SLAVE PRICES, GEOGRAPHY AND INSOLATION IN 19TH CENTURY AFRICAN-AMERICAN STATURE

SCOTT ALAN CARSON

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Abstract

The use of height data to measure living standards is now a well-established method in the economic literature. Moreover, while much is known about 19th century black legal and material conditions, less is known about how 19th century institutional arrangements were related to black stature. Although modern blacks and whites reach similar terminal statures when brought to maturity under optimal biological conditions, 19th century African-American statures were consistently shorter than whites, indicating a uniquely 19th century phenomenon may have inhibited black stature growth. It is geography and insolation that present the most striking attribute for 19th century black stature, and greater insolation and higher slave prices are documented here to be associated with taller black statures.

JEL Code: I32, J15, N31.

Keywords: nineteenth century, African-American stature, slave prices, insolation, vitamin D.

Scott Alan Carson
School of Business
University of Texas, Permian Basin
4901 East University
Odessa, TX 79762
USA
Carson_S@utpb.edu

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Slave Prices, Geography and Insolation in 19th Century African-American Stature

1. Introduction

An anomalous finding in the physical stature of 19th century African-American male slaves is that their physical statures increased during the antebellum period (Komlos, 1992, p. 309; Komlos and Coclanis, 1997, p. 445; Conrad and Meyer, 1964, p. 49; Carson, 2007). If, however, Southern planters and overseers rationally manipulated slave nutrition and medical allocations to maximize their own wealth, slave heights would have increased with antebellum slave prices and probably decreased—at least temporarily—with slavery's removal (Rees et al, 2003, p. 22; Steckel, 1995; Komlos, 1998; Carson, 2007). Although the antebellum slave stature increase has been well documented, a post-bellum black stature diminution deserves more attention. Furthermore, not all 19th century blacks lived in the South, and while much has been written on their legal and socioeconomic status between the Civil War and World War I, less is known about black biological conditions in the United States over this period. This paper addresses 19th century African-American stature, its relationship to Southern institutions and offers a new bio-spatial explanation for the observed 'mulatto advantage'.

A population's average stature reflects the net cumulative interaction between nutrition, disease exposure, work and the physical environment (Fogel, 1994, p. 375). By considering average versus individual stature, genetic differences are mitigated, leaving only influences of the economy and the physical environment on stature. When diets, health or physical environments improve, average stature increases, and it decreases

when diets become less nutritious, disease environments deteriorate or the physical environment places more stress on the body. Hence, stature provides significant insights into understanding historical processes and augments other 19th century welfare measures for US blacks.

Black and white stature comparisons in 19th century America indicates that blacks were consistently shorter than whites, and this is observed for both blacks born in the North as well as blacks born in the South, which suggests a bio-spatial explanation for stature variation. Black stature has also been linked to pigmentation. Lighter colored 19th century blacks were consistently taller than blacks with darker complexions (Steckel, 1979, pp. 374-376; Margo and Steckel, 1982, pp. 532-34, Table 6; Bodenhorn, 1999, 2002). A common explanation for this pattern is that 19th century social and economic forces favored fairer complexions over lighter complexions, and lighter colored blacks benefited from these social and economic institutions. Nonetheless, a more complete explanation may be rooted elsewhere in biology.

It is against this backdrop that this paper uses a new data source from several US state prison records to address three questions on 19th century African-American stature. First, what were the biological relationships between black stature, socioeconomic status and birth period? Although modern black and white statures reach similar terminal levels under optimal biological conditions, 19th century American black statures were consistently shorter than white statures, indicating a uniquely 19th century phenomenon may have inhibited black stature growth (Eveleth and Tanner, 1976; Tanner, 1977; Steckel, 1995, p. 1910; Barondess, Nelson and Schlaen, 1997, p. 968; Komlos and Baur, 2004, pp. 64, 69; Nelson et al., 1993, pp. 18-20; Godoy et al, 2005, pp. 472-473; Margo

and Steckel, 1982, p. 519; Bodenhorn, 1999, p. 985). Second, how did black stature vary with the average price of adult prime field hands? If slave masters and overseers rationally manipulated slave nutrition and medical allocations to maximize slaveowner wealth, slave height should have increased with antebellum slave prices and probably decreased with the removal of the institution (Rees et al, 2003, p. 22; Steckel, 1995; Komlos, 1998; Conrad and Meyer, 1964, pp. 50 and 75). Third, how did black stature differ by nativity? Nineteenth century Southern blacks were taller than Northern blacks, even though Northern blacks were not subject to overt forms of material and biological disparity as experienced by blacks born in the South. This suggests some alternative explanation, not yet considered, influenced black stature by nativity.

2. Geography, Market Valuations, and Human Biology

While much is known about 19th century black legal and material conditions, less is known about how 19th century institutional arrangements influenced black stature. While we know that blacks were shorter than whites, we are less certain of the cause. Moreover, any explanation must account for a robust geographical finding: Southern blacks were shorter than Southern whites, and Northern blacks were shorter than Northern whites (Margo and Steckel, 1992, p. 516). Slaves born in the New South also fared better than slaves in the Old South (Margo, and Steckel, 1982, p. 519). Two possible explanations for this persistent difference are that blacks were subjugated to slavery's brutal effects versus black biological interactions with the physical environment. In the case of slavery, slave-owners' feeding practices, nutrition and labor demands may have distorted black stature growth throughout life. Slave children typically received inferior diets, deficient in animal proteins, and slave youths sought to

enter slave labor forces at young ages to reap the dietary benefits that accrued to working slaves (Harris, 2006, p. 100; Steckel, 1986, p. 740). Furthermore, when slave and cotton prices increased, slaves probably received better nutrition and grew taller. However, because slavery did not apply in the north, poor Northern diets do not account for Northern blacks being shorter than Northern whites.

