ANTHROPOMETRIC HISTORY: WHAT IS IT AND WHAT CAN IT TELL US ABOUT ANTEBELLUM PENNSYLVANIA?[1]

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Anthropometry is the technique of expressing quantitatively the form of the body.[2]

Anthropometric history, the study of longitudinal or cross-sectional patterns in human body size, is a fruitful new avenue of historical research which draws upon the disciplines of history, biology, anthropology, economics, and demography. While social welfare workers, public health specialists, and physical anthropologists have long utilized anthropometric measures as indicators of well-being, only relatively recently have historians begun to use such data to illuminate the historical experience of ordinary men and women of the past.[3] This paper seeks to introduce and more widely disseminate this methodology to an audience of historians interested in the Mid-Atlantic region, and specifically in Pennsylvania, by first describing the biomedical research which supports it, indicating why antebellum Pennsylvania is an appropriate focus of study, highlighting some of the most interesting findings to date about the

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Keystone State and the Mid-Atlantic region more generally, and pointing out potential avenues of future research.[4] Particular attention will be given to data which places Pennsylvanians in national and international comparison, which describes intrastate variation, and which sheds light on the characteristics of men who served Pennsylvania in the American Civil War.

Why Anthropometric History and How Did it Originate?

Several rationales recommend the use of body size to investigate the human condition in a historical context. First, adult stature is a cumulative indicator of net nutritional status over the growth years, and thus reflects the command over food and access to healthful surroundings.[5] The fact that expenditures for these items comprised such a high percentage of family income for historical communities in the now developed world means that stature can be used to examine changes in a population's economic circumstances over time and to compare the well-being of different groups with similar genetic height potential. The World Health Organization describes stature as one of the best measures of overall health conditions within a society.[6]

"Conventional" measures of economic well-being such as per capita GNP, wage and price indices, and income inequality measures have been notoriously problematic to develop for historical communities. Price data often exist only for a few commodities in a handful of cities, while wages are similarly extant only for a few occupations. In contrast, anthropometric measures, especially height, are available for significant segments of the male population in many nations as far back as the early 1700s, and thus can serve as complements to standard economic indicators. In some cases they provide the only means of assessing well-being within historical communities.[7] In addition, and potentially more importantly, anthropometric history broadens the understanding of "well-being" beyond the one-dimensional "ruler" of income, providing another lens through which the quality of life can be viewed in historical perspective. Stature, as an indicator of *net* nutritional status, sums up the results of caloric inputs and the caloric demands of work and the disease environment. It reflects the actual physical outcomes of economic activity, rather than simply potential consumption as estimated by income.[8]

Although the sub-discipline is still relatively young, historical anthropometric research findings have contributed to the scholarly debates over the nature of slavery, mortality trends, and the outcomes of industrialization and

economic development.[9] Height has been the primary indicator utilized to date because it is the most commonly available for historical populations. Some authors have also utilized data on height-standardized weight indices and birth weight.[10] Age at which menarche is reached, while not a body measurement per se, is another biological proxy for net nutritional status, and historical studies of this indicator of female maturation have tended to be associated with the anthropometric approach. While many issues remain to be addressed, this line of research offers the potential to provide many new historical insights and enlighten historians interested in Pennsylvania about historical physical well-being across the Commonwealth.

The Evolution of Body Measurement in Context[11]

The measurement and description of the human form date back to the classical civilizations of Greece and Rome. In these societies, through the Renaissance and into the early eighteenth century, interest centered primarily on the determination of ideal body shapes and proportions rather than on absolute size.[12] The rationale for systematic, large-scale body measurement and record keeping came from neither artists nor doctors; rather,

> it was because of military requirements. Tall soldiers were regarded as preferable to short ones. Not only were they generally stronger; they could cover more ground on the march because of a greater length of stride, and in combat they could reach further with the bayonet and load more easily the long-barreled muskets of the time, in which the charge had to be rammed down the muzzle.[13]

The measurement of military recruits generally began by the mid-eighteenth century. Not only did height provide a means for classifying men into military units, but it also provided a means of identifying them for the payroll or when they deserted.[14] The military's need to identify recruits provided most measurements of young men.

Scientific curiosity spurred the eighteenth-century development of the first textbooks on human growth.[15] In the nineteenth-century class differences in height were readily noted in England, because of their extreme nature.[16] The "moral outrage" generated by the "tiny children," Dickens'

"Oliver Twists," along with the view that medicine had a preventive as well as a curative function, generated an interest in "auxological epidemiology, the use of growth data to search out, and later to define, sub-optimal conditions of health."[17] In particular, this meant anthropometry was directed primarily at the poor, especially children toiling in the factories of English and French industrial cities. Such investigations paved the way for legislation regulating the use of child labor in factories.[18]

Later, fear in Britain over the "degeneration" of its men and concern over their potential to form an effective fighting force provided motivation for large-scale anthropometric surveys, as did efforts evolving out of the child-welfare movement.[19] The early twentieth century saw the establishment of a series of longitudinal population surveys, first in North America and later in Europe. In some cases this work was directed toward the generation of growth standards, while other efforts evaluated social-class differences among children.[20] The world-wide economic depression of the 1930s led to further support for this research program, although the results of several long-term studies of children, begun well before the downturn, were also published during this time.[21] These studies, along with Bowles' 1932 work on several generations of Harvard families from the late nineteenth and early twentieth centuries can be seen as transitional steps between contemporary work and anthropometric history.[22] Since the 1950s, anthropometry has been utilized for a variety of purposes in both the developed and underdeveloped world. Population groups, both in the "modern" urban sector and in the "traditional" rural regions, have been measured in order to develop standards, monitor nutritional status of individuals and populations, assess famines, and evaluate the effectiveness of economic development programs.[23]

Anthropometric studies today can be classified as one of three types.[24] Auxologists perform basic research, collecting body measurements over the human life cycle to generate standards of physical development for twentieth-century populations against which individual development can be assessed. In addition to its medical context, such basic research has application in the field of ergonomics or human factor engineering. The second focus of anthropometric research, a continuation of nineteenth-century work, pertains to the living standards of children. Such investigations often support regulatory legislation or government aid policies. The third direction, and the concern of this work, is anthropometric history. Historians, anthropologists, and economists specializing in this field seek to assess, in physical terms, the well-being of previous societies and the factors which influence it. While historical

anthropometric research is a relatively recent development, an extensive body of medical literature relating nutrition and epidemiological conditions to physical growth provides a strong theoretical underpinning for this line of analysis.

The Bio-Medical Foundations of Anthropometric History

Nineteenth-century laymen were quite aware of the vast differences in the physical characteristics among the various social classes in Britain, but little valid understanding existed as to the cause. While much still remains to be learned, medical knowledge of the factors influencing body size has advanced considerably. It is now understood that maximum attained height, growth profiles during childhood and adolescence, as well as the duration of the growth period itself are sensitive to net nutritional status.[25] These all result from a complex interaction of nutritional intake, genetic endowment, and environmental effects.[26] At the level of the *individual*, genetics are a strong but not exclusive influence on the determination of maximum height and of growth patterns. Genetics are most important when net nutrition is optimal.[27] However, when evaluating differences between *groups* of people in sub-optimal nutritional circumstances, environmental influences predominate.[28]

The physical stature of a population does not reflect nutritional status at the time of measurement, but rather it indicates cumulative net nutrition over the growth period. It is a long-term indicator of relative biological well-being. Due to genetic variation, the same nutritional regime can result in different maximum stature for particular *individuals*, because of variation in the ability to continue growing in the face of adverse nutritional circumstances, or epidemiological and work environments.[29] However, the genetic height potential of most Europeans, Africans, and North Americans of European or African ancestry is comparable.[30] Differences in nutritional intake result in wide variation in adult height even within populations of the same genetic make-up.[31] For example, individuals from higher socio-economic classes tend to be taller than their lower-class counterparts, whether in impoverished third-world countries or in the developed nations.[32]

The growth profile is also an indicator of net nutritional status. The pattern of growth is remarkably similar for all individuals, although the timing of such events as the adolescent growth spurt and age at which terminal height is reached does vary. The body seems to be self-stabilizing, postponing growth

until caloric levels will support it, and maintaining genetically programmed body proportions more rigidly than size potential.[33] Under sub-optimal net nutrition regimes, the tempo of growth may be slower.[34] However, if nutritional status improves within a reasonable length of time, height within the normal range can be achieved through "catch-up" growth, increased growth velocity, and an elongation of the growth period.[35] Such extensions are not indefinite and, should nutritional status improvement be delayed too long, stunting, the permanent retardation of linear growth, will occur.[36] Hence, the process of growth can be thought of as "target seeking."[37]

The body's ability to keep open the window of opportunity for growth when experiencing inadequate nutritional conditions makes the mean age of peak height velocity and the mean age at which growth ceases valuable indicators of a population's nutritional status. While maximum adult height and length of the growth period are not absolutely linked, populations which stop growing earlier usually, although not universally, end up being taller.[38] Late twentieth-century Europeans and North Americans cease growing, on average (although not universally), at age 17.5 for boys and 15.5 years for girls.[39] Among eighteenth- and nineteenth-century Europeans, however, growth continued well into the early to mid-twenties.[40]

Height is the most common, but not the only, anthropometric indicator of nutritional status. Age at menarche, birth weight, and weight for height are also useful. Age at menarche is not a measure of physical size but of sexual maturation.[41] Menarche generally occurs earlier among well-nourished women. The higher the socio-economic standing within the same culture, the earlier is menarche reached, though genetic variation also has an influence.[42] For historians, birth weight is primarily a useful indicator of long-term maternal nutritional status, while weight for height measures, like the body mass index, provide a window into "near" term well-being.[43]

Improvement in net nutritional status, both across wide segments of the population in developed countries and within urban areas of the less developed countries, is generally accepted as the most salient influence on growth patterns and maximum stature. It is viewed as the most likely cause of the "secular trend," a "rather curious phrase [which] denotes both the tendency to get larger and the tendency to get more early maturing."[44] This *unidirectional* trend toward greater stature and faster maturation has been apparent in most of the developed world only during the last century and more recently in the "modern" sector of some LDCs. Before the twentieth century height cycling was the dominant pattern.[45]

The genetic similarity in growth potential for ethnic groups which were significant components of the Western European and North American populations make stature an excellent vehicle for comparing nutritional status and health among and between these groups. As Tanner notes:

> height can indeed be used as a proxy for health, and not only in the nineteenth century and in developing countries. This is true, of course, only when comparing groups, not when comparing individuals, the variation between whom is overwhelmingly due to genetical causes except in the direst circumstances. But between social classes, urban and rural dwellers, educated and uneducated (provided we stay within a single ethnic group) height is a useful-perhaps the most useful-measure of healthiness.[46]

The Determination of Nutritional Status

Human biologists and medical scientists agree that within genetically similar populations net nutrition is the primary determinant of adult physical stature. While nutritional status is a biological term, the influences upon it are mostly environmental in origin. Bielicki stresses that, to a considerable degree, differences in height within a population are "socially induced variation."[47]

Nutritional status, as measured by anthropometric indicators, provides clues about access to nutrients net of the demands placed upon them by bodily functions, exertion, and disease encounters. The relationship between disease encounters, both endemic and epidemic, and nutritional status is synergistic. That is to say, nutritional status itself influences the extent to which disease pathogens impact the human organism. In general, anthropometric indicators reflect the relative ease or difficulty of acquiring sufficient nutrients to provide for growth in excess of the immediate needs of the body. Genetic make-up of an individual determines the general potential for growth and the sensitivity to the nutritional environment. Hence, it accounts for individual variation in stature, even if environmental conditions were identical for all members of the population. However, height variation across populations or sub-populations (within the European and North American gene-pool) is determined, in the main, not by genetic variation, but by such external factors as diet, disease exposure, and work intensity. In turn, these are influenced by the socio-economic environment and the ecological niche which the

individual inhabits. Nutritional status and physical stature clearly are composite measures of well-being linked to economic processes. However, the link is mediated through a variety of social circumstances, some volitional, others not. Hence, anthropometric historians must evaluate each situation within its own economic, cultural, and historical context.

In earlier societies, and to some extent even in some less developed countries today, access to nutrients was determined not as much by money income as by the control over arable land. As markets for food developed and urban living became predominant, for increasing percentages of the population access to nutrients depended upon the ability to purchase food and shelter, i.e. on real income. Additionally, food allocation within the family is not determined by markets but by intra-household bargaining as well as by tastes and custom.[48] The handful of studies which include historical anthropometric data for women reveal that stature trends by gender do not always move in concert. Rather, in some periods of declining nutritional status, women have exhibited a reduction in stature levels before such changes appeared among males.[49] Other cultural practices, including the high status accorded to the use of certain foods, such as white flour, polished rice, tea or coffee, may promote greater consumption of nutritionally less valuable foods among those able to afford them. This would tend to *reduce* the resultant stature differences by income. It may also mean that increases in income might result in less nutritional improvement than was financially feasible.[50] Access to nutrients also depends upon other individual choices. A small landholder might decide to market much of the farm's high-value, high-protein meat and dairy products, reducing thereby his family's consumption of these nutritious food products in order to maximize money income. This would enable him to increase the purchase and consumption of manufactured goods. However, while material welfare might well increase, biological welfare, knowingly or unknowingly, might decrease at the same time.[51]

Disease-exposure variation occurs as a result of some factors under the individual's control, and other factors which are determined at the societal level. The extent of pathogen prevalence and potency and the level of community sanitation are critical factors, which are not directly affected by individual decision making. However, housing and occupation are individually chosen (although, obviously, not without constraint) and do help to determine the extent of disease exposure. Housing quality can be viewed in terms of residence within an urban, rural, or a suburban location. Once transportation improvements allow housing segregation based on socio-economic status to occur within larger urban areas,

residence can become an important factor of environmental influences. However, prior to such, for example in mid-nineteenth-century United States, urban childhood mortality levels were more influenced by the number of children in a family than by parental occupation or socio-economic status. The close proximity of the homes of the wealthy and the poor created a common level of exposure to infectious agents and equally poor sanitary conditions for children of all economic classes.[52] Under such circumstances, wealthier families might have been at a biological advantage because of their ability to purchase more nutrients, but the common epidemiological environment created an equalizing force.[53]

Work intensity is another factor determining nutritional status. It is a function of the age at which youth entered the labor force, educational attainment, the physical exertion needed in a chosen occupation, and by the level of technology. There are obvious feedback effects from current nutritional status to future nutritional status. A low level of nutritional status today might hinder full-time labor-force participation, and result in low incomes, poor housing, and substandard food consumption in the subsequent period as well, thereby reinforcing the cycle of nutritional inadequacy.

Antebellum Pennsylvania as a Case Study/Test Environment

With a strong bio-medical foundation, anthropometric history has the potential for helping historians understand more about the varied impact which economic development has on the men and women who experienced it. Early nineteenth-century Pennsylvania is an interesting "venue" for reviewing how biological well-being changed during a time of rapid economic change. The antebellum period is acknowledged as one during which per capita income rose across the nation.[54] Although data is not available for individual states, Pennsylvania during the first six decades of the century witnessed considerable economic growth that must have produced significant gains in output both in total and on a per capita basis. Yet, a wide range of economic orientations existed across the state based on differences in the length of settlement, the level of accessibility of the region, and natural resource endowments. While Pennsylvania had some communities of very long standing, as initial European settlements in what would become Pennsylvania date to the early 1600s, there were also areas that had only recently been settled by persons of European descent. Yet other locales were not to be settled for another twenty or thirty years.[55]

The physical properties of the land across the state varied and were influential. Terrain ranging from flat lakeside plains and fertile valley bottoms contrasted with the mountainous areas in the center and north central portions of the commonwealth. Land fertility and sub-soil natural resource endowments differed greatly from region to region.[56] The state was a near textbook example of an area economically segmented by transportation barriers. The Allegheny Mountains, which had served as the western boundary of colonial settlement, posed a serious hindrance to the transport of goods from the seaboard to the interior after the Revolution.[57] They divided the state naturally into regions which, in the early nineteenth century, "faced" in opposite directions in terms of their primary trade orientation.[58] Even common roads were lacking in portions of the state, making travel extremely difficult. With such hindrances the economic value of much of the state's land was limited.

