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Abstract

A population's average stature reflects its cumulative net nutrition and provides important insight when more traditional measures for economic well-being is scarce or unreliable. Heights on the US Central Plains did not experience the antebellum paradox experienced in Eastern urban areas, and statures increased markedly in the late 19th and early 20th centuries. Known for offering migrants economic opportunity, the Central Plains received migrant in-flows from Northern, Southern, and Eastern Europe, and US statures were the tallest in the World. Within the US, individuals from the South were taller than individuals from the North, East, and West. Whites were taller than blacks on the Central Plains where slavery was not the primary labor force, but whites were also taller than blacks in the American South where it was. Immigrants from industrialized Europe were shorter than black and white Americans but taller than Latin Americans and Asians.

JEL-Codes: I100, J110, J710, N310.

Keywords: nineteenth century black and white stature variation, urbanization, US Central Plains.

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Frederick Jackson Turner and the Westward Expanse: Changing Net Nutrition with Economic Development

I. Introduction

In 1893, Frederick Jackson Turner proposed that America's Far Western frontier served as an economic 'safety valve,' a place where immigrants could move from the eastern US and Europe to escape the rigid economic conditions that crystalized against their upward economic mobility. During the 19th century, US agricultural output and economic development varied regionally, and regions that are agriculturally productive in the 21st century are not the same as those in the 19th century (Ransom and Sutch, 1977, p. 151; Cochrane, 1979, pp. 24-32, 69-77). Health and statures are related to economic development, socioeconomic status, and occupations, and much of the Plains' economic advantage was associated with fertile farmlands, nutritious diets, and sparse population densities (Komlos, 1987; Haines, Weiss, and Craig, 2003; Carson, 2012). Both the South and Plains had fertile soils; however, labor market arrangements varied between the two regions. Long hostage to slavery, much of the South's labor force was bound and not free to migrate or acquire the human capital that is present among free populations. The result was that with slavery's demise, the South's agricultural efficiencies were eliminated, and the Central Plains became the most productive US agricultural region (Irwin, 1994; Fogel and Engerman, 1974, pp. 236 and 238; Fogel, 1989; Ransom and Sutch, 1977, p. 151). This study, therefore, uses black and white stature variation on the Central Plains to show that male statures

increased with the US transition a free labor force, and agricultural development to offer an economic safety valve to urbanization and industrialization.

The use of height to measure cumulative net nutrition is now a well-accepted methodology in economics and development studies (Fogel, 1994; Case and Paxson, 2008; Deaton, 2008) and reflects the difference between nutrition, disease exposure, and physical activity (Fogel et al., 1978; Komlos, 1985; Komlos, 1987; Komlos, 1989; Floud et al., 2011). There is a complex relationship between heights and genetics, and in developed economies, 80 percent of height is determined by genetics, while stature in developing economies is only 60 percent determined by genetics (Luke et al. 2001, Siventoinen, 2003, pp. 266-271). By considering average versus individual stature, genetic differences are mitigated, leaving only the influence of the economic and physical environments on stature. When diets, health, and physical environments improve, average stature increases and decreases when diets become less nutritious, disease environments deteriorate, or the physical environment places more stress on the body. In sum, stature provides important insight into understanding historical processes and augments other 19th century welfare measures when other measurements are not available.

It is against this backdrop that this study considers three paths of inquiry into late 19th and early 20th century black and white stature variation on the US Central Plains. First, as multiple nationalities streamed westward, how did 19th century statures vary overtime on the Central Plains? Statures increased with the development of large-scale farming and increasing agricultural productivity, indicating that, like material conditions, net nutrition and biological conditions on the Central Plains improved with economic development. Second, how did black and white statures vary by nativity? Rural Southerners were taller than urban Northeasterners, who were shorter than from elsewhere within the US. Third, how did statures vary by

occupations in this rapidly developing Plains economy? Throughout the late 19th and early 20th centuries, rural environments were beneficial for human growth, and farmers and ranchers in close proximity to nutritious diets were taller than their counterparts in other occupations.

II. Nineteenth Century Plains Immigration and Agricultural Development

An important region during US economic development, little is known about how statures varied on the 19th century Central Plains. Between 1840 and 1860, the Plains received many British, German, and Irish immigrants, and British and German migrants were more likely than the Irish to move to the US interior (Ferrie, 1999, pp. 39-70). This willingness to migrate and assimilate was associated with economic opportunity, and the British and Germans experienced greater economic mobility and wealth accumulation than Irish migrants who remained in Eastern States. Between 1890 and 1915, the source of migration changed, and in the late 19th and early 20th centuries, the Plains received many Southern and Eastern Europeans (Cohn, 2013, pp. 206-207).

