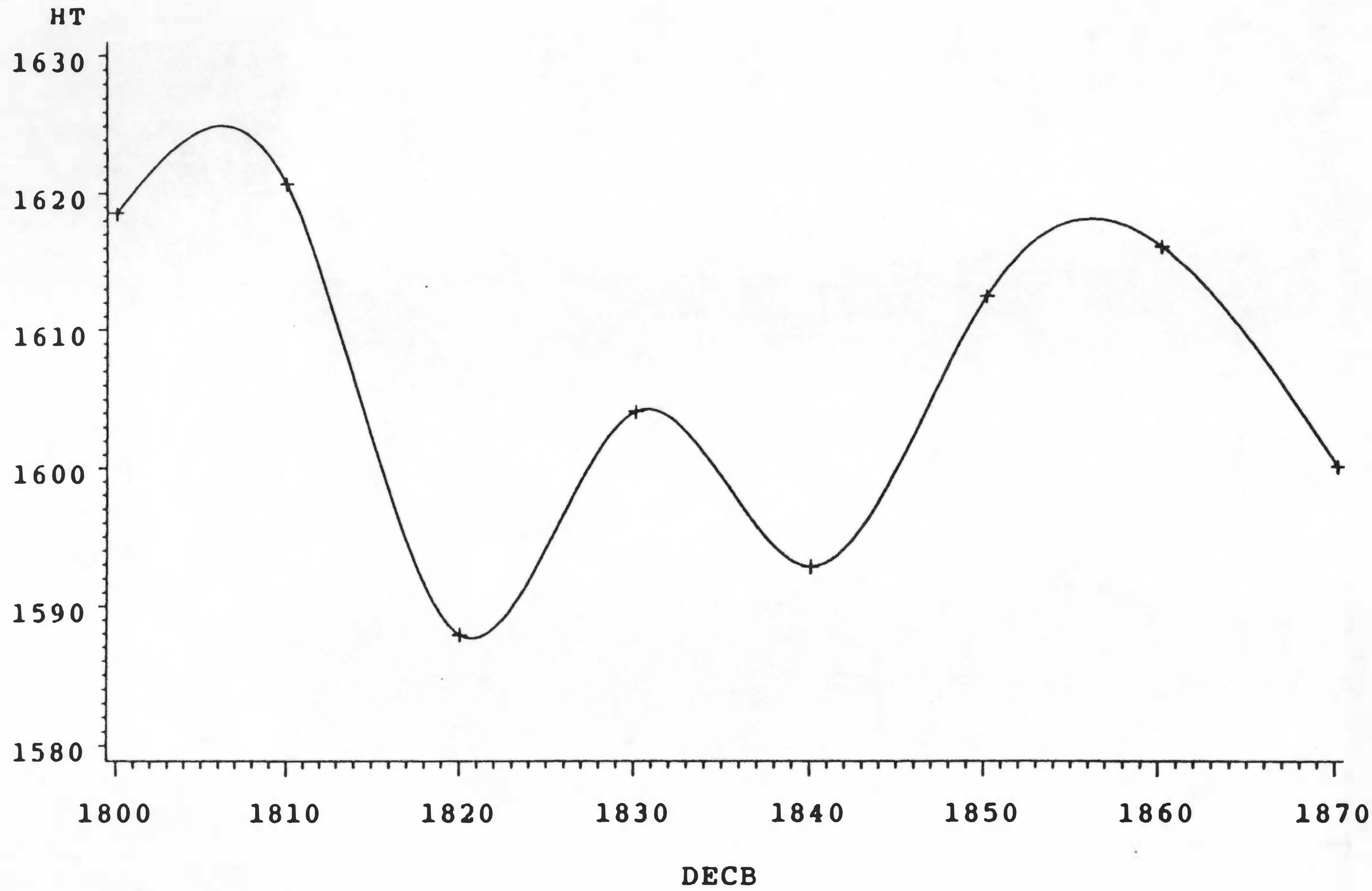

Figure 30. Plot of female adjusted mean heights by decade of birth for Boas Sample.

These results showing Walker's Oglala Sioux males to have significant differences between height means for successive age cohorts would tend to encourage confidence in the previous finding for a secular trend within this sample. A possible anomalous result from this test might be seen upon visual inspection of the plot of female adjusted mean heights by decade of birth for the Boas sample. Although the sample sizes for the early age cohorts are admittedly small, the approximately 3.2 cm difference between the 1810 and 1820 age cohorts should have proved to be significant (and almost certainly would have if larger sample sizes were involved). However, the test of significance utilized to determine if the differences between age cohort means were significant does weight by sample size. Thus, other anomalies to be seen in these plots of adjusted mean heights by decade of birth similarly involve very small sample sizes for early age cohorts, and should not be seen as representing important trends within the samples, nor should they unduly affect the results of these tests.

As mentioned previously, another anomaly was noted when the Boas data set was compared to the Walker set, that of a possible bias within the Walker data set. The larger sample sizes created in the above procedure where height means by decade of birth are generated allows for a more robust test for significant differences (among these 10 year age cohorts) between the two data sets. Tests on the adjusted stature means for comparable decades of birth were carried out to see if the adjusted means were statistically different between the Walker and Boas sample sets. Where feasible these tests were conducted using a Z test. Student T tests were utilized when the numbers of individuals for either sample set fell below 40 for any of the comparable decades of birth (1830-1870 for males and 1840-1870 for females). The T or Z scores for the males (by decade) are: 1830 T = 1.88, 1840 T = 2.0, 1850 Z = 1.29, 1860 Z = 2.31, 1870 Z = 3.73. Only the last two scores for the decades 1860 and 1870 are statistically significant at $p<0.05$ (although 1840 does appear to be marginally significant also). The T scores for the females (by decade) are: 1840 T = 1.66, 1850 T = 1.27, 1860 T = .80, 1870 T = 3.99. For the females, in only the last decade of comparison were the adjusted height means by decade of birth significantly different between the Walker and Boas adult samples ($p<0.05$). Thus, it would appear that the observed differences between the Walker and Boas samples are only statistically significant at younger ages (this is again confirmed in the child analysis below). This, however, does not resolve the issue of a possible bias, but does add the possibility that these differences may be part of an effect of the secular trend observed in Walker males. This would still leave the difference observed between the two adult female samples for the decade of 1870 to be interpreted in some other manner.

Results of the Analyses of Sioux Children Aged 6-11 for Secular Trend

The results of the analysis on the child series of heights essentially involves the results from two regressions on a sample of children (aged 6-11) from each data set, with pooled sexes. The sample sizes, variances and means utilized for these two regressions are supplied in Figures 31 and 32. Again, for an examination of the roughly 15-year interval between the dates when the Boas and Walker data sets were generated (1892-1907 respectively), the two child samples were combined and a test for the equivalence of slopes and for means between the Boas children and the Walker children was carried out. The null hypothesis was that there were no significant ($p<0.05$) differences between the Walker and Boas child samples for either slopes or for means (Ho: $b_1=b_2$). A finding for significantly different slopes between the two samples for heights within the given age range would suggest that the rate of change or tempo of growth was different between the two samples, suggesting a secular shift in height. This would be further supported by a finding for a difference of height means between the Boas and Walker child samples. As in the adult analysis, the statistical tests were carried out using a PROC GLM

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM VALUE	MAXIMUM VALUE
GROUP=BOAS						
AGE	79	9.01265823	1.55657144	2.42291464	6.00000000	11.00000000
STDHT	79	1295.87341772	84.43652434	7129.18889971	1096.00000000	1466.00000000
GROUP=WALKER						
AGE	638	8.64106583	1.59315849	2.5381540	6.00000000	11.00000000
STDHT	638	1302.98119122	104.39751447	10896.7531779	1027.00000000	1600.00000000

Figure 31. Total sample size and means for the tests of the equivalence of slopes and means between the Walker and Boas sample of children (aged 6-11), with pooled sexes.

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM VALUE	MAXIMUM VALUE
GROUP=BOAS AGE=6						
STDHT	6	1167.66666667	57.84692444	3346.26666667	1097.00000000	1240.00000000
GROUP=BOAS AGE=7						
STDHT	11	1205.72727273	48.51410292	2353.61818182	1096.00000000	1286.00000000
GROUP=BOAS AGE=8						
STDHT	11	1233.36363636	47.09410309	2217.85454545	1140.00000000	1292.00000000
GROUP=BOAS AGE=9						
STDHT	13	1318.53846154	38.36581678	1471.93589744	1257.00000000	1376.00000000
GROUP=BOAS AGE=10						
STDHT	24	1328.08333333	44.99267251	2024.34057971	1245.00000000	1388.00000000
GROUP=BOAS AGE=11						
STDHT	14	1394.50000000	48.56043024	2358.11538462	1301.00000000	1466.00000000
GROUP=WALKER AGE=6						
STDHT	66	1144.72727273	39.83177914	1586.57062937	1027.00000000	1240.00000000
GROUP=WALKER AGE=7						
STDHT	115	1222.65217391	61.38990195	3768.72006102	1075.00000000	1553.00000000
GROUP=WALKER AGE=8						
STDHT	121	1281.98347107	74.56529392	5559.98305785	1150.00000000	1599.00000000
GROUP=WALKER AGE=9						
STDHT	118	1331.33050847	70.14613014	4920.47957410	1211.00000000	1590.00000000
GROUP=WALKER AGE=10						
STDHT	116	1370.05172414	60.65208621	3678.67556222	1198.00000000	1600.00000000
GROUP=WALKER AGE=11						
STDHT	102	1411.78431373	68.21959700	4653.91341487	1243.00000000	1573.00000000

Figure 32. Boas and Walker Sample of Children Aged 6-11, With Pooled Sexes.

procedure in SAS (SAS Institute, Inc., 1985) and are essentially reproduced directly as Figures 33, 34, and 35. The regressions were performed using actual heights (as recorded), and will again utilize the F test statistic for the Type III sums of squares due to an unbalanced design.

As can be seen by referring to Figure 33, the null hypothesis of equivalence of slopes cannot be rejected. This is reported by the F test on the inclusion of the interaction term in the regression model coding for GROUP (either "Boas" or "Walker"). Therefore, a plot of both child samples would best be described by a single slope, and we can accept the null hypothesis.

In the test of the null hypothesis of the equivalence of height means between the two child samples, the adjusted means (controlling for age) proved to be significantly different (Figures 34 and 35) and the null was rejected. Again, by referring back to Figure 32, one can see that this is primarily due to the consistently high means for age to be found in the Walker children. This difference usually ranges from about 20 mm to 40 mm above the Boas child means for height by age (except for age 6 where Boas means are 23 mm higher than those for the Walker children). One can also note the result of the regression of height on age from the covariance analysis (Figure 34), which shows an average increase of 50.3 mm per year.

DEPENDENT VARIABLE: STDHT

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	3	4579059.56259896	1526353.18753299	372.47	0.0	0.610471	4.91
ERROR	713	2921800.31466742	4097.89665451		ROOT MSE		STDHT MEAN
CORRECTED TOTAL	716	7500859.87726638			64.01481590		1302.198047

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
AGE	1	4526678.74120941	1104.63	0.0	1	1558303.37990255	380.27	0.0
GROUP	1	46543.69029194	11.36	0.0008	1	1476.74217408	0.36	0.54
AGE*GROUP	1	5837.13109760	1.42	0.2331	1	5837.13109760	1.42	0.23

PARAMETER		ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT		862.98330717 B	61.69	0.0	13.98835436
AGE		50.91939961 B	31.98	0.0	1.59203204
GROUP	BOAS	26.90577521 B	0.60	0.5485	44.82018773
	WALKER	0.00000000 B	.	.	.
AGE*GROUP	BOAS	-5.87338587 B	-1.19	0.2331	4.92117985
	WALKER	0.00000000 B	.	.	.

Figure 33. Test Equivalence of Slopes Between the Boas and Walker Sample of Children, Aged 6-11 years.

DEPENDENT VARIABLE: STDHT

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.
MODEL	2	4571222.43150135	2286611.21575068	557.66	0.0	0.609693	4.91
ERROR	714	2927637.44576502	4100.33255709		ROOT MSE		STDHT ME
CORRECTED TOTAL	716	7503859.87726638			64.03383916		1302.198047

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR >
GROUP	1	3551.36879450	0.87	0.3523	1	46543.69029194	11.35	0.00
AGE	1	4569671.06270685	1114.46	0.0	1	4569671.06270685	1114.46	0.0

PARAMETER		ESTIMATE	T FOR H0: PARAMETER=0	PR > |T|	STD ERROR OF ESTIMATE
INTERCEPT		868.29485267 B	65.46	0.0	13.26545505
GROUP	BOAS	-25.80062247 B	-3.37	0.0008	7.65789342
	WALKER	0.00000000 B	.	.	.
AGE		50.30471322	33.38	0.0	1.50686987

Figure 34. Test for Equivalence of Means Between the Boas and Walker Sample of Children, Aged 6-11 years.

LEAST SQUARES MEANS

GROUP	STHGT LSMEAN	STD ERR LSMEAN	PROB > |T| HO:LSMEAN=0	PROB > |T| HO: LSMEAN1=LSMEAN2
BOAS	1279.24017	7.22158	0.0	0.0008
WALKER	1305.04379	2.53587	0.0	

Figure 35. Least squared means test for significant differences between the means of the Boas and Walker group of children (aged 6-11).

Although it is tempting to interpret this latter result as providing some sort of evidence for a secular trend, the general impression relayed by these tests is equivocal. An unambiguous finding for a secular trend is thus not possible. It does not appear that a different rate of change can be discerned from this analysis, though it possibly indicates that the entire growth profile for Walker's children is shifted upwards, as has been suggested by Fogel et al., (1983) in a different context. However, it should be recognized that these results do not necessarily mean that a secular trend could not have occurred within this time span. It is entirely possible that the growth differential required to produce taller Walker children could have occurred prior to 6 years of age. Again, the unresolved status of a possible bias within the Walker sample does make interpretation much more difficult.

Stature Comparisons With Other Populations

As noted previously, it has long been observed that the Sioux were a relatively tall population when compared to White Americans or Europeans. This was recognized by Franz Boas soon after his initial survey was undertaken (Boas, 1894), and was commented upon by Sullivan (1920) as well as Wissler (1911). This latter researcher made an extensive comparison of Walker's sample of Oglala children with a contemporary sample of White children (ca. 1904) for ages 6-

17. Wissler (1911) found that for almost every corresponding age, Walker's Oglala children (male and female) were absolutely taller than the contemporary Whites. This was true even given the partition of the Walker sample into Indian and "mixed" children, with the only exceptions being relatively small ($\leq$1 cm) and present in 3 "cells" of 48 total comparisons. The magnitude of this difference between Walker's Sioux Indian children and the White children was usually greater than 20 mm (2 cm), with only 6 comparisons yielding smaller differences to Whites (besides the three cases where White children were taller).

A similar result can be gleaned from an examination of Table 3, where a comparison is made with very favorably situated North American White children, as well as two Northern European groups renowned for their exceptional stature. These White comparative populations were gleaned from Steckel (1986, 1987) and represent a readily accessible source for contemporary (late 19th century) comparisons with the present two Sioux child height series. Despite the raw data having been "smoothed" by Steckel to overcome problems of age-heaping, the results are still broadly comparable to the less precise estimation of the centiles of modern height for the two Sioux samples, which were evaluated visually using a graph supplied by Tanner (1978). These were later cross checked with the cross-sectional standards for height attainment published in Tanner et al. (1966: Table III: p.