Philadelphia in 1800 was one of the country's dominant centers of commerce and manufacturing.[59] One of the largest cities in the nation, Philadelphia served as a regional entrepôt for raw materials, as well as being an important consumer of the same.[60] As the 1700s ended it was a commercial city, but early in the new century a transition began which resulted in manufacturing becoming its economic cornerstone.[61] Most of the state's population, over 70 per cent, resided in Philadelphia and its hinterland, the Southeastern Region.[62] Farmers there had already specialized in production for the urban markets of both Philadelphia and Baltimore. However, outside of this region most farmers were engaged in subsistence plus farming involving occasional forays into market activity.[63] Much of the land outside of the Southeastern Region remained close to the frontier stage of development.[64] The indigenous inhabitants had not farmed the land in the European manner, and vast tracts remained heavily forested and required clearing before intensive agriculture could begin. With low population densities throughout much of the state, the "new world" system of agriculture, with the extensive use of land and low yields per acre, but high yields per worker, characterized farming.[65]

Over the course of the following six decades, the state, as a whole, experienced a relatively rapid process of economic development and urbanization, as did much of the new nation. Between 1820 and 1860 the proportion of the work force involved in manufacturing rose from 29 to 36 per cent, while agricultural employment fell from 68 to 37 per cent. The urban share of the population almost doubled from 22.5 per cent in 1810 to 40.5 per cent in 1860.[66] Like settlement itself, the integration of interior trade centers with seaboard markets and the linking of more remote inland sites with early

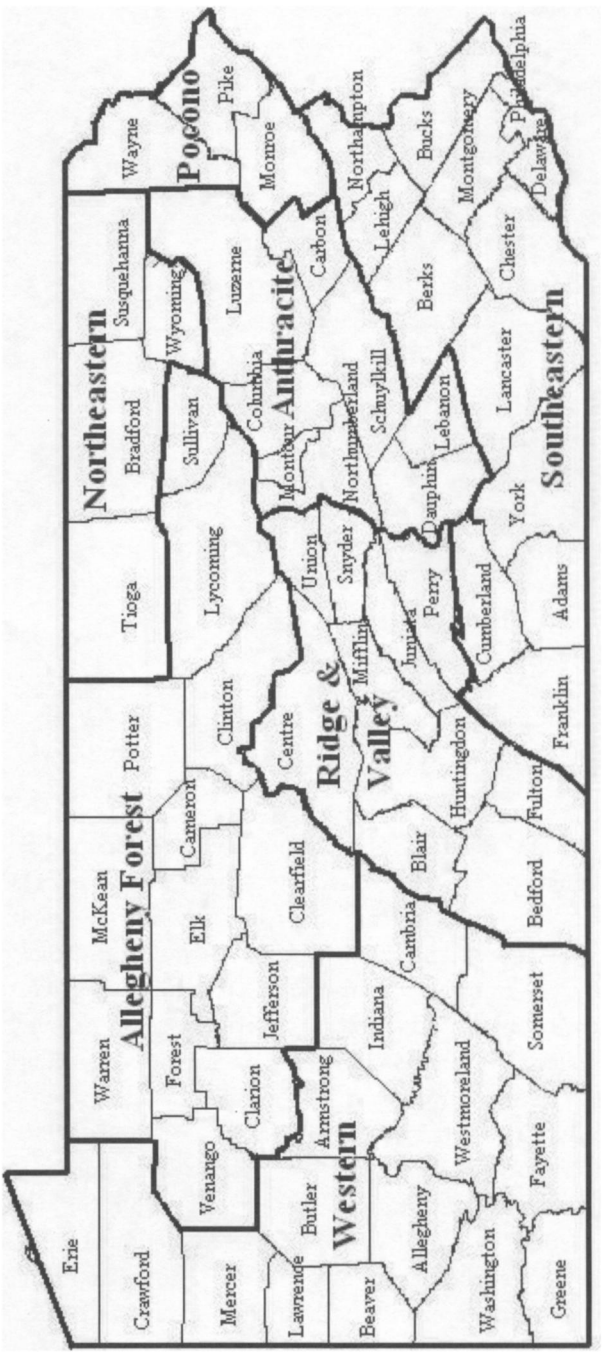

FIGURE 1: Regions of Pennsylvania

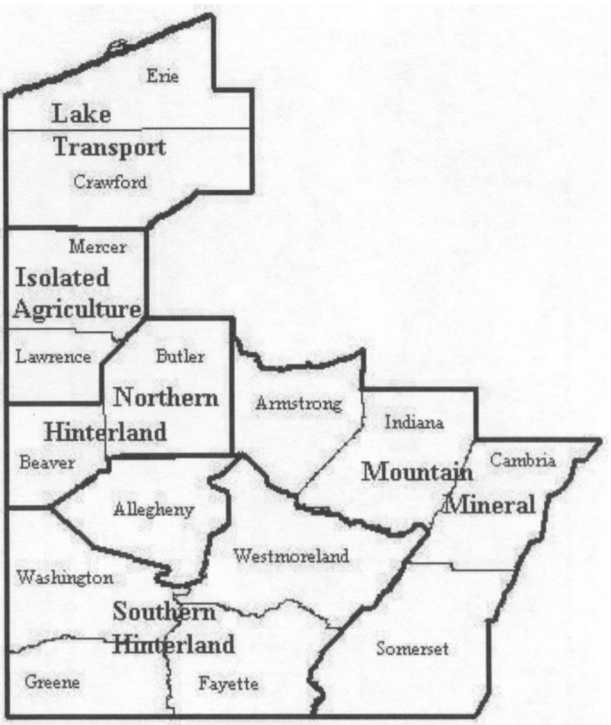

FIGURE 2: Western Sub-Regions

internal cities did not occur uniformly across the landscape. Terrain, natural resource endowments, and access to viable transportation routes determined the rapidity with which localities became part of the intraregional, and later the interregional, trade system. These factors also influenced the speed with which they made the transition from nearly self-sufficient agricultural communities to those based on specialized production for the market.

As this brief summary makes clear, numerous types of economic activity existed across the state throughout the 60 years in question. By 1860, Philadelphia and Pittsburgh were large industrial centers. However, many pockets of semi-subsistence agriculture persisted.[67] The "full range" of economic activity present in the United States existed within the state's borders throughout the period.[68] Great changes occurred in some areas and more modest ones elsewhere. Yet, the results of economic change are not always uniformly positive across the spectrum of economic actors nor across all aspects

of human well-being. Development, while increasing total output and the level of output per capita, seldom results in an equal distribution of income or other material benefits. Similarly, the biological results of economic development and related social changes are not necessarily equally distributed. Antebellum Pennsylvanians experienced the often wrenching transition from a rural agricultural society to one increasingly urban and industrial. Material welfare was affected, but as the following description of height levels and height trends for the native-born male population will show, so was physical well-being.[69]

The Pennsylvanians Under Study

To date, only a relatively few groups of Pennsylvanians have been examined by anthropometric historians. Although not large, Pennsylvania is one of only a few states which have had researchers focus exclusively on men or women drawn from one particular sub-division of the nation.[70] The analysis which follows will rely heavily, but not exclusively, on data drawn from regimental and company descriptive books of Pennsylvania units which served the Union Army during the U.S. Civil War.[71] A statewide sample was constructed in order to assess stature trends across Pennsylvania and provide a context for a second geographically smaller western regional sample. The statewide sample includes 11,953 observations of men *born in Pennsylvania* and enlisted in its Civil War regiments.[72] (Of these, 2330 are from the Union Army sample collected as part of Robert Fogel's Nutrition and Mortality project.[73]) The "western" sample was drawn from the same sources, but was limited to men from units raised in fifteen "western" counties (Tables 1 and 2). It contains an additional 7357 observations of "native born" Pennsylvanians.[74] Set within the larger statewide context, this western sample enables an examination of trends in physical stature at a very early stage in the process of market integration, yet with sufficient observations to make refined statistical analysis possible. In both cases, physical stature, rank, birth place and enlistment place, occupation, and year of enlistment were captured for each man. Other sources of anthropometric data about Pennsylvania includes material drawn from Komlos' sample of nineteenth-century West Point cadets and some late nineteenth-century analyses of the stature of Union soldiers.

TABLE 1. Counties by Region

Southeastern	*Northeastern*	*Western*
Philadelphia*	Tioga*	Erie*
Delaware*	Bradford*	Crawford*
Chester*	Susquehanna*	Mercer
Montgomery*	Wyoming	Beaver
Bucks*		Washington*
Northampton		Greene*
Lehigh*	*Ridge and Valley*	Butler*
Berks*	Snyder	Fayette*
Lancaster*	Centre	Armstrong
York*	Bedford	Westmoreland*
Adams*	Huntingdon	Indiana*
Cumberland*	Mifflin	Cambria*
Franklin*	Juniata	Somerset*
	Perry*	Lawrence
	Union	Allegheny*
Anthracite	Blair	
Montour	Fulton	
Dauphin		
Lebanon		
Northumberland*	*Allegheny Forest*	
Schuylkill*	Forest	
Columbia	Warren	
Luzerne	McKean	
Carbon	Potter*	
	Venango	
	Jefferson	
	Clearfield	
Pocono	Lycoming	
Monroe	Clinton	
Wayne*	Clarion	
Pike	Elk	
	Sullivan	

Source: These county grouping are based on Dykstra's *Region, Economy, and Party,* 1988, 37–38.

Note: * denotes county without border changes between 1820 and 1860.

TABLE 2. Sub-Regions within the Western Region

Allegheny County	*Mountain/Mineral*
Allegheny	Armstrong
	Cambria
Lake Transport	Indiana
Erie	Somerset
Crawford	
	Northern Hinterland
Southern Hinterland	Beaver
Fayette	Butler
Greene	
Washington	*Isolated Agricultural*
Westmoreland	Lawrence
	Mercer

What Anthropometric Measures Can Tell Us About Antebellum Pennsylvanians

Given the context for this work, what can anthropometric data tell us about early nineteenth-century Pennsylvania? The type of information digitized and analyzed to date can inform and enhance our understanding of a number of historical issues. What was the relative biological well-being of residents of North America and Europe? How did physical well-being vary across the state and across the antebellum years and to what extent was that variation congruent with particular economic orientations or demographic characteristics of those sub-regions? What were the social and biological characteristics of Pennsylvania-born men who fought in the American Civil War? Were their characteristics uniform over time?

National and International Comparisons

Early anthropometric research has established the very significant net nutritional and stature advantage which eighteenth and nineteenth-century North Americans enjoyed over their European contemporaries.[75] This difference is also evident between Pennsylvania Civil War soldiers and several nineteenth-century European military samples (Table 3). The mean adult heights of antebellum Pennsylvanians were two and one-half to four inches greater than those of the European soldiers.

TABLE 3. Mean Heights of Adult Males (in inches)

Pennsylvania European Ancestry		Europe		
1861–1865				
Western Sample	Statewide Sample	Hungary, 1813–1835	England, 1816–1821	Sweden, 1843–1886
68.5	68.0	64.2	65.8	66.3

Sources: Hungary: Komlos, *Nutrition and Economic Development,* Table 2.1, 57 (using QBE); Britain: Floud, Wachter, and Gregory, *Height, Health, and History*, Table 4.1, 148 (using RSMLE); Sweden: Sandberg and Steckel, "Overpopulation and Malnutrition," Table 2, 7 (using QBE).
Note: Dates refer to dates of measurement.

However, Pennsylvania Union soldiers were not as tall as those born in other parts of the United States (Table 4). There was a half inch deficit in height between the statewide sample of Pennsylvanians and the national sample of Civil War soldiers.[76] This is consistent with Baxter's summary of the heights of men by state of enlistment during the Civil War which showed Pennsylvanians to be below the national mean. This variation is also consistent with Sokoloff's finding that in the antebellum period men from the mid-atlantic region tended to be shorter than U.S. males generally.[77] The mean adult height for the western sample of 68.5 inches is equivalent to the national average of Civil War soldiers calculated by Sokoloff and much closer to the 68.8 inch level of Union men from the Midwest/West.[78] Western Pennsylvanians had a mean stature between that of the statewide sample and that of Midwestern soldiers.

TABLE 4. Mean Heights of Adult Males, U.S. (in inches)

North America European Ancestry			North America African Ancestry		Pennsylvania European Ancestry 1861–1865	
1775–1783	1861–1865	1943–1944	1811–1861	1943–1944	Western Sample	Statewide Sample
68.1	68.5	68.1	67.0	67.9	68.5	68.0

Sources: U.S. whites, 1775–1783: Sokoloff and Villaflor, "Early Achievement," 458 (using QBE); U.S. whites, 1861–65: Margo and Steckel, "Height of Native Born Whites," 168; U.S. whites and blacks, 1943–44: Karpinos, "Height and Weight of Selective Service Registrants," Table 5, 302; U.S. blacks, 1811–1861: Margo and Steckel, "Height of American Slaves," Table 1, 518.
Note: Dates refer to dates of measurement.

West Point cadets born in Pennsylvania in the mid-1800s were taller than the Union sample at younger ages, but the mean stature of the soldiers exceeded that of the cadets by age 19 in the Western sample (Figures 3 and 4).[79] After

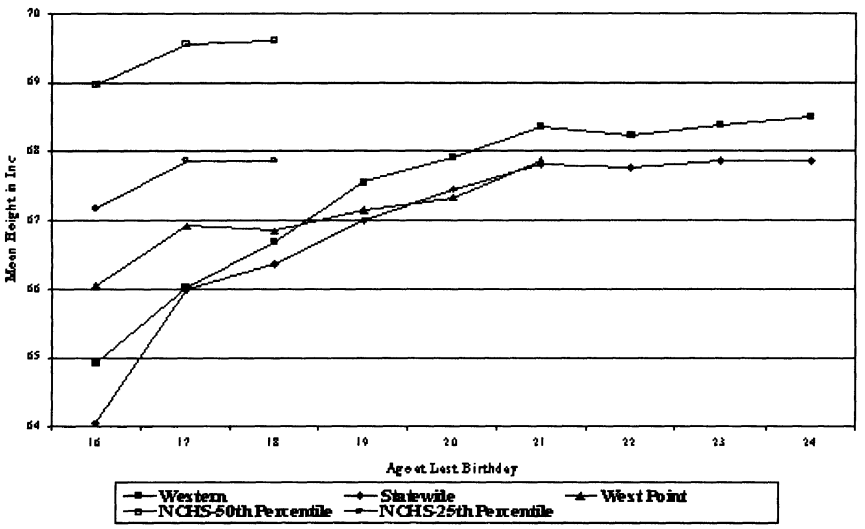

FIGURE 3: Height by Age: Pennsylvania-Born Civil War Soldiers, West Point Cadets, & NCHS Standards (1977)

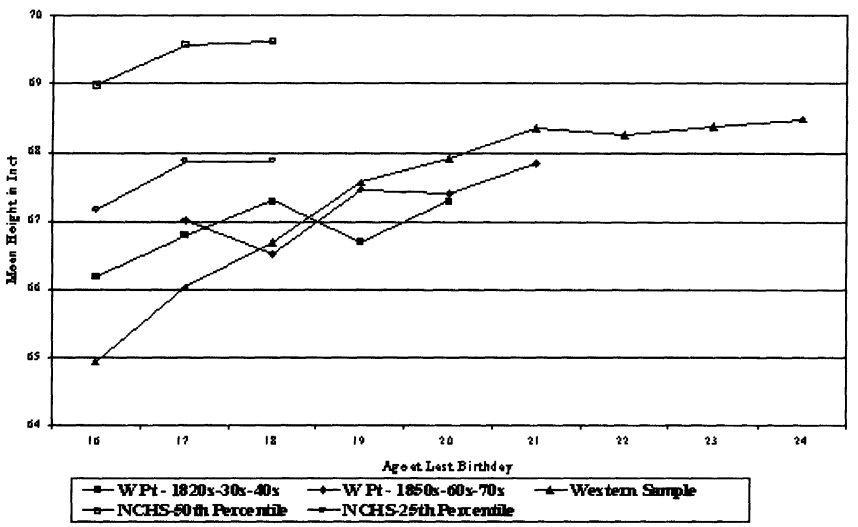

FIGURE 4: Height by Age: Pennsylvania-BornCivil War Soldiers, West Point Cadets, & NCHS Standards (1977)

age 19 the cadets were markedly shorter than the soldiers from the western sample.[80] Cadets were drawn in much greater proportion from urban areas than was the case for the Civil War soldiers.[81] The West Pointers' advantage of being from higher socio-economic class families possibly was counteracted by the fact that the cadets were to a large extent of urban origin. A more detailed examination will reveal significant variation across the state based upon the economic characteristics of a soldier's locale of birth/upbringing.