The second source of 19th century black stature variation may be related to biology, especially its relation to geography, and the 19th century US creates a natural case study to observe the effects of vitamin D consumption with stature before it was added to the US milk supply in the 1930s. Calcium and vitamin D are two chemical elements required throughout life for healthy bone and teeth formation; however, their abundance is most critical for healthy skeletal development at younger ages (Wardlaw, Hampl, and Divilestro, 2004, p. 394-396; Totolani et al, 2002, p. 60; Loomis, 1967). Calcium generally comes from dairy products, and vitamin D is produced by the synthesis of cholesterol and sunlight in the epidermis' stratum basale, granulosum and spinosum (Loomis, 1967, p. 501; Norman, 1998, p. 1108; Hollick, 2007). There are few dietary sources of vitamin D. Greater direct sunlight (insolation) produces more vitamin D, and vitamin D is related to adult terminal stature (Xiong et al, 2005, pp. 228, 230-231; X-ZLiu et al, 2003; Ginsburg et al 1998; Uitterlinden et al, 2004). However, vitamin D production also depends on melanin in the stratum corneum (Norman, 1998, p. 1108). Greater melanin (skin pigmentation) in the stratum corneum interferes with cholesterol's synthesis into vitamin D in the stratum granulosum, and darker pigmentation filters between 50 to 95 percent of the sunlight that reaches the stratum granulosum (Loomis, 1967, p. 502; Weisberg et al, 2004, p. 1703S; Holick, 2007, p. 270). Therefore, darker

skin is considerably less efficient than lighter skin at producing vitamin D, and darker skin is more common in Southern latitudes, where more hours of direct sunlight offsets inefficient vitamin D production (Norman, 1998, pp. 1109-1110).

In the US, southern states are closer to the equator and receive more insolation[1], while Northern states are farther from the equator and receive less direct sunlight. Moreover, a considerable body of evidence demonstrates that mulattos were taller than darker blacks (Steckel 1979, p. 375; Bodenhorn, 1999 and 2002), and Steckel and Bodenhorn point to 19th century Southern social practices to explain the difference. However, social differences between North and South do not explain why Southern blacks were taller than Northern blacks because Southern blacks encountered greater material privation and social exclusion than northern blacks. An alternative explanation for black stature variation is biological. Lighter colored blacks were taller than darker blacks because less melanin in the stratus corneum allowed more sunlight to penetrate the stratum granulosum, produces more vitamin D, leading to taller mulatto statures. Furthermore, the 19th century black forced diaspora to northerly latitudes placed blacks into geographic regions where they received less direct sunlight, and, produced less vitamin D, therefore did not reach their maximum terminal statures (Xiong, 2005, pp. 228-231; Ginsberg et al 1998, p. 320). Consequently, slave prices and hours of direct sunlight are used here to explain black stature variation.

[1] Insolation is a measure of solar radiation energy incident on a surface. It is the amount of solar energy received on a given area. Insulation refers to materials used to reduce the rate of heat transfer.

3. Data

The data used here to study black stature consists of a large 19th century US prison sample. All state prison repositories were contacted and available records were acquired and entered into a master data set. These prison records include those of Arizona, California, Colorado, Idaho, Illinois, Kansas, Kentucky, Missouri, New Mexico, Ohio, Oregon, Pennsylvania, Texas, and Washington. Because the interest here is black male statures, females, whites and immigrants are excluded from the analysis. Between 1830 and 1920, prison guards routinely recorded the dates inmates were received, age, complexion, nativity, stature, pre-incarceration occupation and crime. Fortunately, inmate enumerators were quite thorough when recording inmate complexion and occupation. For example, enumerators recorded inmates' race in a complexion category, and African-Americans were recorded as black, light-black, dark-black and various shades of mulatto (Komlos and Coclanis, 1997). While mulatto inmates possessed genetic traits from both European and African ancestry, they were treated as blacks in the 19th century US and are grouped here with blacks.

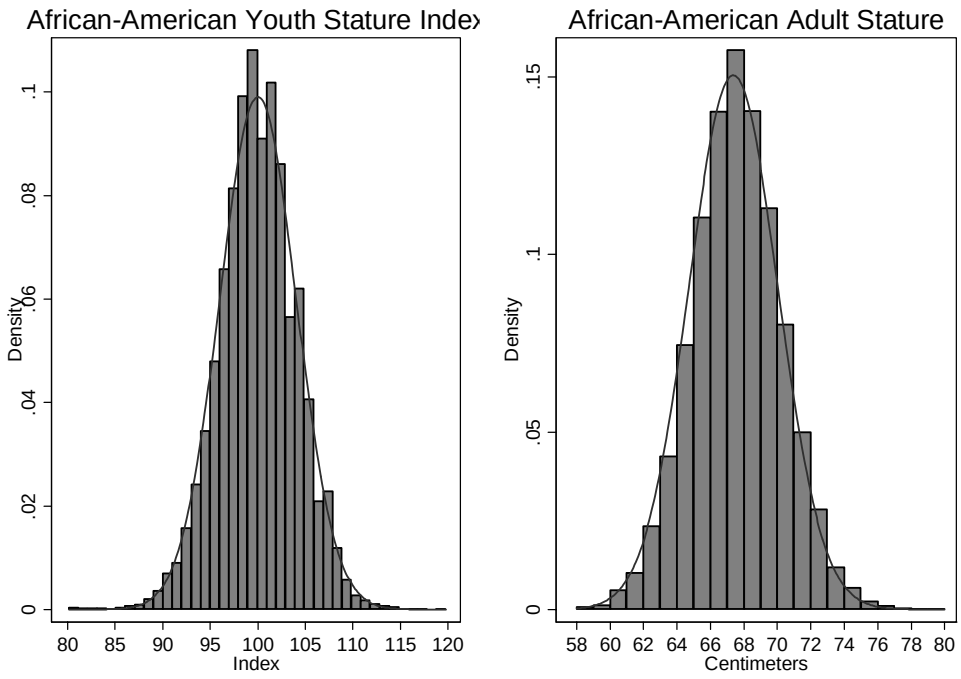
Enumerators recorded a broad continuum of occupations and defined them narrowly, recording over 200 different occupations, which are classified here into four categories: merchants and high skilled workers are classified as white-collar workers; light manufacturing, craft workers and carpenters are classified as skilled workers; workers in the agricultural sector are classified as farmers; laborers and miners are classified as unskilled workers (Tanner, 1977, p. 346; Ladurie, 1979; Margo and Steckel, 1992; p. 520). Unfortunately, inmate enumerators did not distinguish between farm and common laborers. Since common laborers probably faced less favorable biological

conditions, this potentially overestimates the biological benefits of being a common laborer and underestimates the advantages of being a farm laborer.

