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TALLEST IN THE WORLD: NATIVE AMERICANS OF THE GREAT PLAINS IN THE NINETEENTH CENTURY

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ABSTRACT

Historians often portray Native Americans as merely unfortunate victims of European disease and aggression, with lives in disarray that followed the arrival of Columbus and other explorers or conquerors. The data we analyze on human stature show, in contrast, that some Native Americans such as the equestrian Plains nomads, were remarkably ingenious and adaptive in the face of exceptional demographic stress. Using anthropometric data originally collected by Franz Boas, we show that the Plains nomads were tallest in the world during the mid-nineteenth century. We link this extraordinary achievement to a rich and varied diet, modest disease loads other than epidemics, a remarkable facility at reorganization following demographic disasters, and egalitarian principles of operation. The analysis provides a useful mirror for understanding the health of Euro-Americans.

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After a long period of regrettable neglect, Native American history has finally emerged as a growth industry. Inspired in part by a desire for inclusiveness in the study of the past and also by retrospectives associated with the quincentennial of Columbus' arrival in the Americas, scholars have increasingly sought to understand the contours of the Native American experience.

Most Americans are familiar with the broad outlines of Native American history: settlement via the Siberian land bridge some 12,000 to 20,000 years ago followed by widespread geographic diffusion over the ensuing millennia, with the largest concentrations of population ultimately located in Mesoamerica.[1] The arrival of disease-bearing European colonizers, bent on conquest and religious conversion, decimated the aboriginal populations they encountered. In the United States, the population of Native Americans reached a nadir with the reservation period near the end of the nineteenth century.[2]

In telling the story of Native American history, scholars have been ingenious in assembling evidence from archeological and linguistic sources and from eyewitness accounts and oral histories. Inevitably, though, the available information could only be called thin, in part because few written records were ever created until the reservation era. Thus, new information and techniques are always welcome in this field of study, but substantial gaps in our knowledge are likely to persist.

This paper sheds light on the well being of Great Plains equestrian nomads using a source now familiar to economic historians, human stature.[3] Originally collected near the end of the nineteenth century by Franz Boas and his assistants for ethnographic purposes, the present sample contains measurements of 1,485 adult individuals, predominately males, from 8 tribes. The paper offers suggestions for coping with small samples of widely disparate ages by correcting for growth as young adults and for shrinkage at very old ages. After discussing the sample and ecological conditions and tribal ways of life, we consider possible explanations for the remarkable finding that the equestrian nomads of Great Plains were the tallest in the world during the nineteenth century. In addition to shedding light on the exceptional but neglected achievements of Native Americans, the analysis provides a useful mirror for study of influences on health more generally.

The Sample

As the father of American anthropology, Franz Boas is well known for collection and analysis of anthropometric data of North Amerindians. Motivated by an interest in ethnographic study, he was responsible for gathering anthropometric and demographic data on several thousand Native Americans and Siberians from 1888 to 1903. The data analyzed in this paper were collected in 1892 for use in exhibits at Chicago's Columbian Exposition. The worksheets originally coded by Franz Boas and his assistants were rediscovered by Richard Jantz in 1982, and placed in machine-readable form a few years later.[4]

All of the Plains Indians were on reservations or under government agency oversight at the time of measurement. Intent on sampling a large geographic area, Boas trained and dispatched numerous observers to most regions in North America where Native Americans could be found. The composition of the tribal samples collected by Boas can be described as variable and opportunistic, as is the case with most historical anthropological samples. Though not selected by random procedures, there is no reason to believe that individuals with unusual anthropometric features were over or under represented. Only individuals described as "full blooded" or nearly so (3/4 'blood quantum') are included in the analysis as judged from the tribe of the mother and tribe of the father indicated on the original worksheets. All members of a particular tribe were pooled regardless of where they were measured.

Figure 1 shows the land areas of major Great Plains tribes in the middle of the nineteenth century. Most of the important tribes in the region are in the sample, including Blackfeet and Assiniboin in the north; Arapaho, Cheyenne, Crow, and Dakota Sioux in the central; and Comanche and Kiowa in the south. The Sioux and the Crow, however, were the most numerous, comprising nearly three-quarters of the entire sample of 1,485 individuals (see Table 1). About 76 per cent of those measured were males.

Despite the vast land areas controlled by these tribes, their collective population was probably well under 100,000 at the beginning of the nineteenth century.[5] Thus, the Plains were sparsely settled in relation to area and to the primary food source, buffalo. As noted below, horses gave these tribes considerable speed and freedom of movement within their territorial areas.

Franz Boas was a meticulous empirical researcher, and it is safe to argue that the anthropometric

measurements were taken with a great deal of care. Boas himself did some of the anthropometry, and he instructed his staff in the proper techniques of measurement, provided each observer with a standard set of instruments, and training sessions included practice in their use. Whenever possible, Boas sent more than one observer to the same tribe to minimize interobserver variation.

The relative lack of females may be due to cultural norms. Szathmary notes that most women, including aboriginal women today, dislike being touched by strange men.[6] Almost all the observers in the Boas data were indeed males and where the one female observer was present, the female subject participation rates improved greatly.

Although there is no reason to suspect systematic erosion of the height distributions, small sample sizes for some tribes may have resulted in erratic distributions. It is comforting to know that one cannot reject the hypothesis that the height measurements are normally distributed. All of the tribal samples, where the sample size was 20 or more, had distributions that could be characterized as normal at the 0.10 confidence level based on the Shapiro-Wilks 'W" measure. An examination of the plots did suggest some kurtosis, but all indicated an approximately normal variable distribution with the exception of slight kurtosis in the Blackfeet and Comanche female samples.