A binding constraint on late 19th and early 20th century agriculture was labor, and labor in-flows on the Central Plains were insufficient to accommodate the economic growth necessary to improve living conditions. The impetus that sent agricultural productivity forward was technological change (Cochrane, 1979, pp. 189-202), and the first of the great agricultural innovations in the late 1830s were John Deere's plow and Cyrus McCormack's reaper. Other 19th century agricultural innovations included disks, harrowers, corn-planters, mowers, and hay making equipment (Olmstead and Rhode, 1995; Olmstead and Rhode, 2008). The Civil War created an even greater need for labor saving devices, and after 1865, improvements in agriculture came more from adopting existing labor saving technologies than new agricultural innovations. Moreover, hauling plows and heavy farm equipment was demanding on 19th

century draft animals, and required mechanization for agriculture to fully develop. The last of the major 19th century agricultural innovations was the gasoline powered tractor, and by 1910, tractors were integrated into Plains' agricultural production (Cochrane, 1979, pp. 108-109). By the 1930s, corn hybridization became common, and farmers in Plains states adapted these technologies more readily than in other US regions (Griliches, 1971, p. 208).

The Mississippi River is the largest North American river system. Originating in northern Minnesota, it flows southward for 2,530 miles to the Mississippi River Delta, and a medley of tributaries from the Rocky and Appalachian Mountains drain parts of 31 states and two Canadian provinces into the Mississippi River. The Missouri River is also one of North America's largest river systems and drains nearly one sixth of the water from the continent. Originating in Montana's western Rockies, the Missouri River flows eastward for 2,341 miles across Montana, Wyoming, Colorado, the Dakotas, and Nebraska before draining into the Mississippi River just north of Saint Louis, Missouri. Originally used by indigenous cultures to transport goods and peoples, the Mississippi and Missouri Rivers were the mainstay for more prolific agricultural societies. When Europeans arrived in the 16th century, traffic on the Mississippi and Missouri Rivers increased, and immigrants used the Mississippi and Missouri river systems as low cost transportation routes to penetrate Central North America, making these watersheds integral parts of the Central Plains economic development.

Economic development and urbanization can be hazardous to health, and populations in Europe and North America experienced stature declines during periods when economic development changed rapidly. The process is complex, but a few factors are associated with urban stature decline: rapid population growth without adequate improvement in public sanitation; transportation and commercial revolutions; changing disease environments; and

growing populations that depend on wage income (Haines, 2004, p. 249; Zhetmayer, 2011; Zhetmayer, 2013). The Central Plains were also important in 19th century economic development, because while it remained mostly rural, there were rapidly growing urban centers, such as Saint Louis. Between 1850 and 1870, Saint Louis's population grew by 306%. The growth rate slowed after 1860, but between 1870 and 1920, Saint Louis' populations increased by 186% (Carter, et al., 2006, p. 1-140). In sum, economic opportunity attracted many immigrants to the Central Plains and was associated with economic growth; however, when populations concentrated in urban locations, this early growth was associated with health hazards and deteriorating net nutrition.

III. Nineteenth Century Plains Prison Data

North America's Central Plains is the broad expanse of grass-covered prairie that lies west of the Great Lakes and east of the Rocky Mountains. Data used to study statures on the Central Plains is a subset of a large 19th century prison sample. All available US state repositories were contacted, and available records were entered into a comprehensive data set. These records include Arizona, California, Colorado, Idaho, Kentucky, Maryland, Mississippi, Missouri, Montana, Nebraska, New Mexico, Ohio, Oregon, Pennsylvania, Tennessee, Texas, Utah, and Washington. To determine how male statures varied on the Central Plains, observations from the Colorado, Illinois, Missouri, Montana, and Nebraska prisons are included in this study. Between 1800 and 1920, prison officials routinely recorded dates inmates were received, age, complexion, stature, pre-incarceration occupation, and nativity. Physical descriptions were recorded as a means of identification by prison enumerators at the time of incarceration in the case an inmate escaped and was later recaptured; therefore, physical descriptions reflect pre-incarceration conditions.

All historical height data have various biases, and the two most common sources of 19th century heights are military and prison samples. While plentiful, one potential problem with military heights is a truncation bias created by minimum stature requirements for service (Sokoloff and Villaflor, 1982). Like military data, the prison data is not random, but the type of incarceration criteria prison records contain may have their own advantages, such as being drawn from lower social groups, that segment of society more vulnerable to economic change. The prison data are, however, not without limitations, and it is not clear which segment of society prison records represent. For example, law enforcement officials may have incarcerated shorter individuals who were in poor health that resorted to crime out of privation. Alternatively, law enforcement officials may have targeted taller individuals if they stereotyped them as guilty because taller individuals used physical stature to take advantage of their shorter counterparts. Arrests across states may have resulted in various selection biases that may affect the results of this investigation. However, prison stature variation is consistent with other stature studies (Komlos, 1992; Komlos and Coclanis, 1997; Sunder, 2004). By including all crimes, this concern is reduced, and there is little systematic evidence that physical size or body mass were related with crimes committed (Carson, 2005, p. 414; Carson, 2007, p. 44).[1]

Prison enumerators recorded a complexion variable, from which ethnicity is inferred. African-Americans were recorded as light black, mulatto, medium black, copper, and dark black. Whites were recorded as white, light, medium, fair, and dark. While individuals of African and European ancestry were referred to as 'mulattos' in both prisons and the US census until the 1930s, they are referenced to as 'mixed-race' throughout this study (Bodenhorn, 2015, p. 5).