Stature Variation Across Military Components of Pennsylvania's Civil War Units Enlistment Year, Enlistment Type, and Rank

As the initial enthusiasm for the war evaporated, the U.S. government instituted a draft and various bounty systems. Civil War historians have noted that the social status of the men who entered the military declined as the war progressed. Analysis of the occupational distribution of the Pennsylvania born soldiers by year of enlistment confirms it (Tables 5 and 6), and anthropometric indicators indicate that such men were characterized by lower and lower levels of biological well-being as well.

TABLE 5. Occupational Distribution by Category, Statewide Sample[a]

	Pennsylvania Male Population	Pennsylvania Statewide Sample Civil War Enlistees (Native Born)			
	1860[b]	1861	1862	1863/64	1865
Professional Proprietor/	1.4%	0.5%	0.6%	0.6%	0.5%
Low White Collar[c]	9.9	5.8	7.0	4.3	4.5
Skilled Worker	28.0	36.7	29.9	30.1	36.1
Unskilled Worker	30.5	24.4	18.9	34.7	31.9
Farmer	28.7[d]	28.5	36.9	28.7	25.1
Student/ No occupation	0.5	0.5	1.5	0.7	0.8
Unknown	0.9	3.6	5.2	0.9	1.1

a. These distributions were calculated by applying the Herschberg and Dockhorn's classification scheme both to the 1860 statewide distribution of occupations listed in the census and to the lists

of occupations recorded in the enlistment records. Herschberg and Dockhorn, "Occupational Classification," 59–98.

b. United States, *Population of the United States in 1860; Compiled from the Original Returns of the Eighth Census*, Eighth Decennial Census, 1860 (Washington, G.P.O., 1864), 440–441.

c. This category also includes Herschberg and Dockhorn's "work site only" category (men who only listed their work site, e.g. cloth factory, not profession). They believe such men to have been the owners of such operations.

d. This figure includes men classified who identified themselves as farmers or farm laborers to the census takers. It does not include unskilled laborers. In all likelihood a percentage of these men would have also been involved in farm labor.

TABLE 6. Occupational Distribution by Category, Western Sample[a]

	Pennsylvania Male Population	Pennsylvania Western Sample Civil War Enlistees (Native Born)			
	1860[b]	1861	1862	1863/64	1865
Professional	1.4%	0.6%	0.6%	0.4%	0.7%
Proprietor/Low White Collar[c]	9.9	7.5	7.8	3.6	5.0
Skilled Worker	28.0	34.3	24.2	27.5	37.6
Unskilled Worker	30.5	25.8	14.6	24.5	23.4
Farmer	28.7[d]	28.8	49.2	42.0	31.6
Student/ No occupation	0.5	0.9	2.5	1.1	0.7
Unknown	0.9	2.1	1.0	0.9	1.0

a. These distributions were calculated by applying the Herschberg and Dockhorn's classification scheme both to the 1860 statewide distribution of occupations listed in the census and to the lists of occupations recorded in the enlistment records. Herschberg and Dockhorn, "Occupational Classification," 59–98.

b. United States, *Population of the United States in 1860; Compiled from the Original Returns of the Eighth Census*, Eighth Decennial Census, 1860 (Washington, G.P.O., 1864), 440–441.

c. This category also includes Herschberg and Dockhorn's "work site only" category (men who only listed their work site, e.g. cloth factory, not profession). They believe such men to have been the owners of such operations.

d. This figure includes men classified who identified themselves as farmers or farm laborers to the census takers. It does not include unskilled laborers. In all likelihood a percentage of these men would have also been involved in farm labor.

The mean height of adults in the statewide sample who enlisted in 1861 and 1862 was between one-half and three-quarters of an inch above that of men who enlisted in the following three years. The situation in the western sample was similar. Figure 5 shows the pattern of height-by-age for each enlistment year and indicates that variation was not simply a function of younger men being enlisted as the war dragged on. While these figures note that such shifts in stature are not a feature of a changing age distribution across the sample, regression analysis indicates that it was not a function of any other shifts in components of the sample either.[82]

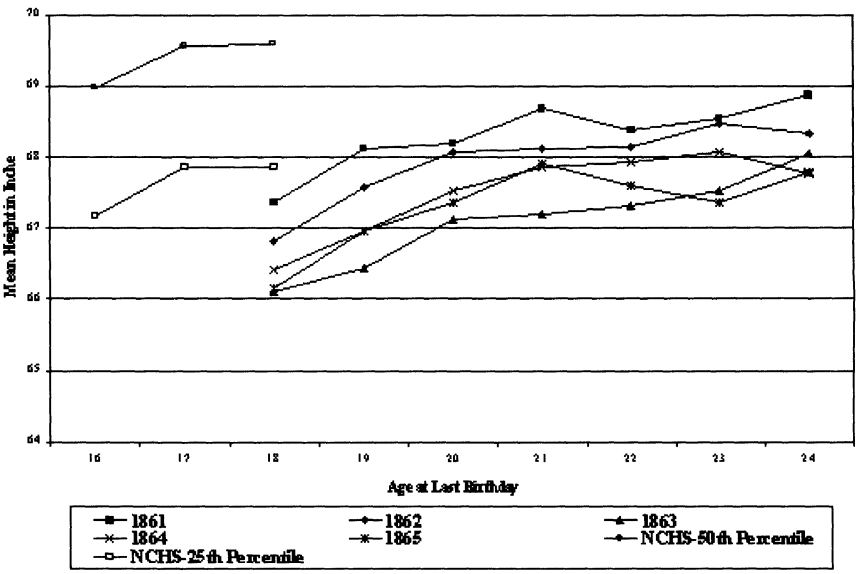

FIGURE 5: Height by Age by Enlistment Year: Merged Sample, Values via Regression

Stevens notes with some pride the relatively low 10 per cent figure for Pennsylvania soldiers who were either drafted or served as substitutes during the conflict.[83] The proportion in these samples is somewhat different: 5.7 per cent in the statewide sample and 2.5 per cent in the west. This is an indication of probable under-reporting. In both the statewide and western samples, the standard enlistees and the draftees have heights which are nearly identical, differing by less than one-tenth of an inch. Bounty recipients in both samples were, on average, between one-quarter and two-thirds of an inch shorter than standard enlistees and/or draftees, while the average substitute in both samples was more than an inch shorter than the standard enlistee. There is great age

variation, however, across the enlistment categories. Drafted men in both samples were 4.5 to 5 years older than the average enlistee, while substitutes were 2.5 to 3.5 years younger. Evaluation of these differences indicates that much of the substitutes' height deficit was a function of this age disparity. Few statistically significant stature differences are found between these categories in multiple regression analyses.

The variation in stature by military rank indicates that height rose in tandem with rank (Table 7).[84] Officers in the statewide sample were on average just under an inch taller than privates, although the difference in the western sample was more than an inch and a half.[85] Sergeants in the statewide sample were, on average, 0.76 inches taller than privates, and the difference in the western sample was 0.53 inches.[86] The election process by which some officers and non-commissioned officers were chosen might itself have been influenced by the social power which height tends to confer upon those whose stature is above the norm. Rank might partially be a function of height. It is not an input to height variation.[87]

TABLE 7. Adult Height by Rank at Enlistment of Pennsylvania-born Civil War Soldiers (in inches)

Rank at Enlistment	Western Sample	Statewide Sample
Captain	69.63 (4)	68.57 (15)
Lieutenant	69.39 (11)	68.33 (30)
Sergeant	69.09 (267)	68.41 (333)
Corporal	68.99 (318)	68.31 (461)
Private	68.33 (4105)	67.88 (5152)
Musician	67.03 (13)	66.64 (26)
Artisan	68.84 (25)	67.44 (27)

Note: The statewide sample, by including the units from Fogel's sample, includes men whose rank is not known. The bulk of them would be privates, however, all Fogel's cases have been omitted from the data in this table.

Variation in Height by Personal Characteristics

Variation in mean height also existed across the characteristics of age, occupation, and migrant status. Each comparison provides additional insight into the nature of Pennsylvania's antebellum society and some results indicate that the assumed positive relationship between wealth and physical well-being was not always present during this period.

Age Pennsylvanian's mean height at various ages, in both the western and the statewide samples, follows the standard pattern described in the biological literature with moderate growth over the late teen years and then a tailing off with terminal height attainment in the early twenties.[88] The process of growth ended by the age 21 in both the statewide and western samples (Figure 3). The later age of growth cessation in these samples is consistent with the level of adult stature in the two samples, mean heights ranging between the 25th and the 35th percentile of current American standards (NCHS, 1977).[89] This height "level" is notable in that mean adult height in European populations did not reach this range of modern height standards until the twentieth century.

Occupation There are clear occupational differences in height across both the statewide and western samples.[90] Other studies have shown that farmers and rural residents had a substantial advantage in height over most other men during the early stages of industrialization.[91] This pattern is quite evident in nineteenth-century Pennsylvania as well (Tables 8 and 9, Figures 6 and 7). Such variation did not exist in the colonial period. Changes in the American antebellum social and economic environment seemingly helped to create a stature gap between occupational groupings and between individuals experiencing their growth years in different environments. Farmers from both the statewide and western samples were 0.4–0.6 inches taller than their contemporaries who were proprietors, skilled or unskilled workers. They were not the tallest, however, being about a half-inch shorter than professionals. In the western sample, farmers had only a negligible height advantage over professionals: 0.1 inches, but they were more than 0.75 inches shorter than soldiers who noted only a work site as a place of employment. In both samples, skilled and unskilled workers show only a slight stature difference as skilled workers were just over two-tenths of an inch taller. Regression analysis indicates the height advantage of farmers over both skilled and unskilled workers are robust and consistent across several formulations of the model. Few other differences across occupations were statistically significant, either because there were few observations available, or because the variation was of negligible size. The propinquity to nutrients and distance from disease centers seems to have conferred a net nutritional advantage to farmers.[92] The stature advantage of farmers over most other men is also consistent across regions so that, regardless of a farmer's birthplace, he was likely to be taller than most other workers (Figures 8 and 9).[93]

TABLE 8. Mean Height and Age by Category—Western Sample

	N	%	Mean Height	SD	Mean Age	SD
Entire Sample	7537	100	67.96	2.54	24.14	6.77
Birth Cohort						
1815–1819	145	1.9	68.89	2.62	44.58	2.75
1820–1824	314	4.2	68.57	2.53	40.84	2.06
1825–1829	441	5.9	68.50	2.42	35.80	1.98
1830–1834	698	9.3	68.68	2.57	30.37	2.07
1835–1839	1577	20.9	68.38	2.41	24.90	1.98
1840–1844	3230	42.9	67.91	2.45	20.35	1.70
1845–1849	1132	15.0	66.56	2.41	18.26	0.92
Enlistment Year						
1861	2217	29.4	68.19	2.57	23.99	6.80
1862	1932	25.6	68.34	2.54	23.74	6.09
1863	298	4.0	67.58	2.55	25.20	6.59
1864	2173	28.8	67.58	2.47	24.58	7.24
1865	917	12.2	67.59	2.41	23.94	6.86
Occupation						
Farmer	2919	38.7	68.24	2.49	23.64	6.62
Proprietor	402	5.3	67.75	2.65	22.97	5.18
Professional	42	0.6	68.11	2.31	27.64	7.06
Work Site Only	50	0.7	69.09	2.17	22.10	5.10
Skilled Worker	2252	29.9	67.87	2.48	25.33	7.05
Unskilled Worker	1675	22.2	67.62	2.64	23.98	6.92
None (Student)	100	1.3	68.11	2.53	19.96	2.42
Unknown	97	1.3	67.47	2.44	22.90	6.24
Rank						
Officer	16	0.2	69.58	1.80	28.00	5.95
Non-comm	691	9.1	68.89	2.44	25.37	6.05
Private	6763	89.7	67.87	2.51	24.01	6.82
Musician	37	0.5	64.56	3.77	19.62	4.00
Artisan	30	0.4	68.59	2.54	28.53	7.96
Enlistment Status						
"Standard"	7132	94.6	67.99	2.54	24.17	6.77

TABLE 8. Mean Height and Age by Category—Western Sample (*Continued*)

	N	%	Mean Height	SD	Mean Age	SD
Drafted	83	1.1	67.94	2.46	28.69	7.10
Substitute	97	1.3	66.65	2.27	20.74	5.03
Recruit	63	0.8	67.72	2.86	22.41	5.92
Bounty Recipient	162	2.1	67.35	2.29	23.26	6.80
Type of Unit						
Infantry	5131	68.1	67.88	2.53	24.05	6.84
Cavalry	1617	21.5	68.06	2.55	24.03	6.55
Artillery	541	7.2	68.14	2.53	25.62	7.08
Reserve Inf.	248	3.3	68.49	2.48	23.33	5.41
Age						
Under 15	12	0.2	62.73	5.12		
16	30	0.4	64.93	3.15		
17	113	1.5	66.03	2.41		
18	1171	15.5	66.70	2.29		
19	796	10.6	67.56	2.50		
20	665	8.8	67.92	2.33		
21	842	11.2	68.35	2.32		
22	573	7.6	68.25	2.52		
23	480	6.4	68.38	2.42		
24	352	4.7	68.49	2.41		
25–49	2496	33.1	68.48	2.50		
50+	7	0.1	67.89	3.51		
Largest town in county of birth (at closest census)						
< 5,000	6315	83.8	67.98	2.54	24.03	6.82
5,000–9,999	286	3.8	67.79	2.67	29.13	8.23
10,000–24,999	797	10.6	67.99	2.43	23.04	6.97
25,000+	139	1.8	67.24	2.42	25.24	6.87
Regional[a]						
Allegheny Co.	1520	18.9	67.77	2.58	23.04	6.01
Mntn/Mineral	1973	24.6	68.07	2.42	24.35	6.83
Southern Hinterland	2144	26.7	68.30	2.47	24.52	6.80

TABLE 8. Mean Height and Age by Category—Western Sample (*Continued*)

	N	%	Mean Height	SD	Mean Age	SD
Northern Hinterland	878	10.9	68.35	2.57	23.93	6.46
Lake Transport	609	7.6	67.61	2.57	23.10	6.05
Isolated Agric.	910	11.3	68.51	2.52	22.82	5.91

a. This section is based not on the western sample but rather from all observations (statewide and western sample) for men born in the western region. See Table 2 for definitions of these regions.