The sample includes a wide distribution of ages, ranging from 20 to 100. Ages were typically calibrated approximately using significant meteorological and historical events of known chronological date, such as unusually harsh winters, major storms, or epidemics. In this way, someone born near the time of one of these events could be assigned an approximate age. These events were typically reckoned by consulting a type of tribal or personal history recording the most significant events occurring during each of the years included in such a "winter count". Originally these were recorded as pictographs painted on tanned hides, and were often displayed as the outer cover of tipi lodges. Tribal historians used these pictographs as mnemonic devices to help in the memorization of the more detailed historical accounts referenced by each of the year-names depicted. For example, the year 1849 was called by the southern Cheyenne "The Winter when the Big Cramps take Place", depicting the agony of the widespread cholera epidemic of that year, an event that is also similarly recorded accurately in a Kiowa winter count, among

other places.[7] Ages could also be calibrated relative to known ages of other members of the tribe.

Table 2 gives the sample distribution by age, which implies that a large majority of men and women were born between 1842 and 1872. Only 21 per cent of the sample was aged 50 or more at the time of measurement in 1892. In data-abundant military samples, such observations (which in any case are very few) might be discarded as biased downwards by shrinkage in old age. However, the small sample size at hand makes it important to use all available information. Here we adjusted using gender specific formulas estimated by physical anthropologists and clinicians from longitudinal data on height by age:[8]

Males: Max height = Standing height + 3.277 - 0.1652 (age) + 0.00209 $(age)^2$

Females: Max height = Standing height + 5.137 - 0.2378 (age) + 0.00276 $(age)^2$

The formulas are parabolic in age, and they call for no adjustment at age 39.5 in men and 43.1 years in women. The curves are rather flat near these ages, with the addition of only 0.2 cm at age 30 and 0.24 cm at age 50 in men. The adjustments rise quickly, however, at older ages. The correction required for men is 0.9 cm at age 60 and 3.4 cm at age 80. As suggested by values of the coefficients, at very old ages the correction is slightly greater for women, amounting to 3.8 cm at age 80.

Alternative age-correction formulas give similar results.[9] Nevertheless, some question may remain about the applicability of the formulas to Native Americans of the nineteenth century. For this reason studies of the time -trend in stature based on one measurement cohort should be undertaken with caution.

Ecological Conditions and Ways of Life

The Great Plains is a region of semi-arid, rolling grasslands located in mid-continental North America. Stretching from the Rocky Mountains on the west to roughly the 98th meridian (which passes through central Oklahoma) in the east and from Central Texas in the south to the southern Canadian prairies in the North. The area west of the 98th meridian generally receives less than 20 inches of rainfall per year, and it is this sparse level and highly variable level of precipitation, combined with high evaporation rates from seemingly ceaseless winds, that defines and unifies the Great Plains.[10]

The precipitation generally occurs as rain falling from May to July. Moisture decreases from east

to west and temperature rises from north to south, creating a major northeast to southwest decrease in effective moisture across the Great Plains. The Black Hills of southwestern South Dakota are an exception where effective moisture increases substantially. Annual variability in effective moisture increases from north to south, and the northern Plains have more severe winters with more snow and more extreme winter conditions.

The most common natural resource of the Great Plains is the natural grasses upon which vast herds of buffalo once grazed.[11] In the semi-arid plains climate, they dominated the ecological community until they were decimated near the end of the nineteenth century. The largest land animal in North America, as many as 30 million buffalo may have roamed the Plains under times of optimal forage conditions.[12]

Critical to the buffalo, overall forage production closely followed the level of local precipitation. The buffalo herds probably migrated opportunistically within and between various habitats in response to forage availability. Movements were also associated with snow, prairie fires, and local factors such as overgrazing, hunting pressures, and encroaching settlement.[13]

Other common resources used by most Plains Native Americans included antelope, elk, sheep, and deer. Wolf, fox, bear, beaver, and muskrats, and to a lesser extent, mink otters, weasels, and raccoons, were mainly hunted for furs. After the 1830s, the Euro-American fur trade with the Plains Indians increasingly focused on buffalo robes and hides.[14] Items received in trade that were particularly useful in exploiting the Plains environment included guns and metal tools such as knives, axes, kettles, awls, and arrowheads. Guns, however, were seldom used to hunt buffalo on horseback until breech-loading models were available around 1870.[15]

Plains tribes utilized a wide variety of plant resources.[16] Most notable among these were prairie turnips, wild artichokes, wild onions, choke cherries, gooseberries, buffalo berries, and elderberries. Use was also made of wild plums, sand cherries, ground beans, sunflowers, prickly pears, and various nuts. Some tribes fed the inner bark of cottonwood trees to hungry horses during severe winters, and the Sioux were known to use sap from the soft maple and box elder for sugar. Important cultigens such as maize,

beans, squash, tobacco, and sunflowers were available to Plains nomads through a long-established intertribal trade with the more sedentary horticultural communities of the Plains villagers. These networks are well documented as existing for at least a century prior to the Lewis and Clark expedition of 1804-1806.[17] The most important focus of this long-lived and widespread system of trade was the mutual barter of foodstuffs. The nomadic tribes coming to the trading centers on the Missouri and elsewhere were eager to trade the villagers for their surplus corn and other crops in exchange for dried meat, buffalo robes, leggings, furs, hides, and prairie turnip flour.

Horses were important for mobility and survival on the Great Plains. It is likely that most Plains tribes acquired their first horses during the eighteenth century in trade or as gifts from southern Plains tribes, the Comanche and Kiowa, who in turn obtained them from the southwestern Spanish colonial settlements. The semi-sedentary Plains riverine tribes such as the Mandans and Arikaras were also reservoirs of knowledge in the breeding, care, feeding, and training of horses. In general, horses diffused northeastwards through the Plains, as firearms and ammunition moved southwestwards from British and French traders in the north. The latter trade was important because 18th century Spanish policy prohibited the trading of firearms, shot and powder to Indians.[18]

The horse led to an intensification of warfare and trade among various tribes on the Plains that largely predated conflict with Euro-Americans and it made possible a more efficient exploitation of the buffalo.[19] The level of dependence upon this single critical resource for food, tools, clothing, shelter and trade was substantial. According to Murdock, all of the tribes studied here were at least 66 per cent to 85 per cent dependent on hunting as their primary subsistence mode.[20] In contrast, the semi-sedentary Plains villagers generally depended on hunting for less than one-half of their subsistence. Buffalo robes were used as garments and bedding, and tanned hides served as food and storage containers, shields, saddles, moccasins, mittens, leggings, shirts, lariats, bridles, rope and the tipi. Bones and horns were made into implements for hide processing, bows and arrow points, drinking cups, spoons, and other tools. Sinews furnished thread and bow strings, and buffalo chips (dried dung) provided fuel.