All historical height data have selection biases, and prison and military records are the most common sources of historical height data. One common shortfall of military samples is a truncation bias imposed by minimum stature requirements (Fogel et al, 1978, p. 85; Sokoloff and Vilaflour, 1982, p. 457). Fortunately, prison records do not suffer from such a constraint and the subsequent truncation bias observed in military samples. However, prison records are not above scrutiny. One potential bias inherent in prison records is they may be drawn from lower socioeconomic groups, although this bias may itself be an advantage to prison records, because lower socioeconomic groups are vulnerable to economic change (Bogin, 1991, p. 288).

Because the youth height distribution is itself a function of the age distribution, a youth height index is constructed that standardizes for age to determine youth stature normality. First, each youth age category's average stature is calculated. Second, each observation is then divided by the average stature for the relevant age group (Komlos, 1987, p. 899). Figure 1 demonstrates that black statures were distributed approximately normal and that prison records do not suffer from the stature truncation observed in military records.

Figure 1, Nineteenth Century African-American Stature Distributions



Source: See Table 1.

Notes: First, each youth age category's average stature is calculated. Second, each observation is then divided by the average stature for the relevant age group (Komlos, 1987, p. 899).

Table 1 presents the proportions for black inmates' age, birth decade, occupations, and nativity. Although average statures are included, they are not reliable because of possible compositional effects, which are accounted for in the regression models that follow. Age percentages demonstrate that black inmates were incarcerated at young ages, and most prisoners were born in the late 19th century. Occupations reflect socio-economic status, and while prison inmates typically come from lower working classes, there was a sizable share of inmates from white-collar and skilled occupations (Riggs,

1994, p. 64). Black inmate nativity was predominantly from the lower South, although some came from other regions.[2]

Table 1, Texas Prison Inmate Demographics and Occupations

Age	*Black*				*Occupations*				
	N	Percent	$\overline{X}$	SD		N	Percent	$\overline{X}$	SD
Teens	10,686	18.72	168.24	7.15	White-Collar	2,316	4.06	169.78	6.74
20s	30,926	54.16	171.10	6.88	Skilled	6,180	10.82	170.19	6.93
30s	9,976	17.47	171.26	6.73	Farmer	5,835	10.22	171.80	6.82
40s	3,691	6.46	170.71	6.80	Unskilled	41,501	72.68	170.48	6.99
50s	1,289	2.26	170.30	6.97	No Occupation	1,266	2.22	169.47	7.50
60s	438	.77	169.77	6.51					
70+	92	.16	169.02	5.91	*Nativity*				
					Northeast	238	.42	169.60	6.46
Birth Decade					Middle Atlantic	4,009	7.02	168.45	6.68
1800s	192	.34	169.42	6.27	Great Lakes	3,484	6.10	170.20	6.94
1810s	636	1.11	169.75	6.96	Plains	7,748	13.57	169.27	6.83
1820s	806	1.41	169.30	6.87	Southeast	20,523	35.94	170.31	6.88
1830s	1,438	2.52	170.11	6.79	Southwest	20,639	36.15	171.73	7.02
1840s	4,311	7.55	170.12	6.88	Far West	457	.80	169.27	6.75
1850s	9,214	16.14	170.69	7.09					
1860s	11,189	19.60	171.07	7.02					
1870s	13,431	23.52	170.58	6.97					
1880s	10,221	17.90	170.27	6.95					
1890s	5,221	9.14	170.37	6.92					
1900s	439	.77	169.43	7.26					

Source: All available records from American state repositories have been acquired and entered into a master file. These records include Arizona, California, Colorado, Idaho, Illinois, Kansas, Kentucky, Missouri, New Mexico, Ohio, Oregon, Pennsylvania, Texas, Utah and Washington. Only observations for African-Americans are presented here.

[2] Steckel, "East-West Migration"; Steckel, "Household Migration and Settlement." Higgs, *Competition and Coercion*, p. 27, indicates that before 1900 that Black migration to the Far West was infrequent.

Table 2,1860-1920 African-American Occupation Distributions

Occupations	*1860*		*1870*		*1880*		*1900*		*1910*		*1920*	
Prisons	N	%	N	%	N	%	N	%	N	%	N	%
White-Collar	105	6.37	279	3.84	403	4.25	473	3.83	403	3.44	8	5.52
Skilled	230	13.96	657	9.03	847	8.93	1,297	10.50	1,505	12.83	22	15.17
Farmer	143	8.68	186	3.78	965	10.17	1,167	9.45	1,703	14.52	17	11.72
Unskilled	1,046	63.47	5,875	80.79	7,166	75.53	9,343	75.65	7,655	65.27	97	66.90
No Occupation	124	7.52	186	2.56	106	1.12	71	.57	3.94	3.94	1	.69
IPUMS												
White-Collar	11	1.15	78	.80	163	1.21	398	2.06	210	2.29	610	2.39
Skilled	59	6.18	297	3.06	365	2.70	528	2.74	264	2.88	942	3.69
Farmer	99	10.37	1,786	18.41	4,047	29.96	7,220	37.43	3,352	36.56	8,843	34.60
Unskilled	775	81.15	7,540	77.72	8,562	63.88	11,130	57.71	4,936	53.83	13,538	52.97
No Occupation	11	1.15	0	0	372	2.75	11	.06	407	4.44	1,624	6.35
Urbanization												
% Urban	696	33.56	716	31.28	2,946	12.43	4,415	13.45	5,137	26.42	17,465	33.63

Steven Ruggles, Matthew Sobek, Trent Alexander, Catherine A. Fitch, Ronald Goeken, Patricia Kelly Hall, Miriam King, and Chad Ronnander. *Integrated Public Use Microdata Series: Version 3.0* [Machine-readable database]. Minneapolis, MN: Minnesota Population Center [producer and distributor], 2004.