Table 3. Some Contemporary Historic American and European Heights Expressed as Centiles of Modern Height Standards Attained from Childhood to Age 18, Males and Females.[a]

	Boas' Sioux[c] 1891-1892		Walker's Sioux 1906-1907		Boston[d] 1875		Milwaukee[e] 1881		Toronto late 1880s		Denmark 1880s		Sweden 1883	
Age[b]	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
5	---	---	65.0	30.0	14.0	17.3	17.2	18.7	15.8	17.2	---	---	---	---
6	---	---	50.0	50.0	15.6	17.4	19.8	17.5	14.5	15.2	10.7	18.9	42.4	23.4
7	35.0	70.0	55.0	50.0	15.8	16.4	20.8	16.3	14.6	14.8	10.4	14.1	35.5	20.7
8	50.0	25.0	65.0	50.0	15.2	14.9	20.7	15.8	13.9	13.8	9.5	10.7	28.0	18.2
9	60.0	30.0	50.0	65.0	13.8	13.1	19.3	15.6	12.4	12.1	8.1	7.8	22.2	15.3
10	25.0	25.0	50.0	50.0	13.8	12.3	18.7	16.7	11.9	11.0	7.4	6.0	17.8	13.1
11	30.0	(25.0)	25.0	35.0	13.3	13.2	16.5	18.7	10.9	11.0	6.3	5.5	13.1	12.2
12	35.0	25.0	30.0	30.0	13.8	12.2	14.3	17.5	10.3	9.2	5.5	3.6	9.5	9.5
13	30.0	20.0	25.0	30.0	14.4	10.9	11.8	15.0	9.9	8.2	4.9	2.7	6.6	7.8
14	20.0	25.0	25.0	25.0	13.4	11.5	9.1	15.4	8.6	10.6	4.0	4.4	4.0	10.2
15	20.0	25.0	25.0	35.0	11.5	15.3	8.9	20.8	7.9	18.1	3.8	12.9	2.8	18.9
16	15.0	40.0	25.0	60.0	12.3	18.4	19.2	25.8	9.6	25.1	6.6	27.0	4.8	28.5
17	15.0	---	25.0	50.0	18.0	20.3	46.6+	29.1	20.3	29.6	14.7	---	13.8	35.2
18	25.0	12.0	50.0	50.0	23.0	21.1	67.6+	30.8	28.1	---	21.9	---	24.0	38.8

[a]"White" comparisons are from: Steckel, R. H. (1987). Growth depression and recovery: the remarkable case of American slaves. Annals of Human Biology, 14: 115-125. Values are smoothed, and the modern standards Steckel utilized were from Tanner, J.M. et al. (1966).
[b]Steckel's smoothed values were centered upon half years (5.5 etc.), these were taken as whole years (5.5 become 5, etc.).
[c]Small sample sizes (n<5) were present for ages 5 and 6 (which were excluded) and also for 11 yr. old girls (n=2). For both Sioux groups, conservative estimations of modern centiles were made visually using Tanner (1978: 169-170). Exact sample sizes for both Sioux groups is available in Appendix A.
[d]Native born parents.
[e]Values for 17 and 18 year old males were taken from adults due to the small sample size for both ages (n=7). Native born parents. N=876 total, all other White samples have populations n>2000 individuals for each sex.

625-628). While it is true that the Boas sample of children by sex for ages before 11 years all have cell sizes of under 10 individuals (height by age and sex), this does not detract from the consistently higher centiles seen throughout the entire age range for both sexes. The Swedish children represented the tallest group presented by Steckel (1987), with the data on Toronto school children possibly the largest historical sample of children available (n=88,449 total) (Boas, 1898). Like the comparisons Wissler (1911) made with his sample of Walker's Sioux children, it does seem readily apparent that the Boas sample of Sioux children were taller than most groups of American and European Whites. We therefore can be reasonably confident, even given some uncertainty about a possible bias within the Walker sample, that the clear trend represented by the Sioux children in both samples is one of quite exceptional stature for most ages within the height by age profile.

Much the same pattern can be observed when a comparison of the two samples of Sioux adult males (by decade of birth) is made with a sample of contemporary native-born American White males supplied by Fogel (1986). These comparisons can be seen in Table 4, and show that both samples of adult male Sioux exceeded the White mean heights for both adjusted and unadjusted means by 1850, and continued to exhibit a taller relative stature up until the time when the child height

Table 4. A Comparison of Sioux Adult Male Mean Heights by Decade of Birth with a Contemporary White American Sample of Native Born Adult Males (all heights in centimeters [cm]).

	Walker's Sioux (Oglala)		Boas' Sioux		Fogel's White Americans[b]
Year or Decade[a]	Adjusted Heights	Unadjusted Heights	Adjusted Heights	Unadjusted Heights	Unadjusted mean heights
1820	------	------	171.89	169.57	172.9
1825	------	------	------	------	173.1
1830	------	------	173.38	171.68	173.5
1835	------	------	------	------	173.1
1840	174.74	172.78	172.67	171.60	172.2
1845	------	------	------	------	171.6
1850	173.36	171.92	172.65	172.18	171.1
1855	------	------	------	------	170.8
1860	176.81	176.01	173.78	173.95	170.6
1865	------	------	------	------	171.1
1870	175.73	175.60	171.48	172.06	171.2
1875	------	------	------	------	170.7
1880	176.16	176.53	------	------	------
1882	------	------	------	------	168.9

[a]For all Sioux sample size n>10. Only Fogel's Whites utilized a five-year birth cohort.
[b]Source: Fogel, R.W. (1986). Nutrition and the Decline in Mortality Since 1700: Some Additional Preliminary Findings. NBER Working Paper No. 1802. Cambridge, MA: National Bureau of Economic Research, p. 144. As this data was compiled from military conscripts, only males are available.

series would continue this trend (1870-1880 onwards). The high relative stature for the Whites at earlier decades is recognized as remarkable and very unusual, and indicates that modern stature was achieved early in American history (Fogel et al., 1982; Fogel, 1986). Although these early (White) American mean heights are quite similar to those reported on for World War II American (White) conscripts, Fogel (1986) reports on a secular decline in the final adult heights of native born Whites after 1830, with a secular increase only occurring sometime after 1890. The much larger sample sizes available from military conscript rolls allows for a considerable greater degree of fine grained analysis and control for this sample of White American males; hence, Fogel et al. (1982) do not correct for aging effects. However, this should not prevent a comparison of adjusted heights for the Boas sample with the mean heights of the Whites for earlier decades. When such a comparison is made, the values for the decades 1830 and 1840 are seen to be fairly similar. Again, as with the child series, Walker's Sioux sample shows mean heights by decade of birth that are absolutely taller than the White means for every decade reported.

A determined search was made in the hope that a comparable modern sample of Sioux heights could be found, but the only study or survey located (Ship, 1964) reports on children only, with the raw data being lost or unavailable.

While a rigorous test for a possible secular trend with the children of the Walker or Boas sample and Ship's "moderns" is thus not possible, a limited test of means for height for age can be made nevertheless. Because of the greater sample sizes, it was decided that the Walker sample of Sioux children should be used. It was also noted that Ship's sample was comprised mainly of children from the Teton band (Western division) of Sioux.

The results of these tests between the Walker sample (1906-1907) of children and those reported on by Ship (measured from 1959-1962), can be seen in Table 5 (boys) and Table 6 (girls). Student T tests were used to determine which height means by age were significantly different between the two samples, and these are marked with an asterisk. As can be seen from an examination of Table 5, there does not appear to be a consistent trend to be seen throughout the entire age range (6-17) for boys. However, Ship's Sioux were significantly ($p<0.05$) taller (in mean heights) in 6 of the 9 ages where significant differences were found. This is particularly true for later ages (14-17), which would come at a time after a growth spurt in boys. In only three of the ages studied were Walker's Oglala Sioux boys definitively taller than Ship's Sioux boys. Of the total (non significant and significant) comparisons, Walker's Sioux exceeded Ship's in only 4 out of 12 cases. While not wholly unambiguous, one would be

Table 5. A Comparison of the Mean Heights of Boys Within the Walker Sample (1906-1907) with a Modern Sample of Mainly Teton Sioux Boys from South Dakota Schools (1959-1962).[a]

Age	Walker's Sioux Mean Ht (mm)	Ship's Sioux Mean Ht (mm)	Difference x_1-x_2 (mm)	D.F.	S.E.	T[b] values
6	1146.360	1233.932	-87.572	31	20.445	-4.283*
7	1229.897	1272.032	-42.135	69	16.603	-2.538*
8	1299.063	1258.316	40.747	113	10.170	4.007*
9	1323.672	1321.054	2.618	112	7.629	0.343
10	1370.281	1384.300	-14.019	118	8.347	-1.680
11	1417.825	1388.110	29.715	110	9.238	3.217*
12	1455.395	1473.708	-18.313	72	11.277	-1.624
13	1497.256	1466.088	31.168	72	10.834	2.877*
14	1551.692	1611.376	-59.684	49	19.064	-3.131*
15	1618.333	1674.368	-56.035	49	12.323	-4.547*
16	1663.600	1779.778	-116.178	45	12.762	-9.104*
17	1701.166	1731.518	-30.352	34	13.296	-2.283*

[a]Modern comparisons are from: Ship, I.I. (1964). Relationships of Dental Caries, Tooth Eruption and Growth. Unpublished M.S. Thesis, University of Pennsylvania, Dept. of Preventive Medicine, School of Medicine.

[b]T values with an asterisk after them are significant at $p<0.05$.

Table 6. A Comparison of the Mean Heights of Girls Within the Walker Sample (1906-1907) with a Modern Sample of Mainly Teton Sioux Girls from South Dakota Schools (1959-1962).[a]

Age	Walker's Sioux Mean Ht (mm)	Ship's Sioux Mean Ht (mm)	Difference x_1-x_2 (mm)	D.F.	S.E.	T[b] values
7	1215.281	1223.264	-7.983	79	12.891	-0.619
8	1262.810	1275.842	-13.032	101	10.779	-1.209
9	1341.392	1295.400	45.992	103	12.010	3.830*
10	1369.769	1397.000	-27.231	100	8.360	-3.257*
11	1404.133	1436.116	-31.983	92	9.776	-3.271*
12	1472.104	1476.248	-4.144	84	8.631	-0.480
13	1523.966	1535.176	-11.210	73	14.693	-0.763
14	1569.286	1577.594	-8.308	54	16.059	-0.517
15	1593.658	1593.342	0.316	50	11.422	0.028
16	1627.429	1600.200	27.229	61	11.556	2.356*
17	1628.385	1608.328	20.057	51	11.417	1.757

[a]Modern comparisons are from: Ship, I.I. (1964). Relationships of Dental Caries, Tooth Eruption and Growth. Unpublished M.S. Thesis, University of Pennsylvania, Dept. of Preventive Medicine, School of Medicine.
[b]T values with an asterisk after them are significant at $p<0.05$.

justified in suspecting that the differences observed within these two samples of Sioux boys may be due to a secular increase in mean heights between 1906-1907 and 1959-1962 (the two dates of observation).

The results of the analysis of the mean heights by age for girls between the two samples of Sioux are a bit more ambiguous. The significant differences found between the mean heights were evenly split, with each sample proving to be significantly taller than the other for 2 out of 4 differences (Table 6). Again, this result is too equivocal to support a finding for a secular trend, and would seemingly indicate a condition of stasis in mean heights for girls over the reported time period. However, the overall impression one can glean from the table is a general trend for the modern Sioux girls to exhibit taller statures over the Walker sample, at least until age 15.

Discussion and Interpretation

An obvious place to begin any discussion of the possible trends within the height series reported on by this thesis should involve an accounting of the fact that only one group of the four adult samples of Sioux Indians showed any sort of statistically significant secular trend. Of the two adult height series analyzed herein (again with each sex treated separately), only the males of the Walker sample showed a positive secular trend in a basic regression test for a linear trend, and significantly different height means by decade of birth in an ANOVA test of significance. Similarly, no conclusive evidence for a secular trend could be found between the two child height series reporting on a period of about 15 years (1892-1907).

Such an examination necessitates a discussion of the concomitant trend in Sioux health status during the time span represented by the height series (again, roughly 1820-1907). As noted by several researchers, a close interrelationship has long been recognized between secular shifts in growth and patterns of morbidity and mortality (Fogel, 1986; Malina, 1979; Van Wieringen, 1986). While it should be recognized that morbidity and mortality estimates are virtually impossible to be generated for most of the period represented by the Sioux adult height series (1820-1880), certain trends can be discerned from available historical accounts. One of the most easily accessible sources reporting on such trends where comparisons by year can readily be made for most of the Sioux tribe are the various published winter counts (Higginbotham, 1981; Howard, 1976). Taylor (1977) has synthesized these accounts as far as reported epidemics prior to 1850 are concerned, and his results for the Sioux are essentially reproduced in Table 7. Using largely the same sources, I have extended the series to report on major epidemics occurring between 1850-1876. Only one additional outbreak was gleaned in this manner,

Table 7. A Summary of Epidemics Reported Within Various Sioux Winter Counts for the Period Prior to 1876, with Dates and Estimated Virulence.[a]

Date	Postulated Disease and Estimated Mortality[b]
1789-1799	Streptococcal Infection with high mortality for pregant women.
1800-1803	Smallpox, Moderate mortality seen.
1806-1814	Whooping Cough, Low mortality.
1818-1820	Measles and Whooping Cough, Moderate mortality.
1837-1838	Smallpox, Low mortality.
1845-1846	Measles, Low mortality.
1849-1850	Cholera and Smallpox, High Cholera, mortality for groups along the Platte River (Low mortality otherwise).
1859-1860[c]	Smallpox, Moderate to High. Especially high for children.

[a]Source: Taylor, J. F. (1977). Sociocultural Effects of Epidemics on the Northern Plains: 1734-1850. Western Canadian Journal of Anthropology 3: 55-81.
[b]Mortality codes from Taylor (1977): "High" indicates mortality at or above 25% of the population, "Medium" or "Moderate" indicates mortality for 10-25% of the population afflicted, and "Low" indicates mortality at 5-10% of the population.
[c]Taylor's (1977) series has been extended by present author using sources quoted in Taylor (1977) or Higginbotham (1981), Howard (1976).

those reported for the years 1859-1860. While such an examination cannot provide "differential" rates for the Oglala band in comparison to other Sioux bands, certain long term trends might be discerned if the record of these epidemics is compared with the patterning seen in the plots of adult adjusted mean heights by decade of birth (Figures 21, 24, 27, and 30: pp. 123-132).

Although the addition of the above information may not be readily interpretable as having certain effects upon the adult height profiles (by decade of birth) certain consistent trends can be seen in the data. However, I may remind the reader that these plots were generated for a test for differences among the means within each plot or sample. As reported on in the previous results section, only one of these samples proved to have significantly ($p<0.05$) different adjusted height means by decade of birth--the Walker adult male sample. Therefore, we are embarking upon a highly speculative enterprise, which nevertheless may reveal some suggestive patterning within the data. The reader is reminded that the decade of birth, 1820 for example, essentially reports on the decade 1820-1830, with the observation centered on a date of birth (DOB) that should represent the mean DOB's within the specific decade, often 1824 or 1825 to give an example. It should also be remembered that the Boas sample's composition represents all major Sioux bands, probably proportional to population size at time of observation. This makes the interpretation of these plots (Figure 27 for the males: p. 129; and Figure 30 for the females: p. 132) still more difficult. It may be conceivable that for certain ages certain bands may be over or under-represented in the sample. However, given that the observations on height are spread out over a decade, this problem should be alleviated. As the Tetons were more numerous (at time of observation, 1891-1892) than any other division, and should have been included in the sample in greater numbers--an interpretation of these plots may not provide any straightforward results. (It is hoped that future research will enable the Boas sample to be disaggregated into the constituent Sioux bands represented within the sample, something that is not possible at the present time).