Most Plains equestrian tribes had a way of preparing dried buffalo meat that is still in use today.

Pemmican was a mixture of dried, pounded and pulverized meat often mixed with wild berries, cherries, or plums. These ingredients were combined with hot animal fat, often laid down in layers, and stored in tightly wrapped and sealed hide bags. These bags, called parfleches, were about the size of pillowcases and weighed about 90 to 100 pounds. Storable like cordwood, these portable food packs resisted spoilage for years and were important as a buffer in transitions from periods of surplus to periods of shortage.[21] Buffalo meat, fat and blood that was not immediately consumed or stewed was either dried, smoked, or made into pemmican for later use.

In the pre-equestrian period, buffalo hunting had a strong communal aspect, in which herds were driven into corrals, dune traps, or over cliffs.[22] With the acquisition of horses and firearms after the early 18th century, hunting increasingly became more individualistic. Traditional drives became less common, and instead small groups of mounted hunters pursued individual animals or small herds. The horse thus made family units more autonomous, and less dependent for their nutritional needs upon large communal activities and controls. This egalitarian shift did not mean that wealth or status distinctions were eliminated, but it does indicate that horses allowed small bands or collections of family groups to subsist. Particularly successful hunting families were able to acquire additional horses and trade goods that were marks of social distinction.

The equestrian Plains tribes had a strong sense of personal property for goods within the tribe or band.[23] A horse and other items such as weapons robes, or toys could be owned, and therefore used or traded, by a man, woman or child.[24] Horses owned by other tribes were fair game, however, and raids to acquire them enhanced one's wealth as well as social status within the tribe. According to societal norms , some horses acquired via raids were distributed as gifts to other tribal members.[25] Equality within the tribe or band was also promoted by the custom that wealthy individuals paid higher prices for items received in trade.[26]

A family of 8 would be well-equipped for Plains life with 12 horses: 1 to carry the lodge and accessories; 2 to drag lodge poles; 2 for packing meat and miscellaneous food; 3 to carry the women and children; 2 common riding horses for the men; and 2 horses trained as buffalo hunters.[27] This estimate

makes no allowance for a cushion that might be needed in case of death, injury, or theft, and a secure family might have 4 or 5 additional animals for this purpose. Wealthy families, amounting to perhaps 5 per cent of the total, would have had 40 or more horses. As many as one-quarter of the families were poor and owned less than 5 horses. The poor were dependent upon their relatives or band leaders for horses, or otherwise use dogs for transport and walked carrying packs. In tribes reasonably well-equipped with horses overall, the poor realized more mental anguish than discomfort, as fellow tribesmen would not let others suffer, particularly if their poverty was due to misfortune rather than indolence.[28]

Their nomadic habits gave rise to a fluid and flexible social organization. According to Eggan,

> tribes of the High Plains were divided into a number of bands, which camped and hunted independently for much of the year. These bands varied in size but were relatively large and often centered on a core of siblings and close relatives of the leader or chief, but anyone was free to join, whether related or not. The typical band might range in size from 150 to 50 persons but would increase or decrease according to the fortunes of warfare and hunting.[29]

This marked social flexibility allowed Plains equestrians to quickly adapt to changing circumstances posed by varying ecological and military conditions. Most tribes spent the winter, late fall, and early spring hunting in bands or small collections of related bands. They commonly converged for summer communal hunts and important ceremonial occasions.

Results

Table 3 presents height means, standard deviations and sample sizes by gender and tribe. Overall, men attained 172.2 cm, or the 24th percentile of modern NCHS height standards, while women averaged 159.7 cm, which corresponds to the 25th percentile of the same standards.[30] Remarkably, these Native American men were about 1 to 2 centimeters taller than Euro-Americans of the same era.[31] Numerous studies of military heights have shown that Euro-Americans of the mid nineteenth century were 5 to 10 centimeters taller than contemporary Europeans, and about the same stature as Euro-Australians.[32] The available historical record of heights therefore indicates that Great Plains Native American men were tallest in the world during the mid-nineteenth century.[33]

The geographic distribution of heights tended to follow an inverted-U shape with respect to

latitude. The southern-most tribes, the Comanche and the Kiowa, were relatively short, as were the northern-most tribes, the Assiniboin and the Blackfeet. The Cheyenne of the mid-latitudes were the tallest, and at 176.7 cm or 5 feet 9.6 inches, they were virtually the same average height as well-nourished, late-twentieth century Americans. The Cheyenne were followed in stature by their neighbors the Arapaho (174.3), the Crow (173.6) and the Sioux (172.8). The men in all of the north-central latitude tribes were taller than Euro-Americans of the same era.

Although women were about the same height as men relative to modern height standards, the male-female difference varied somewhat by tribe. A regression of men's heights on women's heights by tribe shows a substantial correlation. Using tribes with at least 10 observations for each gender (Blackfeet, Comanche, Crow, Kiowa, and Sioux), the following regression was obtained:

$$\text{Mheight} = -6.16 + 1.12\ \text{Fheight},\ N = 5,\ R^2 = 0.82$$

$$(-0.09) \qquad (2.46)$$

T-values are given in parentheses. The coefficient on female height exceeds 1.0, which is consistent with the observation by human biologists that women's growth tends to be more resistant to deprivation than is men's.[34] Thus, the gender difference in stature is relatively larger in good times and shrinks under bad conditions, which is an aspect of sexual dimorphism.

Inspection of the residuals indicates that the largest gender difference by far was among the Crow. In this tribe the men were about 2.2 centimeters taller than the height of women would predict.