TABLE 9. Mean Height and Age by Category—Statewide Sample

	N	%	Mean Height	SD	Mean Age	SD
Entire Sample	11953	100.0	67.49	2.51	24.52	6.96
Birth Cohort						
1815–1819	198	1.7	68.05	2.26	45.02	3.14
1820–1824	501	4.2	68.15	2.37	41.20	2.11
1825–1829	873	7.3	68.06	2.41	35.97	1.97
1830–1834	1232	10.3	68.08	2.46	30.64	2.08
1835–1839	2339	19.6	67.93	2.42	25.23	2.03
1840–1844	4754	39.8	67.48	2.43	20.58	1.81
1845–1849	2056	17.2	66.21	2.49	18.27	0.85
Enlistment Year						
1861	2936	24.6	67.83	2.65	23.99	6.68
1862	2166	18.1	67.80	2.43	24.10	6.46
1863	640	5.4	67.27	2.44	25.17	6.23
1864	4661	39.0	67.34	2.44	24.92	7.28
1865	1550	13.0	66.97	2.48	24.65	7.29
Occupation						
Farmer	3543	29.6	67.84	2.56	23.85	6.68
Proprietor	564	4.7	67.25	2.51	23.72	6.21
Professional	69	0.6	68.35	2.36	29.25	7.25
Work Site Only	58	0.5	67.92	2.54	26.16	6.96
Skilled Worker	3882	32.5	67.43	2.39	25.66	7.24
Unskilled Worker	3458	28.9	67.22	2.54	24.12	6.93

TABLE 9. Mean Height and Age by Category—Statewide Sample (*Continued*)

	N	%	Mean Height	SD	Mean Age	SD
None (Student)	95	0.8	67.59	2.84	20.04	3.05
Unknown	284	2.4	67.44	2.79	23.72	6.09
Rank						
Officer	46	0.4	68.38	2.07	30.09	6.55
Non-comm	976	8.2	68.27	2.40	25.10	5.81
Private	6741	71.1	67.41	2.50	24.31	7.00
Musician	67	0.6	65.22	3.12	21.39	6.18
Artisan	31	0.3	67.33	1.88	26.61	5.95
Unknown	2331	19.5	67.50	2.51	25.01	7.16
Enlistment Status						
"Standard"	8629	72.2	67.52	2.52	24.30	6.80
Drafted	337	2.8	67.57	2.28	29.33	7.47
Substitute	209	1.7	66.50	2.44	21.50	6.71
Recruit	61	0.5	67.73	2.48	22.66	6.48
Bounty Recipient	387	3.2	67.26	2.66	24.13	6.82
Unknown	2330	19.5	67.51	2.48	25.01	7.16
Type of Unit						
Infantry	9800	82.0	67.47	2.52	24.75	7.09
Cavalry	1187	9.9	67.72	2.45	23.29	6.17
Artillery	711	5.9	67.40	2.50	23.81	6.42
Reserve Inf	255	2.1	67.44	2.61	23.35	5.59
Age						
Under 15	9	0.1	61.36	3.72		
16	56	0.5	64.04	3.97		
17	228	1.9	65.99	2.51		
18	1799	15.1	66.36	2.35		
19	1215	10.2	66.99	2.49		
20	1016	8.5	67.46	2.38		
21	1184	9.9	67.82	2.33		
22	786	6.6	67.77	2.41		
23	725	6.1	67.86	2.52		
24	593	5.0	67.86	2.47		
25–49	4327	36.2	67.99	2.41		
50+	15	0.1	68.45	1.83		

TABLE 9. Mean Height and Age by Category—Statewide Sample (*Continued*)

	N	%	Mean Height	SD	Mean Age	SD
Largest town in county of birth (at previous census)						
< 5,000	9606	80.4	67.54	2.54	24.39	7.08
5,000–9,999	1164	9.7	67.25	2.30	24.92	6.32
10,000–24,999	366	3.1	68.01	2.65	23.84	5.03
25,000+	817	6.8	66.93	2.30	25.80	6.88
By Statewide Regions[a]						
Southeastern						
with Phila Co.	3659	34.0	66.99	2.41	24.89	7.14
w/out Phila Co.	2654	24.6	67.13	2.38	25.04	7.19
Phila Co.	1005	9.3	66.63	2.46	24.50	7.00
Anthracite	1401	13.0	67.01	2.52	23.82	6.55
Pocono	73	0.7	68.23	2.20	25.88	7.15
Northeastern	603	5.6	68.01	2.49	24.22	7.12
Ridge & Valley	1704	15.8	67.82	2.37	25.36	7.26
Allegheny Forest	535	5.0	67.98	2.40	24.36	6.30
Western						
with Algny Co.	2794	25.9	68.13	2.52	23.57	6.31
w/out Algny Co.	2291	21.3	68.22	2.48	23.70	6.40
Algny Co.	503	4.7	67.72	2.66	22.95	5.84

a. Summed percentages do not total 100% because of double listing of Philadelphia and Allegheny Counties. Percentages based on the number of cases with valid county codes.

Migrant/non-migrant status Economic and social historians interested in the nature of migration and its effect on economic development have long examined the characteristics of the persons who left one place bound for settlement elsewhere in order to assess the differences between those who migrated and those who stayed behind. Sokoloff and Villaflor's study of French and Indian War and Revolutionary War soldiers found that men who migrated across county lines but within a single state, during the years between birth and enlistment, exhibited no difference in maximum adult height, whereas those crossing state boundaries did.[94] The latter had a height advantage of 0.45–0.85 inches over their less mobile counterparts, after accounting for other variables. Margo and Steckel note that, in their analysis of Fogel's

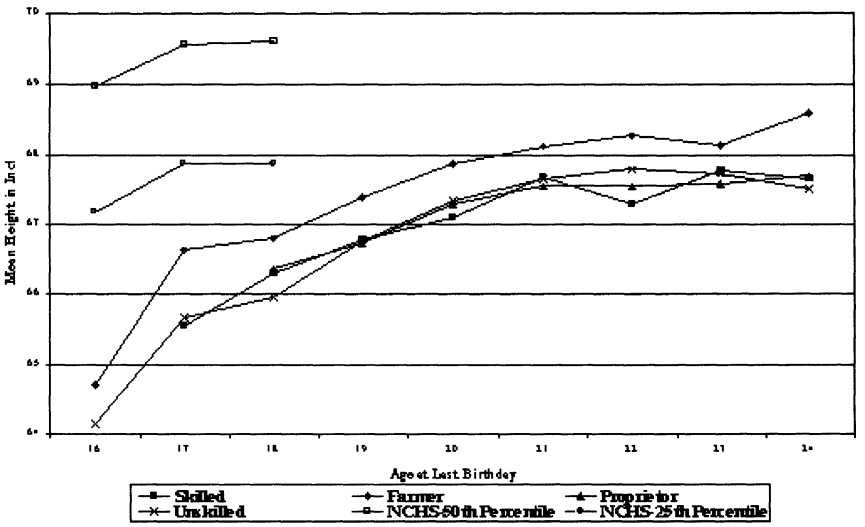

FIGURE 6: Height by Age by Occupation: Pennsylvania-Born Civil War Soldiers, Statewide Sample & NCHS Standards (1977)

national sample of Civil War soldiers, short-distance migrants (which they defined as men moving within census-based regions) exhibited no difference in stature over non-migrants. However, long-distance migrants moving into the West were "significantly" taller (0.7–0.9 inches).[95]

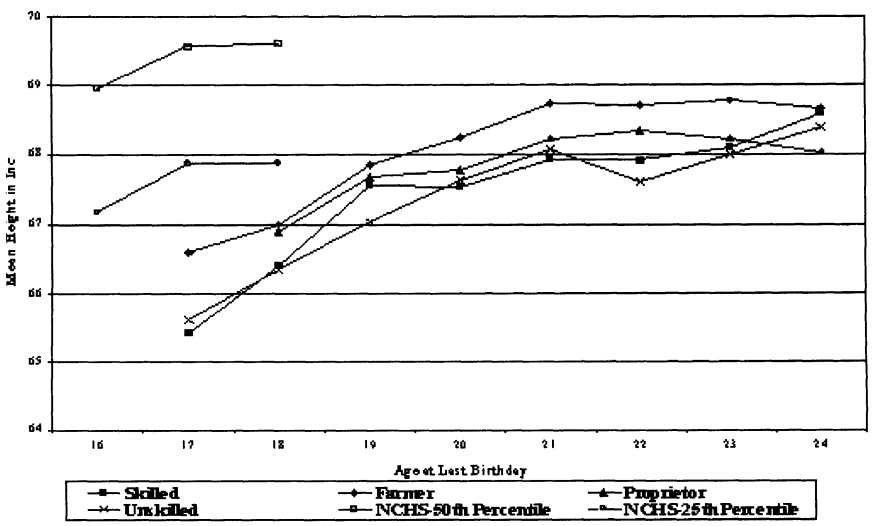

FIGURE 7: Height by Age by Occupation: Pennsylvania-Born Civil War Soldiers, Western Sample & NCHS Standards (1977)

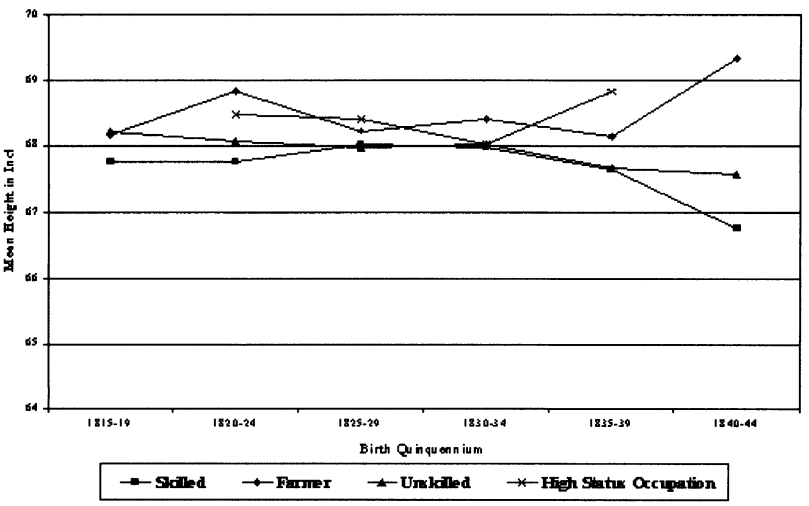

FIGURE 8: Adult Height by Occupation: Pennsylvania-Born Civil War Soldiers Statewide Sample

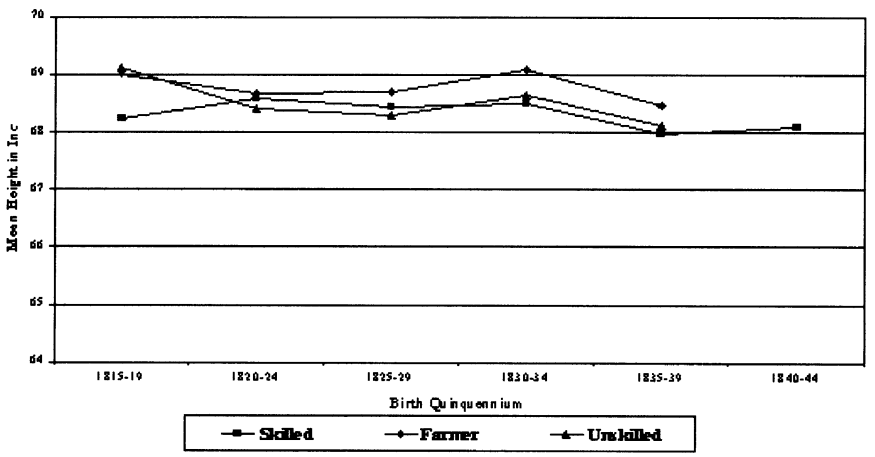

FIGURE 9: Adult Height by Occupation: Pennsylvania-Born Civil War Soldiers Western Sample

A sample which only includes Pennsylvania-born men obviously can only be used to evaluate in-state migration. The height of migrants, men who enlisted in a county other than the one in which they were born, were not consistently different from those of non-migrant men. The height difference in the western sample, while statistically significant, is small, less than two-tenths of an inch. Statewide, however, an opposite pattern is evident. Stayers are taller than leavers, but again by a very small and statistically insignificant

amount. These findings are, in the main, consistent with the results reported by Sokoloff and Villaflor, and Margo and Steckel. Men who migrated short distances were not particularly different from men who did not.

Statewide Variation in Height

When examined spatially or in conjunction with proxies for various types of economic activity, anthropometric data can provide insights into the relationship of economic development and net nutritional status across the Keystone State. Most generally, those regions in Pennsylvania which were most urbanized or most heavily involved in market directed economic activity, i.e., least self-sufficient, displayed the lowest mean stature levels.

Birth Cohort and Regional Stature Patterns

The antebellum stature time trends in the Pennsylvania statewide and western samples are consistent with the trends found in other studies of the antebellum United States. From the 1820–24 through the 1840–44 quinquennia, a slight and uneven fall in mean stature of about two-thirds of an inch occurred in both

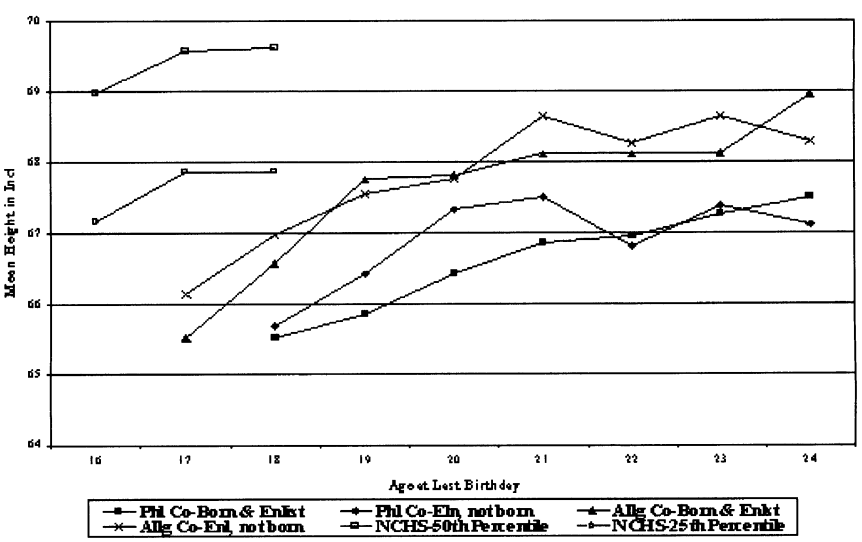

FIGURE 10: Pennsylvania-Born Civil War Soldiers Height by Age: Urban Enlistment County

samples (Tables 8 and 9).[96] The mean data show an upward "blip" of two-tenths of an inch in the western sample in the 1830–34 cohort and a much smaller jump statewide. Regression analysis reveals that, after adjusting for other variables, this general trend—a decline between 1820 and 1844 with a one quinquennium upward jump in the 1830–34 cohort—is still present in the western sample but a somewhat slower, steadier decline occurred statewide. The stature differences in the statewide sample between the earlier and later quinquennia are only weakly statistically significant and on the order of one-quarter inch.

The same time trend is apparent across the occupational spectrum. If the samples are disaggregated by occupational category the mean height for each of the categories follows a trend similar to the one described above. While there is a degree of variability, especially in the early quinquennia in which there are relatively few observations, the trend is rather consistent with falling mean height evident over the entire period, although again, not monotonically. Just as forces had produced an occupational gradient in height by the early nineteenth century, so they caused mean average stature to fall in the later antebellum years. One small, but important, exception is the height of the professionals in the statewide sample, which do not decline in the second half of the 1830s.[97]

Regional analysis of height variation reveals patterns that support the view that men in areas least involved in market activity benefited biologically from their separation.[98] An aggregate view of age standardized height by county for men born between 1815 and 1844 is presented in Figure 11.[99] The overall east-west and north-south gradients in height are immediately evident moving away from Philadelphia.[100] Philadelphia County never had a mean height above 99.25 per cent of the state average over the 1815–1844 period. However, the relatively low stature levels exhibited by Philadelphia County's birth cohorts are not restricted to that county hard on the banks of the Delaware River. Short soldiers were found across the whole of the southeastern corner of the state. It is especially noteworthy that Lancaster County, renowned for its productive farms and shipments of agricultural produce to both the Philadelphia and Baltimore markets, nonetheless, failed to reach the state average except for one quinquennium.