This said, we can now offer some speculative interpretations for the plots of adjusted mean heights by decade of birth for the Boas adult sample. It should be noted that certain trends are consistent between the two plots (male: Figure 27; Female: Figure 30). Both plots show relative low nodes or troughs for the decades 1820 and 1840.[10] This is followed on both plots by relative high

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[10] It seems that through some programming error Figure 30, the graph of male adjusted mean heights by decade of birth for the Boas sample, is distorting the relative decline in mean heights for the decade 1820. This should appear as a slight (2 mm) difference between the decades 1810 (Adjusted height=1720.9 mm) and 1820 (Adjusted height=1718.98) as shown in Figure 29, p. 131. No other

nodes for the decades 1830 and 1860. In light of the Sioux history presented in Chapter II, is there any way to interpret these consistent (if not statistically significant) trends? The only consistent interpretation for the low node of the 1820s might be the strife and disruption generated by the warfare with the Algonquian tribes in the Minnesota woodlands, as well as a possible maternal affect on child heights as a residual effect of previous epidemics (1818-1820 in particular) (Fogel, 1986; Steckel, 1987). A lack of ethnographic detail for this decade also hinders any clear assessment. The relatively higher mean heights seen for the decade 1830 could be interpreted as the establishment of significant numbers of Sioux in new territory (migration away from the Algonquians), where game was more plentiful. Even for those Sioux who remained in Minnesota, strife between the rival Algonquian tribes seemed to abate as these Eastern division Sioux gradually moved to southwestern Minnesota and northwestern Iowa. Although some scarcity of game was noted in several areas, this had yet to become a very widespread phenomenon. The 1840s saw widespread hunger for many Sioux, as well as the few reports of starvation we can glean from the ethnographic record. These reports mainly concern the Middle and Eastern division Sioux (the Yankton and Santee respectively), and coincide

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plot of adjusted mean heights by decade of birth for the adult Boas or Walker sample shows any other similar distortions.

with a severe and continuing scarcity of game in the areas east of the Missouri River. This scarcity of game, particularly buffalo, was also noted west of the Missouri; however, the Teton bands that occupied this territory may have had more opportunity to range further west (into Montana and Wyoming) in search of more adequate supplies of game. The discrepancy seen between the male and female plots for the decade of 1850 is somewhat puzzling. The plot for Boas adult males shows a level of mean heights that are essentially unchanged from the mean for the 1840s. This would seem to fit better with the circumstances facing the Santee and Yankton Sioux during the 1850s. With the depletion of game from their territories east of the Missouri, most of the constituent bands within these divisions were further faced with increasing pressure from White settlers. These pressures forced the Santee to be placed on reserves by a treaty signed in 1851, with the Yanktons similarly following this fate in 1858. Ethnographic reports for this period clearly note the severe disruption and destitution these moves caused these Sioux, as well as continuing instances of widespread hunger and want before this early reservation period.

The plots for Walker's sample of Oglala adults (Figures 21 and 24, p. 123 and 126, males and females respectively), also show a drop in mean adjusted heights for the decade of the 1850s. This trend would also reflect the general "input" of the Tetons within the Boas sample for 1850. This downward trend possibly reflects a time lag in the severe consequences of the buffalo depletion within the traditional Teton Oglala ranges in South and North Dakota and Nebraska. Seemingly then, there cannot be offered a ready explanation for the anomaly represented by the trend seen in the adult females of the Boas sample (Figure 30) for the increase of 2 cm between the low of 1840 and the higher mean for the 1850s.

Yet another trend within both adult series presents some difficulty in interpretation. Three plots--Boas adult males (Figure 27), Boas adult females (Figure 30), and Walker adult males (Figure 21)--all show high nodes for the decade of the 1860s. Yet as noted in the Sioux history provided above, this coincides with a period of intense warfare on the Northern Plains between the mainly Western or Teton Sioux and the U.S. Army. This would also correspond with the first initial decade on new reserves for both the Yankton (starting from 1859) and the Santee. These latter Sioux were transferred to Crow Creek in 1863 as a result of the Minnesota outbreak of 1862, and many Santee are known to have died during their confinement there. All available ethnographic reports suggest that conditions on these reserves during these early years were quite desperate and that the Indians appeared destitute for the most part. The only conceivable explanation for this trend may be that the

Tetons had finally established themselves in the far western reaches of their traditional hunting territory (the Big Horn and Powder River Country of Wyoming and Montana), where the buffalo could still be found in abundance. Possibly the trends depicted within the Boas height series for this decade reflects a greater relative influence from the Tetons within the sample.

Another common trend that can be seen for both Boas samples is a relative downturn for the decade of 1870, which would mark the beginning of the reservation period for at least one-third of the remaining Teton and Yanktonai Sioux with the signing of the Fort Laramie Treaty of 1868. This would be the occasion of severe dislocations and disruptions within the lives of these Sioux, and the beginning of their dependency upon the U.S. government for basic subsistence. This downward trend for 1870 also could have been contributed to by the unfinished growth of the 20 year olds within the Boas sample. This proposition was not explicitly tested given the equivocal results of an inspection of heights by age for the Boas sample (Appendix A, Figure A-1).

It should be noted that for both the male and female plots for mean adjusted heights by decade of birth the means do vary within circumscribed limits. A 2 cm band can cover the 6 of the 9 means for the Boas adult male sample (Figure 30), with 2 of the extreme means being easily explained as being caused by the low sample sizes for early birth cohorts (1790, n=1; 1800, n=2). The Boas female means by decade of birth for adjusted heights (Figure 30) can be described within a band of 2.34 cm that would cover the 5 means after the decade 1830 (5 of the 8 total means). The early means for the decades prior to 1830 may be unduly affected by low sample sizes, and clearly due to the smaller relative sample sizes, the means reported on seem to be more variable than those appearing in the Boas male sample.

The possible trends represented within the Walker sample of Oglala adults may not be as readily interpretable, even given the advantage of their homogeneous composition. What is unique about this sample is that although the males of this sample show both a demonstratable secular trend and a difference among means by decade of birth, the females show neither. This can be seen in Figure 24, which although the scale may be misleading, shows that the 5 adjusted height means by decade of birth since 1840 can be described by a band of less than 6 mm. Even including the outlier representing one individual at 1830, the entire series of female adult heights can be described by a band of 1.8 cm, a much tighter spread of means than could be seen in the Boas adult male sample despite the latter's higher number of individuals per decade.

By imagining a spline connecting the means for Walker's adult males (Figure 21) a few consistent trends can be observed between these two plots of adjusted height means by decade of birth (Figure 21 for Walker adult males and Figure 24 for Walker adult females).[11] Two broad parallel trends can be seen: a decline in mean heights for the 1850s and a "recovery" from these levels in the 1860s (for males) or the 1870s (for females). The decline seen in mean heights during the 1850s follows a common high node for the decade of 1840. While the total number of individuals represented within the decade of 1840 is quite small, these higher heights would generally correspond with predominantly favorable circumstances for the Oglala, at least during the early years of the decade. Seemingly, the scarcity of game noted by various ethnographic sources for this decade may not have yet become acute in the regions utilized by the Oglalas. They may have avoided shortages of game merely by further encroaching upon their Plains neighbors to the north and west.

The decline in heights seen for the 1850s may have a multiple cause. As noted by Hyde (1967) and others, this period saw a great influx of Whites traveling through Oglala territory, and along the Bozeman trail in particular. This has been cited by Taylor (1977) and others as the principal cause of the great epidemic of cholera seen for the years 1849 and 1850. Sporadic outbreaks of smallpox and measles

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[11] The regression line generated by SAS Graph (SAS Institute, Inc., 1985) in Figure 21 is done without regard for an intercept.

were also seemingly not uncommon for many years thereafter for this region along the Platte River. It is also conceivable that the scarcity of game and the disappearance of the buffalo from its former ranges was finally felt throughout most of the traditional range of the Oglalas and the Tetons during the 1850s. This would represent the common environmental deterioration that was first noted within the ranges of the Santee and Yanktons during the 1840s.

The "recovery" from these relatively low heights can clearly be seen for the decade of 1860 for the males in the Walker sample (Figure 21). From the height mean represented by the 1850s to the zenith represented by the 1860s, there is a difference of about 3.5 cm, a fairly substantial difference even given the possible sampling errors due to the relatively modest sample size for 1860 (n=65). As noted previously, this represents something of a paradox. One might expect that given the pressures of increasing White immigration, the depletion of game from former hunting lands, as well as continuing serious armed conflict with the U.S. Army (as well as sundry settlers), we might expect the sort of flat trend that is in fact exhibited by the Walker females (Figure 24). The present author cannot offer a satisfying "explanation" for this divergence. As noted above, it is conjectured that the recovery seen in the 1860s within the Oglala sample would indicate that these Sioux (along with presumably many other Teton bands) had largely abandoned their former territory and were now ranging far beyond the Black Hills to secure adequate supplies of buffalo and other game. This recovery would indicate that for the Oglala at least, this quest was fairly successful. However, other Teton bands would have been similarly situated to enable them to exploit this opportunity.

The high node seen for the decade of 1870 for Walker females (Figure 24) may also reflect this relative abundance within the sanctuary of the Big Horn and Powder River Country of Wyoming and Montana, as this could still represent a pre-reservation period (<1876) for many Oglala. However, the Oglala males are seen to decline slightly for this decade before leveling off (with only a small increase in heights) for the decade of 1880. Walker females show a decline for this latter period, but this may be hard to interpret given that the males show an essentially opposite trend.

Again, it should be mentioned that the above discussion is fairly speculative, and is meant to provide an impressionistic accounting, if at all possible, of the putative trends or patterning (statistically significant or not) within the time series represented by the adult heights within the two samples. It is recognized that such trends or patterning may be highly influenced by random variation, particularly for the age cohorts with small sample sizes. In this regard one can remain very skeptical about any non random trends that might be seen for Walker's sample of adult females, given the overall static nature of the trend in heights over time.

Disease and Sanitary Environment

If only vague generalizations can be provided to describe the disease and sanitary environment faced by the Sioux during the pre-reservation or very early reservation period, the conditions experienced for the last two decades of the 19th century can be reasonably well-documented. While it is true that the disease statistics tend to be highly variable, as are the estimates of mortality made by the agency physicians assigned to each reservation by the Indian Office (Allen 1975; Putney, 1980), a clear enough depiction of reservation life can be gleaned from the Annual Reports to the Commission of Indian Affairs (C.I.A.) so that certain conclusions can be drawn.

From a review of these reports by year from 1882-1892, it should be immediately apparent that the Sioux on the reservations would today be recognized as living in conditions that are quite similar to a "third world" (health) context. There are good reasons to suspect that the morbidity and mortality faced by these Indians was in excess of even the fearsome rates seen for contemporary urban slums in the U.S. Mortality and morbidity figures provided within these year-end summaries were compiled as monthly sanitary reports that were required to be filed with the Indian Office in Washington, D.C. From these figures for mortality by reservation, comparisons can be made with estimates made from the U.S. census on comparable mortality figures for Whites during the same period.

Consistent and "reasonable" figures for crude mortality (simply mortality per year as expressed per 1,000 individuals of a population) for all Sioux reservations range from the mid to high 30s to the mid to high 40s per 1,000 living population ($35^{+}/1000$-$45^{+}/1000$). The figures for some of the larger reservations would occasionally yield estimates of crude mortality rates slightly higher than these (low 50s per 1,000), with the Sisseton and Santee occasionally enjoying slightly lower rates (low 30s to high 20s per 1,000 individuals) for some years. Persistent problems of under-enumeration of deaths were obvious to even the agency physicians of the time, who noted that it was impossible to attempt to provide adequate medical care for a population that might be spread over 100 miles, as was (and still is) common on some of the larger reservations. Over counting of deaths might be seen in some instances where the death of a child or infant was not discovered for some time, and would be carried over to a following year. Problems could also be engendered by a physician leaving before his term expired, thus leaving the statistics to be sorted out by his successor.

While comparable mortality statistics for Whites within South Dakota are impossible to come by due to the fact that most states west of the Mississippi River did not achieve a system of death (or vital) registration until well after 1900 (Condran and Crimmins, 1979), certain general comparisons can be made. The Sioux clearly display an aggregate (total) mortality rate that is 1.5-2.5 times the most favorable comparisons with Whites possible for the year 1890; that with urban areas known to exhibit a higher mortality rate over rural areas (Condran and Crimmins, 1980). As all of the reservations were located in rural areas, a more reasonable comparison with similar rural areas in eastern death registration states would show that the mortality experienced by the Sioux may have approached a level of 3 times that of Whites in some instances (compare with the weighted average of 18.2 deaths per 1,000 for rural Whites in 1890) (Condran and Crimmins, 1980).

Infant mortality is also a very good indicator of a population's general health status (Martorell and Habicht, 1986). Very few agency physicians offered any sort of breakdown necessary for a comparison of specific death rates by age (the few who did generally partitioned deaths as under 5 years and over 5 years). However, in 1907 Dr. Walker (C.I.A., 1907: 18) provided estimates for the (Oglala) average annual infant mortality rate for 11 years (since 1896), as 236.1 per 1,000 for full blood Indians, and

145.4 per 1,000 for "mixed bloods." This would yield a weighted average of about 215.3 Indians per 1,000, which is elevated by similar amounts as seen above over comparable White figures for 1890 (rural weighted average: 154.2 deaths per 1,000), and 1900 (135.8 per 1,000) (Condran and Crimmins, 1980). However, it should be noted that for 1890, Condran and Crimmins (1980: 184) calculate a weighed average (to correct for under-registration) of 251.2 infant deaths per 1,000 for urban areas, which was seen to decline rapidly by 1900, but still was present as rates in excess of the 1890 average for rural areas (generally above 135.5 per 1,000 individuals). In all the above comparisons, infant deaths are those occurring under 1 year of age.

The static nature of the health and living standards for this Oglala population on the Pine Ridge reservation is also indicated by the relatively high mortality rate at 1916 of 37 aggregate deaths per 1,000 population, and a higher percentage of total deaths occurring to Oglala infants (a total of 27.2) for the period of 1910-1915 than was seen for any comparable White group at 1900 (Wissler, 1936; Condran and Crimmins, 1980).

While it appears foolhardy to the author to attempt to make sense of the highly variable disease rates seen in the yearly compilation of sanitary reports, certain trends are clearly evident from these statistics as well as the accompanying written statements submitted by the agency physicians within each annual report to the C.I.A. In one of the few comprehensive historical surveys of Indian health this author is aware of, Putney (1980) notes that tuberculosis was the largest single cause of death among the Indian population in the U.S. at the turn of the century (1897-1928). As reported by the agents and physicians of the Indian Service assigned to the Sioux, since 1882 consumption or scrofula (T.B.) was regularly cited as the greatest single cause of death--often responsible for upwards of 1/2 of all mortality in some years. Clearly then, this would strongly suggest that tuberculosis was endemic within the Sioux population for 15 years prior to 1897.

Again, while comparable historical infectious rates are hard to obtain, Hrdlicka (1908) reports on the incidence of pulmonary tuberculosis for the Oglala on Pine Ridge at 30.8 per 1,000 individuals, one of the highest rates that was reported on for any of the 91 Indian reservations or schools evaluated. In reporting on T.B. of all types, the Sioux of most reservations were shown to have elevated rates. The only comparable figures for Whites cite mortality statistics, which were not reported on directly by the Indian agents or physicians. Dr. Walker (1906) does cite statistics that would seem to indicate that the Oglala under his charge suffered deaths due to tuberculosis that would be in excess of ten times the mortality rate seen for comparable Whites (Condran and Crimmins, 1980): 24-13 per 1,000 for the Sioux versus 150-185 per 100,000 for Whites. However, it is unclear how long such a staggering mortality regime prevailed at Pine Ridge.

The most prevalent diseases (regardless of band affiliation) on the Sioux reservations during this time period can be gleaned directly from an examination of the summary sanitary reports for the years in question, and noting the most consistent and frequently appearing disease categories. Among the more consistently cited disease categories are: acute diarrhea, severe tonsillitis ("quinsy"), rheumatic fever ("acute rheumatism") [Streptococcal infection], tuberculosis, ascaris [and similar parasitic afflictions, slightly less common], conjunctivitis [possibly including trachoma], acute bronchitis [and probably other common respiratory infections under separate descriptive headings], various gastroenteric complaints, and skin disorders. Outbreaks of either smallpox, chicken pox, measles, mumps, whooping cough, or influenza were also seen almost every other year on many reservations.

