The Slaughter of the Bison and Reversal of Fortunes on the Great Plains

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Abstract

In the late 19th century, the North American bison was brought to the brink of extinction in just over a decade. We show that the bison's slaughter led to a reversal of fortunes for the Native Americans who relied on them. Once the tallest people in the world, the generations of bison-reliant people born after the slaughter were among the shortest. Today, formerly bison-reliant societies have between 20-40% less income per capita than the average Native American nation. We argue that federal restrictions limiting the mobility and employment opportunities of Native Americans hampered their ability to adjust in the long-run and generated long lasting economic regional disparities that are associated with other indicators of social dislocation such as suicide and unrest.

Keywords: North American Bison, Buffalo, Extinction, Economic History, Development, Displacement, Native Americans, Indigenous, Income Shock, Intergenerational Mobility

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"But when the buffalo went away the hearts of my people fell to the ground, and they could not lift them up again." (Crow Plenty-Coups quoted in Lindermann (1930, p. 169))

The near-extinction of the North American bison in the late 19th century was a dramatic historical episode. Within a period of less than twenty years the bison population declined from over eight million to less than five hundred (Taylor, 2011). For the Native Americans of the Great Plains, the Northwest, and the Rocky Mountains, this meant the elimination of a resource that had been their primary source of livelihood for over 10,000 years prior to European settlement (Frison, 1991; Gilmore, Tate, Tenant, Clark, McBride, and Wood, 1999; O'Shea and Meadows, 2009; Zedeño, Ballenger, and Murray, 2014). For many tribes, the bison was used in almost every facet of life, not only as a source of food, but also skin for clothing, lodging, and blankets, and bones for tools. This array of uses for the bison was facilitated by generations of specialized human capital, which was accumulated partly in response to the plentiful and reliable nature of the animal (Daschuk, Hackett, and MacNeil, 2006). Historical and anthropometric evidence suggests that these bison-reliant societies were once the richest in North America, with living standards comparable to or better than their average European contemporaries (Carlos and Lewis, 2010; Prince and Steckel, 2003; Steckel, 2010; Steckel and Prince, 2001). When the bison were eliminated, the resource that underpinned these societies vanished in an historical blink of the eye. We show that the loss of the bison had substantial and persistent negative effects for the Native Americans that relied on them.[1] We relate this persistence to the federal restrictions that limited mobility and occupational specialization among Native Americans throughout the twentieth century, and to the lasting psychological effects generated by the economic collapse of bison-reliant societies.

In some regions, the bison was eliminated through a mass slaughter that occurred within a period of just over ten years. The slaughter was, at least in part, spurred by a drastic improvement in European tanning technology that allowed bison hides to be transformed into commercially viable leather, thereby increasing the demand for bison hides internationally (Taylor, 2011). In other regions, the decline of the bison was a gradual process, beginning with the

[1]We use the term Native American to broadly refer to the original inhabitants of North America but acknowledge that this term is imprecise and is not without controversy (Corntassel and Witmer, 2008). We use it here because of its generality and common acceptance.

introduction of the horse and the arrival of European settlers. Our empirical strategy exploits regional variation in the speed at which the bison disappeared as well as tribal variation in bison-reliance to determine the impact of the loss of the bison on the Native American societies that relied on them.

Our primary measures of bison-reliance are constructed by overlaying maps of the historic bison range and the timing of the bison's destruction (Hornaday, 1889) with maps of tribal ancestral territories (Gerlach, 1970; Sturtevant, 1981). This allows us to calculate the proportion of a nation's ancestral territory covered by the historic bison range during the slow and rapid periods of the bison's decline. To establish the contemporaneous impact of the elimination of the bison, we merge our measures of bison reliance with data on the height, gender, and age of over 15,000 Native American peoples collected between 1889 and 1919 by physical anthropologist Franz Boas (Jantz, 1995).[2] The tribe-age structure of Boas' data allows us to use a differences-in-differences strategy to compare age-height trends between societies that were affected by different stages of the bison's depletion. We find that nations that lost the bison most quickly suffered a 5 to 9 cm decline in height relative to those that lost the bison slowly. This decline more than eliminates the initial advantage of the bison-reliant people, providing the first empirical support for the contention of Steckel and Prince (2001) and Prince and Steckel (2003) that the people of the Great Plains derived their height advantage, at least in part, due to their access to the bison. We present additional evidence that bison-reliant nations also suffered non-trivial increases in mortality, suggesting that our estimates may be viewed as lower bounds on the height differential.

Given that other research that has found long-term persistence of historical events (e.g., Caicedo (2018); Nunn (2008); Voigtländer and Voth (2012)) we investigate whether the negative effects of the loss of the bison can be seen in the present, and if so, what factors mediated this persistence. We use data from the Census Fact Finder compiled by Dippel (2014) to show that per capita income on reservations comprised of previously bison-reliant societies was approximately 30% lower in 2000, compared with reservations comprised of non-bison-reliant

[2] We supplement our primary measure of bison-reliance with an anthropological index derived from historical accounts of bison-reliance, the share of a tribe's traditional territory that is covered by short grasses, a measure of cattle carrying capacity based on the 2012 U.S. Census of Agriculture, and tribal self-selection into the Inter-Tribal Buffalo Council.

societies.[3] Further, we find that reservations whose members belonged to societies that lost the bison gradually had approximately 20% less income on average, while those whose members belonged to societies that lost the bison rapidly had roughly 40% lower incomes on average. The contrast in persistence among those belonging to "rapid-loss" and "gradual-loss" bison-societies contributes to a more general question in the economics literature regarding the ability of economies to adjust to gradual versus sudden economic shocks.

An alternative explanation as to why formerly bison-reliant nations are systematically less wealthy than non-bison-reliant nations over 150 years after the slaughter is that the pre-contact, colonial, and post-colonial experiences of formerly bison-reliant nations were different from those of non-bison-reliant nations. We implement four strategies to consider this possibility. First, we restrict our sample to include only formerly bison-reliant nations and compare those that lost the bison rapidly to those that lost the bison slowly. In doing so, unobservable characteristics that are consistent across bison-reliant nations are held constant, and identifying variation comes from the speed at which the bison disappeared from each nation's traditional territory. Second, we include an extensive set of covariates: cultural controls, including historical centralization, forced coexistence, and experience with agriculture, to capture the pre-contact characteristics of tribal groups; colonial controls, including the timing and quality of treaties, involvement in the fur trade, and the expansion of the railway into tribal territories, to account for tribes' interactions with European settlers; and modern controls, including social mobility and soil quality, to capture other contemporary factors that may differ across reservations. Third, following Oster (2017), we bound our estimates of the effect of the loss of the bison under a proportional selection hypothesis. Finally, we construct a set of instrumental variables that leverage the cost-adjusted distance between tribe's traditional territories and cities that were historically important for the trade in bison robes.[4] Each of these strategies yield estimates that are similar in magnitude to the OLS estimates.

Considering that short-run economic events tend to be mitigated by societies' ability to

[3]We view this as building on the literature on the colonial and historical origins of economic development. See for example Acemoglu, Johnson, and Robinson (2001, 2002), Nunn (2008, 2009); Nunn and Puga (2012); Nunn and Qian (2011), Dell (2010), and Dippel (2014).

[4]The intuition behind this strategy is that tribes whose territories were close to cities involved in the trade of bison robes would have been affected by the gradual depletion of bison hides, while tribes whose territories were close to cities that played a significant role in the export of bison hides to Europe would have been affected by the rapid slaughter.

adjust to shocks over the long-run, we suggest three possible explanations for the long-run divergence in well-being between bison-reliant and non-bison-reliant nations. We consider the role of mobility, occupational re-specialization, and psychological persistence. The former two channels operated in part through explicit policies enacted by the federal government that limited occupational choice and mobility of Native Americans, while the latter can be attributed to a particularly acute form of the post-colonial experience of Indigenous Americans

Migration has been shown to be an important margin of adjustment (Hornbeck, 2012). Consistent with this finding, we document a convergence in occupational rank among bison-reliant communities after restrictions that limited movement off reservations were lifted in 1924 (Marks, 1998).[5] The penalty for belonging to a previously bison-reliant nation is smaller outside of native homelands, which suggests that bison-reliant people who left their traditional homelands, and would have had more opportunities to participate in the mainstream economy, experienced modest economic convergence on average.

Potentially the largest mitigating factor was the ability of some Native Americans to transfer pre-existing human capital to crop-based agriculture, which was one of the only sectors permitted and incentivized by the Bureau of Indian Affairs (Daschuk, 2013; Iverson, 1997). We show that bison-reliant communities who had also engaged in agriculture practices prior to the bison's slaughter experienced a near complete economic recovery by 2000, despite facing a similar initial biological and economic shock. [6] This suggests that when nations had opportunities to draw on pre-existing human capital, they were more able to adjust to loss of the bison in the long run.

A final possibility is that the modern economic penalty associated with belonging to a formerly bison-reliant nation is explained by a form of historical trauma. Commonly posed in the psychology literature, this hypothesis posits that groups suffering traumatic events experience a biological response that is transmitted across generations, manifesting itself in maladaptive behavior, such as depression, suicide, and violence, which in turn can affect economic performance among later generations (Sotero, 2006). That past traumatic events may be related to

[5]This time period was also followed by federal efforts to incentivize Native Americans to relocate to urban centres (Gundlach and Roberts, 1978; Sorkin, 1969).

[6]A natural alternative use of land during the twentieth century may have been cattle ranching; however, as suggested by Trosper (1978), limited access to capital markets as late as the 1960s prevented Native American ranchers from producing the same level of output as non-Native ranchers.

current economic behavior and social functioning has been noted in the economics literature (e.g. Acemoglu et al. (2011); Alsan and Wanamaker (2017)), but the transmission mechanism associated with collective depression has not been investigated. We use mortality estimates from the 1988 National Vital Statistics System of the National Center for Health Statistics to show that suicide rates are higher among previously bison-reliant nations, and particularly so for those who were affected by the rapid slaughter.[7]

In addition to contributing to the literature on historical persistence, this research also provides a novel explanation for the geographic clustering of poverty observed among Indigenous communities in North America,[8] and contributes to the growing literature on regional disparities, job displacement, and intergenerational mobility (Chetty, Friedman, Hendren, Jones, and Porter, 2018; Chetty and Hendren, 2018a,b; Chetty, Hendren, and Katz, 2016; Chetty, Hendren, Kline, and Saez, 2014; Oreopoulos, Page, and Stevens, 2008; Solon, 1999; Stevens, 1997). Arguably, the decline of the bison was one of the most dramatic devaluations of human capital in North American history, where a mass industrial restructuring was accompanied by low rates of inter-regional migration. The socioeconomic effects this type of restructuring have been of concern in relation to the decline of the American coal and steel industries in the 1980s (Black, McKinnish, and Sanders, 2003), and of the manufacturing sector in the early 2000s (Autor, Dorn, and Hanson, 2018). Our historical setting allows us to analyze how such a restructuring generates regional differences over a long time horizon.

Our findings are also connected to the work of economic historians who have examined the overuse and depletion of renewable resources in a colonial context (e.g., Allen and Keay (2004) and Carlos and Lewis (1993, 1999)). Taylor (2011), Hanner (1981), and Benson (2006) all examine the nature and causes of the bison's near extinction. We add to this literature by examining the effect of the loss of the bison on those communities that depended on it, instead of the economic reasons behind the depletion of the resource itself. In this sense, we

[7]We use this year because it is the most recent date that does not censor estimates for small counties.

[8]For a discussion of the geographic distribution of poverty in Canada and the United States see AANDC (2015); Anderson and Parker (2009); Hurst (1997). The literature on Native American economic development has emphasized the role of institutions in shaping economic development (Akee, 2009; Akee, Jorgensen, and Sunde, 2015; Akee, Spilde, and Taylor, 2015; Anderson and Parker, 2008, 2009; Aragón, 2015; Cornell and Kalt, 2000; Dippel, 2014; Gregg, 2018), and on the role of modern natural resource development on modern outcomes (Anderson and Parker, 2008, 2009; Aragón, 2015; Aragón and Rud, 2013; Dell, 2010; Leonard and Parker, 2016). Our work deviates from past studies by focusing on the loss of a natural resource that was central to the lives of many Native Americans and the potential intergenerational effects of that loss.

also add the literature on how institutional conditions shape the responses to economic shocks (Robinson and Torvik, 2013). In particular we offer insight into how economies that rely on a single resource respond when that resource is depleted over a short period of time and are governed by institutions that limit responsiveness.

Finally, and perhaps most importantly, we offer a counter-narrative about the colonization of North America. The existing literature proposes that North America's wealth is a function of Europeans' choice to settle, which brought human capital and technology and led to the development of institutions that promoted growth (Acemoglu et al., 2001; Easterly and Levine, 2016; Nunn, 2014). However, Europeans were not importing their institutions or bringing their human capital to a blank slate; Indigenous institutions and human capital were affected in the process. In the case we study, the core institutions of bison societies were eliminated and their human capital devalued in the process, which we show had lasting implications for their growth and prosperity.

In the next section, we review the historical reliance of Native Americans on the bison, how the relationship has evolved over time, the decline and eventual slaughter of the bison, and the policies enacted by the United States government that limited the ability of Native Americans to use transferable human capital associated with bison hunting. In Section II, we discuss the data generation and matching processes we used to construct the datasets used in our empirical analysis. Section III outlines our methodological framework for both the short and long-term impacts of the decline of the bison. We then present the results in Sections IV, including an analysis of the mechanisms through which the effect of the bison's decline has persisted in the long-run. Section V concludes with a discussion of the main findings and suggestions for future work.

I Background on Bison-Reliance and the Bison's Near-Extinction

Before european settlement, between ten to thirty million Plains bison roamed the territory between the Rocky and Appalachian Mountains and from as far south as the Mexican states of Chihuahua and Coahuila to as far north as the Canadian Northwest Territories (Hornaday, 1889; Taylor, 2011). Anthropological evidence suggests that Indigenous peoples in these regions hunted the bison for at least 10,000 years prior to contact (Frison, 1991; Gilmore et al., 1999;

O'Shea and Meadows, 2009; Zedeño et al., 2014).

Originally, the bison were hunted on foot with spears, and eventually bow and arrows, and was often assisted by domesticated dogs (Isenberg, 2000; Kornfeld et al., 2010). Perhaps the most iconic method of the pedestrian hunt was the "buffalo jump", where hunters would set fire to grasses to force herds over a cliff. These large scale hunts were often conducted in conjunction with several nations. In a smaller scale alternative method, hunters would separate a portion of the herd, and lead them into a pen of branches and blankets using fires or dogs. Following the hunt, the large animals were generally skinned and disassembled on-site in order to make the carcasses manageable. Women were primarily responsible for this task and would make use of nearly every part of the animal. They tanned and softened hides for clothing, blankets, and lodging, using the brains as grease. Bones were used to make tools, while the marrow was consumed for its nutritional content, and stomachs were converted into bags or vessels. Bison meat was often preserved by drying, or it was mixed with processed berries and bison fat to produce a mixture called pemmican. Enclosed in a bag made from the bison's stomach, pemmican could be stored for years and, as a result, during times of game shortages or crop failures, bison-reliant nations could sustain their peoples.

Archaeological records indicate that many bison-reliant peoples did not seek diversification in their economic activity, even though other resources were present, suggesting that the bison provided a reliable source of food and wealth (Daschuk et al., 2006; Zedeño et al., 2014). Due in part to the plentiful nature of the bison and the ability to store bison food products for years, the people of the Great Plains were arguably the wealthiest in North America and at least as well off as their average European counterparts (Carlos and Lewis, 2010; Prince and Steckel, 2003; Steckel and Prince, 2001). Early anthropologists often characterized bison hunting societies as egalitarian and lacking organizational complexity; however, the killing and processing of the bison was an endeavor of industrial proportions (Kehoe, 1967). Recent work by anthropologists suggests that bison-reliant societies evolved to have well-defined systems of ownership over hunting grounds, permanent sites of residence, complex kinship networks, and economic power relationships designed to secure the best bison herds (Zedeño et al., 2014). They were also involved in cultivating the lands by burning long grasses to encourage the growth of short grasses that were preferred by the bison (Isenberg, 2000; Zedeño et al., 2014).