This pattern is not perfectly uniform, however, as several counties in the Western Region had average or below average heights. These include Erie and Crawford, two counties that were integrated early into an interregional trading network because of their access to Lake Erie. Allegheny County, the

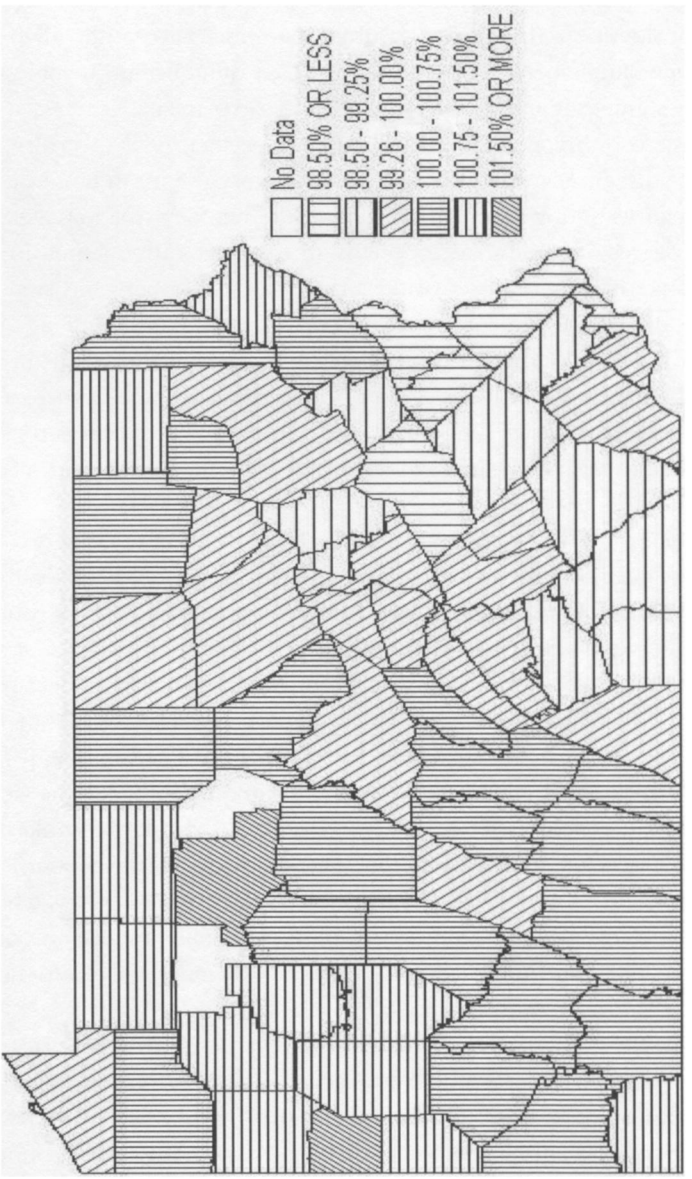

FIGURE 11: Mean Age Standardized Height by County, 1815–44

most urbanized county in the western region, had height levels near the statewide mean, roughly equivalent to those of Erie and Crawford. The tallest men were found in the most remote counties, Mercer, Lawrence, and Greene.

Regional trends reveal two primary groupings (Figure 12).[101] The Anthracite and Southeast regions had age standardized heights which, with one exception, were below the state mean for the entire period. In contrast,

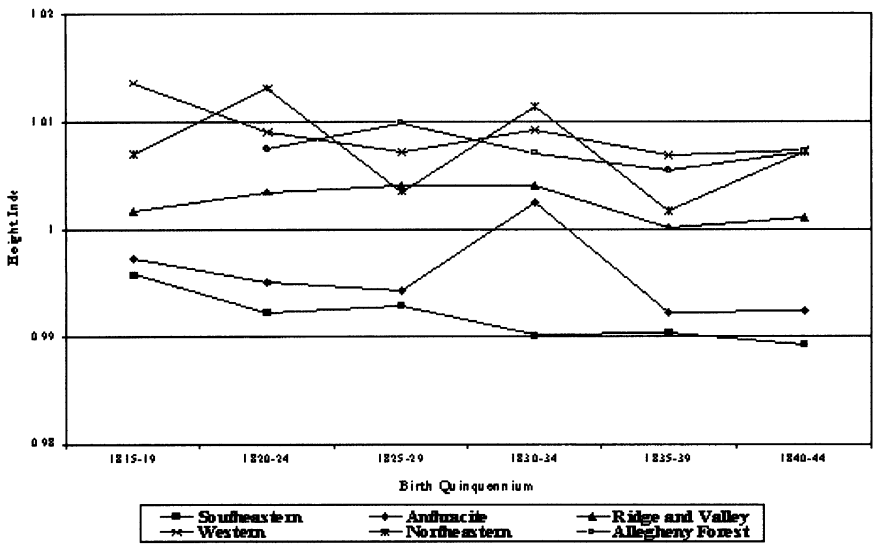

FIGURE 12: Pennsylvania-Born Civil War Soldiers Standardized Height by Region

mean stature in the Ridge and Valley, Allegheny Forest, Northeast, and Western regions was consistently above the state average. The height-by-age profiles reveal a similar regional ranking by height (Figures 13 and 14).[102]

With the exception of the Ridge and Valley region, the regions with the greatest mean stature were found in the most isolated parts of the state. Yet a slight downward trend in mean stature is evident in all regions across the 1815–1844 period.

Occupational composition variation does not seem to be the basis for the regional disparity in mean height. The relative position of the regions is maintained, as is the basic time profile, across the three largest occupational groupings, farmers, unskilled workers, and skilled workers, though with some greater variability due to the reduction in cell sizes.[103] However, age standardized stature reductions were concentrated more among the unskilled and skilled workers than with farmers. Farmers displayed a more stable

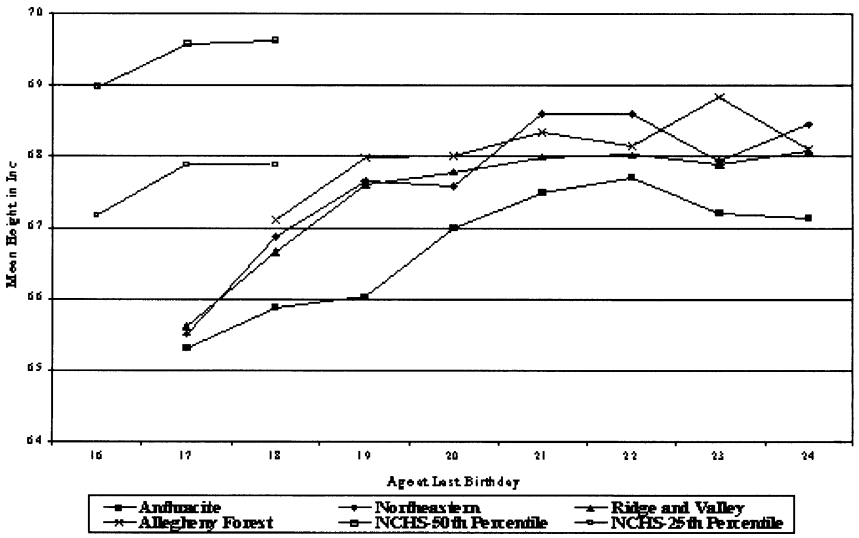

FIGURE 13: Pennsylvania-Born Civil War Soldiers Height by Age: Non-Urban Birth Regions

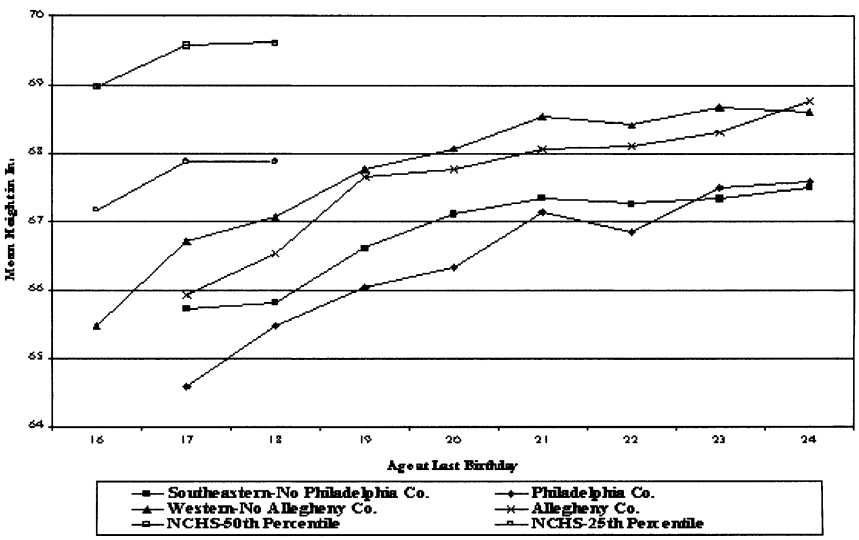

FIGURE 14: Pennsylvania-Born Civil War Soldiers Height by Age: Urban Birth Regions

height profile in the 1830s. The 1840–44 cohort of Western farmers had mean heights nearly identical to that of the 1815–19 group.

Regression analysis does not alter the statewide story described above. Men from the Southeastern and Anthracite Regions were almost a full inch shorter than

men from the Western Region. These coefficients, along with much smaller ones (in absolute value) for the other regions, are consistently statistically significant under numerous formulations. Only the adult men from the undeveloped Allegheny Forest were as tall as the men in the Western Region, and those from the Pocono and Northeastern Regions were insignificantly different, in statistical terms, from heights prevailing in the West. The large variation between the Southeast and the West is not simply a function of the number of Philadelphians in the sample. The results remain unaffected if all Philadelphia County born men are removed from the data set.

Pennsylvania's urban residents, less than fifty years after the Revolutionary War, had a significant deficit in height relative to their rural neighbors. Sokoloff and Villaflor's study of revolutionary-era American soldiers found no significant difference between these groups, although later work on early national period samples did.[104] The disparity between those born in the most urbanized county in the state, Philadelphia, compared to residents of the "non-urban" counties of the Western Region, was 1.0–1.5 inches throughout the growth years (Figure 14).[105] Even after accounting for their Southeastern Region of birth, which is associated with about a one inch height deficit compared to the Western Region, the mean stature of men born in counties containing towns with a population of 25,000+ carried an additional penalty of 0.5 inches relative to men born in counties with no towns larger than 5000 persons. This implies that the difference between rural men born in the Western Region and those born in Philadelphia was a substantial 1.5 inches. Between the birth cohorts of the 1770s and the 1820s, conditions changed significantly enough so that Pennsylvanians born in Philadelphia County were more than an inch shorter than residents of the most rural counties.

The large sample of Civil War soldiers drawn from the Western Region allows a more disaggregated analysis of this area.[106] The region was divided into six sub-regions (Table 2). Sub-regions were determined by geography, topography, the nature of economic activity, and the relationship to Pittsburgh, the region's major city. Because of its urban character, Allegheny County is considered separately. The far southwest corner of the state, which had the oldest agricultural settlements and most mature agricultural system in Western Pennsylvania, is considered as the Southern Hinterland, made up of Fayette, Greene, Washington, and Westmoreland Counties. Its name reflects its connection to the Pittsburgh market via the Monongehela and Youghigheny Rivers. The Mountain/Mineral sub-region, made up of Armstrong, Cambria, Indiana, and Somerset Counties, had difficult terrain,

only moderately productive agricultural soils, and large deposits of bituminous coal. Butler and Beaver Counties, tied to Pittsburgh by the Ohio River as well as by a series of overland routes, comprised the Northern Hinterland. Throughout most of the antebellum period they were predominantly agricultural, although industrial production began to develop about 1860 especially along the Ohio River. Two productive agricultural counties, Mercer and Lawrence, formed the Isolated Agricultural sub-region. They were not settled until very late in the eighteenth century, and until late in the antebellum period transportation routes did not effectively connect them to the rest of the region. In the far northwest corner of the state, Erie and Crawford Counties made up the Lake Transport sub-region. With only moderate per capita crop production levels, this sub-region was the nexus of transshipment of goods from western Pennsylvania to Buffalo and other lake ports.

Mean heights varied widely across the region. In the most isolated agricultural lands of Mercer and Lawrence Counties, adult mean heights were a full inch over the average for Erie and Crawford Counties, with smaller differences between the other sub-regions (Figure 15). These differences are consistent in size and significance using several different regression models. The differences in height between the Isolated Agricultural area and the Mountain/Mineral Region and the Southern Hinterland were about half as large. After adjusting for other variables, Allegheny County had mean heights slightly less than one-half inch below those of the Isolated Agricultural region. The differences in height between the Northern Hinterland and the Isolated Agricultural Region were insignificant.

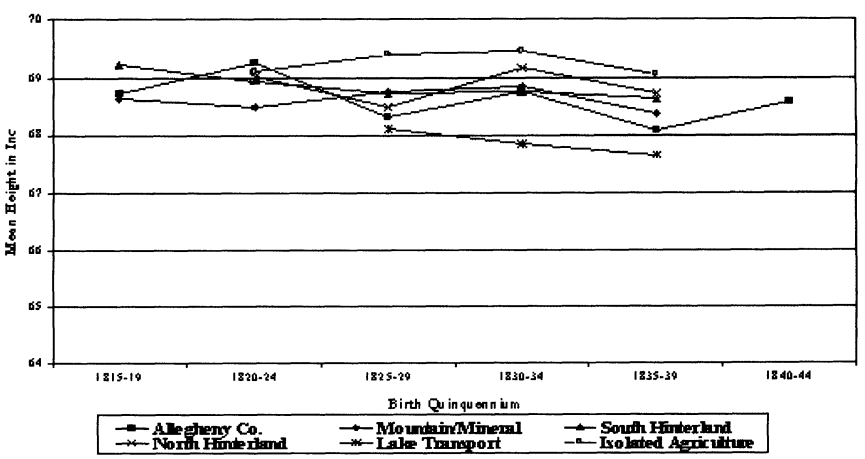

FIGURE 15: Pennsylvania-Born Civil War Soldiers Adult Male Height: Western Sub-Regions

The temporal patterns of height in the Western sub-regions were somewhat different from those in the rest of the state. Except for the Lake Transport Region which had heights between one and one and one-half per cent below those of the rest of the West, heights across the Western Region varied in a narrow band between 1.5–1.75 per cent higher than the state mean. Region-wide temporal decline is evident only in the last quinquennium. Prior to that, stature declines were concentrated in Allegheny County. The pronounced decline in heights statewide during this period is not as clear in the West.[107]

An important pattern *within* the Western Region is similar to that across the rest of the state. Men born in the most recently settled sub-region, the counties least connected by transportation routes, the Isolated Agricultural Region, were the tallest. Those areas with the greatest concentration of population and most connected with the other regions, Allegheny County, the Lake Transport, and Mountain/Mineral Regions, had noticeably lower mean heights.

Variation by County Economic Characteristics

The trends described above are not artifacts of sample composition and cannot be explained by age or occupational variation within the sample of early nineteenth-century Pennsylvanians. Hypotheses by other anthropometric researchers explain antebellum stature variation by the propinquity to food resources and by remoteness from urban centers, with their burdensome disease environments, and their markets for food. Regional, occupational, and age-standardized analysis of variation in height indicates that the regional patterns expected on the basis of such hypotheses are obtained in this sample of Pennsylvanians as well. Areas least densely populated, least tightly connected by transportation routes, and most agriculturally based had mean stature levels significantly above regions at the other end of the developmental continuum. Even these small regions, however, were characterized by disparate economic and social circumstances. These patterns can also be evaluated at a level of aggregation below the regional one in order to account for more localized variation across the Commonwealth. In order to do so, multivariate regression analysis using data on the economic characteristics of counties with all the requisite data was used to evaluate the correlates of height.[108]

A series of proxies was developed to characterize the economies of the counties in the antebellum period.[109] The level of economic development is

represented by the proportion of the population involved in agriculture. Propinquity to nutrients is proxied by the number of swine per capita, the per capita dollar value of dairy production, and the number of per capita surplus calories per day (in thousands) and grams of surplus protein (in hundreds) generated in the birth county.[110] Several potential proxies for the intensity of the disease environment were tested. These include population density, the percentage of the county population living in places with populations over 2500, over 10,000, and over 25,000, as well as the size of the largest city (in the census year nearest to the year of birth). The extent of market participation was proxied by the per capita value of market garden production and by the per capita value of home manufactures. Access to economic markets was proxied by 1845 average land values as well as by the presence of a navigable water transport route in 1850.[111] Anticipating that wealth would provide access to nutritional resources, the per capita value of agricultural and manufacturing assets in the county of birth in 1850 was also included in the equation.[112] Variables to control for occupation, the year of enlistment, "migrant" status, and the quinquennium of birth were also included, as was a dummy for the region of birth. The latter served as a proxy variable for some of the unexplained, but regionally associated, variation.