The general hygiene and sanitary conditions that prevailed for all the Sioux reservations (again regardless of band affiliation) was also recognized by the agency physicians as clearly deplorable and promoting the spread of disease--particularly tuberculosis. In this regard it was frequently noted that the common one-room shacks that housed most of the Sioux were frequently very crowded, had poor or no ventilation, bedding that was rarely cleaned, and dirt floors upon which the expectorations of affected individuals would fall--promoting ready infection and reinfection from the long-lived bacilli. It can readily be imagined that such conditions would almost ensure the infection of any Indian confined, for even a short period of time, with a "consumptive" relative. This problem was further compounded by the poor realization on the part of the Indians (and not a few doctors) of the severely infectious nature of this organism, and the generally poor hygienic practices of most Indians. It was also generally recognized by several agency physicians that the confinement of the Sioux on reservations led to deteriorating hygienic and sanitary conditions, which were seen as a direct outgrowth of increased crowding and decreased group mobility as these Indians adopted a more sedentary lifestyle (Walker, 1906). These factors are also frequently cited by modern researchers when noting changing patterns of disease in acculturating groups (Garruto, 1981).

The Argument For and Against Nutritional Adequacy

Given the relative virulence of the disease and sanitary environment, how is it possible that the Walker Sioux adults as well as both samples of children seem to achieve consistently taller statures than comparable Whites (Tables 3 and 4)? That both sets of children show this consistent trend is important, given the relatively small sample sizes (by age) represented within the Boas data set. The reader may wonder about placing his faith in the Walker values given that absolute values are needed to make this comparison with Whites, and given the unresolved matter of a possible bias within this height series. In this regard, Table 8 can be offered towards a possible resolution of this issue. While the weights supplied in Table 8 do not represent a time series, when they are compared with the unadjusted heights (Walker's) for similar decades of birth, they seem to agree substantially as far as expected relative centiles of modern standards (using age 18 as a base line) are concerned (Tanner, 1978). This can be illustrated by noting that if the decade of 1880 can be taken as a proxy for age 18 (Table 8), and utilizing the relative centiles of modern growth represented for the two sexes for the height data in Table 3, one arrives at estimates of weight as a percentage of modern standards that is about 65-50% for both sexes, indicating substantial agreement of height for weight (Tanner, 1978: 180-181). (This considers some allowance for clothing.) This then gives us an independent source of data that agrees with the higher height means found within the Walker data set. This phenomenon is also noted in the child series examined by Wissler (1911), which

Table 8. Mean Weights in Pounds (lbs.) for Walker's Oglala Sioux Adults by Decade of Birth.

Decade	N	Male	STD	N	Female	STD
1830	5	151.0 (lbs)	19.13	2	139.5	2.12
1840	21	163.57	18.52	12	158.66	18.67
1850	54	168.40	20.54	33	160.48	32.32
1860	66	173.37	20.02	47	168.68	28.60
1870	53	166.39	19.61	55	158.23	32.86
1880	26	153.96	14.92	45	135.73	22.89

also shows that Walker's Oglalas were both taller and heavier than a sample of White children for comparable ages. This would indicate that the higher relative height means seen in the Walker Oglala sample may indeed be a true reflection of a higher populational mean height. It would seem unlikely that a consistent measurement bias could account for the substantial agreement in magnitude and direction that can be seen if the weights reported by Wissler (1911) are expressed as centiles of modern standards and compared with the trends seen for the children of the present Walker sample for percentiles of modern height (Table 3).[12]

It would thus seem more likely that the statistically significant differences that are seen between the Walker adult male sample and Boas' adult males for the height means by decade of birth (for 1860 and 1870) would be an effect of the secular trend in Walker's Oglala males. The statistically significant difference seen between the Walker and Boas child height means cannot be as easily interpreted, given the failure to demonstrate a different slope or tempo of growth for the Walker sample. As noted previously, a conservative interpretation of the findings of the analysis of the child height series cannot support a determination

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[12] The indirect approach to this comparison is made because no weight means were generated for the present analysis. The figures for weight by decade of birth (Table 8) were generated in a previous analysis using a SAS MEANS statement (SAS Institute, Inc., 1985).

for the occurrence of a secular trend for the 15-year interval between the dates of original observations (1892-1907).

Any explanation for both the positive secular trend seen in Walker's sample of Oglala Sioux males, as well as the relatively high levels of height attainment (expressed as centiles of modern standards, Table 3) for both samples of Sioux children should consider the historical circumstances of these Indians that can reveal broad aspects of the health and living standards experienced by these groups.

The positive secular trend in Walker's Oglala males appears to be derived in large part from a substantial increase in adjusted mean heights for the decade of 1860, and a sustained level of higher relative mean heights after this period (Figure 21). This shift seen for the 1860s is largely consistent with Hyde's (1967) accounting of Oglala history for this decade. Hyde (1967) notes that despite several military expeditions sent against these Teton Sioux, they were mainly unaffected, having withdrawn almost entirely into the mountainous Big Horn and Powder River country, the former territory of the Crow Indians. In general, it can be conjectured that the Teton Oglala would have been very favorably positioned at the far western range of the traditional Sioux territory. By simply shifting their territorial range ever westward, these Sioux were seemingly able to avoid much of the detrimental effects of the environmental deterioration represented by the retreating buffalo and game as well as the advancing line of White settlement from the east. The Oglala were able to accomplish this feat through the aggressive prowess they showed as warriors and their greater numbers (as members of the Teton band). The Oglala were additionally among the very last of the Sioux to be forced onto reserves (1874-1876), and made treaties (1868, 1876) with the government ensuring relatively favorable treatment for a considerable period of time after their "surrender."

Indeed, most of the Sioux represented by the 1868 and 1876 treaties represented "special cases" for the government. For the entire early reservation period studied herein, the Sioux tribe seem to have consistently represented the greatest single annual expenditure for any Indian group by the Indian Office. For the time period represented by the adults in the Boas sample for the 1870 decade of birth, most reservation Sioux (about 2/3 of the total population) would have received subsistence rations from the government. While the present author cannot cite figures for the level of this early support, it is probable that such provisions made a substantial impact, given that no statistically significant negative secular trend was seen in either adult height series (this despite the downward trends that can be noted on the plots of mean adjusted heights by decade of birth). That this type of trend cannot be demonstrated for any of the Sioux studied herein should be seen as fairly remarkable, given the drastic and quite sudden radical changes these Indians were forced to endure with their confinement to reservations. The socioeconomic changes these moves caused are fairly obvious: a radical shift to a more sedentary lifeway, attendant changes in activity patterns and subsistence organization, a new dependency status on the federal government--all would seemingly almost ensure some sort of significant, unequivocal growth response.

Such assertions for this early period of the 1870s may not be entirely appropriate for the Oglala, however. Hyde (1967) notes that the Oglala residing within the reservation (Red Cloud) area during the early 1870s (1871-1875) scarcely saw their agent or the agency except for the times when they would receive their weekly rations (as per the 1868 treaty). Thus, they would be free to come and go as they liked, with the only consideration binding them to the agency being the issuance of "free and liberal rations." Thus, it is interesting to note that the Walker sample birth cohorts for 1880, seemingly the only cohort of adults that would have faced the full impact of the forced acculturation on the reservation, also show no statistically significant negative secular trend. Indeed, Walker's males for this period display a slight increase in height (+43 mm) while Walker females show a very small decline (only about 5 mm).

This would seem to directly contradict the frequent assertions one can easily find of starvation, or semi-starvation for the Oglala and other Sioux during this period (Hyde, 1967: 229; Prucha, 1984: 656). Another problem in considering the nutritional status of the Sioux for this period is the issue of the graft and corruption that was seen in the supply system for the reservations (Phillips, 1972; Prucha, 1984). While such a multimillion dollar supply system would certainly have been subject to some frauds, it is unclear how (or if) these allegations would directly affect most Sioux. It should be remembered that such fraud would have had to operate consistently, year in and year out on a massive scale across all the Sioux reservations (especially the Teton agencies), in order to siphon off enough beef to make much of an impact (Table 2). Despite frequent allusions to an "Indian [fraud] ring," to my knowledge no researcher has seriously suggested frauds of such magnitude, although it must be conceded that some fraud did in fact occur. It also should be noted that these scandals peaked before the 1880s, and that the agent for Pine Ridge (V.T. McGillycuddy) from 1879-1885, though frequently investigated, was never found guilty or suspect of much more than general arrogance and irascibility (Hyde, 1967).

Here again the relatively higher percentiles of modern growth standards achieved in the Boas child sample (Table 3) can be offered as an independent source of measurement that would not indicate a chronic condition of poor nutrition for these Sioux children for this time period (1874-1885).

This noted, another more serious question needs to be addressed. How would it be possible that these Boas sample children (and Walker's children reporting on the period 1889-1901, in Table 3) escaped the consequences of the fairly virulent disease context described above? How would it be possible that Walker's adult males and females for the birth cohort of 1880 also seemingly remain unaffected by such environmental conditions that are known to have prevailed during this period? Is there some reason to suspect that Walker's Oglalas at Pine Ridge would have been "favored" over other Sioux groups so that the positive secular trend seen for the adult males, as well as their generally higher heights, could be "sustained" over this period of time? Here we can compare the statistically significant difference in means between Walker's 6-11 year olds (strictly speaking, reporting on conditions around 1896-1901), and Boas 6-11 year olds (1881-1886), which show the children from the Walker sample to be taller than the Boas children overall (Figure 35), although it is recognized that a bias may be affecting this result.

There are several factors which we can consider that could be responsible for this seemingly paradoxical result. Although it would be impossible to estimate the actual consumption trends seen for all the various Sioux reservations, it can be suggested that Pine Ridge (as well as Rosebud) may have fared consistently better as far as the gross availability of protein (beef) was concerned (Table 2, p. 62). This may have also been true for the other foodstuffs supplied as rations, but these cannot be followed as easily. However, it is known that for many years during the early reservation period the rations of flour were largely wasted because many Sioux had little idea of how to use it. It was also noted that the Sioux did not utilize their weekly or biweekly rations so that these rations would last for the entire time between issues, with much feasting noted on issue day, and fasting upon the approach of the next cycle. While caloric demand should not have approached the levels seen for groups requiring large caloric inputs for greater levels of physical activity, i.e. U.S. slaves (Steckel, 1986, 1987) or possibly even middle class Whites (Komlos, 1987), these particular Indians may very well have received enough beef to possibly sustain levels of meat consumption that are clearly in excess of the levels seen for these latter two groups, even given large allowances for waste, fraud, and other losses from the beef issue to the Sioux. This said, it should be recognized again that actual consumption of these supplies way have varied considerably and remains difficult to estimate. This can be seen by the large fluctuations of visiting Sioux that would occasionally visit with relatives in neighboring reservations (especially noted for the early reservation period), as well as other behavioral differences in consumption that could depart significantly from White expectations (feasting and other food sharing practices would be significant in this regard). Also significant is the documented and widespread use of offal among the Sioux, which the U.S. Army had estimated (in 1865) could constitute as much as 16-20% of an average steer's weight (U.S. Army, 1901).

It should also be recognized that the subsistence rations supplied to the Sioux did not represent their only source of food. This has been noted by Nurge (1970) as well as in several C.I.A. reports (1885, 1893). These reports indicate that gathered foodstuffs (timpsina) (C.I.A., 1893 [Rosebud]) still played an important role within the Sioux diet, as did seemingly the dog (C.I.A., 1893 [Pine Ridge]). Although the persistent use of dogs as food has been noted ethnographically for the Sioux (Hassrick, 1964; Seerley, 1965; Snyder, 1988), reports of reservation utilization of the large population of dogs that were reported on for some reservations (upwards of 30,000) (C.I.A., 1885 [Pine

Ridge]), are usually seen as an indication of the destitute situation faced by the Sioux on the reservations.

A direct and contemporary indication of the adequacy of the diet as supplied by the rations to school age Sioux children has been also noted by Putney (1980: 34-36). She reports that an assessment of the two rations schedules that were common on the reservations for this period (one ration schedule pre-dating 1898, and a newly implemented one) made by the Department of Agriculture's Office of Experiment Stations in 1899, showed that both diets seemingly not only provided all the nutrients the body needed, they did so in amounts which exceeded those found in the diet of "average" adult White males. She notes that "even considering waste, the Indian school ration was large" (Putney, 1980: 34). The department's report also noted that although simple and unvaried, this diet supplied more protein and energy than was "required" by the ordinary American mechanic. Putney (1980: 36-37) contends that in practice supplemental foodstuffs (vegetables, fruits, milk products, and eggs) besides the basic issue (see Table 1 for listing) were also often neglected in some schools. However, this should not have been the case for the Pine Ridge schools, which represented the only truly successful farming efforts seen on this reservation, supplying an abundance of fruit, vegetables, and other crops from the mid-late 1880s on.

Seemingly then, the subsistence rations supplied to the Sioux as required by treaty (1877) or practice (from the 1868 treaty) were possibly responsible for the amelioration of some of the negative consequences in the health and living standards that were seen as a result of the placement of these Indians upon permanent reservations. The relative abundance (or availability) of protein in the Sioux diet is particularly important in this regard (Fogel, 1986; Komlos, 1987). How this level of support was first arrived at is unknown (1 1/2 lbs. of net beef per day for each individual), but may be derived from ethnographic or historic estimates of the daily utilization of buffalo meat by the Sioux. Frequent mention of the "carnivorous nature" of the Sioux can often be seen in the annual C.I.A. reports. It is also clearly apparent that many of the Indian agents disagreed strongly with issuance of rations that were not dependent upon any work performed (at least for the Teton), and at levels that some declared as extravagant. Many agents were no doubt cognizant of the fact that poor Whites fared far worse in poor farms and on county relief (c.f. Katz, 1986). Other researchers (Priest, 1942; Prucha, 1984) have noted that Congress was loath to reduce this level of support (despite frequent encouragements to do so) for fear of abrogating the treaty stipulations of 1877, possibly bringing about a new and much more costly state of war with the Sioux. The pervasive fear of an Indian outbreak would still occupy the U.S. Army until the turn of the century (Wooster, 1985), at which time the first widespread reductions of treaty mandated rations were implemented (C.I.A., 1901-02; Prucha, 1984). It is significant that in one of the first surveys of Indian health that was carried out soon after these reductions of 1901-1902, Hrdlicka (1908, 1909) noted widespread hunger and want among the adults and elderly at Pine Ridge, indicating that many Oglala were unready to assume a role of self-support.

Critique and Alternative Explanations for Trends Seen

It should be readily apparent that the Sioux represented a relatively tall population when compared to contemporary Whites living during the 19th century. As children they would have exceeded in height most populations of White children for almost every given age. As suggested by Van Wieringen (1986: 320), the negative influences of poor living conditions may inhibit the growth of groups of short stature more than those of tall stature. This would also suggest some sort of genetic maintenance of tall stature for the Sioux (Tanner, 1981) as being responsible for the trends seen above.