While methods of hunting and employing the bison changed over time, the most dramatic change was driven by the introduction of the horse to North America. With the colonization of South America, horses spread from Spanish controlled territory in the south as far north as Canada, likely through pre-existing trade routes (Hämäläinen, 2003). By the 1650s, colonists had become aware of mounted Indians after encountering the riders of the Apache tribe. The introduction of the horse dramatically decreased the costs associated with hunting bison, leading some societies to shift from agriculture towards bison hunting as their main source of economic activity (Gwynne, 2010); however, it also brought the first waves of European diseases, infecting the people of the plains through their contact with native horse traders who had been exposed to Europeans (Daschuk, 2013). The extent to which Plains peoples were depopulated by European diseases has been intensely debated (Cameron, Kelton, and Swedlund, 2015). Early estimates suggest that, between 1774 and 1839, depopulation among Plains Natives was in the realm of 50%-60% (Decker, 1991), but later estimates suggest that this figure may be closer to 20% (Carlos and Lewis, 2012). Some historians have suggested that depopulation among the peoples of the Great Plains did not occur until *after* the extermination of the bison, when bison-reliant societies were on the brink of starvation and vulnerable to disease from malnutrition (Cameron et al., 2015; Daschuk, 2013; Daschuk et al., 2006). The earliest contact bison-reliant societies had with the English and French was through the fur trade, although this trade was typically indirect. Bison robes and pemmican were traded, but neither commodity was as lucrative as the furs being sought for resale in Europe. Bison-reliant peoples had been tanning hides for centuries, but the process was labour intensive and unprocessed leather from bison hides was not commercially valuable from a European perspective (Taylor, 2011).

With the end of the American Revolution and the westward expansion of the United States, settlers moving westward along the Oregon trail in the early 1800s effectively split the existing bison herd of the Great Plains and plateau region into a northern and southern herd (Taylor, 2011). As settlement continued, the bison were hunted at higher rates, which when combined with years of drought and competition for food sources from settler cattle, slowly began depleting the bison populations east of the Mississippi (Isenberg, 2000). The pace of the bison's extermination drastically increased with the construction of the Pacific Railroad between 1863 and 1869. Upon completion of the railway, settlers had access to the herds of the interior in an unprecedented manner (Hanner, 1981; Hornaday, 1889). Even so, the historical accounts suggest that settlers and native communities did not anticipate the bison's rapid extermination (Daschuk, 2013; Hanner, 1981). In fact, the construction of the railway through the Great Plains was made possible because of a series of treaties the United States negotiated during the late 1860s with the Apaches, Cheyenne, Kiowas, and the Comanche in the south, and North-Western Sioux and Northern Cheyenne—specifically the Teton Sioux, known as the Lakota—in the north.[9] Through these treaties, Natives exchanged large tracts of their ancestral territories for public goods, annuities, and protection of their exclusive right to hunt the bison herds. Moreover, the treaties included clauses that protected the bison from being hunted by settlers, which had resulted in a gradual decline of the herds in other areas of the country (Gwynne, 2010).

The fate of the bison changed unmistakably in 1871 when tanners in England and Germany developed a method for tanning buffalo hides so that they could be commercially viable (Taylor, 2011).[10] In response, hide hunters flooded to the plains. Figure A1 compiles estimates of bison hide exports from Taylor (2011) between 1865 and 1889. This figure shows the large spike in bison hide exports that occurred after the innovation in European tanning technology. Taylor (2011) estimates that in 1875, 1 million bison hides were shipped from the United States to France and England alone. The hide men initially focused on the more accessible southern herd,[11] and by the spring of 1874, the herds on the middle plains had been decimated. A country once "black and brown with bison was left white by bones bleaching in the sun" (Gwynne (2010), p.260-261). By 1879, the southern herd was completely eliminated (Hornaday, 1889). Gwynne (2010) provides a moving account of a group of Comanche men who left the reservation for a traditional bison hunt in the spring of 1878:

> *"They rode west from Fort Sill towards the high plains, full of dreams and nostalgia. They understood that the hide hunters had taken a terrible toll on the buffalo. But they had never doubted that there were herds left to hunt. What they found shocked*

[9]These treaties include, but were not limited to, the Medicine Chest Treaties of 1867 in the South and the Fort Laramie Treaty of 1868 in the North.

[10]The sudden access to the bison from the newly constructed railways may have spurred European innovators to try and find a use for them, but without the commercial demand for the tougher bison leather, the incentive for commercial hunters to rush to the plains and slaughter the animal would not have existed. The European innovators likely did not see the treaties as a significant barrier to bison access.

[11]The railway at that point stopped at Dodge City, Kanas.

them. There were no buffalo anywhere, no living ones anyway, only vast numbers of stinking, decaying corpses or bones bleached white by the sun. The idea of traveling a hundred miles and not seeing a buffalo was unimaginable. It had not been true at the time of their surrender. (p. 294)

The slaughter of the northern herd did not occur until 1881, and, according to estimates of hide exports compiled by Taylor (2011), they were one tenth of those of the earlier southern slaughter. Taylor (2011), among others, attributes the delayed elimination to the "hostile Sioux" and other Native groups who were not part of the reservation system. However, to fully attribute the timing of the northern slaughter to hostile northern nations would be to over-simplify the historical context.

Reservations had already been established for the Northern Cheyenne, Northern Arapaho, and the Sioux by the Treaty of Fort Laramie in 1851 and later in 1868. Thus, they were equally a part of the reservation system as many of the southern communities in the same time period. Second, violence on the southern plains was also common and some authors suggest it may even have been provoked after the signing of the treaties by the slaughter of the bison (Smits, 1994). Once Native groups in the south realized the extent of the bison slaughter, they retaliated against hide hunters with violence, so the danger was not limited to the northern plains. The Sioux's reaction was in response to the violation of treaty terms when white men entered their territories. Even though the hide hunters did not slaughter the bison on the Lakota territory until the early 1880s, the Northern Herd was eliminated from the lands surrounding their traditional territories that had been under protection by the Treaty of Fort Laramie. This slaughter necessarily reduced the potential density of the bison within their lands. Hornaday (1889) suggests that the bison were exterminated in northern Montana and Saskatchewan by 1878, in Wyoming and Alberta by 1880, and that the last bison in the remaining territory was gone by 1883. The last bison hunt by the Sioux was in 1882 (Ostler, 2001). A well-established argument advanced by many scholars suggests that the United States government deliberately promoted the destruction of the northern herd to force the nations to give up their treaty rights (Hornaday, 1889; Smits, 1994). MacInnes (1930) argues that American soldiers drove bison herds south into the region of the hide hunters.

Several scholars have argued that the slaughter of the bison would not have happened in an environment with well-defined property rights (Benson, 2006; Hanner, 1981; Lueck, 2002; Taylor, 2011). As far as the Native nations were concerned, property rights existed, though they were clearly not enforced. One reason for this was political. General Phil Sheridan, then Commander of the Military Division of the Missouri stated in 1875:

> *"These men [hunters] have done in the last two years and will do more in the next year to settle the vexed Indian question, than the entire regular army has done in the last thirty years. They are destroying the Indians' commissary. Send them powder and lead if you will; for the sake of the lasting peace, let them kill, skin and sell until the buffalos are exterminated."* – quoted from Gwynne (2010), p.262

Army Generals actively encouraged their troops to kill the bison for food, sport, or "practice". Many military commanders believed that Native people would not be truly settled onto reservations until the bison were exterminated (Smits, 1994). Despite promises made to the northern nations in 1868, in 1874, the government dispatched the Custer Expedition into Sioux territory and discovered gold in the Black Hills. The Lakota were alarmed at this treaty-violation, as miners began to trespass on their territories. Initially, the government expelled miners that entered, but pressure built to secure the Black Hills from the Lakota, which in 1874 had not yet suffered the loss of the bison to the same extent as the southern nations.[12]

Within less than two decades, the economic and social core of the great bison nations was gone. By the early 1880s, there were no bison, little game, and inadequate and at times non-existent government food supplies. Records from trading posts, native leaders, Indian Affairs officials and media outlets reported widespread malnutrition and hunger among the native populations (Cameron et al., 2015). Communities resorted to eating horses, mules, soiled food, and old clothing to prevent starvation (Daschuk, 2013; Gwynne, 2010). The resource that underpinned centuries of human capital acquisition was eliminated with few alternative options. Some communities resorted to collecting the bison bones that littered the plains after the slaughter and selling them for fertilizer (Ostler, 2001).

Economic activity and mobility were severely constrained during this time period and ar-

[12]At this point, the Northern Pacific Railway was not yet complete, reaching Fargo, Dakota Territory early in June 1872. A severe stock market crash and financial collapse after 1873 led by the Credit Mobilier scandal and the Union Pacific railroad fraud stopped further rail line from being built for 12 years. This halting of the railway may have delayed the destruction of the northern herd.

guably left few dimensions upon which Native Americans could adjust. Specifically in both Canada and the United States Native Americans could only leave their reservations with the permission of government officials on reservations, known as Indian Agents, until close to the 1930s (Marks, 1998). Cattle ranching, a plausible alternative use of skills for many bison peoples, was either activity prevented by Indian Agents or subject to serious credit constraints until the 1940s (Iverson, 1997; Trosper, 1978).[13,14] Agriculture was effectively the only economic activity supported or promoted by North American governments. However, agriculture was abhorred by many in the former bison-reliant nations and few individuals had experience in the area (Gwynne, 2010; Iverson, 1997; Ostler, 2001). That being said, several nations had varying degrees of agricultural reliance prior to the bison's decline, which we show may have provided them with an economic alternative to help mitigate the negative consequences resulting from the loss of the bison (Iverson, 1997).

In the next two sections, we outline the approach we take to empirically evaluate how the loss of the bison altered the historical trajectory for the societies that depended on them.

II Data on Bison-Reliance, Historical and Modern Context and Well-being

A Measures of Bison-Reliance and Timing of Bison-Loss

During this time, William Temple Hornaday was commissioned by the Smithsonian Institute at the end of the nineteenth century to construct a detailed an account of the North American Bison and its elimination. As part of an extensive monograph, Hornaday published maps of the original bison range and of the timing and geographic nature of the bison's extinction. Figure 1 is a digital reproduction of Hornaday's map.[15] The lightest region is the bison range as of 1730, the middle region is the bison range as of 1870, and the final black regions are the remaining

[13]Although some notable native leaders did manage to convince Indian Agents to come to food sharing and cattle ranching agreements, these were not a generally accessible forms of employment and only benefited a few members (Gwynne, 2010; Iverson, 1997).

[14]Using a sample of ranchers from the Northern Cheyenne Reservation in Montana, Trosper (1978) analyzes differences between Native and non-Native ranching and suggests that Native ranchers were as efficient, if not more efficient, than white ranchers, but due to limited access to capital, they produced less output than their non-Native counterparts.

[15]The maps were digitized with at least 24 points of support.

herds as of 1889 with their corresponding sizes. The 1889 ranges were in ranched captivity.[16]

To generate a measure of bison-reliance, we overlay the digitized version of Hornaday's map with maps of traditional ancestral territories of Native American groups. We use ancestral territories from the Map of Early Indian Tribes in the National Atlas of the United States (Gerlach, 1970), combined with the ancestral territory maps from the Smithsonian Handbook of North American Indians (Sturtevant, 1981), as shown in Figuree A5, following Dippel (2014). The outline of the ancestral territories in the continental US are also present in Figure 1. The overlay of the ancestral territories and the bison's range give us a measure of the proportion of ancestral territories that were covered by the bison as of 1730, 1870, and 1889. Note that in 1889, the only bison were found in captivity, so we record the value of this variable as zero for all tribes.

First we form a measure of initial bison-reliance by measuring the proportion of a tribe's ancestral territory that was covered by the bison as of 1730. The next two variables we construct measure the timing of bison loss. The first is the proportion of territory that was covered by bison as of 1730 minus the proportion that was covered as of 1870. The second is the proportion of territory that was covered by bison as of 1870 minus the proportion that was covered in 1889. Our measures give a reasonable approximation as to whether societies experienced a high degree of bison-reliance and the speed at which communities experienced the extermination of the bison from their territory. A large value of the first measure means that the region lost the bison gradually, as discussed in Section I, over a 140 year period. A large value of the second measure implies that the territory lost the bison rapidly, as a result of over-hunting in response to European demand for bison hides. Figure 2 displays histograms of the share of ancestral lands overlapping the original and 1870 ranges. From these plots, we can see that many nations' ancestral lands overlapped with the original bison range; however, by 1870 the number of nations whose ancestral lands were covered by 90% or more of the bison range had dropped from over 60 to approximately 10.

These first measures of bison reliance, while useful in that they allow us to distinguish nations in terms of their potential access to the bison at different point in time, have a few obvious drawbacks. First, the precision of Hornaday's borders and of the ancestral territories

[16] The original map of Hornaday (1889) can be found in Figure A2 of the appendix.

maps are unclear. Second, the measures are entirely based on geography. In some instances, the degree of bison-reliance among Native Americans–even in areas that were densely populated by bison–varied notably. For example, the Mandan peoples lived in the bison-dense territory of what is now North Dakota, yet they relied predominantly on agriculture and traded for bison meat and other supplies (Fenn, 2014). Our geographic measures would identify the Mandan as fully bison-reliant and among those that lost the bison rapidly. In order to account for these cases, we supplement our original measures of bison-reliance with anthropological accounts of bison-reliance taken from Waldman (2009) and construct a scale from 0 to 1 in 0.1 increments that range from "no contact with the bison" to "calories being almost completely based on bison products all year." A full explanation for the coding of this variable and additional sources can be found in Tables A13, A14, A15, A16, and A17.[17]

We assess the robustness of our main results by generating three other proxies for bison-reliance: a measure of the number of cattle per kilometre squared in each tribe's traditional territory using county level data from the 2012 United States Census of Agriculture; the proportion of the traditional territory that is considered part of a temperate grassland ecosystem using the data on the World Wildlife Fund's World Grassland Types (Dixon, Faber-Langendoen, Josse, Morrison, and Louckn, 2014); and self-identification of the importance of the bison to a tribe through modern membership in the InterTribal Bison Cooperative (ITBC).[18] The logic of the first two additional measures is that they proxy for the carrying capacity of the land for bison. The bison range identified in the map of Hornaday (1889) does not take into account other factors that may have affected the density of bison, like the gradient of mountains, the presence of wetlands or lakes, and the diversity of vegetation, while both the modern distribution of cattle and the share of the land covered by temperate grasslands will. The third measure is consisted similar to the anthropological measure of bison-reliance since membership indicates self-identified cultural, spiritual, and ecological significance of the bison to the member tribes and is not based on geography.

[17]For those nations that were not included in Waldman (2009), or whose tribal names in the data sources described below are too broad for reasonable classification of the anthropological measure, we use our original measures of bison-reliance. In all data sets, this represents a relatively small fraction of communities, and the correlation between the anthropological measure and the geographical measure is roughly 0.8.

[18]Table A18 contains the list of all members that are part of the ITBC, as of the Spring of 2017 and all members (63 tribes) are considered bison reliant while the non-members and considered non-reliant. This information was retrieved from the ITBC website: `http://itbcbuffalo.com/itbc_main_files/itbc_buff_tracksweb_spring_2017.pdf`.