Urbanization is defined as living in a town ship with 2,500 or more residents.

How well prison records reflect American socioeconomic processes in general is assessed by comparing blacks in US prisons to blacks in the US federal censuses. Table 2 illustrates that black prisoners were more likely than blacks in the 1860-1920 US federal censuses to be white-collar and skilled workers and less likely to be farmers and unskilled workers. Comparing the prison to census occupations detects the counter-intuitive result that, after controlling for race, inmates were consistently more skilled than the US black population. Much of this is attributable to prisoner ages that were older than the US black population, further along in the occupational life-cycle, therefore, more

skilled than the US black labor force. Blacks generally became less urbanized during the late 19th century, but more urbanized during the earlier 20th century.[3]

New Orleans Slave Prices

Beyond land, slaves were plantation owners' capital investments, and owners had the incentive to adequately care for their slaves (Conrad and Meyer, 1964, p. 49). Market prices probably reflected slave agriculture productivity (Conrad and Meyer, 1964, pp. 50-53; Fogel, 1974), and slave prices increased with cotton prices and declined when cotton prices stagnated. For example, in 1859-60, the New South specialized in the high-value added crop cotton, while the Old South specialized in various lower value added crops. As a result, prime-age male Virginia and South Carolina field hands were valued at $1,350; Texas prime-age male field hands were valued between $1,527 and $2,015 (Conrad and Myer, 1964, p. 74). Slave rental rates also varied regionally; 1859-60 Virginia and South Carolina annual hiring rates were $105 and $103, respectively; Texas, Mississippi, and Louisiana annual hiring rates were between $166 and $171 (Conrad and Myer, 1964, p. 73 and 86).

No slave price series exist that cover all slaves throughout the 19th century. To account for the relationship between slave prices and black stature, one reasonable measure for slave prices is for New Orleans prime fieldhands slave price series recorded between 1802 and 1860; blacks born after emancipation receive zero market value in the models that follow. For the New Orleans slave price series, the average prime field hand price was $948, but varied by approximately $294 throughout the 19th century. Slave

[3] Urbanization is defined as living in a town ship with 2,500 or more residents.

prices were also positively skewed (Figure 2), with the highest prices observed just prior to the Civil War (Fogel, 1974, pp. 86-102).

Figure 2, 19th Century New Orleans Slave Price Series

Source: New Orleans slave price series. Conrad and Myer, 1964, p.76.

United States' Insolation

To account for the relationship between vitamin D and black stature, a measure is constructed that accounts for solar radiation. Insolation is the incoming solar radiation that reaches the earth, its atmosphere and surface objects. Insolation is also the primary source of vitamin D (Hollick, 2007, p. 270). Identifying each slave's African nativity is not possible. Slaves in the 1400s originated in Senegal and Sao Tome (Thomas, 1997,

pp. 11, 76 and 173). The first permanent African mainland slave export-cite was in El Mina, Ghana (Gold Coast) (ibid pp. 154-159), after which the African slave trade moved South, and Angola became the major supplier of Africans to the New World (ibid pp. 13, 81, 117 134, and 143). Before their forced migration to Brazil, the British Caribean and North America, these Africans were exposed to considerable insolation, which was significantly greater than the insolation received by their progeny in the US. Because of its size, Africa has a large insolation variation, and its average insolation is greater than the insolation received in the US because of its proximity to the equator. For example, from a random sample of African sites, Africa receives approximately 5.5 hours of direct insolation per day; however, the US only receives 4.10 hours of direct sunlight per day

and the difference is significant at acceptable levels.