[1] Floud et al. (2011. p. 331) present average stature estimates for 19th century males. Their stature estimates are only .5 percent taller than individuals in prison.

Whereas mixed-race inmates had genetic characteristics common to both African and European populations, they were treated as blacks in the 19th century US and are grouped here with other black inmates. The most common complexion in the Central Plains was white, followed by blacks and mixed-race. Other ethnic groups include Latin Americans, Native Americans, and Asians.

Occupations are an important measure that represent socioeconomic status and are classified here into seven categories. Highly skilled physicians and government administrators are classified as white collar workers. Craft workers, blacksmiths, and light manufacturers are classified as skilled workers. General farmers are classified as farmers. Ranchers lived in rural agricultural areas in close proximity to animal proteins and benefited from a protein-rich diet. There were also laborers designated in the prison records. Farm laborers and ranch hands are classified as farm laborers, while miners, laborers, and cooks are classified as unskilled workers. Some workers were also recorded as not having an occupation, which includes workers who recorded “none” or “no occupation” as their trade.

Table 1, Nineteenth Century Plains Ages, Birth Periods Nativity, and Occupations

	N	*%*	*Cent*	*S.D.*		*N*	*%*	*Cent*	*S.D.*
Ages					*Nativity*				
Teens	11,153	10.60	169.45	6.75	Northeast	2,194	2.09	170.90	6.68
20s	53,493	50.84	171.40	6.65	Middle Atlantic	11,511	10.94	170.80	6.35
30s	24,415	23.21	171.65	6.66	Great Lakes	22,175	21.08	171.73	6.46
40s	10,554	10.03	171.19	6.71	Plains	31,159	29.62	171.67	6.70
50s	4,118	3.91	170.69	6.73	Southeast	13,536	12.87	171.68	6.83
60s	1,267	1.20	169.97	6.94	Southwest	2,648	2.52	172.04	7.10
70s	212	.20	169.87	6.57	Far West	3,654	3.47	172.46	6.70
Birth Decade					Africa	56	.05	168.94	6.61
1800s	273	.26	170.33	6.61	Asia	148	.14	164.10	8.38
1810s	862	.82	170.46	6.65	Australia	101	.10	169.83	6.13
1820s	2,029	1.93	170.69	7.17	Canada	2,051	1.95	170.81	6.84
1830s	4,618	4.39	170.76	6.81	Europe	9,100	8.65	168.86	6.66
1840s	10,430	9.91	170.83	6.70	Great Britain	5,862	5.57	169.63	6.52
1850s	15,805	15.02	170.65	6.70	Latin America	132	.13	169.92	6.96
1860s	14,715	13.99	171.18	6.52	Mexico	885	.84	167.01	6.67
1870s	19,369	18.41	171.21	6.61	*Occupations*				
1880s	19,419	18.46	171.25	6.69	White-Collar	12,535	11.91	171.17	6.48
1890s	12,737	12.11	171.43	6.77	Skilled	25,748	24.47	171.11	6.58
1900s	3,604	3.43	172.69	6.80	Farmer	12,430	11.81	172.47	6.65
1910s	1,193	1.13	175.05	6.36	Rancher	1,075	1.02	173.31	6.81
1920s	158	.15	176.39	6.76	Farm Labor	434	.41	173.62	6.25
					Unskilled	47,920	45.55	170.90	6.76
Ethnic					No Occupations	5,070	4.82	170.37	7.00
White	87,025	82.71	171.50	6.63	Total	105,212	100.00	171.18	6.71
Black	13,177	12.52	169.59	6.80					
Mixed-race	4,170	3.96	170.07	6.89					
Native-American	293	.28	173.16	6.44					
Asian	54	.05	162.71	6.36					
Mexican	493	.47	166.20	6.36					

Source: Colorado State Archives, 1313 Sherman, Denver Colorado; Missouri State Archives, 600 West Main St., Jefferson City, Missouri, 65102; Montana Historical Society, 225 North Roberts St., Helena, Montana, 59620; Nebraska State Historical Society, 1500 R Street, Lincoln, NE 68501; New

Mexico State Records Center and Archives, 1205 Camino Carlos Rey, Santa Fe, New Mexico, 87507.