B Biological Measures of Standard of Living: 1888-1910

Given the lack of comprehensive income and occupational data for Native Americans pre-1900, we instead turn to the anthropometric evidence of well-being, making use of childhood and adult height as biological indicators (Steckel, 1995, 2008). Between 1888 and 1903, a team of anthropologists led by Franz Boas collected measures of height, sex, age, tribal membership and "racial purity" of approximately 15,000 Native Americans in nearly all areas of North America (Jantz, 1995). While there have been questions regarding the representative nature of Boas' sample (Komlos and Carlson, 2014), and of height data more generally (Guinnane, Bodenhorn, and Mroz, 2014), recent work comparing the Cherokee in Boas' sample to the Cherokee census suggests that Boas sample is representative on average, though it may over-represent the upper and lower classes (Miller, 2016). What is important for our empirical strategy is that, conditional on our set of covariates, over- or under-representation does not vary between age groups or between bison-reliant and non-reliant nations.

Women are significantly under-represented in Boas' data and, consistent with prior literature, we focus on men (Prince and Steckel, 2003; Steckel and Prince, 2001). The male sample consists of 9,239 individuals after restricting the sample to those under the age of 60.[19] Table 1 presents summary statistics from Boas' data for bison-reliant and non-bison-reliant nations. For the purpose of this exercise and those that follow, we classify a nation as bison-reliant if 60 percent of its ancestral territory overlapped with the historic bison range. In our empirical specifications, we use the proportion of share lost during various time periods as our primary variables of interest. Bison-reliant nations were approximately 6 cm taller than non-bison-reliant nations and slightly less likely to have some non-Native American ancestry. They are also slightly older on average.[20] On average, operational railways entered the ancestral territories of bison-reliant nations at a later date. Since railways may proxy for the timing of contact and pace of settlement of non-Indigenous peoples, we control for the date of operation

[19]We have matched roughly 60 percent of the observations based on the exact tribal names given in Boas' data and with the tribal names provided in the American Atlas ancestral territories map. The remaining matches are based off both the tribal and band names given in the Boas data. Some of the tribal names given are too broad for an exact match–for example, an observation may be labeled Apache, rather than Tonto Apache or White Mountain Apache–and, in these cases, we construct bison-dependency as a geographically weighted average of all sub-tribal groups. The results are robust to limiting our analysis to our exact matches, but we present the results for the full sample in this paper.

[20]Figure A6 shows that the differences in mean height in Table 1 are due to a uniform left shift in the height distribution, suggesting that the difference is not driven by differences in the tails of the distribution.

in a number of specifications. As described in the historical section, settlement on reservations occurred for bison-reliant peoples largely before the loss of the bison and the introduction of the railway. However, the date of local railway operation will proxy for relative timing of these factors as well.

We also evaluate how the loss of the bison affected population size and child mortality. Complete population accounting of Native American nations was sparse at best before 1910 and the Boas sample was not designed to give by age, representative sample sizes of the Indigenous population of North America. Thus we infer the impact of the loss of the bison on mortality by using data from the 1900 and 1910 Historical Census Over-Sample of Native Americans. This data is available publicly through the Integrated Public Use Microdata Series (IPUMS) (Ruggles, Genadek, Goeken, Grover, and Sobek, 2015). We use the available information on tribe and birth year to construct population sizes before and after the slaughter of the bison for both bison-reliant and non-bison-reliant tribes. In instances where tribe-birth year combinations have no observations, we impute a population size of zero. Since the census weights are constructed to provide a representative sample of the population, this exercise is informative about differential changes in population size among Native nations. An additional advantage of the 1900 and 1910 series is that they also ask women who had ever had children both the total number of children they have had and the number of those children surviving. This allows us to examine the extent to which the loss of the bison also affected child mortality.

C Income Per Capita in 2000, Pre-contact, Colonial Period, and Modern Control Variables

The most complete information for reservation-level per capita income data is available through the 2000 American Census Fact Finder. Although data back to 1970 is available, the number of included communities declines substantially as we approach 1970. As a result, we focus on the year 2000 tribal/reservation sample from Dippel (2014). This also allows us to consistently include factors that have been shown to have large effects on economic development on reservations, such as forced and historic co-existence with other Native cultural groups, and the presence of casinos.

Formerly bison-reliant societies are not strictly comparable to non-bison-reliant societies, as the outcomes of the descendants of these societies and the governance structures on reservations may differ for other reasons. As such, in specifications that compare bison-reliant nations to non-bison-reliant nations, we control for pre-contact differences in culture, tribal experiences with settlers, and other modern and geographic variables. Our preferred specifications include the economic information from Dippel (2014) on the surrounding counties' per capita income, as well as information on historical and forced co-existence, ruggedness, displacement from traditional territory, and the pre-contact cultural measures from the Ethnographic Atlas (EA) Database of Murdock (1967). The EA variables include measures of calories from agriculture, level of sedentariness, wealth distinctions, and the complexity of the location of each community.

Our preferred specifications also control for whether a tribe was ever involved in one of the 23 major "Indian Wars" using an indicator from Spirling (2011). To account for the possible effects of differential depopulation from early exposure to European disease, we also include gridded population data from the HYDE 3.1 database (Goldewijk, Beusen, and Janssen, 2010). We use the population size in 1600 for each ancestral territory as a control in the model.[21] One could imagine population to proxy for wealth, as in Acemoglu, Johnson, and Robinson (2001); however, we remain agnostic on its precise meaning, given that nomadic or semi-nomadic societies could hold large territories relative to their population as a sign of their wealth.

To evaluate the role of other unobservable characteristics and experiences that may have been different for bison-reliant nations, we also estimate specifications with an expanded set of controls. Specifically, to proxy for the timing of settlement, ease of access for settlers, exposure to disease, and pace and extent of economic development, we introduce a series of railway controls from Atack (2016). We overlay Atack's railway mappings with ancestral homelands to generate the date the railway first entered the tribal territory. There is a concern that since the railways are likely highly correlated with a loss of traditional resources, like the bison, we will absorb some variation in outcomes through this channel. However, since there are a number of contributing factors to the bison's decline–as discussed in the historical background–we do not expect the railway controls to absorb all of the effect of the rapid loss of the bison.[22]

[21]The HYDE database uses a number of historical sources to compile comparable estimates of global population density at a 5 minute resolution, including Denevan (1992), Maddison (2001), Lahmeyer (2004), Livi-Bacci (2007), and McEvedy and Jones (1978). While it is likely that the HYDE database is measured with considerable noise, and especially so for Indigenous populations in the 17th and 18th centuries, it is arguably the most reliable source for population data that is both consistent over time and across regions.

[22]As alternative measures of timing and speed of European settlement and potential contact with disease, we

We account for differential experiences in treaty-making in our expanded set of controls by including information on the timing of treaty-making from Spirling (2011). We match signatories of treaties using the location of treaty signing in relation to the traditional territories of nations in our data. Since early exposure to European trading may have also disproportionately affected certain nations, we proxy for fur trade involvement by using the proportion of traditional territory that was covered by the historical range of the beaver.[23]

Finally, we add a comprehensive set of modern controls to account for differential levels of economic activity of the reservations and surrounding areas, and access to other financial resources such as casinos.[24] In addition to the presence of a casino, reservation size, adult population share, and population from Dippel (2014), we add the average absolute mobility of counties within a 50 kilometre buffer surrounding each reservation using the absolute mobility index calculated in Chetty et al. (2014).[25] To account for differences in the quality of reservation land allotted to each tribe that may have impacted their long-run development through their ability to cultivate the land, we construct indicators of soil quality for crop production on each reservation using data from the Harmonized World Soil Database v 1.2 (HWSD) from the Food and Agriculture Organization of the United Nations (Fischer, van Velthuizen, Shah, and Nachtergaele, 2008). The HWSD is a 30 arc-second raster database, containing soil quality along a number of dimensions and each pixel is coded on a scale from 1-7 regarding the suitability of the land for agriculture along the given dimension. This measure is categorical, with 1 representing "no or slight constraints", up to 7 representing "water bodies". We calculate the fraction of non-water pixels in each tribe's reservation that are classified as having "no or slight constraints" for 7 dominant soil quality measures: the nutrient availability of the soil, the nutrient retention capacity, rooting conditions, oxygen availability to roots, excess salts, toxicity, and workability of the soil. Table A19 provides a more detailed description of what each of the soil quality indices captures.

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calculate the state that overlaps with the majority of a tribe's ancestral territory and control for the date in which it was admitted to the union. We also compute the maximum population growth of each of these states prior to 1910. We do not present the results using these controls since they are similar to those that condition on our railway controls and we believe they account for the same variation in outcome variables.

[23]We digitize a map of the traditional beaver range from the Canadian Geographic: `https://www.canadiangeographic.ca/article/rethinking-beaver`.

[24]Dippel (2014) acquires casino data from Taylor and Kalt (2005).

[25]Chetty et al. (2014) calculate two measures of intergenerational mobility. We use absolute upward mobility, which represents the expected income rank of children whose parents are at the 25th percentile of the national income distribution.

Table 2 presents the summary statistics for the reservation/tribal sample taken from Dippel (2014) that we merge with data sources on historical bison-reliance, measures of the timing and the speed of settlement into traditional territories, and cultural controls. On average, bison-reliant nations earn about $2,200 less per capita in 2000, and their light density is 5.92 points lower than non-bison-reliant reservations. We also see that of the bison-reliant nations, only 23% of their traditional territories were covered by bison in 1870. Figure A3 shows the share of ancestral lands overlapping the original bison range and the bison range as of 1870 for this restricted sample. As of 1870, roughly 18 nations' ancestral territories were still covered by the bison range. The data in Table 2 show that bison-reliant nations were equally as likely as non-bison-reliant nations to engage in warfare, be displaced from their ancestral territories, be historically centralized, experience forced coexistence, be sedentary, be located in areas with similar levels of absolute mobility, have the same population density in 1600, and have similar levels of settler population growth; however, there are also notable differences. For example, bison-reliant nations are located in states that were admitted to the union later, they consume fewer calories from agriculture, have less wealth and political distinctions, are located on less rugged terrain, and are located next to slightly poorer counties.

III Methodology

Our empirical strategy uses two primary specifications depending on whether we are analyzing the immediate or long-term effects of the bison's decline. The structure of Boas' data allows us to use a difference-in-differences estimation strategy based on a person's year of birth and the bison-reliance of their tribe, in order to identify the effect of loss of the bison on childhood and adult height. Let i denote the individual, n the Native nation, t the cohort, and H_{int} the height of the individual in centimeters. Then our estimating equation for the immediate effects of the decline of the bison can be written as:

$$\mathrm{H}_{int} = \beta_0 + \beta_1 \mathrm{B}_n + \beta_2 \mathbb{1}_i(\mathrm{BornNoBison}) + \beta_3 \mathbb{1}_i(\mathrm{BornNoBison}) \times \mathrm{B}_n + \mathrm{age}_t + \mathrm{X}_{int}\boldsymbol{\theta} + \varepsilon_{int}, \quad (1)$$

where bison-reliance is given by B_n, one of our continuous measures of bison-reliance or loss, and $\mathbb{1}_i(\mathrm{BornNoBison})$ is an indicator for the individual being born after the bison were eliminated.

The coefficient of interest is β_3 which is the coefficient on the interaction of bison-reliance and the indicator for being born after the bison were eliminated. Each specification includes a full set of age fixed effects to control for trends in height, denoted by age_t. We also include a matrix of controls, X_{int}, for whether the individual is full blood, from Canada, and the expansion of the railway into traditional territories. Standard errors are clustered at the tribal-age level.

The key identifying assumption in the difference-in differences methodology is that of parallel trends in the absence of treatment. In our context, we must assume that the height-trends of bison-reliant nations would have been the same as those of non-bison-reliant nations, were it not for the loss of the bison. This is a plausible assumption, but we also run a more restrictive specification where we compare those that lost the bison quickly (over a 10-20 year period) to those that lost the bison relatively slowly (over a hundred-year period). Restricting the comparison to within bison nations allows us to compare across nations with similar unobservable characteristics, as they would have been subject to similar government policies and had similar cultural backgrounds. In our most stringent specifications, we restrict the sample to those between the ages of 5 and 35.

Our main specification compares trends in the heights of bison-reliant societies to trends in the heights of non-bison-reliant societies, before and after the decline of the bison. We consider those born after 1870 as being affected by the bison's decline. In our specifications that compare trends in the heights of those that lost the bison rapidly to those that lost the bison slowly, we use the date of 1886 as the cut-off for being born after the extinction of the bison. We use this year since the Sioux's last bison hunt was in 1882 and pemmican can last for nearly 3 years (Ostler, 2001), so that cohorts born after 1886 were almost surely born into a time without bison. Varying this date slightly has no qualitative effect on the results.

We also present results using a more flexible event study design, which shows height differentials between bison- and non-bison-reliant nations in two-year age cohorts before and after the rapid slaughter began:

$$\text{H}_{int} = \gamma + \sum_{t=-20, t\neq 0}^{20} \delta_t \text{B}_n \times \text{cohort}_t + \zeta \text{B}_n + \text{age}_t + \text{X}_{int}\boldsymbol{\theta} + \varepsilon_{int}, \tag{2}$$

where, the interaction of bison-reliance and the indicator for being born after the bison's decimation is replaced by a set of interaction terms, $\sum_{t=-20,t\neq 0}^{20} \delta_t \text{B}_n \times \text{cohort}_t$, that measure the differential change in heights between bison-reliant and non-bison-reliant cohorts for a twenty-year window surrounding the beginning of the slaughter. We leave out cohorts born in $t = 0$, so that all coefficients are measured relative to the year in which the slaughter began. The event study specification is useful to assess which cohorts were most affected by the bison's decimation and also allows us to assess whether the parallel trends assumption is likely to hold. We estimate additional event study specifications to infer the impact of the loss of the bison on mortality by using data from the 1900 and 1910 IPUMS Historical Census Over-sample and use the available information on tribe and birth year to construct population sizes before and after the slaughter of the bison.

In order to determine how the loss of the bison affected long-run outcomes, we estimate OLS regressions at the "reservation-tribe" level, following Dippel (2014), since tribal nations that may vary in historic bison-reliance may also share a reservation. Denote i as a reservation-tribe, depending on the specification, and N as a nation, then the estimating equation is given as:

$$\text{O}_{in} = \alpha_0 + \alpha_1 \text{B}_n + \text{X}_{\boldsymbol{i}} \boldsymbol{\theta} + \text{Z}_{\boldsymbol{n}} \boldsymbol{\Psi} + \varepsilon_{in}, \tag{3}$$

where O_{in} is our outcome–primarily income per capita. We control for reservation-level characteristics in $\text{X}_{\boldsymbol{i}}$, like the ruggedness of reservation terrain and surrounding counties economic characteristics, cultural controls that vary at the level of the tribe in $\text{Z}_{\boldsymbol{n}}$, such as whether the society was traditionally nomadic, the proportion of their calories derived from agriculture, whether the society exhibited observable wealth distinctions, or whether the society had an aristocracy. Finally, $\text{Z}_{\boldsymbol{n}}$ also includes colonial controls that vary by tribe–whether the average society experienced forced co-existence (Dippel, 2014), the speed and timing of settlement in a society's ancestral territories, and whether the nation was displaced from their traditional territory which are all discussed in Section II.

We examine the long-run impact of the bison's decline in two ways. We begin by using our full sample and differentiating between tribes whose traditional territories experienced the rapid or gradual loss of the bison. For these specifications we include two measures of bison-reliance: the reduction in a nation's traditional territory's bison-coverage as of 1870, "Share lost as of 1870", and the additional reduction between 1870 and 1889, "Share lost between 1870-1889".