Explanations

We begin by asking whether the tall stature of Native American men might be an artifact of sample composition. Comparison of Table 4 with Table 1 shows that the data gathered by Boas substantially overrepresents the Sioux and the Crow relative to their estimated share of the equestrian population near the end of the eighteenth century.[35] Because these tribes were somewhat shorter than the sample average of heights, this suggests that the weighted mean might exceed the simple mean. Boas' sample, however, also underrepresents the shortest tribes--the Assiniboin, Blackfeet, and Comanche.

Attaching weights given in Table 4, the average heights of the 8 Plains tribes was 172.0 cm, only 0.2 cm less than the sample mean. The weighted average still exceeds that of Euro-Americans of the mid-nineteenth century.

In view of the fact that most Native Americans in the Western Hemisphere, particularly those in Mesoamerica and the U.S. Southwest, were substantially shorter than Euro-Americans, the stature of the Great Plains tribes is exceptional.[36] It should be noted, too, that heights of Euro-American (and of African Americans) also varied by latitude.[37] The shortest soldiers resided in the lower southern states such as South Carolina and Gulf Coast states such as Mississippi and Louisiana. Unfortunately, virtually no troops enlisted from Nebraska, the Dakotas or Montana, and thus an inverted-U shape to Euro-American heights in the area of the Plains tribes cannot be established from the evidence at hand.[38] The sample of Euro-Americans (Union troops) is drawn largely from a region that corresponds to the mid-latitudes of the Plains sample, and the simple average of these male heights (Arapaho, Cheyenne, Crow, and Sioux) is 174.3 cm. This figure gives even more force the claim that Native Americans on the Great Plains were the tallest in the world.[39]

Can their tall stature be attributed to genetics? While the matter cannot be settled completely, this explanation seems unlikely for several reasons. First, ethnically different populations that grew up under good environmental conditions are approximately the same height, which suggests that genetic factors account for at most a small portion of average height differences across a diverse group of populations.[40] Second, there was considerable variation in average height across the Plains tribes. A devil's advocate might argue that this result also follows from genetics, but intermarriage across tribes, and the taking of female captives as wives, argues against this possibility. Third, plausible environmental reasons can be found for the tribal differences in stature.[41]

Knowledge that heights measure net nutrition provides an organizing device for discussing the remarkable stature of Plains tribes. Natural categories of discussion are diet, minus claims on the diet made by work and by disease. Given the heavy toll that epidemic disease took on Plains tribes in the nineteenth century, it is difficult to escape the conclusion that other aspects of the net nutrition equation--diet and

work--must have been adequate if not good for growth. The mystery appears to be why the epidemics were not more of an impediment to growth.

Diet. Protein, energy, and micronutrients are essential for achieving modern height standards.[42] The importance of energy and protein are well-established from studies on animals and from research on human populations in developing countries under conditions of deprivation created by wars, famines, or chronic conditions. Micronutrients such as iron, iodine, zinc, and vitamin A have also been found to promote growth (or retard it, if lacking).[43]

It seems clear that the Plains tribes, particularly those in the mid and northern latitudes, had adequate protein and energy from buffalo, and that this diet typically reached the poor.[44] Due to their more arid conditions, the southern Plains were less abundant in this fundamental resource, which may have contributed to the shorter stature of the Kiowa and the Comanche. These tribes were living and hunting in the most marginal areas for buffalo herds, and by the 1850s many of the southern riverine refuge areas so critical for game were seriously depleted of timber and forage by migrating emigrants and ever increasing overland commerce and transport.[45]

More intriguing are the ways that tribes of the Great Plains achieved something approximating nutritional diversity and thereby consumed important micronutrients. It is possible that the mid-latitude tribes had advantages stemming from climatic conditions and from their more central location with respect to trade networks. The favorable climatic conditions promoted the growth of numerous buffalo and diverse native plant resources that could be eaten or traded. Other Plains tribes may have had less access to plant diversity and buffalo due to arid conditions in the south or to cold and short growing seasons in the far north. The abundant buffalo in the mid-latitudes not only contributed to protein and energy consumption directly, but also enabled hunting and export of buffalo robes and related materials in trade for food.

The mid-latitude tribes were both blessed and cursed by geography. Their central location and easy access to the Missouri River and its tributaries placed them at the heart of the Great Plains trading network from the 1820s on. Compared to other Plains tribes they could more easily (cheaply) trade or import diverse foodstuffs. This central location and its many rivers also afforded easy access to burgeoning

waves of emigrants. Starting in the late 1840s this constant stream of people and animals along these central emigrant trails (the Oregon-California, and Santa Fe trails, among others) put severe stresses upon the limited natural resources of this arid region. As one historian has said, "By the late 1850s these valleys were arguably the most overtaxed terrain in North America."[46]

Disease. The Plains equestrian tribes operated in many ways that significantly reduced the incidence and effects of disease. The horse provided considerable ease of movement and by migrating seasonally and in pursuit of buffalo, they seldom lingered long enough in one location for disease-causing waste and parasites to accumulate. They also operated in small bands, usually less than 150 in number, and often less than 100. These living arrangements and their relative isolation made it more difficult for diseases to become endemic.[47]

The greatest threat to life on the Plains was epidemic disease, a hazard that increased with growth in the number of susceptibles through births following the previous epidemic. Thus, epidemics visited the Plains with a cycle of just under 10 years, or about the length of time required to produce enough individuals lacking immunity for the various diseases to spread.[48] Smallpox, measles, cholera, whooping cough and other diseases may have wiped out as much as one-half the population of some tribes during the course of any one severe epidemic.[49]

There is no question that epidemics significantly reduced population numbers, and had a substantial impact upon these societies. However, their adverse effects on human growth (of those who survived) are open to debate. The organizational flexibility of the tribes was a major adaptive advantage in coping with these periodic crises. Bands hit by significant epidemics were often able to regroup quickly with other bands. Children left parentless were also commonly adopted and families combined to create an effective working group.[50]

Those favored relatives who survived epidemics were typically left with more horses per capita. Horses were by far the most important type of capital on the Plains and they could be readily traded for foodstuffs or other materials that would assist survival (of those still living following an epidemic) during a period of crisis and reorganization. Consistent with this idea, an increase in the ratio of capital to labor has

been cited as ameliorating the effects of the Black Death in Europe.[51] The significance of this phenomenon was probably greater on the Plains compared with Europe, however, as the most important type of capital was not only edible and valuable but highly portable and thus easily traded.