White ethnicity was more common than black, and there are Latin Americans, Native-Americans, and Asian populations in the sample (Table 1). The greatest concentration of whites was in Montana, and the greatest concentration of blacks was in Missouri. Because migrants remained on latitudinal trajectories, most nativities on the Central Plains were from Plains and Great Lakes states (Steckel, 1983; Steckel, 1986). Smaller populations were from the Northeast and Southwest. Most international immigrants were from Europe—especially Germany, Ireland and later Italy—while other immigrants were from Britain and Canada (Cohn, 2013, pp. 206-207). The most common occupations were unskilled and skilled workers, and there were several workers from agricultural occupations (Carson, 2009, p. 153). Like today, prisoners were younger, and most prisoner birth decades were between the 1860s and 1880s (Hirschi and Gottfredson, 1983; Carson, 2009). Reflecting time necessary to reach maturity and migrate to the US, foreign born men were incarcerated at older ages; US-born individuals were incarcerated at younger ages (Table 2). The US had only recently been settled, and most individuals born in the early 19th century were foreign born, while most US-born men were incarcerated in the late 19th century. The foreign-born were more likely to be white-collar and unskilled workers, while US-born men were more likely to be farmers or farm laborers.

Table 2, Nineteenth Century Ages, Birth Periods, and Occupations by Birth

	US-Born				*Foreign-Born*			
Ages	N	%	Cent	S.D.	N	%	Cent	S.D.
Teens	10,073	11.59	169.62	6.73	1,080	5.89	167.89	6.80
20s	45,425	52.29	171.74	6.58	8,068	44.00	169.49	6.68
30s	19,476	22.42	172.21	6.52	4,939	26.94	169.42	6.73
40s	7,867	9.06	171.96	6.54	2,687	14.66	168.93	6.70
50s	2,978	3.43	171.48	6.66	1,140	6.22	168.63	6.47
60s	900	1.04	170.58	6.84	367	2.00	168.48	6.95
70s	158	.18	170.84	6.23	54	.29	167.03	6.78
Birth Decade								
1800s	163	.19	171.89	6.43	110	.60	170.33	6.61
1810s	472	.54	172.11	6.45	390	2.13	170.46	6.65
1820s	1,197	1.38	171.99	7.16	832	4.54	170.69	7.16
1830s	2,873	3.31	171.86	6.81	1,745	9.52	170.76	6.81
1840s	7,704	8.87	171.41	6.66	2,726	14.87	170.83	6.70
1850s	13,056	15.03	170.97	6.68	2,749	14.99	170.65	6.70
1860s	12,235	14.08	171.55	6.46	2,480	13.53	171.18	6.52
1870s	16,684	19.20	171.49	6.52	2,685	14.64	171.21	6.61
1880s	16,518	19.01	171.53	6.59	2,901	15.82	171.25	6.69
1890s	11,278	12.98	171.77	6.68	1,459	7.96	171.43	6.77
1900s	3,374	3.88	172.96	6.70	230	1.25	172.69	6.80
1910s	1,168	1.38	175.16	6.30	25	.14	175.05	6.36
1920s	155	.18	176.54	6.72	3	.02	176.39	6.76
Nativity								
Northeast	2,194	2.09	170.90	6.38				
Middle Atlantic	11,511	10.94	170.80	6.35				
Great Lakes	22,175	21.08	171.73	6.46				
Plains	31,159	29.62	171.67	6.70				
Southeast	13,536	12.87	171.68	6.82				
Southwest	2,648	2.52	172.04	7.10				
Far West	3,654	3.47	172.46	6.70				
Africa					56	.05	168.94	6.61
Asia					148	.14	164.10	8.38
Australia					101	.10	169.83	6.13
Britain					5,862	5.57	169.63	6.52
Canada					2,051	1.95	170.81	6.84
Europe					9,100	8.65	168.86	6.66
Latin American					132	.13	169.92	6.96
Mexico					885	.84	167.01	6.67

Occupations								
White-Collar	9,943	11.44	171.34	6.42	2,592	14.14	169.40	6.41
Skilled	20,717	23.85	171.60	6.45	5,031	27.44	169.07	6.70
Ranchers	903	1.04	173.83	6.63	172	.94	170.59	7.13
Farmers	11,184	12.87	172.74	6.57	1,246	6.80	170.06	6.88
Farm Laborers	356	.41	173.96	6.40	78	.43	172.04	5.24
Unskilled	39,981	46.02	171.26	6.70	7,939	43.30	169.11	6.80
No Occupation	3,793	4.37	170.88	7.08	1,277	6.96	168.85	6.54
Total	86,877	100.00	171.60	6.63	18,335	100.00	169.21	6.71

Source: See Table 1.