Our second and most stringent specification restricts the sample to those whose traditional territories overlap with the original range by more than 60%. These specifications allow us to compare the outcomes of bison-reliant nations that lost the bison quickly to those that lost the bison gradually. The causal interpretation of our results relies on the speed of loss being conditionally uncorrelated with other unobservable differences between these societies. This is an assumption we push further in the sections that follow. It is additionally important to note that in these geographical measures of bison-reliance, the timing of bison depletion is likely correlated with bison density and thus with economic diversification of the Native nations.[26] This is much less of a problem for our alternative measures of bison-reliance discussion in II.

IV Results

Our results are divided into three subsections: 1) the effects of the bison's decline on 19th century heights, cohort sizes, and child mortality; 2) the effects of the bison's decline on more modern outcomes, like income and light density; and 3) an analysis of the possible mechanisms through which historically bison-reliant peoples may still be adversely affected by the loss of the bison today.

A The Immediate Effects of the Bison's Decline

Figure 3 displays the results of the event study design of the bison's decline on heights. We use the full sample and compare bison-reliant to non-bison-reliant individuals. The coefficients of interest, δ_t, display changes in the relationship between bison-reliance and standing height across event-cohorts relative to 1870, the year before the slaughter began. The coefficients for $t = \{-10, \ldots, -1\}$ act as a placebo test for whether the parallel trends assumption holds. Each of these coefficients is both small in magnitude and not statistically different from 0, suggesting that prior to the disappearance of the bison, there were no differential trends in height between those who lost the bison gradually and those who lost it quickly. After 1870, the difference in the heights of bison-reliant and non-bison-reliant nations relative to 1870 increases steadily in successive cohorts. The largest differences are found among those born roughly ten cohorts

[26] For example, we would be considering bison in the woodlands and bison in the high plains as equivalent. However, bison herds in the woodlands were less dense and, given the relative scarcity of the woodlands bison, other game such as deer, or hare were often hunted.

after the slaughter.

These results provide evidence that the parallel path assumption holds and suggests that it was not until three years after start of the rapid slaughter that we see any change in the differences in height between cohorts of bison-reliant and non-bison reliant societies. It is worth noting that pemmican can be stored for up to three years so after this period, food-stuffs from the bison should be starting to rapidly decline. The pattern of decline in Figure 3 suggests that for those born in years with progressively less access to the bison saw progressively larger declines in stature relative to those born in periods with more access. We show larger effects for if we compare those that lost the bison slowly to those that lost the bison rapid, with similar patterns in the effect size (see Figure A7) although these effects are estimated with substantially less precision in later years because of smaller sample sizes. Thus we collapse these later years and estimate equation 1.

Table 3 presents the results of estimating equation 1. All columns include a linear trend in birth year to account for potential trends in heights over this time period. The first column shows that those nations that lost the bison gradually, as measured by a large value of "Share lost as of 1870", were about 2 cm taller than all other Native nations, on average, but lost this height advantage after 1870.[27] In column (2), we restrict our specification to only include nations that had at least 60 percent of their original ancestral territory overlapping the 1730 bison range. This allows us to look within bison-reliant nations and compare those communities that were affected by the gradual decline to those who were affected by the rapid slaughter. Since pemmican could be stored for up to roughly three years and that the last year of the last recorded bison hunt was by the Sioux in 1882 (Ostler, 2001) there would be no remaining food stuffs from the bison after 1885/86. We use being born after the date of 1886 as a cut off for being born into a world with no access to bison for those that were still bison dependent as of 1870.

On average, nations that lost the bison quickly were slightly taller than other bison-reliant peoples, but after 1886 *more than their entire height advantage* was eliminated, with declines

[27] Recall that each of our bison-reliance measures are continuous variables $\in [0, 1]$, so that a one unit change in "share lost as of 1870", for example, can be thought of as moving from the scenario where there is no reduction in bison-coverage in a tribal territory by 1870 to that where the reduction in bison-coverage in a tribal territory is 100%.

in height of up to 5 cm.[28] These findings are consistent across specifications with additional controls, those that focus on individuals aged 5 to 35 years, and those focusing only on Native Americans in the United States.[29] The most dramatic estimates suggest that among those born into bison-reliant nations that lost the bison as part of the rapid slaughter, heights declined by 9 cm relative to those that lost the bison gradually.[30] We replicate Table 3 for female Native Americans in Table A4. In the most restrictive specification, the results for females support a similar narrative. Females are notably under-represented in Boas' sample and we believe the results should be treated with caution. We have also estimated specifications to allow us to infer the effect of an additional growing year spent after the slaughter of the bison, if you are a member of a "still bison-reliant" tribe. In the most restrictive specification (equivalent to column (3) in Table 3) suggests that spending an additional year of your life between the ages of zero to twenty-one without the bison as a member of a fully bison-reliant tribe during the rapid slaughter would reduce your height by 1.511cm (s.e. 0.811) relative to someone from a formerly bison reliant tribe who had lost the bison during the slow decline.

Komlos and Carlson (2014) note a decline in the height of Plains Indian scouts in the U.S. Army after the Civil War; however, they do not connect this to the loss of the bison, nor do they explicitly examine trends in heights by the age or bison-reliance of the individual. Our results present an explanation for their findings. It is important to note that it is unlikely that settlement on reservations are able to offer a reasonable alternative explanation for our findings for two reasons. First, there was a lack of a sharp change in reservation policy after this time period. Second, Steckel (2010) shows that the number of years on a reservation if anything is positively correlated with height in the Great Plains on average. That being said, there may be a concern that our results are driven by differential penetration of the railway and thus European settlement over this time period. Hence, in columns (3) to (6), we control for

[28]The exact coding of the Sioux and Ojibway sub-tribal groups turns out to be important for the precise magnitude of the reversal of fortunes when focusing solely on the former bison-reliant societies. We have taken the approach that uses an average of bison-dependency among the Sioux and Ojibway when the exact tribal grouping is ambiguous here, however, any reasonable coding of these groups yields the result that the loss of the bison at very least eliminated the height advantage of formerly bison-reliant peoples.

[29]Different age restrictions can be used with similar results.

[30]Table A3 shows results when using our alternative measure of bison-reliance constructed from anthropological accounts. A similar pattern is observed and the results are of similar magnitude when we interact our anthropological measure with an indicator that tribal territories still had 80 percent of their territory covered by bison at the time of the slaughter. While the results are similar but more muted if we interact the anthropological measure with an indicator that 60 percent of territory was covered by bison immediately before the slaughter.

the number of years since the railway first entered an individual's tribal territory and whether an individual was born after the first railway entered their traditional territory. Although we see that for every year after someone was born after the introduction of the railway to their territory they are approximately 0.5 cm shorter, this does not significantly diminish the effect of the loss of the bison.

Given we found that on average the bison-reliant nations were slightly older in Table 1, we plot the age distribution of bison-reliant and non-bison-reliant nations in Figure A8, and find there are large differences in the number of individuals under the age of 20, suggesting higher levels of youth mortality among the formerly bison-reliant nations. We further examine whether there is evidence of a population decline after the rapid extinction of the bison in Figure 4 by plotting the estimates of differences in cohort size between the bison-reliant and non-bison-reliant nations from the 1900 and 1910 IPUMS oversamples. Panel 4(a) displays the results using the full sample. Panel 4(b) restricts the sample to only those whose societies were at one point bison-reliant and compares those who lost the bison gradually to those who lost the bison rapidly. The cohort size of bison-reliant tribes who lost the bison quickly decline substantially after the slaughter relative to those who lost the bison gradually. It is important to note that this data is from 1900 and 1910, before Native Americans were citizens of the United States and before there was freedom of mobility from reservations, suggesting that the smaller population sizes were not due to out-migration.

We complement the results on cohort size by compiling the available statistics from the Historical Statistics of the United States on the population counts of American Indians by tribe (Carter, Gartner, Haines, Olmstead, Sutch, Wright, and Snipp, 2006).[31] There is a large gap in data availability between 1780 and 1907, with population counts from 1845 available only for a small selection of tribes, thus we focus on 65 tribes for which we have consistent data in 1780 and 1907. Nations that were bison-reliant had a population that was much larger than non-bison-reliant tribes in 1780, and we find that by 1907 their population size statistically converges to that of the non-bison-reliant tribes. Further, bison-reliant nations lost nearly 70 percent of their population over this period. The sample of tribes contained in the Historical Statistics does not allow us to compare the rapid loss of the bison to the gradual loss. While

[31] We use the tables Ag392-433, Ag265-330, Ag17-129, and Ag130-264.

we view these statistics as substantially less clean than our other results, they offer additional evidence in support of the finding that the loss of the bison had large effects on the people that depended on them. These results can be found in Table A5.

As a final analysis of mortality, we use data on the proportion of children surviving from the 1900 and 1910 IMPUMS over-sample as a direct measure of child mortality. Due to the nature of the data, we cannot use a difference-in-differences structure for this exercise.[32] We estimate equation 3 where our dependent variable is the portion of children surviving for a given mother. The equations are estimated using OLS, but are robust to using a binomial model on counts of births and deaths. We weight the regression by the census person weight multiplied by the number of children a woman has and the standard errors are clustered at the tribe level.

Table 4 presents the results from this exercise. The first three columns display the results for the full sample and the last three columns restrict the sample to include only those who were bison-reliant.[33] Conditional on age, whether the mother is literate, and geographic region, women who belonged to bison nations that lost the bison rapidly have 10 percent fewer of their children surviving relative to those mothers whose tribes were never bison reliant. Restricting the sample to only include mothers whose tribe was at one time bison-reliant reveals that those who lost the bison rapidly have about five percent fewer of their children surviving as of 1900 and 1910. We see this as direct evidence of higher mortality among the bison peoples after the slaughter of the North American bison.

Taken together, all these results and consistent substantial declines in physical well-being among the bison-reliant nations after the slaughter of the bison. Data from numerous sources are consistent with increases in mortality among those nations that lost the bison rapidly relative to those who lost them slowly and thus the height effects we observe are likely a lower bound on the true consequences of the loss of the bison.

B Long-Run Persistence Among Bison Societies

This section examines whether the economic shock generated by the bison's decline led to long-run differences in well-being between bison-reliant and non-bison-reliant nations. Table 5

[32] In Table A2 we present summary statistics from the 1900, and 1910 IPUMS for the women in this sample.

[33] We do not control for Bureau of Indian Affairs (BIA) region because of the smaller subset of tribes and lack of variation in these regional indicators.

presents the average differences in per capita income on reservations based on bison-reliance and the speed of bison loss. In column (1), we look at the average difference in income per capita between tribes whose territory did not overlap with the bison's original range and those whose territory completely overlapped with the bison's range. This income difference is roughly \$2,500 compared to an average income per capita of only \$11,000. In columns (2), (3), and (4), we look at the correlation between losing 100% of the share pre-1870 or losing it post-1870 relative to never having been bison-reliant. Across these specifications, losing the bison as part of the slaughter is associated with a larger negative effect on income. The final column focuses on within bison-reliant nations and shows that those that lost the bison rapidly have \$2,500 lower income in 2000 compared to those who lost the bison slowly. [34]

In the descriptive statistics of Section C, we show that formerly bison-reliant nations are systematically different than non-bison-reliant nations, thus Table 6 reports the results of the exercise above for columns (4) and (5), but conditional on a set of cultural, geographic, colonial, and modern economic factors. Systematically, we find that formerly bison-reliant nations make less on average, even after conditioning on the income per capita of nearby counties. Those that lost the bison as part of the mass slaughter in 1870 (columns (4)-(6)) make less than those that had time to adjust to the bison's gradual elimination from their territory. The results are less precisely estimated in our most restrictive specifications, but the point estimate remains large and negative. Table A7 shows that the results of Table 6 hold when we use the alternative measures of bison-reliance.

In Table 7, we strengthen the selection on observables assumption underlying our identification strategy by including a number of additional controls. First, we include regional fixed effects in all columns. Next, we consider the fact that the bison-reliant nations may have encountered a later and more rapid period of settlement than other Native Americans. This may influence modern development, either through later exposure to disease or through less time for economic assimilation. In the historical section, we argued that bison-reliant nations were likely

[34] Similar results are shown for Canada in Table A6 where we condition on a number of available controls that are comparable to those used with the American data. For the Canadian regressions we focus on the relationship between the share of traditional territory covered by the bison's original range and long-run outcomes. We do not find large differences between bison-reliant nations who lost the bison gradually compared to those that lost the bison quickly. Presumably this is because there is not sufficient variation between those that lost the bison quickly compared to slowly, as evident in Figure 1. Table A21 reports the sources used to construct the Canadian data set.

first exposed to European diseases indirectly through trade, as early as many of the coastal nations, but we view the current exercise as relevant for alleviating any concern that this is not true. To account for the speed and timing of settlement, we condition on the presence and timing of the railway entering a nation's ancestral territory. The results of this exercise can be seen in the first column of Table 7. In column (2) we show that our results are robust to controlling for the date the last treaty was signed with each Native American nation. We use this information, which comes from Spirling (2011), as an additional proxy for settlement and federal policy towards Native Americans.[35] It is important to note that over two thirds of the lands ceded by both bison-reliant and non-bison-reliant peoples were done so prior to 1870, as shown in Table A1, which was before the bison were eliminated.[36] This suggests that the slaughter did not force the signing of treaties, a narrative that has been advanced by some scholars.

In column (3) of Table 7, we attempt to control for the early exposure to European trading using a proxy for the degree of involvement in the fur trade: the proportion of traditional territory that was covered by the historical range of the beaver.[37] Beaver pelts were lucrative commodities that were frequently traded between natives and Europeans and could have likely resulted in earlier initial contact.[38] Conditioning on this measure has little impact on our results. We show that the correlations between our measures of bison-reliance and income decline when we account for our expanded set of contemporary controls in column (4), suggesting that differences in income between bison-reliant and non-bison-reliant nations is explained in part due to differences in their reservation environment. In column (5), we control for differences in soil quality across reservations using the indicators we construct from the HWSD. While soil quality is likely endogenous to factors like irrigation, we continue to find that bison-reliant nations who lost the bison rapidly have lower incomes than other nations.[39]

[35]Spirling (2011)shows that the time period in which treaties were signed is a strong predictor of treaty quality.

[36] These data were taken from digitized maps of the total lands ceded to the United States by Native Americans between 1784 and 1972 from Hilliard (1972). The original version of this map can be found in Figure A4.

[37]We digitize a map of the traditional beaver range from the Canadian Geographic: `https://www.canadiangeographic.ca/article/rethinking-beaver`.

[38]The beaver was also depleted, but it was not a traditional food source or primary resource for the communities that traded it (Carlos and Lewis, 1993; Innis, 1999). Reliance on the beaver as a source of livelihood may be more of a concern for Indigenous groups in Canada, as declining fur prices towards the end of the nineteenth century affected the demand for treaties, as well as conditions for Indigenous peoples in the north of the country (Miller, 2009).

[39]All estimated coefficients can be found in Table A8.

One remaining concern is that the reservations that are included in the publicly available data may be different from the full set of reservations. For instance, Indian reservations that are included in publicly available income data have been shown to differ systematically from those that are excluded in the Canadian case and that this has implications for the conclusions drawn from analyses that use the restricted samples (Feir, Gillezeau, and Jones, 2018). We consider this possibility by presenting results using the log of mean light density of all pixels within a reservation's borders in place of income per capita.[40]. Using nighttime lights as an alternative dependent variable expands our sample from 195 reservation-tribe observations to 338. All specifications include the standard set of controls presented in Table 6, the log of mean light density in the county surrounding the reservation, and an indicator for whether the reservation is a state or federal reservation.[41] We also include a control for the population of the reservation using data from the Gridded Population of the World database from NASA's Socioeconomic Data and Applications Centre to account for the fact that reservations with a larger population might mechanically have a higher light density.[42]. We exclude reservations that cannot be clearly mapped to our controls–in particular, the Ethnographic Atlas.