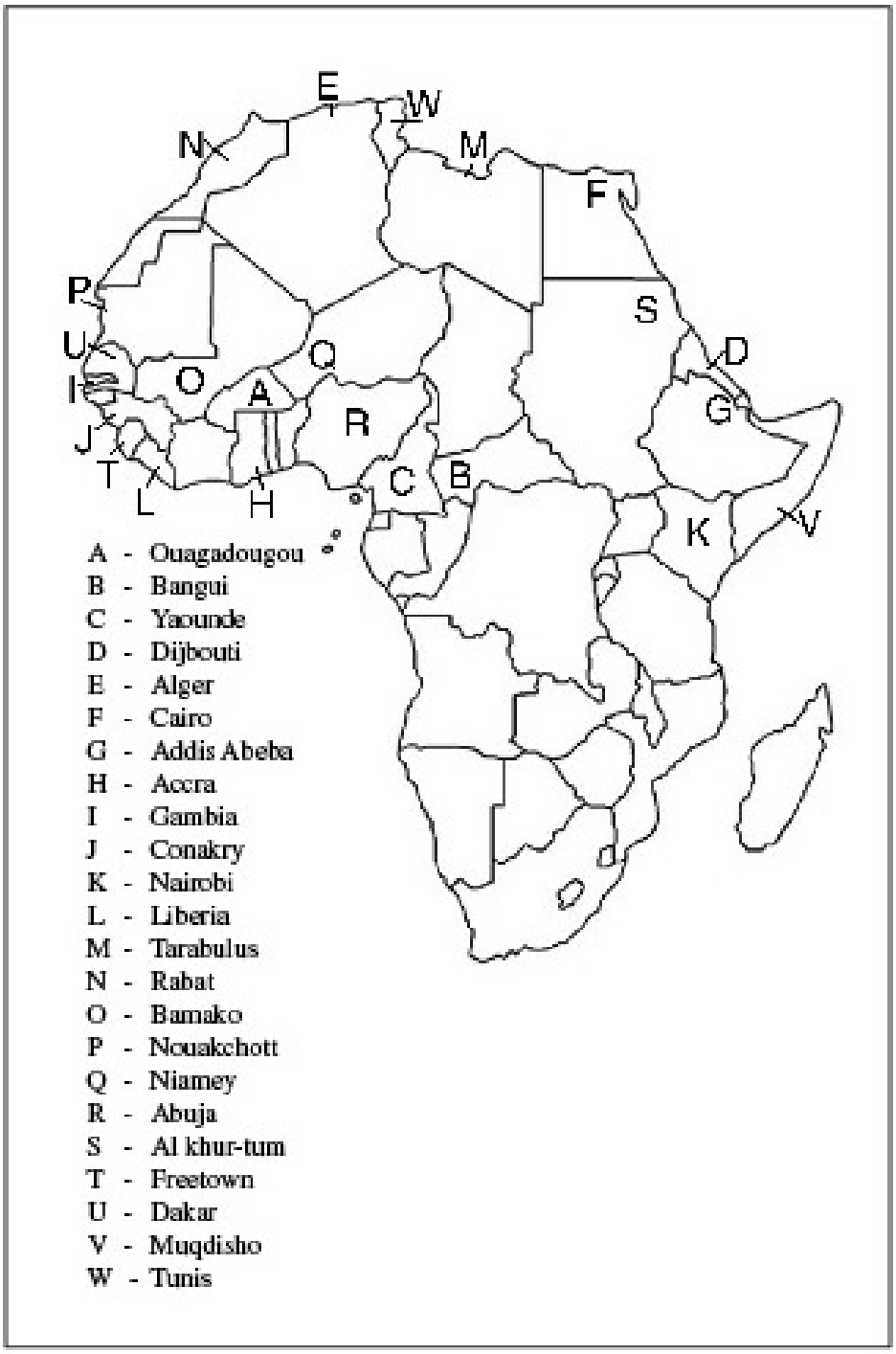


Figure 3, Select African Country's Insolation

Because US historical insolation is unavailable, a modern insolation index (1993-2003) is constructed. The insolation index from each state's county centroid is weighted by county's square miles relative to square miles in the state. While this index is a rough approximation for historical insolation, it provides sufficient detail to capture state latitudinal insolation variation and consequently, vitamin D production. Predictably, Southern states have greater insolation than Northern states, and Western states have greater insolation than Eastern states. For example, Wyoming and Ohio are on similar latitudes, but Wyoming receives 4.22 hours of direct sunlight per day, while Ohio receives only 3.66 hours per day. It is also difficult to interpret insolation's net direct effect on human health, because greater insolation produces more vitamin D, but greater insolation also warms surface temperatures, which may have made disease environments less healthy.

4. Socioeconomic Status, Geography, Insolation, Migration and African-American Stature

Nineteenth century black biological conditions were related to age, socioeconomic status, birth cohorts and nativity; they were also related to slave prices, insolation and vitamin D production. Which of these factors dominates reveals much about 19th century conditions facing black Americans. If black nativity within the US was a source for black stature variation, regional social practices were a possible driving force in stature variation. If occupations were associated with black stature, relative social position was a primary impetus driving black stature variation. If, however, insolation was a significant impetus on black stature, part of 19th century black stature

variation was not due to social or cultural factors but also geographical, and blacks born in the South would have benefited from extended insolation, even though they faced sub-standard diets and more intense work regimes. Moreover, workers in occupations with greater exposure to direct sunlight may have grown taller because they were exposed to greater insolation and produced more vitamin D, which contributed to healthy bone formation (Toretolani, 2002, pp. 57-61).

To illustrate demographic, occupational and residential stature relationships, Table 3 presents three pooled models that regress black stature on age, birth cohorts, occupations, nativity, insolation and New Orleans real slave prices. Models 1 and 2 present youth and adult stature regressions on characteristics. Model 3 pools youth and adult samples and adds dummy variables to account for age, birth cohort and socioeconomic status. To isolate the direct association between slavery and black stature, Model 4 restricts the sample to only blacks born in the South before the Civil War.

Table 3, Nineteenth African-American Adult and Youth Stature

	Youth	*p-value*	*Adult*	*p-value*	*Total*	*p-value*	*Southern Birth Pre-1861 Birth*	*p-value*
Intercept	165.20	<.01	168.44*	<.01	167.31	<.01	162.45	<.01
Ages								
14	-10.75	<.01			-11.00	<.01	-14.05	<.01
15	-8.12	<.01			-8.38	<.01	-8.53	<.01
16	-5.14	<.01			-5.40	<.01	-7.32	<.01
17	-3.05	<.01			-3.32	<.01	-4.02	<.01
18	-2.16	<.01			-2.45	<.01	-3.51	<.01
19	-1.07	<.01			-1.38	<.01	-1.92	<.01
20	-.132	.40			-.416	<.01	-1.13	<.01
21	Reference				-.314	<.01	Reference	
23-55					Reference			
>55					-1.17	<.01	-1.23	<.01
Birth Cohort								
1800s			-.275	.61	-.147	.77	2.22	<.04
1810s	-.821	.24	.405	.27	.208	.48	1.63	<.01
1820s	-1.08	.08	-.437	.17	-.563	.03	.001	.99
1830s	.370	.62	-.662	<.01	-.578	<.01	-.383	.36
1840s	-1.44	<.01	-.603	<.01	-.642	<.01	-.05	.92
1850s	-.513	.12	.136	.48	-.223	.18	.333	.27
1860s	Reference		Reference		Reference			
1870s	-.462	<.01	-.184	.08	-.258	<.01		
1880s	-.690	<.01	-.526	<.01	-.560	<.01		
1890s	-.474	<.01	-.034	.84	-.173	.14		
1900s	.441	.21			.778	.02		
Occupations								
White-Collar	-.193	.67	.159	.58	.089	.71	-.707	.22
Skilled	.388	.31	.219	.39	.279	.18	.009	.99
Farmer	1.85	<.01	1.26	<.01	1.43	<.01	.862	.10
Unskilled	.638	.06	.705	<.01	.690	<.01	.309	.52
No Occupation	Reference		Reference		Reference		Reference	
Nativity								
Northeast	-2.97	<.01	-.196	.71	-.817	.07		
Middle Atlantic	-1.87	<.01	-1.75	<.01	-1.84	<.01		
Great Lakes	Reference		Reference		Reference			
Plains	-1.63	<.01	-1.10	<.01	-1.30	<.01		
Southeast	-.942	<.01	-.164	.35	-.442	<.01	.-.633	.02