Regressions were run including these variables on the restricted statewide sample described above. The exercise was then repeated excluding the men born in the city and county of Philadelphia in order to ascertain the extent to which the results were influenced by this rather atypical region. Regression coefficients for the non-economic/non-demographic variables remain basically the same as reported previously. The inclusion of these new proxy variables does not have an effect on those results. The basic time profile of stature between 1820 and 1839 remains as previously described. Even after accounting for the economic variables, farmers had a significant stature advantage of four-tenths of an inch or larger, depending upon the model. Other occupational variables did not reach the level of statistical significance, although the near equivalence of the stature of skilled and unskilled workers remained. Migrants in both samples were taller than stayers, but not at a statistically significant level.

Several variables consistently appear the most closely linked to stature variation across the 29 counties in the statewide sample. Regardless of the model, the per capita number of swine and the presence of water transportation routes within the county of birth are two variables with the largest consistent relationship to stature variation.[113] The presence of a large number of

hogs per capita in the county of birth is associated with greater stature, while the presence of a navigable water route is associated with lesser stature. When observations for Philadelphia County and dummy regional variables are included in the model, a one standard deviation change in the level of swine per capita yields a two-third inch increase in anticipated stature levels, while the presence of water transportation in the county of birth was associated with nearly one inch lesser height.[114] Other strongly influential variables in statewide-sample regressions include protein and calorie surpluses per capita, the dollar value of dairy production, and the dollar value of home manufacturing. Each is associated with approximately a two-tenth of an inch increase in stature for each one standard deviation positive change in the independent variables. A series of variables with negative coefficients, including the dollar value of market gardening, the mean land value, and population density, are not as statistically significant, nor do they have such a large absolute influence on stature. The percentage of the work force employed in agriculture also had a significant positive effect on stature levels. Dummy variables for the presence of a town in the county of birth or enlistment generally carried negative coefficients ranging from a 0.48 inches for birth in a county containing a town of 25,000 or more persons to -0.34 inches for enlistment in such a county. The coefficient on birth in a county containing a town of 5–10,000 population was negligible. In sum, the signs of the variables were quite consistent with the hypothesis noted earlier. The proxies for propinquity to nutrients (protein and calorie surpluses, swine stocks, and dairy production levels) were all positively correlated with stature, as in some other samples.[115] The positive impact of ready access to nutrients apparently outweighed the negative influence of disease exposure which might also have been associated with these indicators. Distance from markets and urban centers proxied by low dollar values of market gardening, low population concentration levels, and high home manufacturing levels were all correlated with greater stature and thus higher net nutritional status. Connections to markets proxied by the availability of water transportation, high dollar value of market gardening, and high population concentration levels were associated with lower stature. Further analysis indicates that these statewide results did not arise from the statistical dominance and uniqueness of the Philadelphia-born in the sample. Therefore, the link between market participation and stature levels is not simply a function of the effects of the huge Philadelphia urban center on its residents. Rather, the net nutritional effect of a large city spreads well beyond the urban area's boundaries.

Conclusion: What Has it Told Us? What Might it Tell Us?

The analysis presented above confirms and expands upon earlier findings within historical anthropometric literature and points the way for further efforts. Pennsylvanians who fought in the American Civil War had a mean height that ranged between the twentieth and thirty-fifth percentiles of modern height standards. However, they were probably among the tallest populations in their world, with considerably greater stature than their European contemporaries.[116] Men born in western Pennsylvania were taller than the statewide average and had height levels between those of their Midwestern neighbors and their "cousins" in Philadelphia. Statewide stature levels reflect the relatively easy access to nutrients, the extremely productive soil, the favorable climate, as well as the low level of large-scale urbanization in early nineteenth-century Pennsylvania. Similar stature levels would not be achieved by the majority of even West Europeans until the turn of the twentieth century.[117]

The decline in mean stature described by most studies of the antebellum United States is uniformly evident in these samples as well. It is more clearly apparent in the statewide sample and concentrated more among skilled and unskilled workers than in other occupational categories. Farmers' heights in the Western Region show very little decline in this period. They also tended, as did farmers across Pennsylvania, to have mean heights greater than most other occupation groups.

One can infer on the basis of physical stature that men of meaner and meaner estate were pulled into the Civil War as it dragged on. Proprietors and other upper-middle-class persons comprised an increasingly smaller proportion of the enlistees between 1863 and 1865. The latter's mean height reflected their social and political advantages. A height gradient by military rank, somewhat related to the occupational gradient but not fully explained by it, was identified. This seems to be a functional outgrowth of height variation.

Men from counties which were the least involved in market activity and least developed economically were significantly taller than men in more market integrated locales. Stature was positively and strongly correlated with the production of home manufactures and negatively related to the level of market gardening. Men from counties with the largest proportions of their work force in agriculture tended to be taller, as were men from counties without water transport routes—the latter were not linked to distant markets. In antebellum Pennsylvania, being self-sufficient obviously conferred nutritional

advantages. Those who were economically "behind" literally looked down on those who were "ahead."

Distance from markets was not the sole factor related to greater stature. Propinquity to nutrients, the per capita levels of swine stocks, dairy production, and protein and calorie surpluses were all positively correlated with height. While having a somewhat weaker effect, county population characteristics also influenced stature trends. Population density and the presence of large cities in the counties of birth and/or enlistment were negatively related to stature. The case of relatively short men in agriculturally productive Lancaster County highlights the interplay of factors. While large quantities of foodstuffs were harvested in this county, and a considerable nutritional surplus produced, this was not sufficient to generate a high nutritional status for the children growing up there. Either the disease effects associated with being close to an urban center or familial choice to market high value protein foods outweighed the effect of being close to large amounts of proteins and calories. As the cases above indicate, the presence of a navigable water route in Erie County and one in Clearfield County are not equivalent because of who and what was at the other end of that water route and how long it took to reach its terminus. Protein and calorie surpluses in Lancaster County, destined for sale in Philadelphia or Baltimore, clearly mean something different from surpluses of similar size in isolated Tioga County. Statistical analysis can outline the relationship between economic and demographic variables and stature, however, understanding the full pattern also requires knowing the nature of the places and of the connection (or lack thereof) between them.

Future Directions

To date research in Pennsylvania history via anthropometric techniques has informed several fields of study. Civil war historians have been provided with another angle on who the men who fought for the Union from Pennsylvania were and the shifts in their characteristics over the years of the conflict. Those interested in the economic development of the state now know that, from a biological perspective, the economic outcomes of life in Pennsylvania were much better than those in Europe for men of similar classes. Additionally, the net nutritional outcomes of economic development in Pennsylvania varied significantly from region to region within the state. This pattern of regional variation is consistent with patterns found in

Europe in the early phases of modern economic growth. Areas less tightly linked to distant markets, i.e., more self-sufficient, displayed greater stature than those regions, highly urban or otherwise, that were heavily involved in market-based production.

Unfortunately, the patterns of biological well-being which have been developed have relied nearly entirely on measurements and records for males. Efforts to find data sets which record height for significant numbers of women in the eighteenth or nineteenth centuries are still being sought. (Pennsylvania's prison registers provide one possible source, although it is a source with obvious selection issues.) Since those few data sets which record women's heights indicate that trends in women's stature do not move in synchronicity with those of men, more data on females and children would enable researchers to better understand the interplay of economic change, culture and health. School and orphanage records might provide some data relative to children, however, again sample selectivity issues may be a concern. As a northern state with a notable, but small African-American population, few observations for African-Americans who experienced their growth years in Pennsylvania are available from the antebellum period.[118]

While numerous studies of the antebellum United States have been conducted, few have examined trends in biological well-being for birth cohorts from the decades following the Civil War. With support from the Pennsylvania Historical and Museum Commission and the Economic History Association, I have collected and digitized an 8,000 observation sample of men who enlisted in Pennsylvania's National Guard between 1866 and 1918. Analysis of this data, which will require the application of the statistical techniques needed to account for the fact that there were minimum height requirements imposed on potential guardsmen, will begin next year, and should provide evidence of some of the outcomes of economic activity across Pennsylvania in this period of rapid large-scale industrialization and urbanization.

From the perspective of the historian of Pennsylvania, anthropometric techniques have deepened our understanding of life in the commonwealth in the early nineteenth century and hold the promise of informing us about other periods as well. However, and potentially most importantly, the use and purpose of such an approach makes explicit to the reader the multi-dimensional nature of human well-being and the many faceted outcomes of economic activity. In a society dominated by images of consumption and the assumption that increased consumption is the ultimate goal of economic activity, this work points to the fact that economic activity has many consequences, some

immediately obvious, others not. It points out that the results from economic activity, literally can be bad for your health, and that historians examining the "well-being" of any society must use multiple rulers to take that measurement and fully understand the nature of the outcomes.

NOTES

1. Thanks are due to the many individuals who helped me to locate, collect, make machine-readable, code, and manipulate the stature data utilized in this study. They include Michael Meier (U.S. National Archives), Jonathan Stayer (Pennsylvania State Archives), Anne Leonard, Mark Pietrzyk, Dave Sherman, Ed Danielson, Christina Sherman, Eric Foltyn, Meredith Ridl, Matt Boccardi, Kristin Kronstain, Jackie Faber, Matthew Kurtz, Abigail Sumpter, Laura Cuff, Margaret Cuff, Carolyn Cuff, Evann Garrison, Phil Sidel and Eileen S. Kopchik, Ann Throckmorton, and Todd Fleckenstein. Financial and material support was provided by the University of Pittsburgh Faculty of Arts and Sciences, the University's Department of History, and the Pennsylvania Historical and Museum Commission. Many friends and colleagues read all or portions of the manuscript from which this article is an off-spring. They include Eric Davin, Paul Riggs, Mike Naragon, Sue Corbesero, Sam Farmerie, Jim Hines, John Murray, Tom Weiss, Lee Craig, Joerg Baten, Farley Grubb, W. Peter Ward, Michael Haines, and Bernard Harris. To each of the thoughtful and congenial scholars who composed my dissertation committee and advised me on the work out of which this article originated, Van Beck Hall, Ted Muller, Richard Steckel, and Jerome Wells, I will always be indebted. My greatest professional appreciation, however, is reserved for John Komlos. He inspired, encouraged, promoted, and supported (emotionally and financially) my efforts to complete my thesis and turn it into a book as well as to publish this and a series of related articles. Thanks are also in order to two anonymous reviewers and the editor of this journal for their thoughtful critiques and suggestions as well as to participants in the October 2005, PHA meeting in Pittsburgh, at which an earlier version of this paper was presented. However, as is almost always the case, without the support and love of my wife and children, my parents, and my siblings, this work would not have been completed. Many thanks are due to the members of my immediate and extended families.

2. Noel Cameron, "The Methods of Auxological Anthropometry," in *Human Growth: A Comprehensive Treatise*, 2nd ed., Vol. 3, ed. F. Falkner and J.M. Tanner, (New York: Plenum, 1986), 263–281.

3. John Komlos, ed., *The Biological Standard of Living in Europe and America 1700–1900. Studies in Anthropometric History* (Aldershot, England: Variorum Press, 1995); John Komlos, ed., *The Biological Standard of Living on Three Continents: Further Essays in Anthropometric History* (Boulder: Westview Press, 1995); Bernard Harris, "Health, Height, and History: An Overview of Recent Developments in Anthropometric History," *Social History of Medicine* 7 (1994): 297–320.

4. Most of these findings will be drawn from the research presented in my book, *The Hidden Cost of Economic Development: The Biological Standard of Living in Antebellum Pennsylvania*. (Aldershot, England: Ashgate Publishing, Ltd., 2005), however, it draws on the extensive work which has preceded my own by many earlier researchers.

5. Net nutritional status signifies total caloric intake minus the caloric demands of basal metabolism, disease resistance and physical exertion. Remaining calories are available to fuel growth. Robert W. Fogel, "Nutrition and the Decline in Mortality Since 1700: Some Preliminary Findings," in *Long-Term Factors in American Economic Growth*, ed. Stanley Engerman and Robert Gallman (Chicago: National Bureau of Economic Research, 1987), 446–447.
6. World Health Organization Expert Committee on Maternal and Child Care, "New Trends in the Delivery of Maternal and Child Care in Health Services," WHO Technical Report Series, #600 (Geneva: World Health Organization, 1976), 95; Tadeusz Bielicki, "Physical Growth as a Measure of the Economic Well-Being of Populations: The Twentieth Century," in Falkner and Tanner, *Human Growth*, 283. However, unlike contemporary researchers in the less developed countries, who can collect new data pertaining to their respective populations, historians must be content with extant data from the past.
7. David Eltis, "Welfare Trends Among the Yoruba in the Early Nineteenth Century: The Anthropometric Evidence," *Journal of Economic History* 50 (1990): 522; Robert W. Fogel, S. Engerman, R. Floud, G. Friedman, R. Margo, K. Sokoloff, R. Steckel, J. Trussell, G. Villaflor and K. Wachter, "Secular Changes in American and British Stature and Nutrition," *Journal of Interdisciplinary History* 14 (1983): 445–447.
8. R. Floud, K. Wachter, and A. Gregory, *Height, Health, and History: Nutritional Status in the United Kingdom, 1750–1980* (Cambridge, England: Cambridge University Press, 1990), 286–287. As Steckel has noted, using stature as an indicator of economic well-being is congruent with Sen's recent emphasis on functionings and capabilities as the basis for evaluating the efficacy of an economic system, as well as with Adelman and Morris' basic needs approach to living standards. Richard Steckel, "Height, Living Standards, and History," *Historical Methods* 24 (1991): 183–187.
9. John Komlos, "Stature and Nutrition in the Habsburg Monarchy: The Standard of Living and Economic Development in the Eighteenth Century," *American Historical Review* 90 (1985): 1149–1161; for recent contributions see the special issue, "Historische Anthropometrie," Guest Editor, John Komlos, *Jahrbuch für Wirtschaftsgeschichte*, 2000, no. 1. Also see two special issues of *Social Science History* which were devoted to articles either presenting or describing anthropometric historical research (1982, Volume 6, #4 and 2004, Volume 28, #2).
10. Dora L. Costa, "Height, Weight, Wartime Stress, and Older Age Mortality: Evidence from the Union Army Records," *Explorations in Economic History* 30 (1993): 424–449; Robert W. Fogel, "The Conquest of High Mortality and Hunger in Europe and America: Timing and Mechanisms," in *Favorites of Fortune: Technology, Growth, and Economic Development Since the Industrial Revolution*, ed. P. Higonnet, D.S. Landes, and H. Rosovsky (Cambridge, MA: Harvard University Press, 1991), 33–71; Timothy Cuff, "The Body Mass Index Values of Nineteenth-Century West Point Cadets: A Theoretical Application of Waaler's Curves to A Historical Population," *Historical Methods* 26 (1993): 71–83; Thomas E. Jordan, "Linearity, Gender, and Social Class in Economic Influences on Heights of Victorian Youth," *Historical Methods* 24 (1991): 116–123; W. Peter Ward, and Patricia C. Ward, "Infant Birth Weight and Nutrition in Industrializing Montreal," *American Historical Review* 89 (1984): 324–345; W. Peter Ward, *Birth Weight and Economic Growth: Women's Living Standards in the Industrializing West* (Chicago: University of Chicago Press, 1993).
11. This section draws upon James M. Tanner's comprehensive book on this topic, *A History of the Study of Human Growth* (Cambridge: Cambridge University Press, 1981).