The results of this exercise are presented in Table 8 using the log of mean light density in the year 2013–the most recent year for which light data is available–for the expanded set of reservations. Column (1) estimates the relationship between light density and bison-reliance for

[40]Nighttime lights data are gathered from satellites that measure light density at night at 30 arc second grids, which is equivalent to an area of approximately 1 square kilometre at the equator (Pinkovskiy and Sala-I-Martin, 2016). Each pixel is assigned a value between 0 and 63. Figure A9 displays the geographic distribution of light density overlaid with the 2013 boundaries of Native American homelands or reservations in the United States. The boundaries displayed in Figure A9 include federal reservations, off-reservation trust land areas, state-recognized American Indian reservations, Oklahoma tribal statistical areas, tribal designated statistical areas, and state designated tribal statistical areas. Only the reservation boundaries (federal and state) are used in the light analysis, as statistical areas can include non-Native cities. The data can be downloaded online from the National Centres for Environmental Information: `https://ngdc.noaa.gov/eog/dmsp/downloadV4composites.html`. They are available globally for every year between 1992 and 2013, and serve as a reasonable proxy for economic activity in the absence of standard national statistics under the assumption that lighting is a normal good (Donaldson and Storeygard, 2016). We show that this assumption seems likely in our context in Figure A10, which demonstrates that income and light density move in tandem. They have been used extensively in recent economic literature and have been shown to be good proxies for economic activity at various levels of aggregation: countries (Pinkovskiy and Sala-I-Martin, 2016), ethnic homelands (Alesina, Michalopoulos, and Papaioannou, 2016; Michalopoulos and Papaioannou, 2013), sub- and supranational regions (Henderson, Storeygard, and Weil, 2012), and even at the pixel level (Bleakley and Lin, 2012).

[41]In the regressions of GDP per capita, our sample only includes federal reservations. Table A20 lists the additional sources we used in order to include the full set of covariates in our regressions. We do not include the measure of forced coexistence from (Dippel, 2014) in the full set of reservations; however, in Figure A11 in the appendix we show using the set of communities that match to the data from (Dippel, 2014) that our results do not change when we add the full set of controls from this dataset, including forced coexistence.

[42]The gridded population data is available at 5 year intervals from 2000-2015. This data is available for download online from `http://sedac.ciesin.columbia.edu/data/collection/gpw-v4`.

the same set of reservations for which income per capita is available and column (4) includes the expanded set of reservations. The estimates in column (2) are smaller in magnitude compared to those in column (1), suggesting that our main results may slightly overestimate the relationship between bison-reliance and income. When restricting to only tribes who were at one point bison-reliant, we find the difference between those who lost the bison gradually and those who lost the bison quickly to be larger for the expanded set of reservations, suggesting that for the within-bison comparisons, our income per capita results may be slightly underestimating the differences in per capita income between bison-reliant people who lost the bison gradually and those who lost the bison quickly.

Although Table 7 shows that our results cannot be fully explained by observable confounding factors, there may still be concern that some remaining unobservable factor that is both correlated with the loss of the bison as well as income per capita, may bias our findings. As a final test of the unbiasedness of our parameter estimates, we use two separate methodologies to account for the potential selection on unobservables, the results of which can be found in Table 9.

We present these results using our most restrictive specifications: we begin by limiting the sample to only those nations who were historically bison-reliant. This restriction allows us to compare tribes who lost the bison quickly to those who lost the bison gradually, effectively balancing the unobservables that are common across all bison-reliant nations. The OLS coefficient from this exercise, repeated from column (6) of Table 6, is reported in column (1) for comparison. Column (2) applies the methodology of Oster (2017) to the coefficient on "Share lost between 1870-1889" to compute the implied bias of the coefficient estimate. Following the recommendation in Oster (2017) we rely on a proportional selection hypothesis and set our maximum R-squared to be equal to 1.3 times the R-squared using our standard controls.[43]. The coefficient estimate increases slightly in magnitude from the OLS estimate of -1551.0 to -2030.3, suggesting that under the aforementioned assumptions, selection on unobservables results in an underestimation of the magnitude of the effect of the bison's decline.[44]

Next, we turn to an IV specification that leverages the cost of travelling between tribes'

[43]This recommendation is based on a threshold value for the maximum R-squared for which 90% of a sample of randomized results from leading economics journals would survive.

[44]Since the implied bias provides an adjustment to the coefficient estimate, there is no standard error to report from this exercise.

ancestral homelands and historical cities that were important for the trade in bison robes. Identification here is grounded in the idea that these costs would be correlated with the speed at which bison were removed from traditional homelands, but uncorrelated with outcomes over 100 years later, other than through their effect on the loss of the bison. Since it is possible that proximity to important historical cities may be correlated with other forms of colonial contact or pre-contact conditions, we include our standard set of controls from Table 6 in all regressions.

The historical accounts suggest that a number of cities may have been important either as transit points or destination points for the trade in bison hides. At the beginning of the nineteenth century many buffalo hides made their way along the Missouri river to St. Louis to be traded (Taylor, 2011). Fort Leavenworth, Kansas was also an important transit point for hides being collected from the interior (Taylor, 2011), while the cities of New York, Chicago, and Montreal were involved in the sale of bison robes (Hornaday, 1889). By the time of the slaughter, the ports of New York and Baltimore were most involved in shipping the bison robes overseas to be treated in the tanneries in Germany, France, and the United Kingdom (Taylor, 2011).

To compute the cost to transport goods between a tribe's traditional territory and each city that was important for the trade of bison robes, we use the transportation costs constructed in Donaldson and Hornbeck (2016).[45] Our instruments are the cost of shipping freight between the county in which the centroid of a tribe's traditional territory is located and the counties containing the cities of St. Louis, Fort Leavenworth, New York, Chicago, and Baltimore. We include the cost of transporting goods to St. Louis, Fort Leavenworth, New York, and Chicago in 1870, as these were the primary cities involved in trading bison robes at this point in time. We also include the cost of transporting goods to New York and Baltimore in 1890, since these cities were the exit points for hides being shipped overseas. To compute the transportation cost between each tribal territory and Montreal in 1870, we use the cost of transportation to Buffalo, New York from Donaldson and Hornbeck (2016), and then rely on the estimates of transportation costs between Buffalo and Montreal, Canada, from Inwood and Keay (2013, 2015).[46] Since the estimates in Inwood and Keay (2013, 2015) differ slightly from those in

[45]The transportation cost in Donaldson and Hornbeck (2016) is computed by calculating the combination of railway, wagon, and waterway routes between counties and assigning each route a cost based on the per ton-mile cost of shipping goods by each means.

[46]Inwood and Keay (2013, 2015) focus the cost of shipping pig iron (CAD/Net Ton), while Donaldson and

Donaldson and Hornbeck (2016), we also include estimates without the cost to Montreal.

The coefficient estimates from the IV specification are displayed in column (3), including Montreal, and in column (4), excluding Montreal.[47] The IV estimate in column (3) is slightly larger in magnitude than the OLS estimate in column (1).[48] It indicates that tribes whose territory lost 100% of bison during the rapid slaughter have an average of $1826.0 less per capita income today. Excluding Montreal does not alter this finding. The OLS estimates are further supported by the endogeneity test: the p-value for the test of the null hypothesis that the share of territory lost by 1889 can actually be treated as exogenous is 0.513 in column (3) and 0.618 in column (4). If anything, the results from using the bias correction from Oster (2017) and the IV strategy provides evidence that our main OLS results slightly underestimate the magnitude of the effect of the bison's decline.

C Mechanisms: Margins of Adjustment and Channels of Persistence

In this section, we consider the mechanisms that might explain the persistently lower economic well-being of bison-reliant nations into the present. Our main objective is to determine the margins along which individuals and societies were able to adjust to the loss of the bison and along which margins they were inhibited from adjusting. We begin by examining two standard channels that affect the degree to which economic shocks persist: geographic mobility, and population growth. We show that these channels do not fully explain the differences in modern per-capita income between former bison-reliant and non-bison-reliant nations. We then propose two additional channels through which bison-reliant individuals and societies may have been prevented from adjusting economically after the decline of the bison. First, we show that bison-reliant tribes that had pre-existing experience in agriculture fared much better than bison-reliant tribes without such experience, suggesting that, under the restrictive reservation system, occupational diversification in industries that were promoted by the Bureau of Indian

Hornbeck (2016) focus on the cost of transporting grain and meat (USD/Net Ton). We assume an exchange rate of 1 CAD = 1.51375 USD in 1870 (Historical Statistics of the United States, Table EE618).

[47]The first stage and reduced form results can be found in Tables A10 and A11.

[48]We have also estimated the IV specification using a set of instruments containing the "as the crow flies" distance between the centroid of each tribe's ancestral territory and St. Louis, Fort Leavenworth, New York, Chicago, Montreal, and Baltimore to instrument for whether the tribe was subject to the rapid slaughter. It is unclear as to whether these instruments are particularly meaningful, given that transport routes were rarely a straight line between two points; however, these results also suggest that the OLS estimate understates the true magnitude of the effect of the bison's loss, and are available on request.

Affairs was paramount to the long-run economic prosperity of tribes. Second, we show that suicide rates and news stories of corruption and conflict are higher among bison-reliant tribes compared to those who were not bison-reliant. While these results are only suggestive, they provide evidence in line with the idea that societal channels beyond economic forces may also aid in explaining the long-run persistence of the bison shock. Since the bison was not just a form of economic livelihood for many nations, but also central to their spiritual well-being, the loss of this prominent centerpiece of their societies may have had lasting psychological effects.

C.1 Intergenerational Persistence, Mobility, and Population Growth

We use data from the American Census and American Community Survey (ACS) on occupational rank and income to study effects of the loss of the bison on intermediate and long-run outcomes. The occupational rank measure is constructed using the IPUMS occupational income score. This income score ranks occupations using the median incomes for each occupation from data published in the Census Bureau's 1956 special report on occupational characteristics. Apart from minor variations in post-1950 years, which required recoding post-1950 occupational classifications into the 1950 system, the measure of occupational rank is largely invariant across censuses. Unfortunately data is only available on occupational rank and tribal affiliation in 1900, 1910, 1930, 1990, 2000, and later in the ACS and since we require detailed information on the tribal membership of Native Americans in order to determine ancestral dependence on the bison we are restricted to using these years. Measuring the long-run effects of the loss of the bison in a way that is strictly comparable to 1900, 1910 and 1930 is made difficult, as tribal membership in 1990 and 2000 is reported at a higher level of aggregation than in 1900, 1910 and 1930. This has implications for our ability to estimate the effects of the loss of the bison. For example, in 1990, the reported tribal membership may be "Apache"; however, the Apache can hardly be thought of as one unified cultural group, let alone homogeneous in bison-reliance or in the timing of bison loss. Nevertheless, to gain a sense of whether the effects of the loss of the bison have changed over time for the peoples that depended on them, as would be expected from a simple income shock, we aggregate tribal groups by year and compare the effects of bison-reliance and loss over this time period when making comparisons of the early 1900s to the 1990s and 2000s

Table 10 examines whether the effect of the slaughter has diminished over time using individual level data from the IPUMS samples discussed in the data section. Since the historical censuses do not contain information on income, we use the concept of occupational rank to examine convergence in economic outcomes over time. Our results focus on male occupational rank, given the dramatic changes in female labour force participation over the twentieth century. We acknowledge that if the rank of occupations that are more common in specific geographic areas change over time, this may affect the conclusions we draw about economic convergence. To partially address this concern, all specifications include region fixed effects.[49]. We also control for a quadratic in age and whether the individual is literate. Standard errors are clustered by tribe, and since data availability requires that we to aggregate to large tribal groupings, we also report bootstrap p-values from the wild cluster bootstrap (Cameron et al., 2008).

Our results suggest that individuals who were members of nations that still relied on the bison at the time of the slaughter have systematically lower occupational rank scores. These effects are substantially larger in 1900, 1910 and 1930. Since tribal information is not included in the censuses between 1940 and 1980, we are unable to determine exactly when the convergence occurred. Moreover, it is difficult to pinpoint one particular policy between 1930 and 1990 that may have contributed to the convergence, as a number of important federal policies were implemented throughout the twentieth century that fundamentally changed the economic and social landscape for many Native nations. Notable policies included the *Indian Reorganization Act* [1934], which supposedly provided a path for tribes to regain sovereignty, but has been shown to have reduced long-run economic growth (Frye and Parker, 2016). The 1956 *Indian Relocation Act*, implemented concurrently with a number of termination acts that were designed to reduce Indian tribes' dependence on the Bureau of Indian Affairs, sought to assist Native Americans in relocating to cities. While Native Americans who ended up moving to urban centres as a result of the relocation policy experienced additional hardships (Walls and Whitbeck, 2012), the agglomeration of urban Indians may have spurred the movements the created legislation like the *Indian Civil Rights Act* [1968] and the *Indian Self Determination Act* [1975]. That being said, the fact that we continue to observe a strong correlation between income and bison-reliance for the present-day reservation-level sample suggests that whatever policies contributed to the

[49]The top five occupations by race and year are listed in Table A12.

adjustment were not sufficient to fully offset the negative effects from the rapid loss of the bison.

Given data limitations, it is not possible for us to investigate any one of these particular policies and how they contributed to the reduced bison-penalty in occupational rank over time. To shed further light on the extent to which migration acts as a initiating factor, we examine whether the effect of the bison's decline is different for those living on Native homelands and those living outside of homelands. We use information available in the 2000 Census and 2010 ACS 5 year sample, which report an individual's tribal association and whether they were living within native homelands.[50]. Since average income per capita is much lower on homelands than off homelands, using the level of income per capita could mechanically generate smaller coefficients on bison-reliance for the sample living on Native homelands. Thus to assess the relative differences in income per capita we regress the logarithm of individual total income on our measure of bison-reliance. Standard errors are clustered by tribe and bootstrap p-values are reported below standard error estimates.

Table 11 presents the results of this exercise. The effect on occupational rank is much larger for those living on homelands–column (1)–compared to off homelands–column (2). The effect is still negative for those living off homelands, although this effect is not statistically different from 0 when taking into consideration the bootstrap p-value. In column (3) we show that we cannot reject that the effects on occupational rank are statistically different between those living on and off homelands. Since occupational rank is tied to the distribution of occupations in 1956, we check whether our results also hold for per capita income in Columns (4) through (6). Once again we see that the effect of the bison's decline is much larger for those living on homelands compared to those living off homelands, but that we cannot reject the null hypothesis that the estimates are the same. For both occupational rank and the log of per capita income, the magnitude of the coefficient estimates suggest that those who were able to move off homelands may have been able to recover partially from the shock of the bison's decline, although these effects are not statistically different from one another. Therefore, although migration is a

[50] According to IPUMS documentation, Native homelands can include federal American Indian reservations and off-reservation trust land areas, the tribal subdivisions that can divide these entities, state reservations, Alaska Native Regional Corporations, Hawaiian homelands, Alaska Native village statistical areas, Oklahoma tribal statistical areas, tribal designated statistical areas, and state designated American Indian statistical areas. Ideally we would compare the population living on American Indian reservations to those not living on Indian reservations; however, given the limitations of the data we cannot differentiate between any of these Native homelands and therefore can only split our sample between those living on or off homelands.

channel of adjustment that has been highlighted in the literature (see, e.g., Hornbeck (2012)), it does not seem to have played as large a role for Native Americans in this context.

Another possible explanation for the persistently lower income on previously bison-reliant reservations is that the increase in mortality following the bison's demise affected communities in the long-run by initially lowering their populations and consequently preventing future agglomerations from spurring development. Table 12 considers this possibility by regressing the log of population on our measures of bison-reliance. If anything, the positive coefficient estimates on each of the bison shocks suggest that this was not the case. In fact, if bison were eliminated from 100% of a tribe's traditional territory in 1889, the tribe is, on average, 1.64 log points larger today, conditional on income per capita. The average population, excluding the Navajo, of an Native American reservation in our sample is 2,082 and the maximum is 14,255. 1.64 log points is equivalent moving from a population of 2,082 to a population of 8,661. The results are unchanged if we exclude the Navajo. Although this result may seem counterintuitive in tandem with the results for long-run income and short-run mortality, they should be interpreted with caution. Our observations are measured at the reservation-level, thus if bison-reliant tribes had less opportunity for migrating off reservations, or were less able to as a result of their situation after the bison's loss, then we should expect reservation population to be larger in present day.