IV. The Effects of Demographics, Socioeconomics Status, and Residence with Black and White Stature Variation on the Central Plains

The timing and extent of stature variation depends on ethnicity, demographics, birth period, nativity, and occupations. These variables are now tested with least squares regression models to assess how characteristics were associated with 19th century stature variation on the US Central Plains. To start, individuals are partitioned into total, black, white, US born, and foreign born samples.

$$Centimeters_i = \alpha +_i + \sum_{r=1}^{4} \beta_r Ethnicity_i + \sum_{a=1}^{15} \beta_a Age_i + \sum_{t=1}^{13} \beta_t Birth\,Period_i +$$

$$\sum_{n=1}^{11} \beta_n Nativity_i + \sum_{i=1}^{6} \beta_l Occupations_i + \varepsilon_i$$

Ethnic dummy variables are included to determine how statures varied with skin complexion, and age dummy variables are included to assess how Plains' youth statures increased between ages 15 through 22; 10 year adult age dummy variables are included for ages 40 through 70 (Huang et al., 2013). Because stature varies considerably over the life-course, age

dummy variables are included because they impose less rigid constraints on the relationship between height and age. To measure how statures varied with economic development, birth decade dummy variables are included for birth between 1800 and 1920. Stature is sensitive to the physical environment, and nativity dummy variables are included to account for the relationship between cumulative net nutrition and the physical environment in which a person came to maturity. Individual white-collar, skilled, rancher, agricultural workers, and unskilled laborer occupation dummy variables are included to measure how statures varied by socioeconomic status.

To assess the relationship between stature and skin complexion, black, mixed-race, Native-American, Latin American, and Asian dummy variables are included in model 1. Model 2 accounts for US-born black stature variation, while Model 3 does the same for whites. To isolate how statures varied with US nativity, the sample is restricted in Model 4 to only US births and to non-US births in Model 5. Because there are few females, only males are included in Models 1 through 5. However, the stature of women on the Plains is combined with other women in the US in other studies (Carson, 2011; Carson, 2013a).

Table 3, Nineteenth Century Plains Statures by Ethnicity, Demographics, and Occupations

	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*
	Total	Black	White	US Born	Non-US Born
Intercept	173.71***	172.43***	173.46***	173.97***	169.57***
Ethnicity					
White	Reference			Reference	Reference
Black	-2.51***	Reference		-2.56***43**	-.364
Mixed-race	-1.77***	.841***		-1.78***	-1.92**
Native American	.584				
Asian	-3.91**				
Latin	-4.35***				
Ages					
15	-8.45***	-10.07***	-7.55***	-8.66***	-7.07***
16	-4.50***	-4.32***	-4.76***	-4.60***	-4.74***
17	-3.36***	-3.61***	-3.51***	-3.54***	-2.78***
18	-2.02***	-2.48***	-2.02***	-2.21***	-1.41***
19	-1.16***	-1.57***	-1.20***	-1.30***	-1.09***
20	-.577***	-1.01***	-.681***	-.749***	-.121*
21	-.256***	-.802***	-.318**	-.418***	-.112*
22	-.181***	-.647***	-.241*	-.330***	.008
23-39	Reference	Reference	Reference	Reference	Reference
40s	-.120	-.182	.021	-.016	-.421***
50s	-.561***	-.791***	-.495***	-.545***	-.616***
60s	-1.21***	-1.29***	-1.43***	-1.44***	-.689***
70s	-1.27***	-.070	-1.45***	-1.23***	-1.89***
Birth Year					
1800s	-1.43**	.428	-.897	-.749	-2.07*
1810s	-1.33***	-2.35*	-.456	-.738	-1.69**
1820s	-1.34***	-2.61***	-.730*	-1.01**	-1.40*
1830s	-1.52***	-1.76***	-1.16***	-1.31***	-1.54**
1840s	-1.58***	-2.33***	-1.41***	-1.58***	-1.29*
1850s	-1.63***	-2.12***	-1.58***	-1.70***	-1.14
1860s	-1.27***	-1.73***	-1.19**	-1.30***	-.932
1870s	-1.32***	-1.55***	-1.37***	-1.39***	-.817
1880s	-1.27***	-1.88***	-1.25***	-1.38***	-.467
1890s	-1.08***	-1.72***	-.989***	-1.12***	-.571
1900s	Reference	Reference	Reference	Reference	Reference
1910s	1.77***	1.88**	1.78***	1.80***	.847
1920s	3.74***	3.74**	3.89***	3.91***	-1.50
Nativity					
Northeast	-1.42***	-1.21***	-1.28***	-1.58***	
Middle Atlantic	-1.48***	-1.85***	-1.32***	-1.64***	
Great Lakes	-.625***	-1.17***	-.411***	-.750***	

Plains	-.430***	-1.68***	-.046	-.533***	
Southeast	.130	-.772***	.291*	-.014	
Southwest	Reference	Reference	Reference	Reference	
Far West	-.047	-.678	.238	-.105	
Africa	-3.00***				Reference
Asia	-6.56***				-3.36***
Australia	-2.33**				.935
Britain	-2.72***				.975
Canada	-1.55***				1.87**
Europe	-3.70***				-.147
Latin America	-1.56**				1.20
Mexico	-4.29***				-1.71*
Occupations					
White-Collar	.166	.776	.094	.124	.410
Skilled	.182	.630	.222	.237	.037
Ranchers	1.83***	.308	2.04***	1.96***	1.42*
Farmers	1.26***	2.15***	1.44***	1.29***	1.38***
Farm Laborers	2.88***	5.18**	2.89***	3.02***	2.97**
Unskilled	.288**	.635	.375*	.342*	.180
No Occupation	Reference	Reference	Reference	Reference	Reference
N	105,212	16,922	69,497	86,419	17,953
R^2	.0663	.0449	.0337	.0531	.0264