The relatively good nutritional circumstances of Plains tribes are mirrored in their very low incidence of tuberculosis, a disease that tends to strike the poorly nourished. It is well established that TB was a major killer in the eastern United States and especially in England during the nineteenth century.[52] Substantial numbers of Euro-Americans afflicted by the disease traveled west in search of cures because the climate and manner of life was thought to be healthy. According to Rothman:

> It was commonly reported by the first soldiers who went west that Indians had fewer 'diseases and morbid afflictions...than that of civilized men. Rheumatism is rare, and gout appears to be unknown. No cases of phthisis or jaundice fell under our observation.'... A physician who traveled to Colorado in 1860 noted that 'among all the Indian tribes inhabiting this tableau, tubercular consumption is almost unknown.'[53]

Though not a disease, military conflict (both intertribal and with U.S. governmental forces) may have had a similar effect on health.[54] While all tribes were eventually confronted U.S. military action, tribes in the southern Plains were the first to face this threat, which disrupted tribal ways of life and diverted resources from food production. Led by the boom in cotton and the search for a low-cost route to the West Coast, the Comanche and the Kiowa were continually harassed by the military as early as the 1840s, which may also help to explain their relatively short stature.[55] The Sioux, for example, were not seriously threatened by U.S. military action until the late 1860s and early 1870s.

Work. Unfortunately, little information is available on work effort, which drains net nutrition. Assessing the effects of work on net nutrition is complicated by the fact that it is composed of both hours and intensity of effort. While something can be said about the former among farmers, relatively little is known about the latter.

The most comprehensive, recent study of the agricultural work routine was undertaken by John Olson, whose major focus was the labor of slaves and free farmers.[56] Olson noted that work in agriculture varied by crop or activity and by season of the year. His results rely on extensive studies of the agricultural work routine undertaken in the early twentieth century and on spotty evidence for the nineteenth century.

He concludes that the typical mid-nineteenth century northern former probably worked an average of at least 60 hours per week, and perhaps as much as 72 hours.

The nineteenth century was a difficult time for women of the Plains tribes. With the rise of export-based trade in hides and furs, the health of women tended to deteriorate. Preparing furs and buffalo hides for sale was arduous women's work, which was often combined or added to traditional work responsibilities.[57] As occupiers of some of the best and the last game regions on the great Plains, the Crow were particularly active in the export of furs and hides. It is possible that these activities reduced the heights of Crow women relative to men, noted earlier.

Unfortunately, we know of no estimates of duration or intensity of work effort by Plains tribes and therefore we cannot make reliable comparisons with Euro-Americans. It is conceivable that these tribes obtained high net nutrition despite a heavy disease load simply by expending few calories on physical activity, and by carefully using available storage technology to conserve whatever occasional surplus dietary resources they had.[58] The plausibility of such a scenario, however, is currently impossible to evaluate.[59] We know that the tribes moved regularly, often long distances, and this alone would have consumed considerable energy, particularly for those who walked. It is known, however, that the horse improved the efficiency of hunting, transport and trade compared with that using dogs and released time for other activities such as warfare, feasting, and ceremonies.[60] In the absence of detailed information, it is reasonable to conjecture that energy expended on physical activity might have been similar for Plains tribes and Euro-Americans.

Concluding Remarks

The tall stature of Great Plains tribes conflicts with preconceptions of their standard of living relative to Euro-Americans. Presumably technology and institutions provided advantages in many dimensions of the quality of life for Euro-Americans. How did apparently 'poor' tribes become the tallest in the world? Why were they so successful in the dimension of nutritional status, particularly in the face of significant stress from disease?

The tribesmen clearly consumed adequate protein and energy from the abundant buffalo and game that typically roamed the Great Plains, a process that was made much easier and reliable with horses and with metal tools such as axes, knives, and guns.[61] Less well known is the dietary diversity that provided vitamins, minerals and other micronutrients. This rich diet was supplemented by an extensive network of trade in foodstuffs among tribes and by exploitation of extensive native plant resources.[62]

It is well established that the Plains tribes shrank significantly in numbers during the nineteenth century, primarily through and excess of deaths over births brought on by epidemic disease and to some extent through warfare. In contrast the Euro-American population expanded rapidly, primarily through an excess of births over deaths. These facts, and what is known about the disease history of the two groups, indicate that the Plains tribes unquestionably bore a heavier load of epidemic disease. While this would be a disadvantage for the Native Americans in net nutrition comparisons, the diseases they faced came and went quickly. Survivors should have been left with more capital (horses) per capita and they were in many instances able to minimize the effects of epidemic losses through rapid reorganization in methods of production (hunting and gathering) that had no large scale economies.

Comparisons of work effort are the most problematic, in part because information on the intensity of work is generally lacking. Although any conclusion will be necessarily qualified, we suspect that the Plains tribes probably worked no harder than northern farmers. Though a distinct possibility, it is impossible to determine whether relatively light work loads contributed importantly to the tall stature of the Plains tribes.

The net nutritional experience of tribes on the Great Plains is important for the questions it leads us to ask about Euro-American history. Historians readily chronicle the advantages of whites over Indians, including not only horses but factories, steamboats, canals and railroads. Moreover, they had forms of organization (government) that could bring huge quantities of resources to bear on particular problems. Yet, whites were relatively disadvantaged when it came to net nutritional conditions. Why?