C.2 Occupational Diversification and Non-Transferable Human Capital

Given that there was modest economic convergence within bison-reliant nations across the twentieth century, we now attempt to understand whether nations that had some additional ability to adjust to the loss of the bison were able to mitigate the negative effects of the bison's decline. Specifically, we hypothesize that bison-reliant communities that had more traditional experience with agriculture would be more likely to have their human capital maintain value, especially since the agriculture sector was promoted by the Bureau of Indian Affairs. Table 13 shows the results of interacting bison-dependency with a measure of tribal reliance on agriculture. This measure is an index of calories coming from agriculture that we take from Murdock's Ethnographic Atlas. For those nations that lost the bison rapidly, a larger share of calories from agriculture mitigates up to 90% of the negative long-run effect of the bison's loss. These results are consistent with the hypothesis that bison-reliant tribes that were a priori diversified in sectors agreeable to the Bureau of Indian Affairs were partially able to mitigate the negative effects of the bison's decline.

One reason why bison societies that had more historic experience with agriculture do not seem to have suffered the same long-run consequences as those with less experience with agriculture is simply that the initial biological and economic shocks were not the same.[51] We present the results from Table 3 on height and Table 4 on child mortality in columns (1) and (2) of Table 14. Column (3) shows the results for the effect on occupational rank in 1900 and 1910 from Table 10. First, thing to note from column (1) is that the interaction between being born after the end of the slaughter, the extent the of the loss of the bison, and the percentage of calories from agriculture positive, but small and statistically insignificant. In the second column, the interaction between the share lost between share lost and calories from agriculture are small and for those that lost the bison as part of the rapid slaughter, positive (although only marginally statistically significant). These findings are consistent with the argument that the long-run mitigating effects of agriculture are not due to initial differences in the health extent of the shock. In column (3) we can see that on the other hand, those nations that had relied to some extent on agriculture in the historically, by 1900/1910, had slightly higher occupational rank than other bison dependent nations suggesting that there was some protective effect on the economic prospects of men after the decline of the bison. This suggests that the mitigating role of historical experience with agriculture is operating through an economic channel potentially unrelated to the initial health shock. Again, this suggests the mitigating role of pre-contact diversification into agriculture.

It worth noting that it is diversification in crop-based agriculture in particular that is relevant here. A natural alternative use of the land and human capital previously acquired by the non-agricultural bison nations may have been cattle ranching. However, as suggested by Trosper (1978), limited access to capital markets as late as the 1960s prevented Native American ranchers from producing the same level of output as non-Native ranchers. In addition, in Table 15 we use data from the 1910 IPUMS over-sample to demonstrate that formerly bison reliant nations were significantly less likely to be engaged in live-stock occupations than whites within their

[51]We expect biological shocks to have economic consequences that persist intergenerationally from the economic implications of the fetal origins hypothesis and the work on epigenetics (Aizer and Currie, 2014; Almond, 2006; Almond and Currie, 2011; Heckman and Mosso, 2014; Karlsson et al., 2014).

same county.[52] The first three columns present the results for all Native Americans relative to whites and final three columns restrict the sample to bison-reliant nations. While Native Americans were marginally more likely to engage in stock-based agriculture on average, the nations that were still bison reliant in 1870 were significantly less likely to be employed in stock-based agricultural occupations – approximately eight percentage points less likely and there is no improvement in this over time. If we further restrict the sample to those that had some occupation, they are still five percentage points less likely to be employed in stock-based agriculture than their white counterparts in the same county. This pattern is consistent with bison-reliant nations experiencing restricted entry into an occupational sector in which their previously acquired human capital may have been transferable. Thus, while diversification explains part of the persistence of the economic shock, an equally important dimension of this historical persistence is the extent to which pre-existing human capital stocks were transferable given the restrictive conditions of the time. Columns (4) and (5) in Table 15 also show that those that lost the bison quickly were far more likely to have no recorded occupation in 1900, and that nearly the *entire* shift away from having no reported occupation in 1910 and 1930 is towards farming. Again, it is important to note that this is relative to whites within there own county. To put this in to context, it is also worth noting that the vast majority of this is towards farm labor occupations rather than farm owner.

C.3 The Persistence of Historical Trauama

A final explanation for the persistent impact of the loss of the bison on the people that relied on them is psychological. It is not difficult to believe that the dramatic fashion in which the bison where brought to near extinction, and the biological and economic consequences that followed, were traumatic for the people that had relied on them for over 10,000 years and whose economies, spirituality, and culture had evolved around. The resulting trauma may lead to disparities in socioeconomic outcomes for successive generations. The concept of historical trauma as an explanation for many of the socioeconomic problems faced by today's Native Americans has been explored in the psychological literature (e.g., Brown-Rice (2013)), but is a

[52] We only use this year because, to our knowledge, it is the only year that breaks out stock-based agriculture from other agriculture.

less well-known channel of persistence in the economics literature.[53]

Proponents of the historical trauma hypothesis in psychology suggest that historical loss symptoms, like depression, substance dependence, and diabetes are the result of intergenerational transmission of trauma resulting from historical losses. The process occurs in three stages (Sotero, 2006). In the first stage, a mass trauma is inflicted upon a minority population by the dominant population. In the current analysis, the bison's deliberate slaughter can be thought of as the traumatic event. This is followed by a biological, societal, and psychological response. The decline in heights and increase in child mortality we observed in Section **??** are consistent with the second stage of historical trauma. In the final stage, the trauma response is transmitted intergenerationally, manifesting in socioeconomic disparities among future generations, often in the form of higher levels of depression, suicide, and other instances of maladaptive behavior.

We consider this channel by compiling Multiple Cause of Death Mortality Data from the National Vital Statistics System of the National Center for Health Statistics.[54] The Multiple Cause of Death data report county-level counts of all deaths occurring within the United States. The earliest date for which inclusive county and race data are available is 1988.[55] We overlay county boundaries in 1990 with reservation boundaries in 1990 to determine which reservations were located in each county at this time. We then make the assumption that Native American deaths that are reported in the Multiple Cause of Death database are from individuals whose tribal ancestry comes from the reservation located in their county of residence. This allows us to construct county-level estimates of bison-reliance by averaging over the bison-reliance of all Native groups within the county. We also present alternative estimates at the reservation level for the sample of reservations for which we also have income data. For these specifications, we assume the reservation's mortality rate is determined by the mortality rate of Native Americans in the county in which the reservation is located. If a reservation crosses the border of two counties, then their mortality rate is averaged over both counties.

Table 16 presents the results from this exercise for causes of mortality associated with historical trauma (Sotero, 2006): suicide, homicide, alcohol, diabetes, as well as all deaths.[56]

[53]Most closely related to the concept of historical trauma is the study of Acemoglu et al. (2011) of the long-run effects of the Holocaust, although they do not specifically outline historical trauma as a possible mechanism to explain the persistence they observe.

[54]We access these data through the NBER data portal.

[55]After 1988 counties with low numbers of deaths are censored.

[56]We do not have enough variation to study deaths due to drug use.

Panel A displays the county-level estimates, and Panel B displays the reservation level estimates. Given the discrete nature of the data, and that the data contain a disproportionate number of zeros, we estimate our equations with Poisson regressions. We include the full set of controls from Table 6, in addition to controls for the log of white mortality due to the form of mortality under examination, as well as the log of total Native mortality in the county. We present marginal effects, with the first five columns making use of the full sample, and the last five columns restricting to only bison-reliant tribes.

For both county-level and reservation-level estimations we observe that formerly bison-reliant nations that experienced the rapid slaughter have higher suicide rates. Looking within bison-reliant nations, we observe that this difference is statistically significant for the reservation-level estimates. Although not statistically different from zero in the county-level specifications, it is still large in magnitude. Interestingly, Native Americans in counties where reservations are comprised of formerly bison-reliant tribes who were affected by the rapid slaughter have higher total mortality. The marginal change in all deaths associated with being from a tribe who lost 100% of their territory in the rapid slaughter is nearly identical to the marginal change in suicides. Marginal changes in other causes of death, such as homicide, alcohol, and diabetes, are not statistically different from 0. This indicates that differences in overall mortality between bison-reliant nations who lost the bison gradually and those who were not bison-reliant are driven by differences in suicide rates. These "deaths of despair" are consistent with a decline in psychological well-being following the bison's demise, from which formerly bison-reliant nations had not recovered, at least by 1988

We provide additional evidence of social disruption, by taking advantage of counts of news stories involving conflict or corruption compiled by Dippel (2014). Table 17 presents marginal effects from Poisson regressions where the dependent variable is the count of the number of news stories related to various forms of social disruption. We include the full set of controls from Table 6 in addition to controlling for the logarithm of total news stories (both positive and negative). Column (1) analyzes stories relating to conflict in government, (2) relating to conflict not involving the government, (3) corruption in government, and (4) corruption not involving the government. Columns (5) through (8) repeat this exercise restricting the sample to only include bison-reliant nations.

We find evidence that both tribes affected by the gradual and rapid decline of the bison have higher counts of conflict within their tribal governments. The difference between these estimates is not statistically different from 0, as indicated by column (5). We also see that the gradual loss of the bison is associated with higher counts of conflict not involving governments. Looking within bison tribes, we find that those affected by the rapid slaughter have higher counts of corruption within their governments compared to those affected by the gradual loss of the bison. While instances of conflict and corruption are not systematically higher across the board, we view the results of Table 17 as providing additional evidence that bison societies suffered from increased social disruption in the long-run.

V Conclusion

At the beginning of the 19th century, the North American bison roamed the Great Plains in the tens of millions, but by 1880, the bison were nearly extinct from a mass slaughter that occurred within as little as 10 years. This is the first paper to empirically quantify the long-run effects of the slaughter on the Native Americans who relied on the bison for over 10,000 years prior to its extinction. We compile historical, anthropological, ecological, geographic, and modern economic data to show that the elimination of the bison affected the well-being of the Indigenous peoples who relied on them, both immediately after the bison's decline, and up to 130 years later. We argue that the loss of the bison resulted in a dramatic reversal of fortunes: historically, bison-reliant societies were among the richest in the world and now they are among the poorest.

We study the channels through which this shock has persisted into the present day, highlighting several possible mechanisms that have been suggested by others scholars to be important margins of adjustment, and proposing one new channel through which economic shocks may persist in the long-run. We find that the ability to migrate played a role in some tribes being better equipped to adapt to the shock. Likely the largest contributing factor was the fact that a subset of tribes had pre-contact experience with agriculture, which allowed them to integrate into crop-based agriculture, one of the few occupations that was supported by the Bureau of Indian Affairs throughout the twentieth century. Finally, we find increased levels of suicide and news reports of social dislocation among formerly bison-reliant tribes, suggesting that the bison's decline may have generated a psychological impact that has persisted across generations. This result is consistent with the psychological literature on historical trauma, but has not yet been investigated as a channel of persistence in the economics literature.

In September 2014, a cross-boarder treaty was signed by several formerly bison-reliant Native American nations to restore the bison to traditional Indian territory with the added goals of co-managing and preserving the animal (ICMN, 2014). Although the economic environments and institutional structures have changed significantly since the bison was first exterminated, the restoration of this symbolic icon has great political and cultural significance for formerly bison-reliant nations. It remains to be seen whether the re-introduction of the bison will reverse the negative economic effects that resulted from the bison's extermination, but we view this initiative as a significant step towards improving the standard of living of those who were once decimated by the bison's extinction.

Tables

Table 1: Summary Statistics from Boas Data

	Not bison-Reliant	Bison-Reliant	Diff
Standing Height in cm	156.92	162.33	-5.42***
	(20.05)	(16.87)	
Year Community was Sampled	1892.56	1891.72	0.84***
	(2.11)	(1.18)	
Year of Birth	1864.72	1863.36	1.35***
	(19.27)	(18.79)	
Age	27.85	28.36	-0.51
	(19.26)	(18.64)	
Canada	0.23	0.15	0.08***
	(0.42)	(0.36)	
# Yrs Since Rail	3.42	7.02	
	(29.22)	(27.60)	
			-3.60***
Born After Rail	0.42	0.37	
	(0.49)	(0.48)	
			0.05***
# Yrs Born After Rail	9.01	7.26	
	(14.43)	(12.76)	
			1.75***
Born During War	0.03	0.10	
	(0.18)	(0.30)	
			-0.06***
Only Native American Ancestors	0.81	0.78	0.02**
	(0.39)	(0.41)	
Observations	5390	3849	9239

Notes: The data above is from Franz Boas' data expedition between 1888 and 1899. Means are reported with the standard deviations in parentheses. Difference-in-means tests are reported in the last column. Tribes are classified as "bison-reliant" if 60 percent or more of their ancestral territory overlaps with the historic bison range. "Full blood" is the proportion of people indicated to have no white ancestry. "Years since rail" is the number of rails between an individual's year of birth and the date the first railway went thorough their nation's traditional territory. "Born after rail" is the proportion of the sample that was born after rail went through their traditional territory. "Years born after rail" are the average years of age of someone born after the railway was introduced. Note that the data on wars and railways is only available for American tribes (the American only sample sizes are 4149 and 3270 for the non-bison reliant and bison-reliant respectively). Thus in our regressions we include a dummy and interaction for Canada to account for missing values.

Table 2: Summary Statistics: Dippel's (2014) Census Tract Sample by Tribe-Reservation in 2000 and Additional Colonial Variables

	Not Bison-Reliant	Bison-Reliant	Diff
Per Capita Income	10837.46	8629.64	2207.82
	(5120.06)	(4005.72)	
Nighttime Light Intensity	10.23	4.31	5.92
	(11.85)	(9.27)	
Percent Bison Coverage 1870	0.00	0.23	-0.23
	(0.00)	(0.38)	
# Cattle per sq km	7.39	12.56	-5.17
	(7.91)	(9.38)	
Nearby # Cattle per sq km	8.06	44.43	-36.36
	(8.93)	(213.45)	
Indian War	0.49	0.63	-0.14
	(0.50)	(0.49)	
Distance Displaced	11.74	11.97	-0.23
	(1.02)	(0.95)	
Historic Centralization	0.20	0.14	0.06
	(0.40)	(0.35)	
EA Calories Agriculture	1.59	2.61	-1.02
	(2.01)	(3.06)	
EA Sedentary	3.00	3.21	-0.21
	(1.65)	(2.13)	
Jurisdictional Hierarchy	2.75	2.31	0.45
	(0.43)	(0.46)	
Wealth Distinctions	1.32	1.03	0.29
	(0.76)	(0.17)	
Population in 1600	1947.04	1966.37	-19.32
	(3445.03)	(3244.10)	
Log Ruggedness	-1.28	-1.64	0.36
	(1.36)	(0.87)	
Forced Co-existence	0.66	0.65	0.01
	(0.47)	(0.48)	
Nearby Income Per Capita	18448.98	17438.36	1010.62
	(2939.09)	(2874.21)	
Observations	125	72	197

Notes: Means are reported with the standard deviations in parenthesis. Distance displaced is the distance in km from the centroid of a nation's traditional territory and the centroid of the current reservation. "bison-reliant" is 60 percent of a tribe's ancestral territory overlapping the historic bison range.