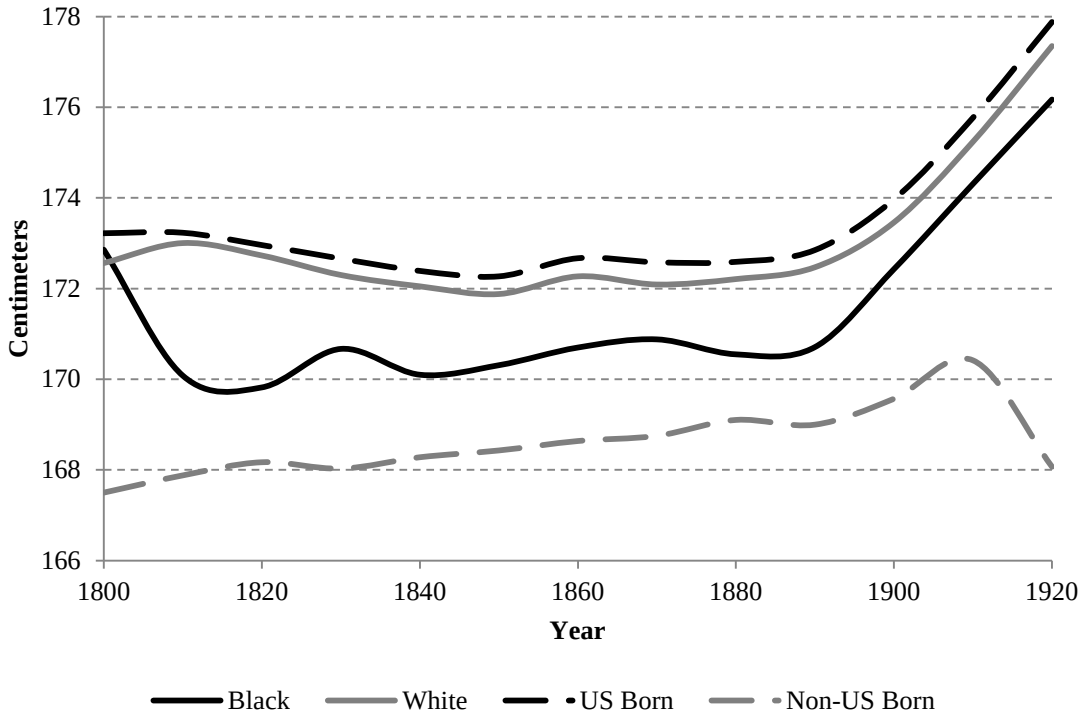
Source: See Table 1.

Notes: Models estimated with least squares and White robust standard errors.

Three patterns emerge when comparing how statures varied on the Central Plains with demographic characteristics, socioeconomic status, and nativity. First, the antebellum paradox is the proposition that US heights declined during the 19th century's second and third quarters at the same time that income and wealth increased (Fogel et al., 1978; Komlos, 1987; Fogel, 1994; Steckel and Haurin, 1994, p. 124; Fogel, 2000, pp. 139-142). Moreover, Frederick Jackson Turner hypothesized in 1893 that when economic and social conditions crystalized in eastern states and Europe that the Plains and Far West served as a 'safety valve' for economic development because settlers could move west in search of opportunity. However, this view has recently been challenged Libecap and Hansen (2002) and Hansen and Libecap, (2004), who maintain that Central Plains' material conditions decreased with economic development when settlers were slow to respond to information asymmetries regarding the weather and slow to change their crop mixes, agricultural techniques, and farm sizes (Libecap and Hansen, 2002; Hansen and Libecap 2004; Libecap and Hansen, 2004). However, black and white statures on the Central Plains increased after the Civil War, indicating that rather than a region of biological stress created by economic development and imperfect information, statures on the Central Plains increased with agricultural and economic development (Figure 1; Stewart, 2006; Stewart, 2009, pp. 261-264). Moreover, there is little evidence of the anti-bellum paradox, which is expected given that the Central Plains during the mid-19th century did not experience wide-scale urbanization and the corresponding increase in the relative price of food (Komlos, 1987, p. 915; Carson, 2008a, pp. 366-368). Therefore, black and white working class statures on the Central Plains may not have experienced the antebellum paradox to the same degree as in other regions, and the post-Civil War stature increase indicates that rather than an area of economic and

geographic net nutritional stress, conditions on the Central Plains improved with economic development.