As little comparative study has been done, what we have to say by way of a reply largely amounts to a sketch of a research agenda. Clearly, important differences in life style were density of settlement and

the extent of movement. Euro-Americans were more densely settled and sedentary, while the Plains populations were widely spread and typically moved many times per year. As a result, the tribal populations were seldom in one place long enough for waste or parasites to accumulate. The importance of waste (or lack of it) for health has been established from sanitary measures that preceded the germ theory of disease.[63] The incidence of endemic diseases was worsened for Euro-Americans by sedentary life styles and significantly higher population densities, which increased their exposure to disease causing organisms. Thus, it seems plausible that while epidemic diseases were devastating on the Great Plains, Euro-Americans suffered relatively more from chronic, endemic diseases.[64]

Given the importance of diet to nutritional status, it is worthwhile to extend comparatives studies of food intake to Native Americans. Something is known about nineteenth-century Euro-American diets from probate inventories, widows' allowances, culinary history, and archeology.[65] It is quite possible that a great deal could be learned about Native American diets from archeology and from reconstruction of trade patterns, studies of locally available plant resources, oral histories, and methods of food preservation. Perhaps specialization in a small array of market food crops limited the dietary diversity, and therefore the nutritional content of Euro-American diets, relative to the diet of Native Americans.

It is possible that greater inequality among whites adversely affected their health relative to Native Americans. Height and health are known to be sensitive to inequality.[66] Hunter-gatherer and the Plains equestrian societies were known for their egalitarian practices of sharing food and shelter, and for their communal efforts in caring for the sick or wounded.[67] As small communities of similar ethnic heritage where people knew each other well and misfortune was readily distinguished from shirking, sharing and helping others in need was a form of social insurance. Some status item did exist, as known from oral histories and artifacts, and some individuals such as chiefs exercised considerable power, but Plains societies also exhibited social and economic fluidity. Hazards such as horse raids, winter storms or disease destroyed herds of the wealthy and mitigated social entrenchment. These hazards also inclined the rich to be generous so that favors could be returned in times of need. Unlike the capitalist societies of the nineteenth century, most wealth on the Great Plains was readily moveable, which limited the amounts that could be accumulated. In contrast,

vast quantities of wealth could be acquired in more impersonal capitalist societies in the form of land, structures, and financial assets. Rich Euro-Americans had little need for community-based social insurance programs because they could fend for themselves using the market, but the poor who lacked family connections or access to markets were at risk. Thus, it is likely that the social safety net was considerably more porous in Euro-America compared with the smaller, more cohesive societies of the Great Plains.

It seems plausible that the net nutritional success of the Plains tribes in the face of extraordinary epidemic adversity might be attributable in part to their organizational flexibility. In the face of huge losses through death, survivors usually regrouped quickly with other bands to resume their seasonal rounds. Though we have not given the matter much study, it seems likely that chaos would have followed very large numbers of deaths through epidemics in any town or city of Euro-Americans. Plausibly, many survivors would have streamed out of the community and those left behind would have faced enormously disrupted lives as the intricate networks of specialization and interdependencies came unraveled. American society anticipated continuity and gradual replacement of losses through death, and was not built to withstand major demographic shocks.

The difficult adjustments routinely faced by the Plains tribes were eased by having much of their assets in easily portable and eminently tradable forms of capital—horses and pemmican. Though Euro-Americans also had portable and tradable assets (money), much of their wealth was tied-up in non-edible and non-portable land, structures, and equipment. With half the population of New York City dying from an epidemic, for instance, who would have been willing to risk their life to bring food into the city from the outside? Under these conditions, what would physical assets in the city have been worth? For what could they have been traded that would have enhanced the chances of survival? Fortunately for Euro-Americans, they rarely had to test their system of production and distribution against the kinds of demographic disasters faced by Plains tribes.

Whatever the reasons for the outstanding net nutritional success of the equestrian Plains tribes, it is clear that historians have overlooked this accomplishment. Too often Native Americans have been portrayed as passive victims of European expansion, as mere numbers who were lost in a holocaust. Given

a lack of detailed research and understanding, this image of haplessness has been reinforced by a misguided tendency to read backward into time the more familiar plight of Native Americans on reservations.[68] While we know their populations ultimately diminished significantly, this paper provides a more nuanced view of Native American history. We show that in the face of extraordinary change and turmoil, Native Americans were ingenious and adaptive. For a time, some were exceptionally successful in an important dimension of the quality of life, until European numbers and technology were overwhelming. Thus, we have much to learn from the remarkable achievements of the equestrian Plains tribes.