My argument for higher relative levels of net nutrition for the Sioux (particularly Walker's sample of Oglala) should have also (ideally) engendered a concomitant reduction in morbidity and/or mortality rates (Fogel, 1986), yet this cannot be readily demonstrated. This may be due to the short time period examined, and is certainly made all the more difficult to evaluate given the very variable nature of the crude mortality rates (which could vary as much as 50% for successive years on any one reservation). It is therefore possible, but not very likely, that my estimates of crude mortality may be overstating the mortality on some individual reservations for a given year. However, in general the clear trend represented by the mortality statistics is the sustained higher relative rates seen for the Sioux over that of Whites, especially for aggregate mortality rates. Wissler (1936) also shows us that any improvement in crude mortality for the interim years up to 1916 would have been slight or nonexistent. What is also somewhat disturbing about the morbidity rates are a greater inclusion of infections and disease states that are known to be nutritionally sensitive (tuberculosis and respiratory infections in particular) (Fogel, 1986; Martorell, 1980). It could be that the virulent disease and hygienic contexts would have extracted an even higher mortality toll than was seen, had not the Sioux been liberally supplied with government rations. It is significant to note in this regard that earlier American White populations (1850-1860) facing a similarly elevated mortality schedule, also showed equivocal results in reduced mortality with rising living standards (Steckel, 1988b). Steckel posits fertility rate, or the number of young siblings as being particularly important for the survival of infants and children. As this would be a reflection of crowding conditions, it can readily be seen why the Sioux might have continued to exhibit higher mortality rates, even given putative higher levels of net nutrition. The small cabins in which they lived were frequently cited as being very crowded and dirty. They would probably represent a toxic environment no amount of excess supplementation could compensate for. It is also significant to note the high fertility rate that did indeed prevail on most Sioux reservations.

However, it can also be noted that Fogel et al. (1983) report on the occurrence of higher differential mean heights between a cohort of native born Southern White males over the heights exhibited by New Englanders for the late 18th-early 19th century. They explained this difference, even given the higher mortality rates seen for these Southerners (50-25/1000), by positing superior levels of nutritional circumstances that operated to counteract the relatively more virulent disease environment and hence close the mortality gradient between the North and South. They also noted that part of the height advantage seen for the South may have been derived in part from the culling effects of differential mortality. This certainly could be possible for the Sioux, but this would remain difficult (if not impossible) to test for.

Another possibility can be suggested for an explanation for the finding of a lack of any statistically significant trends for 3 out of 4 samples of adults (Boas' males and females, and Walker's females), as well as between the 2 child samples. Prazuck, et al. (1988) present a series of heights from rural Mali (Africa) from different observations taken since 1885 up to 1985. They could not document any occurrence of a secular trend in their population over this span of 100 years. They present an "etiologic hypothesis" to explain this lack of any statistically significant trend, noting the high prevalence of infectious disease and poor sanitation. Significantly, their population is a naturally tall one, and in 1885 would also have exceeded most Europeans for height (Floud, 1984).

Another factor that may be affecting the results is increasing admixture over time within my two Sioux samples. This was not controlled for in this study, as reliable estimates for admixture within the Boas sample are currently unavailable (although the clear majority are probably "pure bloods"). In a previous analysis, estimates of admixture within the Walker sample did show increasing admixture over time. This phenomenon may represent a second secular trend within the sample, but should not be contributing to the positive secular trend in height seen in Walker adult males.

This can be seen in Figure 21, where increasing admixture after 1860, would if anything, be slightly depressing the general positive secular trend in heights seen in this sample. This also largely agrees with Wissler's finding (1911) that Sioux "mixed blood" children were consistently shorter than full-blood children.

Finally, it should be noted that a lack of a secular trend may also reinforce the author's argument for the maintenance of the Sioux at the levels of heights they would have enjoyed in an otherwise pre-reservation state. In this regard it can be noted that relatively constant growth curves can be seen for France between ca. 1820 and ca. 1900, and for Belgium between ca. 1830 and ca. 1900 (Floud, 1984), which would indicate the experience of broadly similar living standards operating within each population over this relatively long period.

CHAPTER V

SUMMARY

This thesis has attempted to explore the possibility of the occurrence of secular trends in height in an historic population of Sioux American Indians. Two different data sets were utilized in this regard: a composite Sioux data set generated by Franz Boas and co-workers for the World's Columbian Exposition during the years 1891-1892; and a data set derived from the measurements taken on Oglala (Teton) Sioux by Dr. James R. Walker during the years 1905-1907, while he was agency physician on the Pine Ridge (S.D.) reservation. These samples are a subset of the Boas North American Indian anthropometric data set now being curated at The University of Tennessee, Knoxville. The samples utilized in this thesis are thought to represent the largest historical American Indian data set yet examined for secular trends. The Sioux were chosen for this study because they represent one of the best documented historical American Indian group, given their storied conflicts with the U.S. Army on the Great Plains during the mid-late 19th century. Such detailed historical documentation is both useful and necessary for a reasonable interpretation of any secular trends seen.

A working hypothesis was constructed about the possible direction or shape of a secular trend in 19th century Sioux that posited a negative secular trend over time. That is, with the probable stress engendered by reservation life (worsening living conditions, inadequate nutritional levels, and other dramatic social changes), one would expect those individuals born during or after the reservation period to exhibit shorter statures when compared to adults born earlier in the 19th century. These shorter statures, if seen in the younger Sioux, would be a reflection of a reduced nutritional status (the balance between nutrient intake and claims on that intake), as a result of the deterioration of living standards seen on the Indian reservations (from about 1876 on for the Teton Sioux).

In a test for a basic linear secular trend over the time period 1820-1880, a cross sectional design was used, with the two samples (Boas' and Walker's) analyzed separately by sex. To correct for aging over time due to shrinkage resulting from the compression of intervertebral disks, regression coefficients are derived from subischial length in order to estimate yearly expected statural loss. These coefficients are then used to adjust stature for loss due to aging, and their adjusted stature is assessed for secular trend using a regression on age. Only one adult sample of the four adult height samples showed a statistically significant secular trend ($p<0.05$), this being a positive trend seen for Walker's Oglala males.

In a test for heterogeneity between adjusted height means by decade of birth over this same time span, an ANOVA test of significance is utilized to again show that Walker's adult males display statistically different height means among decades of birth, reinforcing the finding for a secular trend. A plot showing this upwards shift, centered on the birth cohort for the decade of 1860, can readily be interpreted in light of what is known about Teton Sioux history.

A comparison with a contemporary 19th century series of heights for native born adult White males shows that the adult male Sioux of both the Boas and Walker samples display higher mean heights (unadjusted and adjusted) after the decade of 1850.

In the analysis of child heights meant to examine the period between the original dates of observation (1892-1907) for secular trend, pooled sexes are used to examine a combined sample of 6-11 year olds using two regressions. The regression for a test of equivalent slopes between the two child samples could not reject the null hypothesis, indicating that the spread of height means could best be described by one slope and a similar growth tempo. A least squared means test for different means showed that the means between these two samples of children are significantly different, with Walker's sample of children being taller than the Boas sample of 6-11 year olds. This was not seen as a strong endorsement for a secular trend, however, given that no different growth pattern could be discerned. It would indicate, however, that Walker's Sioux consistently display higher height means than are seen for the Boas sample.

A comparison of both the Walker and Boas sample sub-adults ($\leq$18) with contemporary 19th century Whites shows that these Sioux children consistently grew taller than most White groups for almost every age. Although the sample sizes for these comparisons range from small to modest, these findings appear very consistent and would also agree with the adult height series in this regard.

Thus, we can tentatively reject our working hypothesis and the persistent reports of widespread hunger or chronic under-nutrition, in that Sioux children continued to grow at very favorable rates (by any standard), well into the reservation period. It may have been possible for some Sioux (particularly the Oglala) to achieve levels of net nutrition that actually exceeded White standards in some regards. The Oglala may have been able to sustain these higher levels for the beef they were issued as part of the treaty obligations of the U.S. Government from the treaty of 1876.

That the Sioux children do not seem to exhibit any noticeable growth stunting is also remarkable, given the increased virulence of the disease context they were brought up into. This would also reinforce the impression from the adult series, noting no negative secular trend despite the drastic economic changes these Indians endured.

BIBLIOGRAPHY

BIBLIOGRAPHY

Allen, V. R.
1975 Agency physicians to the Southern Plains Indians, 1868-1900. Bulletin of the History of Medicine, 49: 318-331.

Anderson, J. A. and Hamilton, H. W. and J. H. Hamilton
1971 The Sioux of the Rosebud. Norman: University of Oklahoma.

Bad Heart Bull, A.
1967 A pictographic history of the Oglala Sioux. Lincoln: University of Nebraska Press.

Balazs, R., Jordan, T., Lewis, P. D., and Patel, A. J.
1986 Undernutrition and brain development: In Human growth, a comprehensive treatise, Volume 3, Second edition, F. Falkner and J. M. Tanner, eds. New York: Plenum Press.

Bielicki, T.
1986 Physical growth as a measure of the economic well-being of populations: The twentieth century: In Human growth, a comprehensive treatise, Volume 3, Second edition, F. Falkner and J. M. Tanner, eds. New York: Plenum Press.

Boas, F.
1894 The anthropology of the North American Indian: Memoirs of the International Congress of Anthropology: In The Shaping of American Anthropology, 1883-1911, G. W. Stocking, ed. New York: Basic Books.

Boas, F.
1898 The growth of Toronto children: In Annual Report of the Commission of Education for 1896-97. Washington: U.S. G.P.O.

Bogin, B.
1988 Patterns of human growth. Cambridge: Cambridge University Press.

Bowler, M. J.
1944 The Sioux Indians and the United States Government, 1862-1878. St. Louis: Washington University.

Carmichael, A. G.
1983 Infection, Hidden Hunger, and History: In Hunger and History, R. I. Rotberg and T. K. Rabb, eds. Cambridge: MIT.

Chen, C. and Scrimshaw, N. S., eds.
1983 Diarrhea and malnutrition. Interactions, mechanisms, and interventions. New York: Plenum Press.

Commissioner of Indian Affairs
1870-1910 Annual Report of the Commissioner of Indian Affairs to the Secretary of the Interior, 1870-1910. Washington: U.S. G.P.O.

Condran, G. A. and Crimmins, E.
1979 A description and evaluation of mortality data in the federal census: 1850-1900. Historical Methods, 12: 1-23.

Condran, G. A. and Crimmins, E.
1980 Mortality differentials between rural and urban areas of states in the northeastern United States 1890-1900. Journal of Historical Geography, 6: 179-202.

Cunningham-Rundles, S.
1984 Nutritional factors in immune response: In Malnutrition: Determinants and consequences, P. L. White and N. Selvey, eds. New York: Alan R. Liss, Inc.

DeMallie, R. J.
1984 The sixth grandfather. Lincoln: University of Nebraska Press.

Eveleth, P. B.
1986 Population differences in growth: environmental and genetic factors: In Human growth, a comprehensive treatise, Volume 3, Second edition, F. Falkner and J. M. Tanner, eds. New York, Plenum Press.

Eveleth, P. B. and Tanner, J. M.
1976 Worldwide variation in human growth. Cambridge: Cambridge University Press.

Feraca, S. E. and Howard, J. H.
1963 The identity and demography of the Dakota or Sioux tribes. Plains Anthropologist, 8: 80-84.

Floud, R.
1984 The heights of Europeans since 1750: A new source for European economic history. National Bureau of Economic Research Working Paper Series, 1318.

Fogel, R. W.
1986 Nutrition and the decline in mortality since 1700: Some additional preliminary findings. National Bureau of Economic Research Working Paper Series, 1802.

Fogel, R. W., Engerman, S. L., and Trussell, J.
1982 Exploring the uses of data on height: The analysis of long-term trends in nutrition, labor, welfare, and labor productivity. Social Science History, 6: 401-421.

Fogel, R. W., Engerman, S. L., Floud, R., et al.
1983 Secular changes in American and British stature and nutrition. Journal of Interdisciplinary History. 14: 445-481.

Frisancho, A. R.
1978 Nutritional influences on human growth and maturation. Yearbook of Physical Anthropology, 21: 174-191.

Garn, S. M. and Clark, D. C.
1975 Nutrition, growth, development, and maturation: Findings from the ten-state nutrition survey of 1968-1970. Pediatrics, 56: 300-319.

Garn, S. M. and Bailey, S. M.
1978 Genetics of the maturational processes: In Human growth, Volume 1, F. Falkner and J. M. Tanner, eds. New York: Plenum Press.

Garruto, R. M.
1981 Disease patterns of isolated groups: In Biocultural aspects of disease, H. Rothschild, ed. New York: Academic Press.

Gerlach, L. K.
1970 The Sioux Indians of western South Dakota: 1891-1905. University of Denver, Masters Thesis, unpublished.

Gilmore, M. R.
1919 Uses of plants by the Indians of the Missouri River region. Annual Report to the Bureau of American Ethnology, 33: 43-154.

Greene, L. S.
1980 Conclusions: In Social and biological predictors of nutritional status, physical growth, and neurological development, L. S. Greene and F. E. Johnston, eds. New York: Academic Press.

Greene, L. S. and Johnston, F. E., eds.
1980 Social and biological predictors of nutritional status, physical growth, and neurological development. New York: Academic Press.

Hagen, E. E. and Shaw, L. C.
1960 The Sioux on the reservations: The American colonial problem. Cambridge: MIT, unpublished.

Hassrick, R. B.
1964 The Sioux: Life and customs of a warrior society. Norman: University of Oklahoma Press.

Hickerson, H.
1974 Sioux Indians, I: Mdewakanton Band of Sioux Indians. New York: Garland Publishing.

Higginbotham, N. A.
1981 The Wind-Roan winter count. Plains Anthropology, 26: 1-42.

Higgs, R.
1973 Mortality in rural America, 1870-1920: estimates and conjectures. Explorations in Economic History, 10: 177-195.

Himes, J. H. and Mueller, W. H.
1977 Aging and secular change in adult stature in rural Colombia. American Journal of Physical Anthropology, 46: 275-280.

Holder, P.
1970 The hoe and the horse on the Plains: A study of cultural development among North American Indians. Lincoln: University of Nebraska Press.

Hoover, H. T.
1983 Arikara, Sioux, and government farmers: Three American Indian agricultural legacies. South Dakota History, 13: 22-48.

Howard, J. H.
1966 The Dakota or Sioux Indians: A study in human ecology. Vermillion: University of South Dakota.

Howard, J. H.
1972 Notes on the ethnogeography of the Yankton Dakota. Plains Anthropologist, 17: 281-307.

Howard, J. H.
1976 Yanktonai ethnohistory and the John K. Bear winter count. Plains Anthropologist, 21: part 2, 1-45.

Howe, G. M.
1972 Man, environment and disease in Britain. New York: Barnes and Noble.

Hrdlicka, A.
1908 Physiological and medical observations. Smithsonian Institution, Bureau of American Ethnology, 34: 172-219.

Hrdlicka, A.
1909 Tuberculosis among certain Indian tribes of the United States. Smithsonian Institution, Bureau of American Ethnology, 42: 1-48.

Hurt, W. R.
1974 Dakota Sioux Indians. New York: Garland Publishers.

Hyde, G. E.
1956 A Sioux chronicle. Norman: University of Oklahoma Press.

Hyde, G. E.
1967 Red Cloud's folk. Norman: University of Oklahoma Press.

Jantz, R. L. and Key, P. J.
1987 Preservation of Boas' North American anthropometric data. Proposal to National Science Foundation.

Johnston, Sr. M. A.
1948 Federal relations with the great Sioux Indians of South Dakota, 1887-1933. Washington: Catholic University of America Press.

Katz, M. B.
1986 In the shadow of the poorhouse: A social history of welfare in America. New York: Basic Books.

Kielmann, A. A., DeSweemer, C., Chjernichovsky, D., et al.
1983 Child and maternal health services in rural India: The Narangwal experiment. Vol. 1: Integrated nutrition and health. Baltimore: Johns Hopkins Press.

Komlos, J.
1987 The height and weight of West Point cadets: Dietary change in antebellum America. Journal of Economic History, 47: 897-927.

Macgregor, G.
1946 Warriors without weapons: A study of the society and personality development of the Pine Ridge Sioux. Chicago: University of Chicago Press.

Malina, R. M.
1979 Secular changes in size and maturity: Causes and effects. Monograph. Society for Research in Child Development, 44: 59-192.

Malina, R. M.
1987 Nutrition and growth: In Nutritional anthropology, F. E. Johnston, ed. New York: Alan R. Liss, Inc.