12. Tanner, *Study of Human Growth*, 32–33, and 65.
13. Tanner, *Study of Human Growth*, 98.
14. The earliest systematic military records date from the early 1700s. Tanner, *Study of Human Growth*, 99–101, 142–4; and private communication with Michael Meier, Military Reference Branch, U.S. National Archives, Washington, D.C.
15. Tanner notes Bergmuller's book of growing children's proportions (1723), Buffon's publication of the first fetal and early childhood growth measurements (1749), Stoller's textbook on human growth (1729) and Jampert's valuable, but seldom referenced, table on human growth from age 1–25 (1754). Tanner, *Study of Human Growth*, 49–52, 73–74, 79–83, 88–89.
16. Floud, Wachter and Gregory, *Height, Health, and History*, 3.
17. Villerme's comments in 1829 sound like calls in the late twentieth-century United States for more focus on the ambient conditions which result in ill-health and less on curing illness. L. R. Villerme, "Memoire sur la Taille de L'homme en France," *Annales d'Hygiene Publique* 1 (1829): 351–397, cited in Tanner, *Study of Human Growth*, 162–163. Auxology is the study of human growth, auxologists those who study it. Tanner, *Study of Human Growth*, 142.
18. Tanner, *Study of Human Growth*, 147–153, and 163–164.
19. Roderick Floud and Kenneth Wachter, "Poverty and Physical Stature, Evidence on the Standard of Living of London Boys, 1770–1870," *Social Science History* 6 (1982): 426.
20. Tanner, *Study of Human Growth*, 299–301. Some of these continued well into the recent period ending only in the 1960s and 1970s.
21. Tanner, *Study of Human Growth*, 312.
22. Tanner, *Study of Human Growth*, 228–229; Bowles notes height variation between generations. G. T. Bowles, *New Types of Old Americans at Harvard and at Eastern Women's Colleges* (Cambridge, MA: Harvard University Press, 1952).
23. See James M. Tanner, "Growth and Physique in Different Populations of Mankind: A Proposal for the Establishment of an International Bureau of Growth Studies," in *The Biology of Human Adaptability*, ed. P.T. Baker and J.S. Weiner (Oxford: Clarendon Press, 1966), 44–66, for a description of the proposal to begin collection of such data on a worldwide basis.
24. Tanner identifies three impulses for anthropometry, "the social, the medical, and the intellectual." Tanner, *Study of Human Growth*, 397. An anonymous reviewer of this article also noted that a fourth rationale for anthropometric monitoring is its use in assessing individual health status among many populations.
25. The term "nutritional status" is used to encompass more than simply diet, i.e. the intake of calories and nutrients, and is thus distinct from the more common term "nutrition." While nutrition refers to the quantity and quality of food *inputs* to the human biological system, it makes no reference to the amounts needed for healthy functioning. The latter varies with demands on the organism. Thus, nutritional status refers to the balance between caloric and nutrient intake and the demands placed on the body. Cameron notes that "nutriture" is a "functional concept involving the dynamic process of 'intake' and 'expenditure,'" nutritional status describes the physical outcome. Noel Cameron, "Measurement Issues Related to Anthropometric Assessment of Nutritional Status," in *Anthropometric Assessment of Nutritional Status*, ed. John H. Himes (New York: Wiley-Liss, Inc., 1991), 348. While work intensity makes the most obvious demands on nutrient intakes, it is

just one of many. Energy is required to resist infection, so the epidemiological environment also influences nutritional status. Disease exposure reduces growth through a variety of mechanisms, some by choice, others not: 1) dietary restrictions imposed upon the ill, 2) diversion of energy from other uses to fighting infection, 3) direct energy loss via fever, 4) poor nutrient absorption by the body during illness, 5) vomiting, 6) infection spurs the release of hydrocortisone from the adrenal glands. Hydrocortisone impedes growth processes. Reynaldo Martorell and Jean-Pierre Habicht, "Growth in Early Childhood in Developing Countries," in Falkner and Tanner *Human Growth*, 251; James M. Tanner, *Foetus into Man: Physical Growth from Conception to Maturity* rev. and enl. ed. (Cambridge, MA: Harvard University Press, 1990), 95. Pregnancy adds caloric and nutrient demands, as does breast-feeding. Calories expended in any of these fashions are available neither for basal metabolism, the energy used to breathe, pump blood, and run other body systems in the rest state, nor for growth. It is important to maintain the conceptual distinction between nutritional intake and (net) nutritional status. Nutritional status is also sometimes known as "net nutritional status" to make explicit the idea that this term encompasses both the in-flow of calories and the demands placed upon them. Such information can be gathered either from data collected longitudinally, that is from a series of measurements of single individuals taken over the course of his/her life, or cross-sectionally, measurements of many individuals each of whom is at a different point in the aging process. The former type would be most useful and is preferable, however, it is the latter type which is the most abundant in historical records. The data type available also influences the type of standards which should be used in evaluating stature and net nutrition. Phyllis B. Eveleth and James M. Tanner, *Worldwide Variation in Human Growth* (Cambridge: Cambridge University Press, 1976), 5–10.

26. Phyllis Eveleth, "Population Differences in Growth: Environmental and Genetic Factors," in Falkner and Tanner, *Human Growth,* 221; Tanner, *Foetus into Man*, 117.
27. Tanner, *Foetus into Man*, 163.
28. For example, correlation between parents' and children's maximum height generally range between 0.25 and 0.50, but the correlation between brothers is higher, an indicator of the relatively larger importance of environmental factors. William H. Mueller, "The Genetics of Size and Shape in Children and Adults," in Falkner and Tanner, *Human Growth*, 147 and 157–59. The decreasing range of variation in height between unrelated adult males (25 cm.), adult brothers (16 cm.), and monozygotic twins (1.6 cm.) points to the influence of genetic factors. Tanner, *Foetus into Man*, 123–124, 163 and 211; Eveleth, "Population Differences," 221, 244; Richard Steckel, "Slave Height Profiles from Coastwise Manifests," *Explorations in Economic History* 16 (1979): 369.
29. Napoleon Wolanski, "Biological Reference Systems in the Assessment of Nutritional Status," in *Nutrition and Malnutrition: Identification and Measurement*, ed. A.E. Roche and F. Falkner (New York: Plenum Press, 1974), 231–233; Thomas K. Landauer, "Infantile Vaccinations and the Secular Trend in Stature," *Ethos* 1 (1973): 499–503.
30. Under equivalent environmental circumstances the *groups* have achieved nearly identical mean adult stature. Tanner, *Foetus into Man*, 163 and 239. This is not to say that all physical differences have short term environmental origins. For example, as a result of evolutionary climatic adaptation, Africans are generally longer limbed and have less body fat than Europeans, but adult stature differences between these groups are not similarly determined. Tanner, *Foetus into Man*, 143–145.

31. Eveleth and Tanner, *Worldwide Variation*, 241–261. This variation is generally rather uniform, and, in fact, adult human height distributions provided one of the first examples of normal distributions.
32. Martorell and Habicht's Figure 2 demonstrates that height differences across socio-economic classes dwarf genetic differences. Martorell and Habicht, "Growth in Early Childhood," 244.
33. M.T. Newman, "Nutritional Adaptation in Man," in ed. Albert Damon, *Physiological Anthropology* (New York: Oxford University Press, 1975), 234; Tanner, *Foetus into Man*, 138; Tanner, "Growth and Physique," 49.
34. The World Health Organization indicates that children's growth patterns, when compared to norms for the developed countries, comprise one of the best indicators of health and nutritional status within a community. WHO Expert Committee, "Delivery of Maternal and Child Care," 95; Bielicki, "Physical Growth as a Measure," 283. See also Tanner, *Foetus into Man*, 283; Eveleth and Tanner, *Worldwide Variation*, 275.
35. Tanner, *Foetus into Man*, 166.
36. Martorell and Habicht, "Growth in Early Childhood," 245; Stunting can be seen as the body's adaptation to sub-optimal nutrition. Smaller persons have lower basal metabolic requirements. Fogel, "Conquest of High Mortality," 50. Psychological adaptation may also occur to restrict activity under poor nutritional circumstances. Herman Freudenberger and Gaylord Cummins, "Health, Work, and Leisure Before the Industrial Revolution," *Explorations in Economic History* 13 (1976): 1.
37. James M. Tanner, "Growth as a Target-Seeking Function, Catch-up and Catch-down Growth in Man," in Falkner and Tanner, *Human Growth*, 167 and 176. Maximum height is independent of the timing of growth spurts. Tanner, *Study of Human Growth*, 280.
38. James M. Tanner, "The Potential of Auxological Data for Monitoring Economic and Social Well-Being," *Social Science History* 6 (1982): 575; Tanner, *Foetus into Man*, 122 and 129–131. Auxologists define growth as having stopped when its rate falls below 1 cm per year and when 98 per cent of maximum adult height has been achieved. Tanner, *Study of Human Growth*, 118.
39. With a standard deviation of two years. Tanner, *Foetus into Man*, 19.
40. A. Theodore Steegmann, Jr., "Eighteenth-Century British Military Stature: Growth Cessation, Selective Recruiting, Secular Trends, Nutrition at Birth, Cold and Occupation," *Human Biology* 57 (1985): 80.
41. Tanner, *Study of Human Growth*, 298.
42. John Bongaarts, "Does Malnutrition Affect Fecundity? A Summary of the Evidence," *Science* 208 (1980): 565–566; Eveleth and Tanner, *Worldwide Variation*, 217 and 245.
43. It may take up to two generations for the stature effect of a severe case of lifelong maternal malnutrition to be overcome in the adult height of a woman's offspring and their children. However, brief periods of even intense malnutrition seem to leave little "mark" on the children exposed *in utero* to such conditions. Tanner, *Foetus into Man*, 43; Zena Stein, Mervyn Susser, Gerhart Saenger, and Francis Marolla, *Famine and Human Development: The Dutch Hunger Winter of 1944–45* (New York: Oxford University Press, 1975). Public health officials currently use the percentage of low birth weight babies (<2500 g) as a national measure of social and economic development. Ward, *Birth Weight and Economic Growth*, 12. The optimal range of birth weights in the developed world today is between 3500 and 3900 grams. Ward's recent work indicates that birth weights in lying-in hospitals in three large European cities averaged well below 3300 grams for the last half of the nineteenth and early twentieth centuries as compared to weights near 3500 grams in Boston and Montreal

during the same period. Ward attributes this, in great part, to the better nutritional environment in North America. There was, however, considerable variation over the course of the seventy-five years covered by his study. Ward, *Birth Weight and Economic Growth*, 114–116.

44. Brinkman, Drukker, and Slot show that DeWijn was the first to use the term in a 1954 article. Henk Jan Brinkman, J.W. Drukker, and Brigitte Slot, "Height and Income: A New Method for the Estimation of Historical National Income Series," *Explorations in Economic History* 25 (1988): 227–264. Tanner, *Study of Human Growth*, 116. This getting larger has been concentrated in increased leg length rather than purely proportional increases throughout the body. J.C. van Wieringen, "Secular Growth Changes," in Falkner and Tanner *Human Growth*, 308.
45. Bielicki, "Physical Growth as a Measure," 297–98. Recent experience in the developed world (e.g. the former Soviet bloc), again shows cycling. I am indebted to one of the anonymous reviewers of this article for this insight. See Steven Stillman, "Health and Nutrition in Eastern Europe and the Former Soviet Union during the decade of transition: A Review of the Literature," *Economics and Human Biology* 4 (2006), 104–146.
46 Tanner, *Foetus into Man*, 163.
47. It should be noted that stature variation across social classes has been eliminated in some countries, notably in Scandinavia. Bielicki, "Physical growth as a measure," 291; Floud, Wachter, and Gregory, *Height, Health, and History*, 135; Martorell and Habicht, "Growth in Early Childhood," 284.
48. Steckel argues that the feeding practices of plantation owners produced a pattern of severely delayed growth among the slave population. Richard Steckel, "A Peculiar Population: The Nutrition, Health, and Mortality of American Slaves from Childhood to Maturity," *Journal of Economic History* 46 (1986): 734–36, 739–40. For an economic model explaining this strategy, see Ray Rees, John Komlos, Ulrich Woitek, and Ngo Van Long, "Optimal Food Allocation in a Slave Economy," *Journal of Population Economics* 16 (2003): 21–36.
49. John Komlos, "Toward an Anthropometric History of African-Americans: The Case of the Free Blacks in Antebellum Maryland," in *Strategic Factors in Nineteenth-Century American Economic History: A Volume to Honor Robert W. Fogel*, ed. by Claudia Goldin and Hugh Rockoff (Chicago: University of Chicago Press, 1992), 267–329; Paul Riggs, "The Standard of Living in Scotland, 1800–1850," in *Stature, Living Standards, and Economic Development: Essays in Anthropometric History*, ed. John Komlos (Chicago: University of Chicago Press, 1994), 60–75; John Murray, "Stature Among Members of a Nineteenth-Century American Shaker Commune," *Annals of Human Biology* 20 (1993): 121–129; Jialu Wu, "The Anthropometric History of Pittsburgh and Allegheny County, Pennsylvania, 1890–1945," *Annals of Human Biology* 19 (1992): 79–86; Stephen Nicholas and Deborah Oxley, "The Living Standards of Women during the Industrial Revolution, 1795–1820," *Economic History Review* 46 (1993): 723–749.
50. John Komlos, *Nutrition and Economic Development in the Eighteenth-Century Habsburg Monarchy* (Princeton: Princeton University Press, 1989), 31.
51. John Komlos, "The Height and Weight of West Point Cadets: Dietary Change in Antebellum America," *Journal of Economic History* 47 (1987): 921.
52. Richard Steckel, "The Health and Mortality of Women and Children," *Journal of Economic History* 48 (1988): 339–40; Eric L. Davin, "The Era of the Common Child: Egalitarian Death in Antebellum America," *Mid-America* 75 (1993): 135–163.

53. The initial efforts at the provision of clean water for urban residents were private ones whose impact was limited to families with the means to pay for such a "luxury" and thus were of limited success. See Stanley K. Schultz, *Constructing Urban Culture: American Cities and City Planning, 1800–1920* (Philadelphia: Temple University Press, 1989), 163 and Howard P. Chudacoff, *The Evolution of American Urban Society* (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1975), 36–37.
54. Robert Gallman, "The Statistical Approach: Fundamental Concepts as Applied to History," in *Approaches to American Economic History*, ed. George Rogers Taylor and L.R. Ellsworth (Charlottesville, University of Virginia Press, 1971), 87–105; Paul David, "The Growth of Real Product in the United States Before 1840: New Evidence, Controlled Conjectures," *Journal of Economic History* 27 (June 1967): 151–197; Robert Gallman, "The Pace and Pattern of American Economic Growth," in *American Economic Growth: An Economist's History of the United States,* ed. Lance Davis, Richard Easterlin, and William N. Parker (New York: Harper and Row, 1972), 15–60; Thomas Weiss, "Long Term Changes in U.S. Agricultural Output Per Worker, 1800–1900," Working Paper 23, National Bureau of Economic Research Series on Historical Factors in Long Run Growth, 1991.
55. John William Florin, *The Advance of Frontier Settlement in Pennsylvania, 1638–1850: A Geographic Interpretation* (University Park, PA: Pennsylvania State University, 1977), 9–10. Florin's definition for "settlement" was the date of the first permanent settlement in a minor civil division (townships, towns, boroughs). He obtained his data from county histories.
56. Murphy and Murphy, *Regional Geography*, 67; Stevenson Whitcomb Fletcher, *Pennsylvania Agriculture and Country Life, 1640–1840* (Harrisburg: Pennsylvania Historical and Museum Commission, 1950), 5; Florin, *Frontier Settlement*, 28.
57. George Rogers Taylor, *The Transportation Revolution, 1815–1860*, Vol. 1, *The Economic History of the United States* (New York: Rinehart and Company, Inc., 1951), 158.
58. Susan P. Lee and Peter Passell, *A New Economic View of American History* (New York: W.W. Norton and Company, 1979), 64. This was not simply the result of transportation difficulties however, but also the inability of western Pennsylvanians, at that stage of development, to produce goods for Philadelphia and other eastern seaboard communities which residents of these areas could not obtain more cheaply, after factoring in transportation costs, from their own hinterlands. Solon J. Buck and Elizabeth H. Buck, *The Planting of Civilization in Western Pennsylvania* (Pittsburgh: University of Pittsburgh Press, 1939), 291–292.
59. Diane Lindstrom, *Economic Development in the Philadelphia Region, 1810–1850* (New York: Columbia University Press, 1978), 18–19.
60. Donna Andriot, *Population Abstract of the United States* (McLean, VA: Documents Index Inc., 1993), 272, 295, 304, 461, 570. While Andriot places Philadelphia second, a review of the 1800 census indicates that Philadelphia, per se, is smaller than New York City per se, but the latter's home county population is smaller than that of Philadelphia County. United States, *Returns of The Whole Number of Persons within the Several Districts of the United States According to "An Act Providing for the Second Census...,"* Second Decennial Census, 1800 (Washington: Duane, 1801).
61. Lindstrom, *Economic Development*, 40–44.
62. This is an area east of Kittatinny Ridge/Blue Mountain or an imaginary line drawn from just west of Allentown through Harrisburg to Chambersburg. Murphy and Murphy, *Regional Geography*, 98 and 108.