Southwest	-.017	.97	.948	<.01	.616	<.01	Reference	
Far West	-1.84	<.01	-1.25	<.01	-1.48	<.01		
Insolation								
Direct Sunlight	1.42	<.01	.499	<.01	.837	<.01	1.84	<.01
Slave Price								
1860 Real Slave Price	-2.4^{-4}	.94	4.3^{-3}	.02	2.7^{-3}	.10	7.6^{-4}	.05
N	17,918		38,340		57,098		12,267	
Adj. R^2	.1190		.0279		.0710		.0714	

Source: See Table 1.

Note: Insolation is state hours of direct sunlight weighted by county square miles. Slave prices are from the New Orleans prime field hand series, 1802-1860.

For several categories, expected patterns hold: farmers were taller than non-farmers; average black unskilled worker statures and field hands were taller than household servants and skilled slaves (Metzer, 1975, p. 134; Margo and Steckel, 1982, p. 525; Cuff, Timothy, 2005). If there was little movement away from parental occupation, 19th century occupations may also be a good indicator for the occupational environment in which individuals came to maturity (Margo and Steckel, 1992, p. 520; Wannamethee et al, 1996, pp. 1256-1262; Nyström Peck and Lundberg, 1995, pp. 734-737). For instance, 19th century farmers were taller than workers in other occupations (Komlos and Coclanis, 1997, p. 441; Komlos, 1987, p. 902; Steckel and Haurin, 1994, p. 170; Sokoloff and Villaflor, 1982, p. 463; Margo and Steckel, 1983, pp. 171-172), and farming is an outdoor occupation that exposes farmers to more direct sunlight, while white-collar workers worked indoors and were exposed to less direct sunlight.

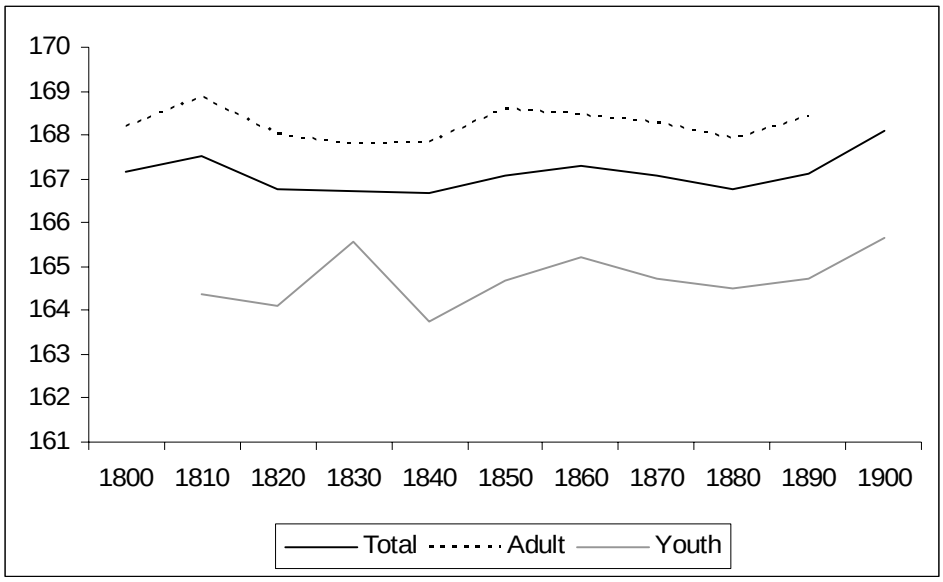


Figure 5, Black Total, Adult and Youth Stature

Source: See Table 3.

Consistent with the Rees et al hypothesis, black inmate statures increased during the antebellum period and decreased during the post-bellum period (Figure 3). Black stature varied regionally, and Southwestern blacks reached the tallest statures. Although Southern wages were in general lower than Northern wages, West South Central laborer's wages were comparable to those in the middle Atlantic region and limited skilled immigration into the West South Central created a relative scarcity of skilled labor, which, after emancipation, may have increased Southern black material and biological conditions (Rosenbloom, 2002, pp. 53, 124-125; Margo, 2000). The relative price of dairy and calcium were lowest in dairy producing regions, such as Great Lake states, but 19th century blacks were overwhelmingly native to the South, and the South

was notoriously low in dairy production.[4] Northeastern blacks, especially youth, encountered adverse biological environments, and contemporary reports of rickets may have contributed to shorter Northeastern black statures (Kiple and Kiple, 1977, p. 293-294; Tortolani et al, 2002, p. 62).

Insolation also mattered in 19th century black stature, and blacks born in states that received more insolation were taller than blacks who lived in areas that received less insolation, which is supported by modern population studies (Norman, 1998, pp. 1108-1110; Weisberg et al, p. 1703S-1704S; Holick, 1995, pp. 641S-642S; Nesby-O'Dell et al 2002, p. 189). An additional hour of direct sunlight added approximately seven-tenths of one centimeter to 19th century stature, indicating that much of black stunting in northern latitudes was attributable to their physical presence in northern latitudes where they were not biologically suited (Loomis, 1967, pp. 501-504; Neer, 1979, p. 441).