Margo, R. A. and Steckel, R. H.
1983 Heights of native-born whites during the antebellum period. Journal of Economic History, 43: 167-174.

Marken, J. W. and Hoover, H. T.
1980 Bibliography of the Sioux. Metuchen: Scarecrow Press.

Martorell, R.
1980 Interrelationships between diet, infectious disease and nutritional status: In Social and biological predictors of nutritional status, physical growth and neurological development, L. S. Greene and F. E. Johnston, eds. New York: Academic Press.

Martorell, R. and Habicht, J. P.
1986 Growth in early childhood in developing countries: In Human growth, a comprehensive treatise, Volume 3, Second edition, F. Falkner and J. M. Tanner, eds. New York: Plenum Press.

Masse, G. and Hunt, E. E. Jr.
1963 Skeletal maturation in the hand and wrist of West African children. Human Biology, 35: 3-25.

Maynard, E. and Twiss, G.
1969 That these people may live. Pine Ridge Reservation: U.S. Public Health Service.

McMahon, S. F.
1981 Provisions laid up for the family. Historical Methods, 14: 4-21.

Mooney, J.
1892-93 The ghost dance religion and the Sioux outbreak of 1890. Annual Report to the Bureau of American Ethnology, 14: 641-1136.

Nurge, E.
1970 Dakota diet: Traditional and contemporary: In the modern Sioux, E. Nurge, ed. Lincoln: University of Nebraska Press.

Olson, J. C.
1965 Red Cloud and the Sioux problem. Lincoln: University of Nebraska Press.

Phillips, G. H.
1972 The Indian ring in Dakota Territory, 1870-1890. South Dakota History, 2: 345-376.

Powers, W. K.
1977 Oglala religion. Lincoln: University of Nebraska Press.

Prazuck, T., Fisch, A., Pichard, E., and Sidibe, Y.
1988 Lack of secular change in male adult stature in rural Mali (West Africa). American Journal of Physical Anthropology, 75: 471-476.

Priest, L. B.
1942 Uncle Sam's stepchildren: The reformation of United States Indian policy, 1865-1887. New Brunswick: Rutgers University Press.

Prucha, F. P.
1984 The great father: The United States government and the American Indians, Vol. I and II. Lincoln: University of Nebraska Press.

Putney, D. T.
1980 Fighting the scourge: American Indian morbidity and federal policy, 1897-1928. Marquette University, Doctoral Dissertation, University Microfilms International.

Relethford, J. H. and Lees, F. C.
1981 The effects of aging and secular trend on adult stature in rural western Ireland. American Journal of Physical Anthropology, 55: 81-88.

Rotberg, R. I., Rabb, T. K. and the Conferees of the Bellagio conference
1983 The relationship of nutrition, disease and social conditions: A graphical presentation: In Hunger and history, R. I. Rotberg and T. K. Rabb, eds. Cambridge: Cambridge University Press.

Sandberg, L. G. and Steckel, R. H.
1987 Heights and economic history: The Swedish case. Annals of Human Biology, 14: 101-110.

SAS Institute, Inc.
1985 SAS user's guide. 1985 Edition. Cary, N.C.: SAS Institute, Inc.

Satterlee, J. L. and Malan, V. D.
1968 History and acculturation of the Dakota Indians. Brookings: South Dakota State University.

Schell, H. S.
1975 History of South Dakota, Third edition. Lincoln: University of Nebraska Press.

Schell, L. M. and Johnston, F. E.
N.D. (1978?) Physical growth and development of American Indian and Eskimo children and youth: In Handbook of North American Indians. In press.

Schmeckebier, L. F.
1927 The Office of Indian Affairs: Its history, activities and organization. Baltimore: Johns Hopkins University Press.

Scrimshaw, N. S.
1983 The value of contemporary food and nutrition studies for historians: In Hunger and History, R. I. Rotberg and T. K. Rabb, eds. Cambridge: MIT.

Scrimshaw, N. S. and Young, V. R.
1976 The requirements of human nutrition: In Human nutrition: Readings from Scientific American. San Francisco: W. H. Freeman and Company.

Seerley, N. R.
1965 A social system analysis of the changing food practices of the Teton Dakota Indians, 1800-1900. South Dakota State University, Masters Thesis, unpublished.

Ship, I. I.
1964 Relationships of dental caries, tooth eruption and growth: Based on a study of dicalcium phosphate dietary supplementation in an American Indian boarding school population. University of Pennsylvania, Masters Thesis, unpublished.

Snyder, L. M.
1988 Barking mutton: Ethnohistoric archaeology and nutritional evidence pertaining to the domestic dog as a Native American food resource on the plains. Abstracts from 46th Annual Plains Conference.

Standing Bear, L.
1928 My people, the Sioux. Boston: Houghton Mifflin.

Steckel, R. H.
1986 A peculiar population: The nutrition, health and mortality of American slaves from childhood to maturity. Journal of Economic History, 46: 721-741.

Steckel, R. H.
1987 Growth depression and recovery: The remarkable case of American slaves. Annals of Human Biology, 14: 101-132.

Steckel, R. H.
1988a Heights and health in the United States, 1710-1950. Presentation at the Fifth International Auxology Congress, Exeter, July.

Steckel, R. H.
1988b The health and mortality of women and children, 1850-1860. Journal of Economic History, 48: 333-345.

Sullivan, R.
1920 Anthropometry of the Siouan Tribes. Anthropological Papers of the American Museum of Natural History, 23: Pt. 3, 93-101.

Susanne, C.
1980 Aging, continuous changes of adulthood: In Human physical growth and maturation: Methodologies and factors, F. E. Johnston, A. F. Roche and C. Susanne, eds. New York: Plenum Press.

Tanner, J. M.
1966 The secular trend towards earlier physical maturation. T. Soc. Geneesk, 44: 524-538.

Tanner, J. M.
1978 Fetus into man: Physical growth from conception to maturity. Cambridge: Harvard University Press.

Tanner, J. M.
1981 A history of the study of human growth. Cambridge: Cambridge University Press.

Tanner, J. M.
1982 The potential of auxological data for monitoring economic and social well being. Social Science History, 6: 571-581.

Tanner, J. M.
1986 Use and abuse of growth standards: In Human growth, a comprehensive treatise, Volume 3, Second edition, F. Falkner and J. M. Tanner, eds. New York: Plenum Press.

Tanner, J. M.
1988 Human growth and constitution: In Human biology: An introduction to human evolution, variation, growth, and adaptability, Third edition, G. A. Harrison, J. M. Tanner, et al. eds. Oxford: Oxford University Press.

Taylor, J. F.
1977 Sociocultural effects of epidemics on the northern plains: 1734-1850. Western Canadian Journal of Anthropology, 7: 55-81.

Taylor, C. E.
1983 Synergy among mass infections, famines, and poverty: In Hunger and history, R. I. Rotberg and T. K. Rabb, eds. Cambridge: MIT.

Textor, L. E.
1896 Official relations between the United States and the Sioux Indians. Palo Alto: Stanford University Publications.

U.S. Army--The Secretary of War
1901 How to feed an army. Washington: G.P.O.

U.S. Public Health Service
1959 Indians on federal reservations in the United States: A digest. Washington: U.S. Dept. of HEW.

Utley, R. M.
1963 The last days of the Sioux Nation. New Haven: Yale University Press.

Van Wieringen, J. C.
1986 Secular growth changes: In Human growth, a comprehensive treatise, Volume 3, Second edition, F. Falkner and J. M. Tanner, eds. New York: Plenum Press.

Walker, J. R.
1906 Tuberculosis among the Oglala Sioux Indians. American Journal of the Medical Sciences, 132: 600-605.

Walker, J. R.
1980 Lakota belief and ritual, R. J. DeMallie and E. A. Jahner, eds. Lincoln: University of Nebraska Press.

Walker, J. R.
1982 Lakota society, R. J. DeMallie, ed. Lincoln: University of Nebraska Press.

Walker, J. R.
1983 Lakota myth, E. A. Jahner, ed. Lincoln: University of Nebraska Press.

Warren, R. E.
1986 Ice glider faunal remains and Yanktonai ethnohistory: In Papers in northern Plains prehistory and ethnohistory, W. R. Wood, ed. South Dakota Archeological Society, No. 10.

Wedel, W. R.
1940 Culture sequence in the central Great Plains, Smithsonian Miscellaneous Collection, Volume 100: Essays in Historical Anthropology of North America: In Plain Anthropology, 17: 291-353.

Wedel, W. R.
1986 Central Plains prehistory: Holocene environments and culture change in the Republican River Basin. Lincoln: University of Nebraska Press.

Weist, K. M. and Sharrock, S. R.
1985 An annotated bibliography of Northern Plains ethnohistory. Missoula: University of Montana.

Winich, M. and Brasel, J. A.
1980 Nutrition and cell growth: In Modern nutrition in health and disease, R. S. Goodhart and M. E. Shils, eds. Philadelphia: Lea and Febiger.

Wissler, C.
1911 Measurements of Dakota Indian children. Annals of the New York Academy of Science, 20: 355-364.

Wissler, C.
1936 Distribution of deaths among American Indians. Human Biology, 8: 223-231.

Wood, W. R., ed.
1986 Papers in northern plains prehistory and ethnohistory. South Dakota Archaeological Society, 10.

Wood, W. R. and Liberty, M.
1980 Anthropology on the Great Plains. Lincoln: University of Nebraska Press.

Woolworth, A. R. and Champe, J. L.
1974 Sioux Indians III: Ethnohistorical report on the Yankton Sioux and Yankton chronology. New York: Garland.

Wooster, R. A.
1985 The military and United States Indian policy 1865-1903. Austin: The University of Texas. Phd. Dissertation. University Microfilms.

APPENDIX

Figure A-1 Boas sample complete listing of height means by age and sex.

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM VALUE	MAXIMUM VALUE
---------- AGE=4 SEX=F ----------						
STDHT	1	965.00000000	.	.	965.00000000	965.00000000
---------- AGE=4 SEX=M ----------						
STDHT	1	1029.00000000	.	.	1029.00000000	1029.00000000
---------- AGE=5 SEX=F ----------						
STDHT	1	1100.00000000	.	.	1100.00000000	1100.00000000
---------- AGE=6 SEX=F ----------						
STDHT	3	1217.00000000	24.06241883	579.00000000	1192.00000000	1240.00000000
---------- AGE=6 SEX=M ----------						
STDHT	3	1118.33333333	22.03028219	485.33333333	1097.00000000	1141.00000000
---------- AGE=7 SEX=F ----------						
STDHT	5	1226.40000000	38.73370625	1500.30000000	1187.00000000	1286.00000000
---------- AGE=7 SEX=M ----------						
STDHT	6	1188.50000000	52.18716317	2723.50000000	1096.00000000	1237.00000000
---------- AGE=8 SEX=F ----------						
STDHT	5	1209.80000000	44.66766168	1995.20000000	1140.00000000	1251.00000000
---------- AGE=8 SEX=M ----------						
STDHT	5	1261.80000000	41.18494871	1696.20000000	1193.00000000	1292.00000000
---------- AGE=9 SEX=F ----------						
STDHT	4	1285.25000000	32.62284476	1064.25000000	1257.00000000	1323.00000000
---------- AGE=9 SEX=M ----------						
STDHT	9	1333.33333333	31.75688902	1008.50000000	1295.00000000	1376.00000000
---------- AGE=10 SEX=F ----------						
STDHT	11	1329.00000000	46.00217386	2116.20000000	1245.00000000	1387.00000000
---------- AGE=10 SEX=M ----------						
STDHT	13	1327.30769231	45.98982608	2115.06410256	1253.00000000	1388.00000000
---------- AGE=11 SEX=F ----------						
STDHT	2	1374.50000000	70.00357134	4900.50000000	1325.00000000	1424.00000000

Figure A-1 (Continued)

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM VALUE	MAXIMUM VALUE
AGE=11 SEX=M						
STDHT	12	1397.83333333	47.90279099	2294.51515152	1301.00000000	1468.00000000
AGE=12 SEX=F						
STDHT	15	1440.53333333	38.04295817	1447.26666667	1389.00000000	1510.00000000
AGE=12 SEX=M						
STDHT	11	1487.63636364	48.58245100	2360.25454545	1415.00000000	1598.00000000
AGE=13 SEX=F						
STDHT	13	1493.61538462	49.56063367	2456.25641026	1392.00000000	1565.00000000
AGE=13 SEX=M						
STDHT	11	1498.63636364	74.67298404	5576.05454545	1332.00000000	1600.00000000
AGE=14 SEX=F						
STDHT	16	1560.43750000	54.63572549	2985.06250000	1392.00000000	1623.00000000
AGE=14 SEX=M						
STDHT	13	1544.76923077	45.60030530	2079.35897436	1445.00000000	1645.00000000
AGE=15 SEX=F						
STDHT	7	1581.71428571	48.04759549	2308.57142857	1505.00000000	1635.00000000
AGE=15 SEX=M						
STDHT	15	1610.06666667	34.65022504	1200.63809524	1540.00000000	1652.00000000
AGE=16 SEX=F						
STDHT	10	1592.70000000	24.83187915	616.67777778	1547.00000000	1625.00000000
AGE=16 SEX=M						
STDHT	20	1655.85000000	57.32481322	3286.13421053	1560.00000000	1796.00000000
AGE=17 SEX=M						
STDHT	22	1664.72727273	39.59579321	1567.82683983	1598.00000000	1750.00000000
AGE=18 SEX=F						
STDHT	17	1570 00000000	59 20409614	3505 12500000	1412 00000000	1656 00000000
AGE=18 SEX=M						
STDHT	23	1694.13043478	38.01591096	1445.20948617	1616.00000000	1768.00000000

Figure A-1 (Continued)

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM VALUE	MAXIMUM VALUE
AGE=19 SEX=F						
STDHT	17	1600.23529412	45.55563825	2075.31617647	1493.00000000	1666.00000000
AGE=19 SEX=M						
STDHT	21	1716.71428571	79.58652075	6334.01428571	1445.00000000	1808.00000000
AGE=20 SEX=F						
STDHT	9	1610.11111111	42.00429872	1764.36111111	1546.00000000	1672.00000000
AGE=20 SEX=M						
STDHT	29	1717.55172414	50.05752848	2505.75615764	1630.00000000	1810.00000000
AGE=21 SEX=F						
STDHT	9	1614.55555556	40.58359001	1647.02777778	1556.00000000	1672.00000000
AGE=21 SEX=M						
STDHT	28	1712.75000000	61.28296543	3755.60185185	1574.00000000	1849.00000000
AGE=22 SEX=F						
STDHT	8	1591.62500000	52.21093892	2725.98214286	1497.00000000	1661.00000000
AGE=22 SEX=M						
STDHT	18	1737.72222222	38.55905411	1486.80065359	1687.00000000	1806.00000000
AGE=23 SEX=F						
STDHT	7	1626.14285714	78.75156839	6201.80952381	1520.00000000	1742.00000000
AGE=23 SEX=M						
STDHT	22	1740.27272727	53.67555249	2881.06493506	1641.00000000	1829.00000000
AGE=24 SEX=F						
STDHT	2	1626.50000000	4.94974747	24.50000000	1623.00000000	1630.00000000
AGE=24 SEX=M						
STDHT	13	1755.07692308	53.00072568	2809.07692308	1620.00000000	1807.00000000

Figure A-1 (Continued)