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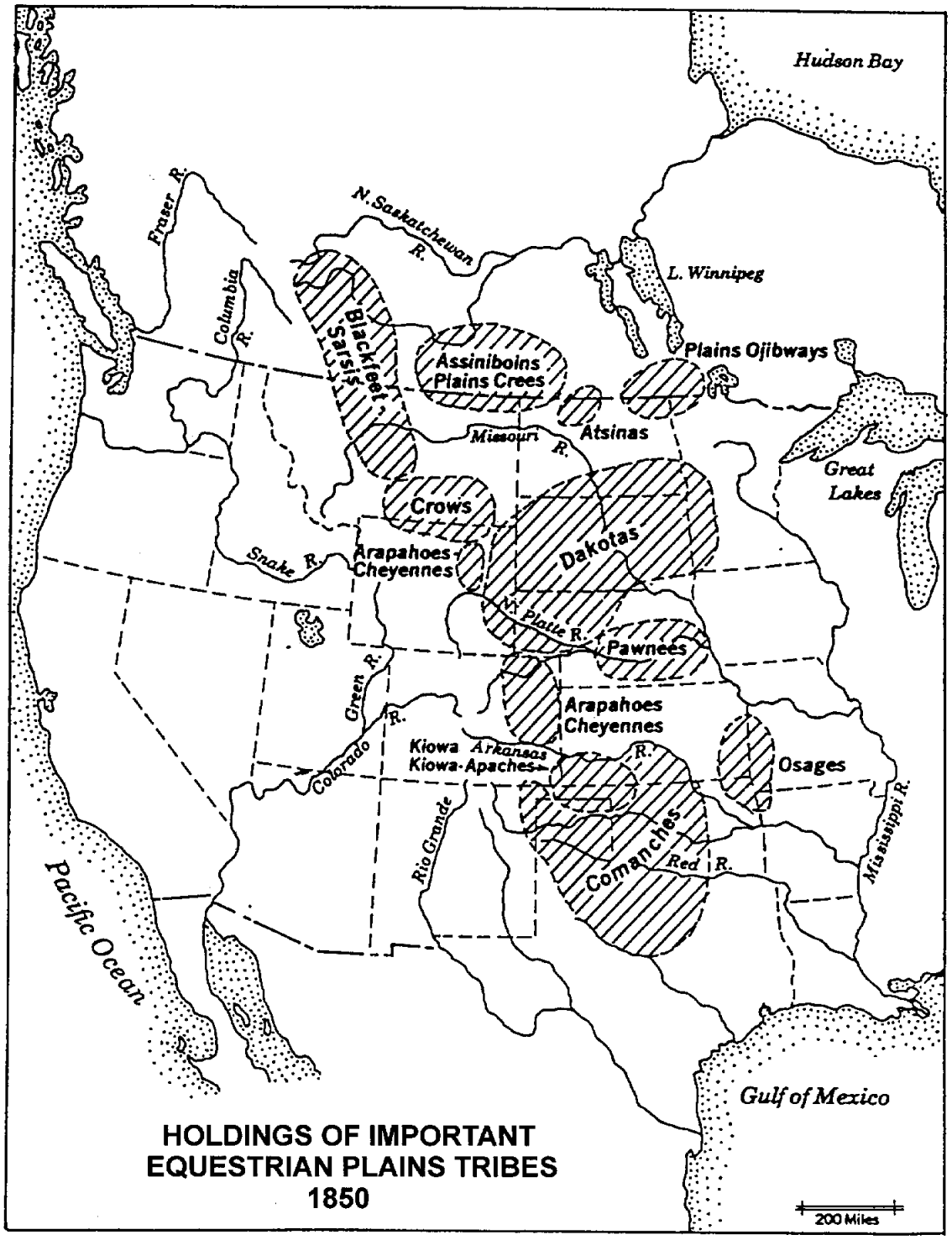

Figure 1: Map of Plains Tribal Territory, ca. 1850

Source: Haines, F. 1976. The Plains Indians. New York: Thomas Crowell.

Table 1: Sample Sizes by Tribe

Tribe	Sample Size	Per Cent of Sample	Per Cent Female
Arapaho	61	4.11	6.6
Assiniboin	23	1.55	4.3
Blackfeet	71	4.78	18.3
Cheyenne	31	2.09	6.5
Comanche	104	7.00	29.8
Crow	323	21.75	29.7
Kiowa	105	7.07	30.5
Sioux	767	51.65	23.9
All Tribes	1,485	100.0	24.4

Source: Prince, Plains, Table 2, p. 113.

Table 2: Distribution of Sample by Age and Gender

Age	Male (%)	Female (%)
20-29	35.0	32.6
30-39	23.9	23.5
40-49	21.3	20.7
50-59	12.1	13.3
60-69	5.6	6.9
70-79	1.5	1.7
80+	0.6	1.4
Sum	100.0	100.1
Total Number	1,123	362

Source: Prince, Plains.

Table 3: Means, Standard Deviations, and Sample Sizes of Height by Tribe and Gender

	Males			Females		
Tribe	Height	s.d.	N	Height	s.d.	N
Arapaho	174.3	6.9	57	161.8	6.4	4
Assiniboin	169.6	6.0	22	159.2	-	1
Blackfeet	172.0	5.3	58	160.5	4.9	13
Cheyenne	176.7	5.6	29	161.5	2.7	2
Comanche	168.0	6.4	73	156.7	4.5	31
Crow	173.6	6.7	227	159.1	4.7	96
Kiowa	170.4	5.7	73	158.5	4.9	32
Sioux	172.8	5.6	584	160.6	5.2	183
Total Sample	172.2	6.2	1,123	159.7	5.1	362

Note: Average heights have been rounded to nearest 0.1 centimeter.

Source: Prince, Plains.

Table 4: Approximate Distribution of the Plains Equestrian Population in 1780

Tribe	Per Cent
Arapaho	4.62
Assiniboin	13.63
Blackfeet	18.93
Cheyenne	5.30
Comanche	10.6
Crow	6.06
Kiowa	3.03
Sioux	37.85

Source: Ubelaker, Sources. The range of estimates has been averaged for the Arapaho, Assiniboin and Blackfeet. N = 66,050.

Footnotes

[1] Genetic and linguistic evidence point to the possibility of even earlier settlement.

[2] Thornton, Indian Holocaust; Aboriginal North American.

[3] For a recent survey of methodology and applications see Steckel, "Stature,"

[4] Jantz, "Special Issue."

[5] Prince, Plains, p. 55.

[6] Szathmary, "Overview."

[7] Howard, "Yanktonai;" Sundstrom, "Smallpox;" West, Way West.

[8] Cline et al., "Decline of Height."

[9] Meadows Jantz, Secular; Prince, "Intersection Economics;" Relethford, "Re-examination."

[10] Webb, Great Plains.

[11] For general discussion of ways of life for Native Americans on the Great Plains see Ewers, Horse, Indian Life; Isenberg, Indians; Prince, Plains.

[12] Bamforth, Ecology; Isenberg, Indians; West, Contested.

[13] Bamforth, Ecology; Hanson, "Bison Ecology;" West, Contested.

[14] Wishart, Fur Trade; Wedel, "The High Plains."

[15] Ewers, Horse, p. 7 and p. 156.

[16] Wedel, Central Plains, "The High Plains;" Kindscher, Edible Wild, Medicinal Wild.

[17] Ewers, Horse, Indian Life.

[18] Swagerty, "Indian Trade."

[19] Ewers, Horse; Hanson, "Adjustment."

[20] Murdock, Ethnographic.