63. Stevenson Whitcomb Fletcher, *Pennsylvania Agriculture and Country Life: 1840–1940* (Harrisburg: Pennsylvania Historical and Museum Commission, 1955), 1.
64. Florin's maps indicate that by 1810 less than 50 per cent of the Allegheny Forest Region's minor civil divisions had seen the establishment of initial settlements. In 1830 a significant fraction of the region still exhibited that pattern. Even areas as close to Philadelphia as Cumberland and Adams Counties were described in this period as being peopled by "scattered farmers" with few small towns. Florin, *Frontier Settlement*, see Figures 6–9, 11, 12, 14–24 on pages 34, 39, 40, 42, 46, 49, 53, 59, 60, 66, 74, 75, 80, 83–86.; *History of Cumberland and Adams Counties, Pennsylvania* (Chicago: Warner, Beers & Co., 1886), 109.
65. Yujiro Hayami and Vernon W. Ruttan, *Agricultural Development: An International Perspective*, rev. ed. (Baltimore: Johns Hopkins University Press, 1985), 69–71. Ethnic composition of the farmers was an important variable in that regard with Scotch-Irish farmers generally being seen as more likely to run the land down and move on than German farmers who tended to invest heavily in fertility maintenance and improvement. Philip S. Klein and Ari Hoogenboom, *A History of Pennsylvania*, 2nd ed. (University Park, PA: Pennsylvania State University, 1980), 191–193.
66. Changes in the nature of data collected by the census takers prevent a further direct comparison with 1860 figures. The 36.2 per cent figure for manufacturing employment proportion was calculated by classifying individual occupations in the 1860 census into a manufacturing category. The urban population is defined as those living in towns or cities of more than 2500 inhabitants. The 2500 cut-off figure is one not based on the importance of a city/town of that size but on later Census Office convention. During the antebellum period urban places of smaller size would have been important trading centers and points around which economic production was organized.
67. Fletcher notes that, as late as 1930, 25 per cent of the farms in Clearfield County were still self-sufficient as defined by the census (50 per cent or more of production consumed on the farm itself). "They are most common on rough and poor land, especially in the coal regions and in areas remote from markets." Fletcher, *Country Life, 1840–1940*, 8.
68. Obviously, slave based plantation agriculture was an exception.
69. The term "native-born" Pennsylvanian has a more restrictive definition than "native-born" may carry in some other contexts. For purposes of this study, a native-born Pennsylvanian is not a Pennsylvania resident born in the United States but rather a Pennsylvanian born within the boundaries of the Keystone State.
70. Komlos' study of nineteenth-century slaves from Maryland, Komlos and Coclanis's study of convicts in Georgia, and Steckel's study of Ohio national guardsmen being the most prominent examples.
71. Housed in the U.S. National Archives, these books were compilations of various rolls kept by company clerks. Data were drawn from the descriptive rolls, a roll of men who enlisted when the unit was formed as well as those who enlisted later to take the place of the fallen. It was one of four record books kept at the company level. United States War Department, *United States Army Regulations of 1861 with an Appendix Containing the Changes and Laws Affecting Army Regulations and Articles of War to June 25, 1863* (Washington, D.C.: G.P.O., 1863), 20 and 24. Data for each soldier included name, date of enlistment, age, birth place, place of enlistment, occupation, rank, and remarks about the man's military career. Data collected for each company and applied to each man's data record included company name and unit type (e.g. infantry, artillery). Adjutant General's

Office, *Descriptive Books of Volunteer Organizations: Civil War, 1861–65*, Record Group 94, Item 114, (National Archives. Washington, D.C.). For a discussion of the extent to which the sample is representative of the Pennsylvania male population see the Appendix of Cuff, *The Hidden Cost of Economic Development.*

72. For the primary place of origin of the units, see R.A. Sauers, *Advance the Colors: Pennsylvania Civil War Battle Flags* (Harrisburg: Capitol Preservation Committee, 1987); Samuel P. Bates, *Bates's History of Pennsylvania Volunteers, 1861–1865* (Harrisburg: B. Singerly, 1869).
73. Robert W. Fogel, Stanley Engerman, et.al., *Union Army Recruits in White Regiments in the United States, 1861–65*, computer file, Study #9425 (Chicago: University of Chicago, Center for Population Economics\producer\,1990). Ann Arbor, MI: Inter-University Consortium for Political and Social Research\distributor\,1990.
74. For full details of sample creation, issues of sample representativeness and the evaluation of potential left-tail truncation, please see the Appendix of Cuff, *The Hidden Cost of Economic Development*.
75. See Chapters One and Two of Cuff, *The Hidden Cost of Economic Development.*
76. Robert Margo and Richard Steckel, "Heights of Native Born Whites During the Antebellum Period," *Journal of Economic History* 43 (1983): 167–174.
77. Kenneth L. Sokoloff, "The Heights of Americans in Three Centuries: Some Economic and Demographic Implications" in *The Biological Standard of Living on Three Continents: Further Explorations in Anthropometric History*, ed. John Komlos (Boulder, CO: Westview Press, 1995), 136.
78. Sokoloff, "Three Centuries," 136.
79. See John Komlos, "The Height and Weight of West Point Cadets: Dietary Change in Antebellum America," *Journal of Economic History* 47 (1987): 897–927, for a complete analysis of this data set. The much lower mean heights for the Civil War soldiers below age 18 in all likelihood is a reflection of the role which such boys played in the Civil War. Many in this age category were noted as musicians rather than privates.
80. This anomaly of "very large" 16 and 17 year olds may be a function of the need for a "young" potential cadet to be as physically developed as the standard 18 year old cadet in order to warrant "early" admittance.
81. Among the Pennsylvania-born cadets who reported the nature of their residence at the time of enlistment, 196 out of 245 indicated that they resided in a town or city, with only 98 indicating that they resided in a rural area.
82. Regression results described in this paper, but not presented in detail here, may be found in Cuff, *The Hidden Cost of Economic Development*, 114–117, 120–121, 150–161, and 180–203.
83. Sylvester K. Stevens, *Pennsylvania: The Keystone State,* Vol. I, Historical (New York: The American Historical Co., Inc., 1956), 361.
84. Fogel's 39,000 observation national sample of Civil War enlistees does not include a rank variable. This avenue of interpretation is thus not available when using observations from that data set. However, even though rank was not noted, non-commissioned officers were seemingly included in his sample. Company C of the 76th Pennsylvania Infantry was collected by both Fogel and me. A comparison reveals that Fogel's sample does contain some soldiers who had a rank of sergeant or corporal, however without a rank indication.

85. While most units identified their officers by name and rank, only a few recorded physical descriptions of them. Since the purpose of these physical descriptions was to prove identity on pay day and in the event of desertion it may have been that commanders in the units did not feel it necessary to have descriptions of their officers recorded because of their belief that officers, as gentlemen, would never claim undeserved pay or desert. I thank Michael Meier, National Archives, Military Reference Branch for this insight.
86. In both samples, non-commissioned officers, sergeants, and corporals were about an inch taller and a year older than the men serving under them. After accounting for age, occupation, and other influencing factors, the regression equation reduces the height advantage of non-commissioned officers to between one-half and two-thirds of an inch. The latter finding is quite robust and stable across several regression formulations.
87. Modern psychological studies have indicated that height does confer status reflected in faster promotion and greater salaries holding other factors constant.
88. See Cuff, *The Hidden Cost of Economic Development* and Tanner, *Study of Human Growth*, 118.
89. Richard Steckel, "Percentiles of Modern Height: Standards for Use in Historical Research," *Historical Methods* 29 (1996): 163. Age variation is obviously a critical issue in evaluating inter-group height differentials. As a result, most of the analysis will take account of it. In some cases data will be presented for the entire sample along with data for only the 25–49 year olds (in order to exclude any influence of variation due to the continuation of the growth process). In addition, height standardization by age will be performed in some cases, in order to allow for comparisons with larger sample sizes by including cases on youth.
90. The use of reported occupation of the soldier has some inherent problems. It would be preferable to have information on father's occupation, as that had a more direct influence on the soldier's nutritional and health circumstances during most of his growing years. However, young men in the early nineteenth century entered the labor market before completion of the biological growth process, so their own occupation would also have had an effect on their maximum height. Additionally, "occupation" was not always recorded in such a way to reflect the person's role in the business or firm. Men noting only a business site are believed to have been owners of these places of business. Theodore Herschberg and Robert Dockhorn, "Occupational Classification," *Historical Methods Newsletter* 9 (1976): 68.
91. It is appropriate to say "most other men" because most had occupations in the skilled and unskilled categories, categories which have lower mean stature than farmers.
92. Except for men without an occupation, the stature advantage of high status occupations over farmers in the unadjusted statewide mean disappeared in the regressions. The advantage apparently was a function of an average age two and a half to six years higher for the proprietor and work site groups. High status occupations have been defined as students, professionals, men listing only a work site, and men with no occupation.
93. Regressions run separately for men born in each of the seven regions all show farmers with a stature advantage over the omitted category (skilled workers) but it is only significant in the Southeastern Region (without Philadelphia County), Allegheny County, and the Western Region (without Allegheny County). These regional regressions also show that in the Southeastern Region and in Philadelphia County unskilled workers were one-quarter to one-fifth of an inch shorter than their skilled brethren and that this difference is weakly statistically significant (0.10 level).

94. Kenneth L. Sokoloff and Georgia C. Villaflor, "The Early Achievement of Modern Stature in America," *Social Science History* 6 (1982): 462–465.
95. R.W. Fogel, S. Engerman, et al., "Changes in American and British Stature Since the Mid-Eighteenth Century: A Preliminary Report on the Usefulness of Data on Height for the Analysis of Secular Trends in Nutrition, Labor Productivity, and Labor Welfare," Cambridge, MA: NBER Working Paper #890; Robert Margo and Richard Steckel, "Heights of Native Born Whites During the Antebellum Period," *Journal of Economic History* 43 (1983): 171.
96. The 1845–49 quinquennium is omitted from this description. Most men born in that five year span had not completed their growth prior to enlistment. Additionally, almost all these men enlisted in 1863 or later—years known to have seen the enlistment of men of smaller stature.
97. This might well have been a general pattern, insofar as Komlos has already noted that the height of those West Point cadets who had middle-class parents did not decline in the second half of the 1830s, although decline in heights among the cadets in general was, indeed, evident John Komlos, "Anomalies in Economic History: Reflections on the 'Antebellum Puzzle'," *Journal of Economic History* 56 (March, 1996): 202–214.
98. See Cuff, *The Hidden Cost of Economic Development* for a list of the counties in each region, circa 1860.
99. In order to standardize heights, the mean height for each age category was calculated. Each individual height was then divided by the mean height for that age of that individual to give the standardized height as a percentage of the mean over the whole of the 1815–1850 period. An eighteen year old soldier with a height of 66.66" would have an age standardized height of 1.01 if the mean height of eighteen year olds were 66 inches (66.66/66 = 1.01). This technique allows for height comparisons across regional or occupational categories regardless of the age composition of that category.
100. These maps show county boundaries at the beginning of the war, not during the quinquennium of birth. Later regression analysis will include only men who were born in counties which experienced no border changes during the years between 1820 and 1860.
101. Fifteen observations per period minimum. Unless noted, the charts and maps do not account for county border changes which may have occurred during the antebellum period. No adjustment was made for such changes, except the analysis below does exclude data from counties which experienced border changes during the period under consideration.
102. The figures' titles "urban" and "non-urban" refer to the presence or absence of a large urban center, i.e., Philadelphia or Pittsburgh.
103. Cell sizes were so small for several regions that unreasonably large fluctuation existed in the mean heights by quinquennium and they were not plotted.
104. There was a difference between urban and rural residents but it was only significant at the 0.10 level. In their view, the situation was one in which the less well off became concentrated in cities as time went on. Sokoloff and Villaflor, "Early Achievement," 463; Sokoloff, "Three Centuries," 137.
105. Note that Allegheny County is plotted separately and is *not* part of the Western Region in this graph.
106. Due to the interesting patterns across the West, men who were born in Lawrence County (which actually would have been possible only for those 20 years and younger since Lawrence County was not formed until 1845) were reported as such, even though they would have been born in either Mercer or Beaver County. This is true only for the regional analysis, not the analysis involving county level economic data. Men from all three counties were excluded from that analysis.

107. The Lake Transport region's time trends in age standardized height and mean adult height diverge sharply. The standardized height moves upward toward the values of the other sub-regions, while the absolute mean (based only on men who have completed their growth) declines. This would seem to indicate some divergence in the net nutritional status of men who had not completed their growth from men who had in the late 1820s and 1830s.
108. The statewide regression utilized the data for anyone in the statewide or western samples who fit the noted characteristics. The western analysis included all men who met the noted requirements and who also were born in one of the ten "western" counties. In order to eliminate the influence of small categories of observations which might be unrepresentative and to stabilize the regression results, the sample was pared rather extensively. Only infantrymen, who enlisted as "standard" enlistees, between 25 and 45 years of age, and who were born in counties a) without border changes between 1820 and 1845 and b) for which all relevant economic data were available, were included in this reduced sample. A total of 1907 men from 29 counties fit these characteristics and are included in the statewide county level regression analysis.
109. See Tables 4.1 through 4.16 in Cuff, *The Hidden Cost of Economic Development* for sources of the various indicators. Most data used in these analyses were drawn directly from the U.S. Census. However, several variables were obtained from data gathered by Craig and Weiss, and by Craig, Palmquist and Weiss on agricultural surpluses in 1840 and access to water transportation routes in 1850. These variables and their calculation are fully described in Lee A. Craig and Thomas Weiss, "Nutritional Status and Agricultural Surpluses in the Antebellum United States," NBER Working Paper Series on Historical Factors in Long Run Growth, Historical Paper 99, April 1997 and Lee A. Craig, Raymond B. Palmquist, and Thomas Weiss, "Transportation Improvements and Land Values in the Antebellum United States: A Hedonic Approach," Working Paper 95–2–5, North Carolina State University, May 1997. I adjusted several of their specifications according to whether or not a county had usable access to a navigable waterway, slightly expanding the list of those that did. The initial file supplied only included rivers and canals as waterways. Erie County, according to that definition, did not have access to a waterway. It was one of three counties which had their waterway variables changed.
110. The amounts produced in a county minus the amounts consumed are considered agricultural surpluses.
111. Since canal construction had, for the most part, ended by 1840 and river navigability did not change appreciably between 1840 and 1850, using a variable developed for 1850 does not pose a difficulty in this analysis.
112. Craig and Weiss note that these data were not collected during the 1840 Census. Craig and Weiss, "Nutritional Status and Agricultural Surpluses," 11–12.
113. See the Appendix of Cuff, *The Hidden Cost of Economic Development* for a description of why no counties with border changes were entered into this part of the analysis.
114. Means and standard deviations for all the economic/demographic variables in the statewide and western regression models described here are found in Tables 5.20 and 5.21 of Cuff, *The Hidden Cost of Economic Development*.
115. Craig and Weiss, "Nutritional Status and Agricultural Surpluses."

116. This is consistent with other work on Union soldiers. Margo and Steckel, "Native Born Whites," 168; Sokoloff, "Heights of Americans in Three Centuries," 136.
117. See Chapters One and Two of Cuff, *The Hidden Cost of Economic Development* for more details and sources.
118. See Wu, "The Anthropometric History of Pittsburgh and Allegheny County," 79–86 for some data on African-Americans later in the century.