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM VALUE	MAXIMUM VALUE
			AGE=25 SEX=F			
STDHT	2	1641.00000000	60.81118318	3698.00000000	1598.00000000	1684.00000000
			AGE=25 SEX=M			
STDHT	19	1743.05263158	52.94176432	2802.83040936	1666.00000000	1890.00000000
			AGE=26 SEX=F			
STDHT	4	1614.50000000	15.69500982	246.33333333	1600.00000000	1630.00000000
			AGE=26 SEX=M			
STDHT	11	1703.72727273	77.95779744	6077.41818182	1541.00000000	1790.00000000
			AGE=27 SEX=F			
STDHT	2	1617.00000000	9.89949494	98.00000000	1610.00000000	1624.00000000
			AGE=27 SEX=M			
STDHT	13	1743.61538462	60.52759489	3663.58974359	1661.00000000	1841.00000000
			AGE=28 SEX=F			
STDHT	5	1602.40000000	43.24696521	1870.30000000	1540.00000000	1655.00000000
			AGE=28 SEX=M			
STDHT	18	1721.00000000	67.04870925	4495.52941176	1612.00000000	1838.00000000
			AGE=29 SEX=F			
STDHT	3	1626.33333333	2.88675135	8.33333333	1623.00000000	1628.00000000
			AGE=29 SEX=M			
STDHT	11	1742.09090909	42.45575237	1802.49090909	1690.00000000	1828.00000000
			AGE=30 SEX=F			
STDHT	3	1596.66666667	94.07621024	8850.33333333	1489.00000000	1663.00000000
			AGE=30 SEX=M			
STDHT	25	1735.28000000	57.13034804	3263.87666667	1562.00000000	1862.00000000
			AGE=31 SEX=F			
STDHT	2	1562.50000000	60.10407640	3612.50000000	1520.00000000	1605.00000000
			AGE=31 SEX=M			
STDHT	8	1784.75000000	54.98766095	3023.64285714	1730.00000000	1883.00000000

Figure A-1 (Continued)

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM VALUE	MAXIMUM VALUE
AGE=32 SEX=F						
STDHT	4	1650 50000000	54. 28627819	2947 00000000	1577. 00000000	1705. 00000000
AGE=32 SEX=M						
STDHT	14	1747. 42857143	47 90329085	2294. 72527473	1668 00000000	1820. 00000000
AGE=33 SEX=F						
STDHT	5	1634. 20000000	67. 87635818	4607. 20000000	1548. 00000000	1721. 00000000
AGE=33 SEX=M						
STDHT	15	1705. 20000000	60. 22363086	3626 88571429	1565. 00000000	1793. 00000000
AGE=34 SEX=F						
STDHT	6	1641. 16666667	51. 89765570	2693. 36666667	1576. 00000000	1693. 00000000
AGE=34 SEX=M						
STDHT	14	1729. 50000000	66. 74261699	4454. 57692308	1600. 00000000	1855. 00000000
AGE=35 SEX=F						
STDHT	3	1606 66666667	32 59345538	1062 33333333	1580. 00000000	1643. 00000000
AGE=35 SEX=M						
STDHT	13	1718. 69230769	43. 36547132	1880 56410256	1655. 00000000	1782. 00000000
AGE=36 SEX=F						
STDHT	3	1609. 00000000	69 07242576	4771. 00000000	1548 00000000	1684 00000000
AGE=36 SEX=M						
STDHT	16	1729 43750000	66 30230640	4395 99583333	1627. 00000000	1899. 00000000
AGE=37 SEX=F						
STDHT	5	1568 00000000	29 62262649	877 50000000	1536. 00000000	1610. 00000000
AGE=37 SEX=M						
STDHT	9	1735. 11111111	53 90835845	2906 11111111	1615 00000000	1780. 00000000
AGE=38 SEX=F						
STDHT	4	1630 25000000	115 65573916	13376 2500000	1468 00000000	1720 00000000
AGE=38 SEX=M						
STDHT	13	1715 53846154	62 70515049	3931 93589744	1620 00000000	1834 00000000

Figure A-1 (Continued)

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM VALUE	MAXIMUM VALUE
AGE=39 SEX=F						
STDHT	2	1586.50000000	43.13351365	1860.50000000	1556.00000000	1617.00000000
AGE=39 SEX=M						
STDHT	10	1748.30000000	65.55752351	4297.78888889	1610.00000000	1839.00000000
AGE=40 SEX=F						
STDHT	10	1604.10000000	46.32362008	2145.87777778	1545.00000000	1678.00000000
AGE=40 SEX=M						
STDHT	19	1722.36842105	47.42621231	2249.24561404	1647.00000000	1827.00000000
AGE=41 SEX=F						
STDHT	2	1578.50000000	45.96194078	2112.50000000	1546.00000000	1611.00000000
AGE=41 SEX=M						
STDHT	13	1720.15384615	41.37601188	1711.97435897	1631.00000000	1796.00000000
AGE=42 SEX=F						
STDHT	4	1578.75000000	51.21441854	2622.91666667	1505.00000000	1620.00000000
AGE=42 SEX=M						
STDHT	13	1704.46153846	61.02405999	3723.93589744	1580.00000000	1835.00000000
AGE=43 SEX=F						
STDHT	2	1517.50000000	45.96194078	2112.50000000	1485.00000000	1550.00000000
AGE=43 SEX=M						
STDHT	15	1736.60000000	54.12525157	2929.54285714	1652.00000000	1866.00000000
AGE=44 SEX=F						
STDHT	1	1522.00000000			1522.00000000	1522.00000000
AGE=44 SEX=M						
STDHT	19	1714.36842105	52.49360863	2755.57894737	1591.00000000	1786.00000000
AGE=45 SEX=F						
STDHT	9	1591.77777778	37.71530783	1422.44444444	1548.00000000	1669.00000000
AGE=45 SEX=M						
STDHT	15	1727.06666667	42.34124411	1792.78095238	1660.00000000	1798.00000000

Figure A-1 (Continued)

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM VALUE	MAXIMUM VALUE
AGE=46 SEX=F						
STDHT	2	1555.50000000	28 99137803	840.50000000	1535 00000000	1576.00000000
AGE=46 SEX=M						
STDHT	18	1706 44444444	43 03380644	1851.90849673	1632.00000000	1819.00000000
AGE=47 SEX=F						
STDHT	4	1576.00000000	65 50318058	4290.66666667	1500.00000000	1660.00000000
AGE=47 SEX=M						
STDHT	11	1717.09090909	66 15051707	4375.89090909	1626.00000000	1837.00000000
AGE=48 SEX=F						
STDHT	4	1564.25000000	50 68448152	2568.91666667	1493.00000000	1613.00000000
AGE=48 SEX=M						
STDHT	10	1703.50000000	61.93769271	3836 27777778	1607.00000000	1821.00000000
AGE=49 SEX=F						
STDHT	2	1567.50000000	60 10407640	3612 50000000	1525.00000000	1610.00000000
AGE=49 SEX=M						
STDHT	6	1724.66666667	46 92831413	2202.26666667	1637.00000000	1764 00000000
AGE=50 SEX=F						
STDHT	7	1626.57142857	27 20206575	739.95238095	1600.00000000	1682.00000000
AGE=50 SEX=M						
STDHT	21	1715 09523810	47.69895676	2275 19047619	1625 00000000	1795.00000000
AGE=51 SEX=F						
STDHT	2	1576 00000000	62 22539674	3872 00000000	1532 00000000	1620.00000000
AGE=51 SEX=M						
STDHT	7	1708 71428571	49 61086671	2461.23809524	1639 00000000	1790 00000000
AGE=52 SEX=F						
STDHT	2	1575 50000000	2 12132034	4 50000000	1574 00000000	1577.00000000
AGE=52 SEX=M						
STDHT	8	1699 25000000	48 88105096	2389 35714286	1634 00000000	1798 00000000

Figure A-1 (Continued)

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM VALUE	MAXIMUM VALUE
AGE=53 SEX=F						
STDHT	2	1571.50000000	43.13351365	1860.50000000	1541.00000000	1602.00000000
AGE=53 SEX=M						
STDHT	13	1702.92307692	62.93311468	3960.57692308	1605.00000000	1786.00000000
AGE=54 SEX=F						
STDHT	5	1570.40000000	34.16577235	1167.30000000	1530.00000000	1605.00000000
AGE=54 SEX=M						
STDHT	5	1757.40000000	47.88841196	2293.30000000	1715.00000000	1832.00000000
AGE=55 SEX=F						
STDHT	4	1584.75000000	77.94175176	6074.91666667	1517.00000000	1672.00000000
AGE=55 SEX=M						
STDHT	2	1673.00000000	52.32590181	2738.00000000	1636.00000000	1710.00000000
AGE=56 SEX=F						
STDHT	2	1632.00000000	31.11269837	968.00000000	1610.00000000	1654.00000000
AGE=56 SEX=M						
STDHT	12	1707.25000000	75.73413425	5735.65909091	1527.00000000	1820.00000000
AGE=57 SEX=F						
STDHT	4	1612.50000000	71.96990112	5179.66666667	1524.00000000	1688.00000000
AGE=57 SEX=M						
STDHT	4	1743.50000000	63.02116047	3971.66666667	1664.00000000	1818.00000000
AGE=58 SEX=F						
STDHT	2	1563.50000000	51.61879503	2664.50000000	1527.00000000	1600.00000000
AGE=58 SEX=M						
STDHT	11	1701.00000000	38.06573262	1449.00000000	1634.00000000	1758.00000000
AGE=59 SEX=M						
STDHT	7	17[illegible].00000000	33.93130315	1151.33333333	1693.00000000	1787.00000000
AGE=60 SEX=F						
STDHT	4	159[illegible].00000000	42.30839160	1790.00000000	1555.00000000	1633.00000000

Figure A-1 (Continued)

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM VALUE	MAXIMUM VALUE
AGE=60 SEX=M						
STDHT	11	1725.54545455	40.84694269	1668.47272727	1658.00000000	1790.00000000
AGE=61 SEX=M						
STDHT	2	1736.50000000	89.80256121	8064.50000000	1673.00000000	1800.00000000
AGE=62 SEX=F						
STDHT	1	1570.00000000			1570.00000000	1570.00000000
AGE=62 SEX=M						
STDHT	4	1707.75000000	11.41271221	130.25000000	1694.00000000	1719.00000000
AGE=63 SEX=F						
STDHT	1	1609.00000000			1609.00000000	1609.00000000
AGE=63 SEX=M						
STDHT	6	1679.83333333	117.63913748	13838.9666667	1470.00000000	1790.00000000
AGE=64 SEX=F						
STDHT	2	1582.50000000	74.24621202	5512.50000000	1530.00000000	1635.00000000
AGE=64 SEX=M						
STDHT	5	1695.00000000	55.17698796	3044.50000000	1635.00000000	1760.00000000
AGE=65 SEX=F						
STDHT	3	1543.33333333	20.52640576	421.33333333	1526.00000000	1566.00000000
AGE=65 SEX=M						
STDHT	1	1632.00000000			1632.00000000	1632.00000000
AGE=66 SEX=F						
STDHT	1	1598.00000000			1598.00000000	1598.00000000
AGE=66 SEX=M						
STDHT	2	1676.50000000	19.09188309	364.50000000	1663.00000000	1690.00000000
AGE=67 SEX=F						
STDHT	1	1548.00000000			1548.00000000	1548.00000000
AGE=67 SEX=M						
STDHT	4	1734.00000000	57.75234483	3335.33333333	1679.00000000	1792.00000000

Figure A-1 (Continued)

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM VALUE	MAXIMUM VALUE
AGE=68 SEX=F						
STDHT	1	1547.00000000	.	.	1547.00000000	1547.00000000
AGE=68 SEX=M						
STDHT	3	1701.00000000	54.06477596	2923.00000000	1640.00000000	1743.00000000
AGE=69 SEX=M						
STDHT	1	1592.00000000	.	.	1592.00000000	1592.00000000
AGE=70 SEX=M						
STDHT	2	1719.50000000	102.53048327	10512.5000000	1647.00000000	1792.00000000
AGE=71 SEX=M						
STDHT	2	1683.00000000	52.32590181	2738.00000000	1646.00000000	1720.00000000
AGE=72 SEX=M						
STDHT	3	1658.66666667	9.86576572	97.33333333	1652.00000000	1670.00000000
AGE=73 SEX=M						
STDHT	2	1746.00000000	11.31370850	128.00000000	1738.00000000	1754.00000000
AGE=75 SEX=F						
STDHT	1	1547.00000000	.	.	1547.00000000	1547.00000000
AGE=75 SEX=M						
STDHT	1	1672.00000000	.	.	1672.00000000	1672.00000000
AGE=76 SEX=F						
STDHT	1	1575.00000000	.	.	1575.00000000	1575.00000000
AGE=76 SEX=M						
STDHT	1	1706.00000000	.	.	1706.00000000	1706.00000000
AGE=77 SEX=F						
STDHT	1	1597.00000000	.	.	1597.00000000	1597.00000000
AGE=78 SEX=F						
STDHT	1	1571.00000000	.	.	1571.00000000	1571.00000000
AGE=79 SEX=F						
STDHT	1	1623.00000000	.	.	1623.00000000	1623.00000000

Figure A-1 (Continued)

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM VALUE	MAXIMUM VALUE
---------- AGE=80 SEX=F ----------						
STDHT	3	1605.33333333	81.30395644	6610.33333333	1553.00000000	1699.00000000
---------- AGE=80 SEX=M ----------						
STDHT	1	1600.00000000	.	.	1600.00000000	1600.00000000
---------- AGE=81 SEX=M ----------						
STDHT	1	1680.00000000	.	.	1680.00000000	1680.00000000
---------- AGE=83 SEX=F ----------						
STDHT	1	1586.00000000	.	.	1586.00000000	1586.00000000
---------- AGE=84 SEX=M ----------						
STDHT	1	1643.00000000	.	.	1643.00000000	1643.00000000
---------- AGE=91 SEX=M ----------						
STDHT	1	1643.00000000	.	.	1643.00000000	1643.00000000
---------- AGE=100 SEX=M ----------						
STDHT	1	1742.00000000	.	.	1742.00000000	1742.00000000

Figure A-2 Walker Sample complete listing of height means by age and sex

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM VALUE	MAXIMUM VALUE
AGE=1 SEX=0						
HT	2	718.50000000	4.94974747	24.50000000	715.00000000	722.00000000
AGE=1 SEX=1						
HT	3	744.33333333	47.07794954	2216.33333333	690.00000000	773.00000000
AGE=2 SEX=0						
HT	3	879.00000000	28.47806173	811.00000000	854.00000000	910.00000000
AGE=2 SEX=1						
HT	4	781.50000000	39.02563260	1523.00000000	761.00000000	840.00000000
AGE=3 SEX=0						
HT	18	905.66666667	43.19313671	1865.64705882	847.00000000	1027.00000000
AGE=3 SEX=1						
HT	12	945.33333333	53.39958007	2851.51515152	885.00000000	1041.00000000
AGE=4 SEX=0						
HT	10	981.60000000	32.75226879	1072.71111111	932.00000000	1041.00000000
AGE=4 SEX=1						
HT	14	1026.85714286	32.25107546	1040.13186813	950.00000000	1073.00000000
AGE=5 SEX=0						
HT	25	1061.72000000	90.83296024	8250.62666667	773.00000000	1191.00000000
AGE=5 SEX=1						
HT	16	1104.93750000	50.06990946	2506.99583333	1015.00000000	1165.00000000
AGE=6 SEX=0						
HT	36	1143.36111111	43.96372061	1932.80873016	1027.00000000	1230.00000000
AGE=6 SEX=1						
HT	30	1146.36666667	34.90428620	1218.30919540	1100.00000000	1240.00000000
AGE=7 SEX=0						
HT	57	1215.28070175	62.90972965	3957.63408521	1075.00000000	1430.00000000
AGE=7 SEX=1						
HT	58	1229.89655172	59.51048548	3541.49788264	1151.00000000	1553.00000000

Figure A-2 (Continued)