Table 3: The Impact of the Loss of the Bison on Male Native American Height

	(1)	(2)	(3)	(4)	(5)	(6)
I(Born After 1870)X	-2.172**			-2.047*		
Shr lost btw 1730-1870	(0.976)			(1.069)		
I(Born After 1886)		-5.322**	-9.435**		-5.495**	-4.790
X Shr lost btw 1870-1889		(2.327)	(3.543)		(2.441)	(3.688)
I(Born After 1870)	1.538*			1.569**		
	(0.828)			(0.759)		
Share lost btw 1730-1870	2.174**			1.608		
	(1.082)			(0.998)		
I(Born After 1886)		4.370***	6.486**		2.892	3.213
		(1.606)	(2.424)		(1.821)	(2.069)
Shr lost btw 1870-1889		1.690**	1.651**		1.181	0.848
		(0.809)	(0.777)		(1.055)	(0.996)
Year of Birth	-0.154***	-0.170***	-2.082***	-0.136***	-0.180***	-2.051***
	(0.035)	(0.003)	(0.048)	(0.041)	(0.011)	(0.061)
Year Sampled	-0.104	-0.182	1.477***	-0.149	0.0826	1.845***
	(0.149)	(0.209)	(0.288)	(0.152)	(0.140)	(0.160)
Canada	-0.893	0.797*	0.783*	2.194***	1.337*	1.790**
	(0.941)	(0.423)	(0.435)	(0.725)	(0.713)	(0.711)
Only Native American Ancestors	-1.200***	-1.127**	-1.263***	-0.940***	-1.156**	-1.292***
	(0.366)	(0.463)	(0.459)	(0.330)	(0.449)	(0.447)
# Yrs Since Rail				-0.0177	0.0123	0.0278
				(0.018)	(0.012)	(0.018)
Born After Rail				1.642**	-0.352	-0.706
				(0.692)	(0.674)	(0.777)
# Yrs Born After Rail				-0.0279	-0.0354	-0.0515
				(0.025)	(0.027)	(0.032)
Born During War				2.238***	2.134***	1.784**
				(0.617)	(0.697)	(0.745)
Observations	9239	3849	2597	9239	3849	2597
Adjusted R^2	0.870	0.856	0.868	0.873	0.858	0.871

Notes: Clustered standard errors at the tribe level in parentheses. There are 133 clusters at most and 48 clusters at least. The columns (2), (3), (5) and (6) are for only bison-reliant nations (i.e. only includes only those tribes whose traditional territories overlap with the historic bison range by at least 60%). Columns (3) and (6) restrict the age of the sample to be between 5 and 35 and the last three columns are for American tribes only. Note that the data on wars and railways is only available for American tribes (the American only sample sizes are 4149 and 3270 for the non-bison reliant and bison-reliant respectively). Thus specifications reported in columns 4-5 include a dummy and interaction for Canada to account for missing values.

Table 4: Correlation between Bison Reliance and Proportion of Children Ever Born Surviving in 1900 & 1910

	Full Sample			Bison-Reliant		
	(1)	(2)	(3)	(4)	(5)	(6)
Share lost 1730-1870	-0.0141	-0.0192	-0.0308			
	(0.030)	(0.030)	(0.035)			
Share lost 1870-1889	-0.104***	-0.105***	-0.106**	-0.0791**	-0.0590*	-0.0537
	(0.028)	(0.029)	(0.045)	(0.035)	(0.030)	(0.044)
I(1910)	0.0102	0.00397	-0.00497	0.0117	0.00135	0.00357
	(0.009)	(0.009)	(0.015)	(0.012)	(0.012)	(0.009)
I(Literate)		0.0533***	0.0535***		0.0765***	0.0765***
		(0.010)	(0.010)		(0.014)	(0.014)
I(1910)*Share lost 1870-1889			0.0213			-0.00953
			(0.018)			(0.042)
I(1910)*Share lost 1730-1870			0.00216			
			(0.042)			
Quadratic in Age	X	X	X	X	X	X
BIA Region FE	X	X	X			
Observations	14451	14451	14451	6040	6040	6040
Adjusted R^2	0.173	0.179	0.179	0.159	0.176	0.175
# of Clusters	126	126	126	48	48	48

Clustered standard errors at tribe level in parentheses. Women only. "Bison-reliant' is defined as at least 60 percent of a tribes' ancestral territory being covered by the original historic bison range. Literature is a indicator variable for whether an individual is literature. Data is from the IPUMS 1900 and 1910 Census 1.4 percent samples with the over-sample of Native Americans and the 1930 Census 5 percent sample. The occupation codes are from the 1950 consistent occuptiona codes produced from by IPUMS. Steven Ruggles, Sarah Flood, Ronald Goeken, Josiah Grover, Erin Meyer, Jose Pacas, and Matthew Sobek. IPUMS USA: Version 8.0 [dataset]. Minneapolis, MN: IPUMS, 2018. https://doi.org/10.18128/D010.V8.0.

Table 5: Correlation between the Share of Bison Covering Traditional Territory and Income Per Capita by Reservation in 2000

	(1)	(2)	(3)	(4)	(5)
Original share	-2529.9***				
	(829.359)				
Share of territory lost by 1870		-1590.5*		-1966.4**	
		(899.832)		(898.331)	
Share lost between 1870-1889			-3841.5***	-4293.5***	-2571.1***
			(591.900)	(675.093)	(615.889)
Constant	10992.1***	10477.9***	10289.8***	10957.7***	9212.5***
	(623.846)	(603.806)	(444.061)	(629.644)	(499.558)
Observations	195	195	195	195	72
# of Clusters	99	99	99	99	37

Notes: Clustered standard errors at the tribe level in parentheses. The last column only includes tribes for whom at least 60% of their original territory was covered by bison.

Table 6: Correlation between the Speed of Bison Loss and Income Per Capita by Reservation in 2000

	Full Sample			Bison-Reliant		
	(1)	(2)	(3)	(4)	(5)	(6)
Share lost as of 1870	-1304.9	-1618.0**	-1393.0*			
	(831.196)	(765.026)	(792.797)			
Share lost between 1870-1889	-4663.6***	-3714.1***	-2862.6***	-2677.4***	-1809.5	-1551.0
	(799.784)	(895.968)	(871.810)	(946.595)	(1155.132)	(959.504)
Historic Centralization	1646.9	3314.6***	3117.7***	1009.4	2244.4*	2070.8*
	(1081.444)	(983.264)	(880.459)	(749.155)	(1166.109)	(1058.023)
EA Calories Agriculture	-233.1	-322.3	-280.0	-304.8	330.1	240.1
	(356.008)	(227.477)	(205.883)	(420.169)	(547.660)	(574.939)
EA Sedentary	28.44	1.312	-67.57	596.0	-1108.1	-1028.8
	(310.385)	(267.813)	(233.504)	(514.264)	(899.652)	(920.086)
Jurisdictional Hierarchy	-304.4	-688.6	-408.7	-1117.8*	-922.4	-819.9
	(920.736)	(635.831)	(644.461)	(607.072)	(697.842)	(881.371)
Wealth Distinctions	-315.7	622.5	453.7	2590.1**	3355.2**	3449.2**
	(990.589)	(597.040)	(599.235)	(972.510)	(1346.606)	(1378.452)
Population in 1600	23.53	5.129	43.42	-15.57	308.0	285.5
	(90.743)	(86.810)	(81.318)	(118.958)	(214.758)	(226.665)
Log Ruggedness	474.8	362.2	286.7	-511.4	-734.1	-608.8
	(399.866)	(270.997)	(264.949)	(608.695)	(566.159)	(488.526)
Forced Co-existence		-5185.3***	-4750.4***		-7705.2*	-6886.4*
		(865.058)	(885.303)		(3858.110)	(3532.312)
Indian War		-722.9	50.75		156.9	452.2
		(676.928)	(742.687)		(1251.482)	(1324.757)
Distance Displaced		812.7***	636.1**		477.3	553.8
		(287.241)	(245.191)		(1055.099)	(977.840)
Nearby Income Per Capita			0.360***			0.340
			(0.126)			(0.235)
_cons	12349.9***	5887.4	353.1	5897.1***	6820.6	-781.7
	(1515.866)	(3684.071)	(4079.599)	(1825.770)	(13182.215)	(14418.583)
Observations	195	195	195	72	72	72
Adjusted R^2	0.060	0.300	0.332	-0.027	0.262	0.293
# of Clusters	99	99	99	37	37	37

Notes: Clustered standard errors at the tribe level in parentheses. The last three columns only include tribes for whom at least 60% of their original territory was covered by bison.

Table 7: Correlation between the Share of Bison Covering Traditional Territory and Income Per Capita by Reservation in 2000: Robustness Checks

	(1)	(2)	(3)	(4)	(5)
Share lost as of 1870	-1249.0*	-902.2	-1459.9*	-450.7	-701.1
	(735.960)	(707.064)	(832.472)	(1011.925)	(1076.371)
Share lost between 1870-1889	-4058.7***	-4187.5***	-4551.2***	-1927.3*	-1754.4
	(1446.637)	(1462.013)	(1488.201)	(1150.910)	(1188.295)
Constant	13880.7***	13791.4***	13678.2***	1518.7	-1557.7
	(2010.410)	(2027.207)	(2112.460)	(6862.684)	(6653.931)
Cultural & Colonial Controls	X	X	X	X	X
Railway Indicators	X	X	X	X	X
Treaty Indicators		X	X	X	X
Beaver Share			X	X	X
Extended Modern Controls				X	X
Soil Quality Indicators					X
Observations	195	195	195	195	195
Adjusted R^2	0.077	0.071	0.068	0.284	0.292
# of Clusters	99	99	99	99	99

Notes: Clustered standard errors at the tribe level in parentheses. All columns includes cultural region fixed effects which include: California, the Great Basin, the Northeast, the Northwest, the Plains, the Plateau, the Southeast and the Southwest. Railway indicators include dummy variables for never having a rail line in your territory, the first developed in 1840-1850, 1851-1860, 1861-1870, 1871-1880, 1881-1890, and after 1890. The treaty controls include dummy variables for signing post-1880, between 1861-1870, 1871-1880, 1881-1890, and after 1890. The omitted treaty category is 1870-1880, and omitted railway category is 1830-1840. The extended modern controls include log reservation kilometers squared, nearby GDP per capita, nearby absolute mobility, log distance to nearest city, log population, presence of a casino, log of land ruggedness on each reservation, and the adult population share. Soil quality controls include share of reservation land without constraints from excess salts, nutrient availability, nutrient retention, rooting conditions, oxygen availability, toxicity, and workability. The cultural and colonial controls are the same as in 6. For all estimated coefficients, please see Table A8.

Table 8: Correlation between Share of Bison Territory Lost and Light Density

	Full Sample		Bison-Reliant	
	(1)	(2)	(3)	(4)
Share lost as of 1870	-0.549***	-0.341		
	(0.208)	(0.211)		
Share lost between 1870-1889	-1.036***	-0.719***	-0.450*	-0.532*
	(0.226)	(0.211)	(0.233)	(0.267)
Constant	2.179***	2.651***	2.256*	3.340***
	(0.565)	(0.502)	(1.142)	(0.929)
Observations	195	338	72	109
Adjusted R^2	0.404	0.371	0.437	0.386
N_clust	99	128	37	46

Notes: Clustered standard errors at the tribe level in parentheses. The last two columns only include tribes for whom at least 60% of their original territory was covered by bison. "Lights Controls" include the full set of controls in Table 6, but with mean light density in the counties surrounding the reservation in replace of mean per capita income in nearby counties and a control for whether the reservation is federal or state.

Table 9: Robustness: Accounting for Selection

	(1) OLS	(2) Oster	(3) IV: With Montreal	IV: No Montreal
Share lost between 1870-1889	-1551.0	-2030.3	-1826.0*	-1808.8*
	(959.504)	·	(1063.144)	(1062.897)
Constant	-781.7	·	-639.3	-648.2
	(14418.583)	·	(12999.292)	(13000.091)
Observations	72	·	72	72
R^2	0.413	·	0.412	0.412
# of Clusters	37	·	37	37
F-Statistic on excluded instruments	·	·	13.146	15.388
p-value for overidentification	·	·	0.457	0.3673
p-value for endogeneity	·	·	0.513	0.618

Notes: Clustered standard errors at the tribe level in parentheses. All specifications restrict the sample to tribes whose traditional territory was at least 60 percent overlapping with the bison range. Each regression includes the full set of controls from Table 6. The F-statistic on the excluded instruments is the Kleibergen-Paap Wald rk F statistic; the overidentification test is the Hansen J statistic.

Table 10: Correlation between Standardized Occupational Rank and Tribe Historic bison-reliance for bison-reliant Native Americans

	1900	1910	1930	1990	2000	2010
Panel A: All tribes						
Share lost between 1870-1889	-0.391***	-0.310***	-0.341**	-0.117***	-0.237***	-0.0802**
	(0.110)	(0.103)	(0.148)	(0.035)	(0.022)	(0.033)
	[0.027]	[0.033]	[0.087]	[0.00]	[0.00]	[0.094]
Constant	-0.961***	-0.910***	-1.363**	-0.578***	-0.373*	-0.529***
	(0.102)	(0.209)	(0.510)	(0.045)	(0.162)	(0.107)
Observations	3102	3508	1216	8516	6909	6742
Adjusted R^2	0.135	0.071	0.092	0.034	0.028	0.023
# of Clusters	44	47	37	10	6	8
Panel B: Tribes that appear in all years						
Share lost between 1870-1889	-0.513***	-0.539***	-0.664**	-0.101*	-0.238***	-0.0779
	(0.036)	(0.078)	(0.186)	(0.040)	(0.028)	(0.043)
	[0.241]	[0.241]	[0.140]	[0.054]	[0.000]	[0.441]
Constant	-1.273***	-1.356***	-1.544***	-0.533***	-0.360*	-0.448***
	(0.070)	(0.235)	(0.192)	(0.037)	(0.160)	(0.079)
Observations	1525	1918	817	7813	6715	6336
Adjusted R^2	0.181	0.089	0.118	0.031	0.027	0.021
# of Clusters	5	5	5	5	5	5

Notes: Clustered standard errors at the tribe level in parentheses. Bootstrap p-values constructed using the method of Cameron et al. (2008) with 299 replications are included below in brackets to account for the small number of clusters in some years. All columns include regional fixed effects (Census regions as defined by IPUMS: the New England Division, Middle Atlantic Division, East North Central Division, West North Central, South Atlantic Division Division, East South Central Division, West South Central Division, Mountain Division, and the Pacific Division). All specifications restrict the sample to tribes whose traditional territory was at least 60 percent overlapping with the bison range.

Table 11: Correlation Between Bison-Reliance and Occupational Rank and Income: Individuals On and Off Homelands in 2000

	Occupational Rank			Log PC Income		
	(1) Off	(2) On	(3) Full Sample	(4) Off	(5) On	(6) Full Sample
Share lost between 1870-1889	-0.0985**	-0.227***	0.0301	-0.312*	-0.992***	0.368
	(0.039)	(0.029)	(0.078)	(0.150)	(0.266)	(0.291)
	[0.241]	[0.047]	[0.662]	[0.508]	[0.067]	[0.274]
Homeland			-0.129**			-0.680**
X Shr lost btw 1870-1889			(0.044)			(0.235)
			[0.127]			[0.355]
Constant	-0.343	-0.313	-0.343	6.615***	7.106***	6.615***
	(0.202)	(0.171)	(0.202)	(0.466)	(0.806)	(0.466)
Homeland			X			X
Age & Age-Squared	X	X	X	X	X	X
Region of residence fixed effects	X	X	X	X	X	X
Observations	6226	7425	13651	6226	7425	13651
Adjusted R^2	0.032	0.039	0.037	0.027	0.033	0.034
# of Clusters	8	8	8	8	8	8

Notes: Clustered standard errors at the tribe level in parentheses. All columns include region and place of birth fixed effects. Results are statistically equivalent if state fixed effects are used instead of region fixed effects. Log real wages with a base year of 99 are the dependent variable. These only include tribes whose share of territory was at least 60 percent covered by the historic bison range as of 1730. The last column includes interaction of homeland with the other covariates in specifications 1 and 2.