[21] Barsness, Heads; McHugh, Time of Buffalo.

[22] Bamforth, Ecology; Klein, "Political Economy."

[23] Ewers, Horse, p. 240.

[24] Ibid, pp. 216-21.

[25] Ibid, pp. 176-91.

[26] Ibid, p. 313.

[27] Ibid, p. 138.

[28] Ibid, pp. 240-44.

[29] Eggan, American, p. 53.

[30] Percentiles were calculated from Steckel, "Percentiles."

[31] For data on Euro-Americans see Costa and Steckel, "Long-Term," Table 2.6.

[32] Numerous height studies are discussed in Steckel and Floud, Health. For data on Australia, see Whitwell et al., "Height."

[33] Prince, "Intersection Economics."

[34]Tanner, Fetus.

[35] There is necessarily some hazard in estimating population shares due to a lack of censuses and dramatic changes in population size. The issue is discussed in more detail in Prince, Plains, Chapter 2.

[36] Heights of Native Americans throughout Western Hemisphere are under study in a project described in Steckel, Rose, and Sciulli, "Skeletal Remains."

[37] Margo and Steckel, "Heights;" Margo and Steckel, "Heights of American Slaves".

[38] States of the eastern Plains did provide a substantial number of troops for the Union Army. As reported by Gould, Investigations, p. 122, the average height of troops from Minnesota, Iowa, and Missouri was 173.8 cm, which approaches that of the mid-latitude Plains tribes. Among these, troops enlisting from Iowa were the tallest (174.5 cm), exceeding those from Minnesota by 1.9 cm and those from Missouri by 0.9 cm, which establishes an inverted-U gradient of heights by latitude on the eastern Plains. In another comparison of interest, Murray, "Standards," p. 592, finds that students from Amherst College born in the 1830s attained 174.1 cm. In playing the comparison game by locality or social class, however, we note that the Cheyenne, at 176.7 cm, were the tallest of any group we have discovered for the era under study.

[39] Their tall stature cannot be attributed to adjustments to height for shrinkage. If no adjustments were made, the average height would be only 0.4 cm lower for men and 0.6 cm lower for women. This result is due to the fact that most of the sample of was concentrated at ages (the mid-twenties through the mid fifties) where adjustments were small in any case.

[40] See, for example, Malcolm, "Ecological" and Martorell and Habicht, "Growth."

[41] One might speculate that tall stature was adaptive to Plains conditions, i.e. that tall tribesmen had an advantage hunting buffalo on horseback. This is unlikely because young teenage boys, who were shorter than adults, regularly hunted on horseback. See Ewers, Horse, p. 159.

[42] Tanner, Fetus; Scrimshaw et al., Energy.

[43] Allen, "Nutritional."

[44] Ewers, Horse, p. 305 notes that the poor who owned no hunting horses would have been provided for by the wealthy by loans of hunting horses or by outright gifts of meat.

[45] Bamforth, Ecology; Flores, "Bison Ecology and Diplomacy;" Prince, Plains; Sherow, "Workings;" West, Way West.

[46] West, Contested.

[47] Trimble, "Infectious Disease;" "1832 Inoculation;" "1837-1838 Smallpox."

[48] Vehik, "Problems." Sundstrom in "Smallpox" has suggested that on the northern Plains, epidemics may have occurred on average about every six years.

[49] Ewers, "Influence;" Decker, "Depopulation;" Thornton, American Indian.

[50] Isenberg, Indians; Taylor, "Sociocultural Effects;" Sundstrom, "Smallpox."

[51] See, for example, Miskimin, Economy, p. 29.

[52] Smith, Retreat and Rothman, Shadow.

[53] Rothman, Shadow, p. 135.

[54] Ewers, Horse; McGinnis, Counting Coup; Prince, Plains.

[55] Fehrenbach, Comanches; Utley, "Indian-United States."

[56] Olson, "Clock Time."

[57] Reinhard et al., "Trade;" West, Contested.

[58] Managers of the American Fur Company frequently complained that mid-nineteenth century Native American trappers were lazy, or at least would not produce nearly as many furs as they could. Tribal members may have limited work effort, however, because the trade goods acquired were often distributed among family and friends. Moreover, tribal members apparently believed that food and furs would always be readily available, and therefore hard work was unnecessary to accumulate inventories for coping with possible shortages. For a discussion of these issues see Whelan, "Dakota Indian."

[59] See Panter-Brick and Pollard, "Workload," for a discussion of issues and results in measuring energy expenditure. In modern studies, total energy expenditure (TEE) is usually estimated using one of the following approaches: (a) factorial method, in which time devoted to various activities is multiplied by the energy cost of those activities; (b) heart-rate monitoring, in which heart beats reflect physical activity; and (c) doubly-labeled water, in which tracing doses of stable isotopes indicate gross daily energy expenditure. Physical activity levels (PAL) are often stated in terms of multiples of basal metabolic rate (BMR), where PAL = TEE/BMR. The fact that PAL varies widely (by a factor of more than 2:1; see Panter-Brick and Pollard, Table 5.1) among pre-modern agriculturists around the world, according to the nature of their environment and season of the year, leads us to be cautious in attempting to draw conclusions about the work effort of the Plains tribes relative to northern farmers. For what it is worth, we observe that PAL averaged 1.81 in 18 low-tech agricultural populations and 1.95 in two foraging populations (the Paraguay Ache and the Botswana !Kung).

[60] Ewers, Horse, p. 305.

[61] Important aspects of tribal life without horses are discussed in Ewers, Horse, pp. 299-322.

[62] West, Contested; Helleson and Gadd, Ethnobotany.

[63] Szreter, "Importance."

[64] Cohen, Health and Rise.

[65] Walsh, "Consumer Behavior."

[66] Steckel, "Height."

[67] Ewers, Horse, Indian Life; Isenberg, Indians; Prince, Plains; Whelan, "Dakota Indians."

[68] After the turn of the century the reservation populations experienced very high rates of TB and other diseases. For a discussion of health on the reservations see Putney, Fighting.