VAPIARLF	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM VALUE	MAXIMUM VALUE
AGE=8 SEX=0						
HT	57	1262.80701754	73.00915760	5330.33709273	1150.00000000	1599.00000000
AGE=8 SEX=1						
HT	64	1299.06250000	72.27260453	5223.32936508	1217.00000000	1564.00000000
AGE=9 SEX=0						
HT	51	1341.39215686	87.95205022	7735.56313725	1243.00000000	1590.00000000
AGE=9 SEX=1						
HT	67	1323.67164179	52.19787180	2724.61781999	1211.00000000	1462.00000000
AGE=10 SEX=0						
HT	52	1369.76923077	59.03758038	3485.43589744	1220.00000000	1521.00000000
AGE=10 SEX=1						
HT	64	1370.28125000	62.39695474	3893.37996032	1198.00000000	1600.00000000
AGE=11 SEX=0						
HT	45	1404.13333333	68.40773481	4679.61818182	1249.00000000	1520.00000000
AGE=11 SEX=1						
HT	57	1417.82456140	68.06355297	4632.64724311	1243.00000000	1573.00000000
AGE=12 SEX=0						
HT	48	1472.10416667	53.07651626	2817.11657801	1341.00000000	1580.00000000
AGE=12 SEX=1						
HT	43	1455.39534884	62.62478573	3921.86378738	1330.00000000	1587.00000000
AGE=13 SEX=0						
HT	59	1523.96610169	58.46689783	3418.37814144	1390.00000000	1646.00000000
AGE=13 SEX=1						
HT	43	1497.25581395	59.45670414	3535.09966777	1405.00000000	1682.00000000
AGE=14 SEX=0						
HT	42	1569.28571429	59.71080129	3565.37979094	1423.00000000	1780.00000000
AGE=14 SEX=1						
HT	39	1551.69230769	65.56080097	4298.21862348	1320.00000000	1650.00000000

Figure A-2 (Continued)

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM VALUE	MAXIMUM VALUE
AGE=15 SEX=0						
HT	38	1593.65789474	42.45714935	1802.60953058	1517.00000000	1679.00000000
AGE=15 SEX=1						
HT	39	1618.33333333	42.37261612	1795.43859649	1525.00000000	1740.00000000
AGE=16 SEX=0						
HT	48	1631.00000000	35.32583889	1247.91489362	1552.00000000	1720.00000000
AGE=16 SEX=1						
HT	35	1663.60000000	43.88299952	1925.71764706	1570.00000000	1740.00000000
AGE=17 SEX=0						
HT	39	1628.38461538	42.43919203	1801.08502024	1548.00000000	1715.00000000
AGE=17 SEX=1						
HT	24	1701.16666667	45.71810284	2090.14492754	1600.00000000	1786.00000000
AGE=18 SEX=0						
HT	16	1641.68750000	31.20409962	973.69583333	1595.00000000	1688.00000000
AGE=18 SEX=1						
HT	25	1754.32000000	60.67998022	3682.06000000	1600.00000000	1846.00000000
AGE=19 SEX=0						
HT	9	1629.66666667	30.67979791	941.25000000	1577.00000000	1681.00000000
AGE=19 SEX=1						
HT	4	1800.75000000	69.58627738	4842.25000000	1700.00000000	1860.00000000
AGE=20 SEX=0						
HT	5	1585.60000000	46.05757267	2121.30000000	1528.00000000	1652.00000000
AGE=20 SEX=1						
HT	3	1739.33333333	63.79132647	4069.33333333	1666.00000000	1782.00000000
AGE=21 SEX=0						
HT	6	1580.16666667	64.80869283	4200.16666667	1515.00000000	1693.00000000
AGE=22 SEX=0						
HT	3	1692.00000000	74.32361670	5524.00000000	1614.00000000	1762.00000000

Figure A-2 (Continued)

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM VALUE	MAXIMUM VALUE
---------- AGE=22 SEX=1 ----------						
HT	3	1781.00000000	44.53088816	1983.00000000	1743.00000000	1830.00000000
---------- AGE=23 SEX=0 ----------						
HT	8	1634.75000000	49.66674656	2466.78571429	1560.00000000	1695.00000000
---------- AGE=23 SEX=1 ----------						
HT	6	1783.33333333	65.73177821	4320.66666667	1664.00000000	1850.00000000
---------- AGE=24 SEX=0 ----------						
HT	5	1629.20000000	17.07922715	291.70000000	1610.00000000	1650.00000000
---------- AGE=24 SEX=1 ----------						
HT	2	1785.50000000	50.20458146	2520.50000000	1750.00000000	1821.00000000
---------- AGE=25 SEX=0 ----------						
HT	9	1640.55555556	56.63504019	3207.52777778	1569.00000000	1773.00000000
---------- AGE=25 SEX=1 ----------						
HT	2	1769.50000000	13.43502884	180.50000000	1760.00000000	1779.00000000
---------- AGE=26 SEX=0 ----------						
HT	8	1633.37500000	43.73275170	1912.55357143	1575.00000000	1696.00000000
---------- AGE=26 SEX=1 ----------						
HT	9	1764.55555556	34.68108674	1202.77777778	1693.00000000	1800.00000000
---------- AGE=27 SEX=0 ----------						
HT	6	1619.66666667	41.00569066	1681.46666667	1549.00000000	1664.00000000
---------- AGE=27 SEX=1 ----------						
HT	2	1706.50000000	9.19238816	84.50000000	1700.00000000	1713.00000000
---------- AGE=28 SEX=0 ----------						
HT	2	1622.50000000	24.74873734	612.50000000	1605.00000000	1640.00000000
---------- AGE=28 SEX=1 ----------						
HT	7	1793.00000000	56.46828018	3188.66666667	1740.00000000	1894.00000000
---------- AGE=29 SEX=0 ----------						
HT	3	1580.00000000	103.14552826	10639.0000000	1462.00000000	1653.00000000

Figure A-2 (Continued)

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM VALUE	MAXIMUM VALUE
---- AGE=29 SEX=1 ----						
HT	6	1741.83333333	61.85601561	3826.16666667	1665.00000000	1816.00000000
---- AGE=30 SEX=0 ----						
HT	3	1583.66666667	89.51163798	8012.33333333	1530.00000000	1687.00000000
---- AGE=30 SEX=1 ----						
HT	4	1713.25000000	26.37391388	695.58333333	1683.00000000	1740.00000000
---- AGE=31 SEX=0 ----						
HT	5	1601.20000000	48.11652523	2315.20000000	1556.00000000	1676.00000000
---- AGE=31 SEX=1 ----						
HT	5	1766.60000000	66.89768307	4475.30000000	1673.00000000	1850.00000000
---- AGE=32 SEX=0 ----						
HT	10	1613.10000000	58.21502288	3388.98888889	1513.00000000	1680.00000000
---- AGE=32 SEX=1 ----						
HT	8	1777.37500000	44.71157568	1999.12500000	1714.00000000	1829.00000000
---- AGE=33 SEX=0 ----						
HT	6	1630.33333333	36.05921057	1300.26666667	1566.00000000	1660.00000000
---- AGE=33 SEX=1 ----						
HT	9	1740.77777778	58.95714074	3475.94444444	1672.00000000	1824.00000000
---- AGE=34 SEX=0 ----						
HT	4	1653.00000000	52.81413952	2789.33333333	1595.00000000	1715.00000000
---- AGE=34 SEX=1 ----						
HT	5	1746.80000000	53.77452929	2891.70000000	1700.00000000	1837.00000000
---- AGE=35 SEX=0 ----						
HT	6	1628.33333333	61.50338744	3782.66666667	1573.00000000	1737.00000000
---- AGE=35 SEX=1 ----						
HT	2	1720.00000000	145.66399692	21218.0000000	1617.00000000	1823.00000000
---- AGE=36 SEX=0 ----						
HT	9	1644.22222222	32.26367066	1040.94444444	1582.00000000	1695.00000000

Figure A-2 (Continued)

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM VALUE	MAXIMUM VALUE
AGE=36 SEX=1						
HT	4	1781.25000000	38.93049362	1515.58333333	1750.00000000	1838.00000000
AGE=37 SEX=0						
HT	9	1621.00000000	38.57784338	1488.25000000	1560.00000000	1666.00000000
AGE=37 SEX=1						
HT	4	1738.75000000	70.50000000	4970.25000000	1640.00000000	1790.00000000
AGE=38 SEX=0						
HT	6	1594.50000000	40.32741003	1626.30000000	1542.00000000	1650.00000000
AGE=38 SEX=1						
HT	7	1763.28571429	68.64574346	4712.23809524	1655.00000000	1857.00000000
AGE=39 SEX=0						
HT	4	1656.50000000	35.96757799	1293.66666667	1624.00000000	1707.00000000
AGE=39 SEX=1						
HT	2	1767.50000000	3.53553391	12.50000000	1765.00000000	1770.00000000
AGE=40 SEX=0						
HT	4	1658.00000000	95.86101050	9189.33333333	1600.00000000	1800.00000000
AGE=40 SEX=1						
HT	8	1777.00000000	51.22220501	2623.71428571	1732.00000000	1855.00000000
AGE=41 SEX=0						
HT	6	1623.50000000	33.95732616	1153.10000000	1572.00000000	1665.00000000
AGE=41 SEX=1						
HT	7	1749.57142857	55.34394620	3062.95238095	1694.00000000	1863.00000000
AGE=42 SEX=0						
HT	5	1602.60000000	32.79939024	1075.80000000	1550.00000000	1640.00000000
AGE=42 SEX=1						
HT	7	1744.42857143	60.23801995	3628.61904762	1645.00000000	1831.00000000
AGE=43 SEX=1						
HT	9	1752.66666667	47.31807266	2239.00000000	1678.00000000	1835.00000000

Figure A-2 (Continued)

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM VALUE	MAXIMUM VALUE
AGE=44 SEX=0						
HT	5	1595.60000000	49.69205168	2469.30000000	1518.00000000	1653.00000000
AGE=44 SEX=1						
HT	6	1791.83333333	72.81323140	5301.76666667	1660.00000000	1877.00000000
AGE=45 SEX=0						
HT	2	1607.00000000	60.81118318	3698.00000000	1564.00000000	1650.00000000
AGE=45 SEX=1						
HT	6	1765.83333333	44.49906366	1980.16666667	1712.00000000	1832.00000000
AGE=46 SEX=0						
HT	6	1605.33333333	49.37475738	2437.86666667	1566.00000000	1700.00000000
AGE=46 SEX=1						
HT	9	1737.33333333	49.08920452	2409.75000000	1659.00000000	1800.00000000
AGE=47 SEX=1						
HT	4	1775.75000000	44.09365034	1944.25000000	1730.00000000	1836.00000000
AGE=48 SEX=0						
HT	4	1633.75000000	24.99833328	624.91666667	1597.00000000	1653.00000000
AGE=48 SEX=1						
HT	4	1721.00000000	22.00000000	484.00000000	1700.00000000	1740.00000000
AGE=49 SEX=0						
HT	7	1617.71428571	33.80194415	1142.57142857	1573.00000000	1660.00000000
AGE=49 SEX=1						
HT	3	1778.33333333	36.11555528	1304.33333333	1756.00000000	1820.00000000
AGE=50 SEX=0						
HT	5	1598.60000000	35.84410691	1284.80000000	1560.00000000	1643.00000000
AGE=50 SEX=1						
HT	5	1714.40000000	24.01666088	576.80000000	1685.00000000	1750.00000000
AGE=51 SEX=0						
HT	3	1641.66666667	28.43120352	808.33333333	1610.00000000	1665.00000000

Figure A-2 (Continued)

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM VALUE	MAXIMUM VALUE
AGE=51 SEX=1						
HT	5	1711.00000000	49.96498774	2496.50000000	1650.00000000	1763.00000000
AGE=52 SEX=0						
HT	6	1598.16666667	41.40249590	1714.16666667	1541.00000000	1642.00000000
AGE=52 SEX=1						
HT	8	1730.12500000	68.47197028	4688.41071429	1603.00000000	1800.00000000
AGE=53 SEX=0						
HT	2	1604.50000000	45.96194078	2112.50000000	1572.00000000	1637.00000000
AGE=53 SEX=1						
HT	5	1681.00000000	62.48999920	3905.00000000	1640.00000000	1790.00000000
AGE=54 SEX=1						
HT	5	1719.80000000	70.04070245	4905.70000000	1646.00000000	1825.00000000
AGE=55 SEX=0						
HT	4	1589.25000000	68.93656504	4752.25000000	1525.00000000	1687.00000000
AGE=55 SEX=1						
HT	8	1745.12500000	54.25715884	2943.83928571	1650.00000000	1834.00000000
AGE=56 SEX=0						
HT	2	1570.00000000	141.42135624	20000.0000000	1470.00000000	1670.00000000
AGE=56 SEX=1						
HT	7	1693.28571429	39.80667568	1584.57142857	1610.00000000	1735.00000000
AGE=57 SEX=0						
HT	1	1682.00000000	.	.	1682.00000000	1682.00000000
AGE=57 SEX=1						
HT	4	1708.50000000	3.69684550	13.66666667	1705.00000000	1713.00000000
AGE=58 SEX=0						
HT	2	1611.00000000	25.45584412	648.00000000	1593.00000000	1629.00000000
AGE=58 SEX=1						
HT	5	1738.80000000	38.25833243	1463.70000000	1693.00000000	1783.00000000

Figure A-2 (Continued)

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM VALUE	MAXIMUM VALUE
AGE=59 SEX=0						
HT	1	1790.00000000	.	.	1790.00000000	1790.00000000
AGE=59 SEX=1						
HT	4	1715.50000000	51.57195620	2659.66666667	1645.00000000	1765.00000000
AGE=60 SEX=0						
HT	2	1590.50000000	41.71930009	1740.50000000	1561.00000000	1620.00000000
AGE=60 SEX=1						
HT	2	1746.00000000	77.78174593	6050.00000000	1691.00000000	1801.00000000
AGE=61 SEX=1						
HT	1	1750.00000000	.	.	1750.00000000	1750.00000000
AGE=63 SEX=0						
HT	2	1556.50000000	9.19238816	84.50000000	1550.00000000	1563.00000000
AGE=63 SEX=1						
HT	1	1700.00000000	.	.	1700.00000000	1700.00000000
AGE=64 SEX=0						
HT	1	1580.00000000	.	.	1580.00000000	1580.00000000
AGE=64 SEX=1						
HT	1	1796.00000000	.	.	1796.00000000	1796.00000000
AGE=65 SEX=0						
HT	1	1550.00000000	.	.	1550.00000000	1550.00000000
AGE=66 SEX=0						
HT	2	1602.50000000	3.53553391	12.50000000	1600.00000000	1605.00000000
AGE=66 SEX=1						
HT	3	1704.66666667	23.45918441	550.33333333	1679.00000000	1725.00000000
AGE=67 SEX=0						
HT	1	1620.00000000	.	.	1620.00000000	1620.00000000
AGE=67 SEX=1						
HT	1	1693.00000000	.	.	1693.00000000	1693.00000000

Figure A-2 (Continued)

VARIABLE	N	MEAN	STANDARD DEVIATION	VARIANCE	MINIMUM VALUE	MAXIMUM VALUE
AGE=69 SEX=1						
HT	2	1644.00000000	9.89949494	98.00000000	1637.00000000	1651.00000000
AGE=72 SEX=0						
HT	1	1583.00000000	.	.	1583.00000000	1583.00000000
AGE=72 SEX=1						
HT	1	1697.00000000	.	.	1697.00000000	1697.00000000
AGE=73 SEX=1						
HT	1	1700.00000000	.	.	1700.00000000	1700.00000000
AGE=77 SEX=1						
HT	1	1700.00000000	.	.	1700.00000000	1700.00000000

VITA

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Mr. Prince entered graduate school at The University of Tennessee at Knoxville in the beginning of 1984 and began study toward the Master of Arts degree.

He is a member of the American Association of Physical Anthropologists, as well as the following organizations:

Society for the Study of Human Biology,

Human Biology Council,

New York Academy of Sciences,

Cultural Survival, Inc.,

Union of Concerned Scientists.