Slave prices—as measured by New Orleans slave prices—had only a minor role in black adult stature and did not influence black youth stature. However, when the black sample is restricted to only blacks born in the South before emancipation (Model 4), slave prices at New Orleans were positively related to black stature, but the magnitude was small. After accounting for nativity, direct insolation illustrates that spatial-biological relationships were significant in black stature, and direct sunlight was critical during key growth years.[5] However, even after insolation is accounted for, blacks born in

[4] Southern observers at the time reported that milk was fairly abundant in border states but in short supply in the Deep South (Kiple and King, 1981, p. 83).

[5] Other non-quantifiable sources point to African-Americans receiving insufficient vitamin D compared to what they received in Africa, such as Southern blacks bad teeth (Kiple, 1977, p. 291-293).

the Southwest were taller than blacks born elsewhere within the US, indicating that Southern access to abundant food sources benefited stature.

Migration

Although novel, the prison data has its own limitations. For example, nativity and state prisons are identified, but when migrants left their native state is not identified. Moreover, migrants are taller than non-migrants (Sokoloff and Vilaflour, 1982), which potentially distorts the relationship between stature and insolation. Because many individuals migrated under adult supervision, migration also does not necessarily reflect individual choices to migrate or physical conditions associated with stature. To account for this possibility, Table 4 uses demographic, birth cohort, occupation, insolation and slave prices used earlier, and migration variables to account for insolation differences between birth and incarceration regions. Table 4's model 1 presents regression estimates for black stature on characteristics for only those who persisted in their native state. Model 2 presents regression estimates for only blacks who migrated away from their native states and adds binary migration variables to account for North-South moves. North1 is an intermediate move from southern to central or central to northern states. North2 is a long distance move from southern to northern states. South1 is a move from a northern to central or central to southern state. South2 is a move from northern to southern states. If insolation was a driving force in stature growth, northward moves will have adverse stature effects, and southern moves will have beneficial stature effects. Model 3 omits these North-South moves, and only considers insolation differences between sending and receiving states, while Model 4 controls for both migration

variables and insolation differences to assess whether migration or insolation had the most pronounced effect on stature.