Figure 1, Nineteenth Century Central Plains Stature



Source: See Table 2.

Second, statures also varied by nativity and individuals born on the Central Plains were among the tallest international populations. Prince and Steckel (2003, p. 369) find an inverted U-shaped height by latitude gradient for white Union Army recruits and Plains' Native Americans and attribute the pattern to spatial differences in diets, work effort, and disease. This Plain's height by latitude gradient across Native, African, and European Americans indicates that biological conditions by geography had a significant role in 19th century stature variation and economic development. Moreover, individuals born in the South but who migrated north to the

Central Plains had the tallest US statures (Steckel and Haurin, 1994; Carson, 2009; Zahetmeyer, 2011, p. 6). Before the Civil War and emancipation, the South was self-sufficient in food production and a geographic area that was sparsely populated (Ransom and Sutch, 1977, p. 150; Carson, 2009a, p. 151; Carson, 2012). However, after the War, Southern agriculture productivity decreased, and the South became a net food importer (Ransom and Sutch, 1977, pp. 150-155). On the other hand, individuals born in Middle Atlantic and Northeastern states were shorter because these regions had greater population densities and were separated from agricultural production, which increased the relative price of nutrition (Komlos, 1987, Table 8, p. 909; Carson, 2008c, pp. 366-368; Carson, 2010, p. 475). Stature is also related to population density, and the 19th century South was more rural than Middle Atlantic and Northeastern states. Statures increased in states with low population densities and reached a maximum in states with population densities of 42 persons per square mile, which is approximately equal to Illinois' population density (Carson, 2009c, p. 51; Carson, 2010, p. 475).

The 19th century Central Plains received many international immigrants, and Canadians who migrated south were the tallest international migrants on the Central Plains. During the 19th century, Canadian-born statures remained constant or decreased slightly, despite increasing income (Cranfield and Inwood, 2007, pp. 212-216). British-born immigrants were shorter than Canadians but were taller than Continental Europeans, and 19th century Europeans encountered some of the dreadful net nutritional conditions within what was then the developing world (Floud et al., 2011). Latin Americans on the Central Plains were among the shortest ethnic groups (Lopez-Alonzo, 2003; Carson, 2005, pp. 413-415). However, the shortest ethnic group was Asians, and short and decreasing Chinese sojourn workers indicates that net nutritional conditions in Southeast Asia decreased with the Opium Wars and Taiping Rebellion (Morgan,

2004, p. 206; Carson, 2005; Carson, 2007, pp. 178-181). In sum, international nativity on the Plains confirms other nativity patterns, and Southern black and white Americans had the tallest statures, while their counterparts from rapidly industrializing Europe and underdeveloped Latin America and Asia were considerably shorter.

Third, statures were also related to occupations and socioeconomic status, and ranchers, who were in close proximity to animal proteins, amino acids, and dairy products, were taller than workers in other occupations (Komlos, 1987; Carson, 2008b; Silventoinen, 2003). Rural agricultural farmers, who lived in close proximity to agricultural output and mild disease environments, were also taller than workers in workers other occupations. Moreover, white-collar and skilled workers were urbanized and faced relatively high food prices and were shorter than workers in other occupations (Komlos, 1987; Carson, 2009, p. 155; Komlos, 1998). On the other hand, non-agricultural unskilled laborers on the Central Plains were shorter than workers in other occupations and indicate that unskilled laborers' working-class conditions were associated with inferior net nutrition. Because many 19th century prison enumerators failed to distinguish between unskilled and agricultural laborers, the omission likely over-estimates the benefits of being an unskilled laborer and under-estimates the benefits of being a farm laborer (Carson, 2011; Carson, 2013b).

Other patterns are consistent with expectations. A common finding in historical and contemporary studies is that fairer complexioned individuals are taller than their darker complexioned counterparts, and an early interpretation for this stature difference was Southern social preferences that disproportionately favored fairer to darker complexioned blacks.[2]

[2] Modern black and white statures are comparable when brought to maturity under optimal biological conditions (Eveleth and Tanner, 1976; Tanner, 1977; Steckel 1995, p. 1910; Barondess et al., 1997, p. 968; Komlos and Baur,

However, if fairer complexioned mixed-race individuals on the Plains were taller than darker complexioned blacks, it indicates Southern social prejudice may not account for fairer complexioned individuals because slavery was not prominent on the Northern Plains. Whites and mixed-race individuals were taller than blacks in all regions within the 19th century US, which indicates that Southern social prefaces by skin complexion as the sole explanation for height differences does not account for the black-white stature differential (Table 3). There are other reasons why 19th century whites were taller than blacks. Whites had greater access to meat and better nutrition (Margo and Steckel, 1982, pp. 514-515, 517, and 519), and up to 40 percent of stature variation in developing economies is due to environmental conditions. Blacks also did not consume as many dairy products as whites (Hilliard, 1972; Kiple and King, 1981, pp. 83-85; Carson, 2008c), and milk consumption is positively related with stature growth (Wiley, 2005, pp. 432-440). Two other complexion patterns on the Central Plains are consistent with the existing literature. Native-American statures were comparable to white statures (Steckel and Prince, 2001; Komlos, 2003), and Latin American and Asian statures were shorter than other populations (Morgan, 2004; Carson, 2005; Carson, 2007).

V. Explaining the Difference between Plains White and Black Stature Differences

To more fully account for the Central Plains white-black stature differential, a Blinder-Oaxaca decomposition is constructed for white and black statures (Oaxaca, 1973). A Blinder-Oaxaca decomposition is a statistical procedure used to detect labor market discrimination but is also used to distinguish between dependent variable differences that are due to average characteristics and returns to characteristics. Let S_w and S_b represent the statures of whites and

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2004, pp. 64 and 69; Nelson et al., 1993, pp. 18-20; Godoy et al. 2005, pp. 472-473; Margo and Steckel, 1982, p. 519).

blacks, respectively; α_w and α_b are the autonomous stature components that accrue to whites and blacks; β_w and β_b are returns associated with specific stature enhancing characteristics, such as age and occupation. X_w and X_b are black and white average characteristic matrices, and whites are assumed to be the base structure.

White stature function: $$S_w = \alpha_w + \beta_w X_w$$

Black stature function: $$S_b = \alpha_b + \beta_b X_b$$

The white and black stature gap is the difference between white and black statures.

$$\Delta S = S_w - S_b = \alpha_w + \beta_w X_w - \alpha_b - \beta_b X_b$$

Adding and subtracting $\beta_w X_b$ to the right hand side of the equation and collecting like terms leads to

$$\Delta S = S_w - S_b = (\alpha_w - \alpha_b) + (\beta_w - \beta_b) X_w + \beta_b (X_w - X_b)$$

The first right-hand side element, $(\alpha_w - \alpha_b)$, is the part of the stature differential due to non-identifiable sources, such as better access to nutrition that favored whites. The second right hand-side element, $(\beta_w - \beta_b)$, is the component of the stature differential due to characteristic returns. The third right-hand side element, $(\overline{X}_w - \overline{X}_b)$, is the part of the stature differential due to differences in average characteristics.

Table 4, Central Plains Black and White Stature Decompositions

Levels	$(\beta_w - \beta_b)\bar{X}_b$	$(\bar{X}_w - \bar{X}_b)\beta_w$	$(\beta_w - \beta_b)\bar{X}_w$	$(\bar{X}_w - \bar{X}_b)\beta_b$
	Returns to Characteristics	*Mean Characteristics*	*Returns to Characteristics*	*Mean Characteristics*
Sum	2.59	-.073	2.34	.177
Total		2.52		2.52
Proportions				
Intercept	.409		.409	
Ages	.058	.054	.054	.058
Birth Decade	.206	.021	.217	.009
Nativity	.487	-.128	.402	-.042
Occupations	-.131	.024	-.152	.045
Sum	1.03	-.029	.930	.070
Total		1		1

Source: See Tables 1 and 2.

Using coefficients from stature regressions (Table 3, Models 2 and 3), the white-black stature decomposition indicates taller white statures were due to unobservable characteristics in the intercept, such as better nutrition that accrued to whites. Figure 1 illustrates that after 1860, black stature increases were greater than for whites. The net cumulative rate of stature returns increased more for blacks than for whites, indicating that black cumulative net nutritional returns increases were greater for blacks than whites on the Central Plains; however, the majority of the white-black stature differential is explained by non-identifiable characteristics, such as differences in white and black access to cumulative net nutrition.

VI. Conclusion

In 1893, Frederick Jackson Turner proposed that America's Far Western frontier was a 'safety-valve' against the economic stress associated with industrialization and urbanization. Despite recent challengers to the safety value hypothesis, Jackson's hypothesis with respect to

statures on the Central Plains cannot be rejected and is robust to recent criticism. The late 19th and early 20th century US Central Plains was a dynamic region during a period of considerable economic change associated with high mass immigration and market development. Central Plains' stature variation over the late 19th and early 20th century indicates that rather than an area of stagnation and decline, net cumulative nutrition on the Central Plains improved considerably with economic development. Individuals on the late 19th and early 20th century Central Plains were taller than other international nativities, in part because they were in close proximity to greater net nutrition and faced lower relative food prices; the development of large-scale farming created an environment where biological conditions on the Central Plains improved with economic development. Statures were also related to rural western environments, and individuals in states with population densities approximately equal to those in Illinois reached the tallest statures. Proximity to nutritious diets was associated with taller statures, and ranchers and farmers were taller than workers in other occupations. Therefore, statures on the Central Plains illustrate that rather than a time and place of economic and nutritional stagnation, net nutrition improved with economic development in this largely rural agricultural region.

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