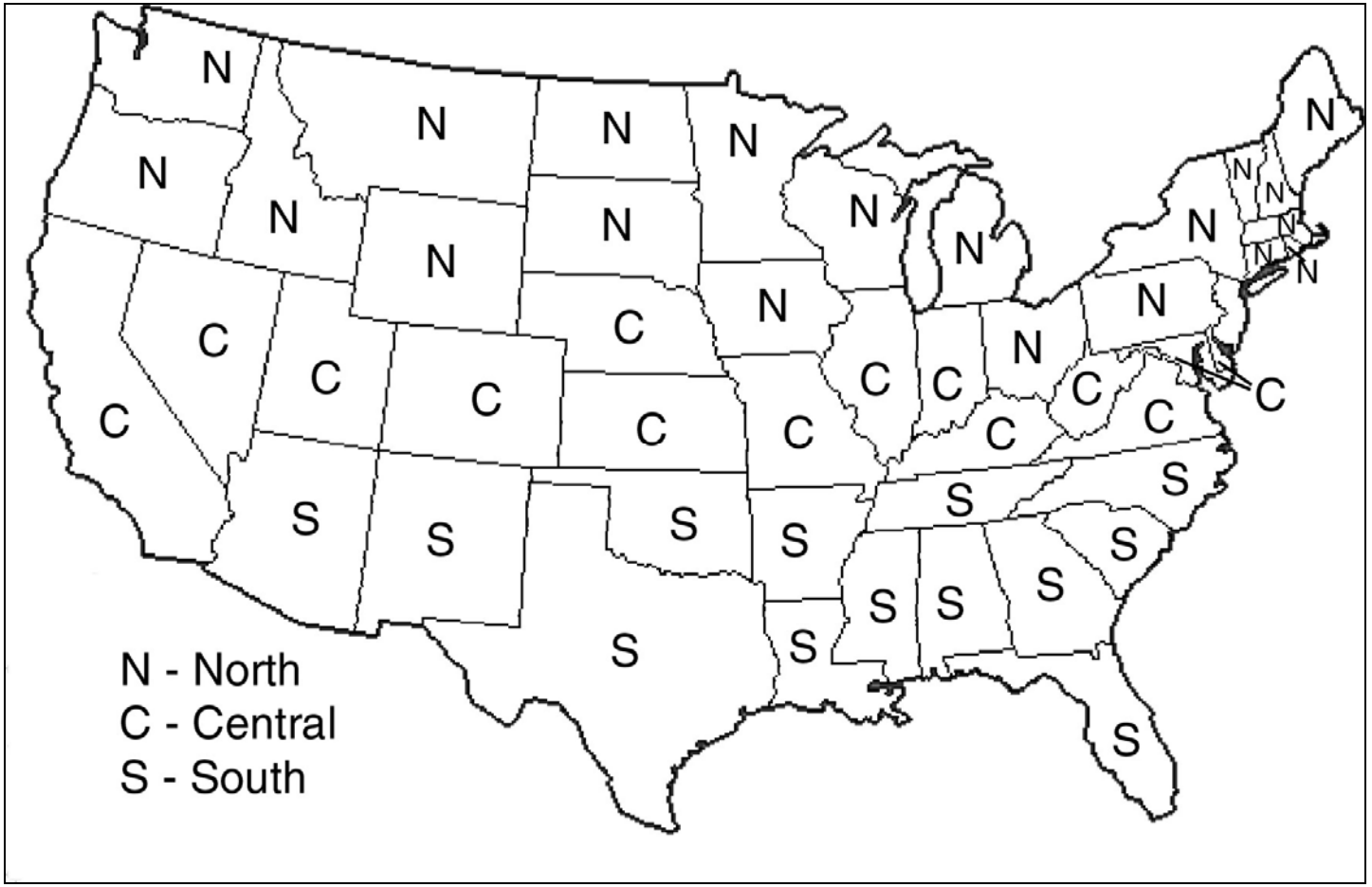


Figure 4, United States' Insolation

Table 4, Nineteenth Century African-American Stature, Insolation and Migration

	Model 1, Persisters	*p-value*	*Model 2, Movers, with Move Direction*	*p-value*	*Model 3, Movers, Insolation Difference*	*p-value*	*Model 4, Movers, Insolation Difference with Move Direction*	*p-value*
Intercept	165.53	<.01	168.04	<.01	166.98	<.01	166.49	<.01
Age								
14	-11.10	<.01	-10.15	<.01	-10.15	<.01	-10.12	<.01
15	-8.41	<.01	-7.96	<.01	-8.00	<.01	-7.98	<.01
16	-5.41	<.01	-5.17	<.01	-5.21	<.01	-5.18	<.01
17	-3.17	<.01	-3.51	<.01	-3.48	<.01	-3.46	<.01
18	-2.25	<.01	-2.71	<.01	-2.66	<.01	-2.63	<.01
19	-1.23	<.01	-1.69	<.01	-1.67	<.01	-1.65	<.01
20	-.235	.11	-.710	<.01	-.693	<.01	-.076	<.01
21	-.084	.56	-.603	<.01	-.573	<.01	-.563	<.01
22-55	Reference		Reference		Reference		Reference	
>55	-1.08	.01	-1.37	<.01	-1.45	<.01	-1.46	<.01
Birth Cohort								
1800	.227	.76	.078	.91	.250	.71	.341	.62
1810	.70	.13	.315	.43	.454	.25	.522	.19
1820	.056	.90	-.787	.02	-.732	.03	-.681	.04
1830	.278	.45	-1.08	<.01	-1.05	<.01	-1.03	<.01
1840	-.656	<.01	-.797	<.01	-.683	<.01	-.655	<.01
1850	-.606	<.01	.022	.93	.046	.85	.063	.79
1860	Reference		Reference		Reference		Reference	
1870	-.080	.47	-.297	.04	-.250	.09	-.260	.08
1880	-.399	<.01	-.552	<.01	-.544	<.01	-.534	<.01
1890	.008	.95	-.268	.22	-.319	.14	-.283	.19
1900	1.21	<.01	-.420	.55	-.481	.49	-.451	.52
Occupations								
White-Collar	-.181	.59	.486	.15	.44	.20	.385	.26
Skilled	-.119	.68	.699	.023	.616	.04	.581	.06
Farmer	1.13	<.01	1.84	<.01	1.77	<.01	1.71	<.01
Unskilled	.425	.10	-1.13	<.01	1.05	<.01	1.03	<.01
No Occupation	Reference		Reference		Reference		Reference	
Nativity								
Northeast	na		-.295	.53	-.568	.23	-.543	.25
Middle Atlantic	-2.71	<.01	-.855	<.01	-.851	<.01	-.832	<.01

Great Lakes	Reference		Reference		Reference		Reference	
Plains	-2.27	<.01	.317	.18	.374	.12	.443	.06
Southeast	-1.55	<.01	1.07	<.01	.690	<.01	.648	<.01
Southwest	-.484	.70	2.00	<.01	1.87	<.01	1.79	<.01
Far West	-3.41	<.01	-.030	.95	.333	.48	.427	.37
Insolation								
Direct Sunlight	1.45	.16	.363	.07	.613	<.01	.697	<.01
Difference					1.30	<.01	1.55	<.01
Slave Price								
1860 Real Slave Price	4.9^{-4}	.03	-2.6^{-5}		-7.3^{-5}	.76	6.8^{-5}	.77
Internal Migration								
North1			-.800	<.01			.196	.20
North2			-.800	<.01			.935	<.01
Same Latitude	Reference		Reference		Reference		Reference	
South1			.790	<.01			.053	.78
South2			2.10	<.01			.468	.27
N	33,790		23,308		23,308		23,308	
Adj. R^2	.0948		.0460		.0487		.0493	

Source: See Table 1.

Note: Northward moves form Southern to Central regions or Central to Northern regions are the binary variable North1. Long distance Northward moves from Southern to Northern states is North2. Southward moves from North to Central or Central to Southern states are South1; long distance southward move from Northern to Southern states is South2. Sunlight difference is the receiving state's insolation minus the sending or nativity state's insolation.

In nearly all cases, results in Table 3 are maintained in Table 4. Moreover, after migration is accounted for, persisters in Great Lake states—with easier access to dairy products—were taller than other blacks who lived in non-dairy producing states (Toretolani et al, 2002, pp. 57-61). After long distance moves and insolation differences are accounted for, North-South migrations were not the source of black stature variation. Rather, it was insolation in the native state and insolation differences between sending and receiving regions that were significant in black stature variation (model 4), and indiviuals from high insolation states were consistently taller than individuals from low insolation states (Table 4, Model 4; Komlos, 1992; Komlos and Cocalis, 1997).

5. Conclusion

This paper has identified two important sources for 19th century black stature variation: slave prices and insolation. African-American statures were positively but only marginally related with New Orleans slave prices, and slave planters and overseers rationally manipulated slave nutrition and medical allocations to maximize their wealth (Rees et al, 2003, p. 22; Carson, 2007). Once slavery was removed, black stature experienced a short-run stature decline that was reversed by the end of the 19th century. However, it was stature and insolation that present the most striking aspect of 19th century African-American stature variation. Slavery facilitated the forced migration of millions of Africans to latitudes where they were not biologically suited. For example, Africans are biologically suited for optimal stature growth on or near the equator, and while it is not possible to identify each slaves' origin, African insolation was significantly greater than North American insolation. Until at least the 1930s, black diets were

probably calcium and vitamin D deficient, and blacks born in states that received greater insolation were taller than blacks from states that received less insolation. This solar radiation explanation also addresses the long-standing conundrum for why lighter pigmented African-Americans were taller than darker pigmented African-Americans. Mulattoes had less melanin in their stratus corneum than darker blacks, which filtered out less sunlight and allowed mulattos to produce more vitamin D. Therefore, rather, than only sociological processes explaining the stature difference between light and dark complected African-Americans, part of this mulatto advantage is consistent with a biologically-based explanation.

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