Table 12: Correlation between Share of Bison Territory Lost and Log Population

	Full Sample		Bison-Reliant	
	(1)	(2)	(3)	(4)
Share lost as of 1870	0.339	0.321		
	(0.249)	(0.247)		
Share lost btw 1870-1889	1.679***	1.641***	1.069***	1.005***
	(0.232)	(0.238)	(0.296)	(0.295)
Constant	6.263***	6.268***	9.277***	9.244***
	(1.099)	(1.095)	(3.322)	(3.278)
PC Income		X		X
Observations	195	195	72	72
Adjusted R^2	0.402	0.400	0.418	0.422
N_clust	99	99	37	37

Notes: Dependent variable is the log of population. Clustered standard errors at the tribe level in parentheses. The last two columns only include tribes for whom at least 60% of their original territory was covered by bison. All columns include the full set of controls in Table 6.

Table 13: Correlation between Share of Bison Covering Traditional Territory and Income Per Capita Adjusted for Experience with Agriculture

	(1)	(2)	(3)
Share lost as of 1870	-3884.2	-2294.6	-1098.5
	(1494.426)	(1210.170)	(1217.349)
Share lost as of 1870 X AG Cal	941.4	26.41	-341.3
	(344.777)	(341.150)	(394.416)
Share lost btw 1870-1889	-2998.7	-4370.0	-4866.3
	(1390.663)	(1499.165)	(1580.858)
Share lost btw 1870-1889 X AG Cal	1490.4	2836.9	4290.2
	(922.949)	(1129.248)	(1345.322)
Cultural Controls	X	X	X
Soil Quality Controls	X	X	X
Colonial Controls		X	X
Contemporary Controls			X
Observations	197	197	197
Adjusted R^2	0.113	0.292	0.420

Notes: Clustered standard errors at the tribe level in parentheses. "Cultural controls" include calories from agriculture, historic centralization, measures of nomadism, jurisdictional hierarchy, wealth distinctions, log ruggedness and population in 1600. "Colonial controls" include being involved in an Indian war, a measure of forced co-existence, and distance displaced from traditional territory. "Contemporary controls" include nearby income per capita, log distance to the nearest city, presence of a casino. "Soil Quality controls" include share of reservation land without constraints from excess salts, nutrient availability, nutrient retention, rooting conditions, oxygen availability, toxicity, and workability.

Table 14: Correlation between Agriculture and Outcomes

	Height in cm	Proportion Children Surviving	Occupational Rank
Shr lost btw 1730-1870	.	-0.0881**	-0.200*
		(0.034)	(0.107)
Shr lost btw 1870-1889	0.654	-0.0841***	-0.450***
	(1.32)	(0.031)	(0.112)
Shr lost btw 1870-1889 X AG Cal.	-0.344	-0.0226*	0.0719*
	(0.43)	(0.012)	(0.041)
Shr lost btw 1730-1870 X AG Cal.	.	0.0246**	0.0631**
	.	(0.012)	(0.026)
I(Born After 1886) X AG Cal.	0.390	.	.
	(0.46)	.	.
I(Born After 1886)X Shr lost btw 1870-1889 X AG Cal.	0.159	.	.
	(1.20)	.	.
I(Born After 1886)	2.266	.	.
	(2.49)	.	.
I(Born After 1886)X Shr lost btw 1870-1889	-3.330	.	.
	(2.95)	.	.
EA Calories Agriculture (AG Cal)	-0.283	-0.00137	-0.00458
	(0.220)	(0.009)	(0.021)
I(Year=1910)	.	0.0117	-0.0525**
	.	(0.010)	(0.024)
Region FE		X	X
Quadratic in Age		X	X
Year of Birth	X		
Year Sampled	X		
Only Native American Ancestors	X		
Canada	X		
Observations	3765	13996	15372
Adjusted R^2	0.857	0.181	0.070
N_clust	46	112	114

Clustered standard errors at tribe level in parentheses. Column (1) uses the data and models in Table 3 on height. Columin (2) uses the data and models from Table 4. Column (3) shows the results for the effect on occupational rank in 1900 and 1910 from Table 10. The samples are smaller than the samples in other tables because of the imperfect match rate of the Ethnographic Altas with the tribal codes in the Boas and IPUMS samples.

Table 15: Probability of Engaging in Live-Stock based Occupations in 2010 Relative to White Counter Parts

	All Native Americans			Bison-Reliant		
	Farming	None	Live Stock	Farming	None	Live Stock
Year 1910	-0.0357***	-0.000288	0.000232	-0.0357***	-0.000246	0.000216
	(0.003)	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)
Year 1930	-0.0855***	0.00700***		-0.0855***	0.00704***	0
	(0.005)	(0.001)		(0.001)	(0.001)	
Native American	0.0550*	0.151***	-0.0133*	-0.301***	0.504***	-0.0807***
	(0.033)	(0.024)	(0.007)	(0.022)	(0.022)	(0.011)
1910 X Native American	0.00492	-0.000707	0.0406***	0.0879***	-0.0918***	0.0138
	(0.030)	(0.023)	(0.015)	(0.029)	(0.028)	(0.019)
1930 X Native American	0.0845**	-0.0588**		0.280***	-0.249***	
	(0.033)	(0.025)		(0.042)	(0.038)	
Constant	0.289***	0.118***	0.00240***	0.289***	0.118***	0.00229***
	(0.003)	(0.002)	(0.000)	(0.002)	(0.002)	(0.000)
Age Fixed Effects	X	X	X	X	X	X
County Fixed Effects	X	X	X	X	X	X
Observations	2126860	2126860	553417	2109818	2109818	538788
Adjusted R^2	0.317	0.034	0.106	0.317	0.033	0.105

Notes: Notes: Clustered standard errors at county level are in parenthesis. Sample is the male population between the ages of 20 and 65. The "live-stock" based occupations are only indicated in the 1900 and 1910 Census data. "Bison-reliant' is defined as at least 60 percent of a tribes' ancestral territory being covered by the original historic bison range. Data is from the IPUMS 1900 and 1910 Census 1.4 percent samples with the over-sample of Native Americans and the 1930 Census 5 percent sample. The occupation codes are from the 1950 consistent occuptiona codes produced from by IPUMS. Steven Ruggles, Sarah Flood, Ronald Goeken, Josiah Grover, Erin Meyer, Jose Pacas, and Matthew Sobek. IPUMS USA: Version 8.0 [dataset]. Minneapolis, MN: IPUMS, 2018. https://doi.org/10.18128/D010.V8.0. Clustered standard errors at the county-level in parentheses.

Table 16: Correlation between Share of Bison Territory Lost and Mortality in 1988

	Full Sample					Bison-Reliant				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)		
	Suicide	Homicide	Alcohol	Diabetes	All Deaths	Suicide	Homicide	Alcohol	Diabetes	All Deaths
				Panel A: County Level						
Share lost as of 1870	-0.165	-0.275	-0.222	-0.267	-0.370					
	(0.323)	(0.424)	(0.265)	(0.327)	(0.287)					
Share lost between 1870-1889	0.824*	-0.220	-0.0714	0.331	0.879**	1.152	0.555	0.916	1.382*	0.585
	(0.434)	(0.552)	(0.332)	(0.443)	(0.400)	(0.807)	(0.821)	(0.695)	(0.784)	(0.402)
Constant	-5.174***	-2.295***	-3.850***	-4.256***	-1.124	-6.233***	-1.665	-5.754***	-7.756***	1.432
	(0.882)	(0.866)	(0.670)	(0.775)	(0.799)	(1.841)	(1.227)	(2.048)	(1.444)	(1.611)
Observations	422	422	422	422	422	203	203	203	203	203
N_clust	422	422	422	422	422	203	203	203	203	203
				Panel B: Reservation Level						
Share lost as of 1870	0.295	-0.0695	-0.142	-0.731***	-0.908***					
	(0.193)	(0.259)	(0.181)	(0.193)	(0.242)					
Share lost between 1870-1889	0.708**	0.469	-0.0349	-0.436	0.140	0.690**	0.571**	0.270	0.360	0.365
	(0.341)	(0.388)	(0.283)	(0.341)	(0.401)	(0.287)	(0.272)	(0.234)	(0.356)	(0.322)
Constant	-3.592***	-3.729***	-3.097***	-3.180***	0.603	-3.436***	-1.662*	-4.367***	-6.553***	-1.214
	(0.729)	(0.842)	(0.570)	(0.605)	(0.741)	(0.978)	(0.942)	(1.004)	(1.121)	(0.991)
Observations	195	195	195	195	195	72	72	72	72	72
N_clust	99	99	99	99	99	37	37	37	37	37

Notes: Clustered standard errors at the tribe level in parentheses. The last five columns only include tribes for whom at least 60% of their original territory was covered by bison. The dependent variable in each column is the count (poisson) of the given manner of death. Panel A uses county-level estimates of mortality, while panel B estimates reservation-level regressions where the dependent variable is the count of instances of the given manner of death among Native Americans in the county in which the reservation is located. All columns include the full set of controls in Table 6 as well as controls for the log of white deaths attributable to the mortality cause under investigation, as well as the log of all Native American deaths.

Table 17: Correlation between Share of Bison Territory Lost and News Stories Involving Corruption and Conflict

	Full Sample				Bison-Reliant			
	(1) Conflict Government	(2) Conflict Not Government	(3) Corruption Government	(4) Corruption Not Government	(5) Conflict Government	(6) Conflict Not Government	(7) Corruption Government	(8) Corruption Not Government
Share lost as of 1870	1.242***	0.788*	-0.260	0.0354				
	(0.475)	(0.437)	(0.226)	(0.174)				
Share lost btw 1870-1889	0.869*	0.577	0.271	0.139	-0.0953	-0.0552	0.509***	0.0160
	(0.473)	(0.400)	(0.201)	(0.166)	(0.123)	(0.197)	(0.162)	(0.063)
Constant	2.235	6.970**	-2.225	-3.970***	11.45	13.55***	7.268***	-1.803
	(4.075)	(3.456)	(1.532)	(1.460)	(8.537)	(4.913)	(1.970)	(1.915)
Observations	195	195	195	195	72	72	72	72
# of Clusters	99	99	99	99	37	37	37	37

Notes: Clustered standard errors at the tribe level in parentheses. The last four columns only include tribes for whom at least 60% of their original territory was covered by bison. The dependent variable in each column is the count (poisson) of the type of news stories. All columns include the full set of controls in Table 6 and we also control for the log of the total number of news stories (both positive or negative) involving the tribe.

Figures

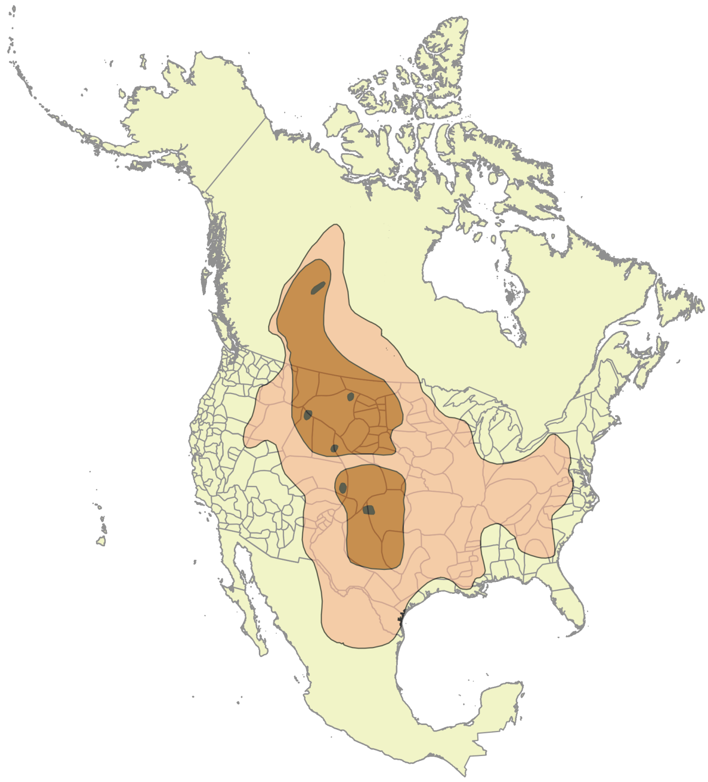


Figure 1: This is a digitized version of the map generated by Hornaday (1889), illustrating the original range of the North American bison and the timing of its decline. The lightest region is the range as of 1730, the middle region is the bison range as of 1870, and the final black regions are the remaining herds as of 1889 and their sizes. The 1889 ranges were in ranched captivity. Tribal territory boundaries are also displayed for the continental U.S.

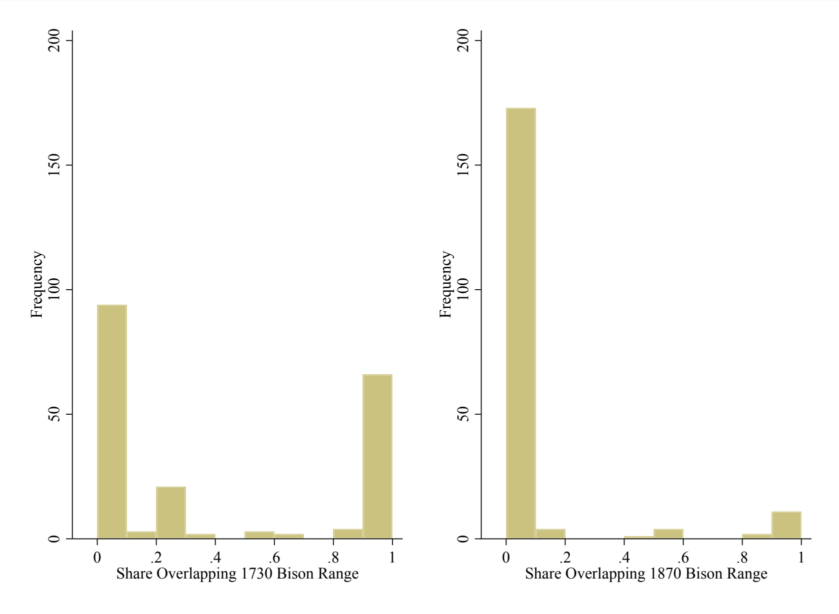


Figure 2: These histograms show the share of ancestral lands overlapping the original bison range (left) and the bison range as of 1870 (right).

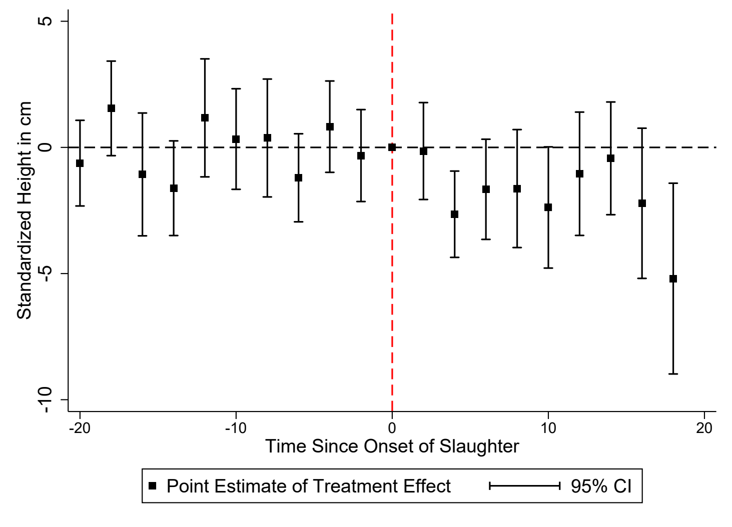
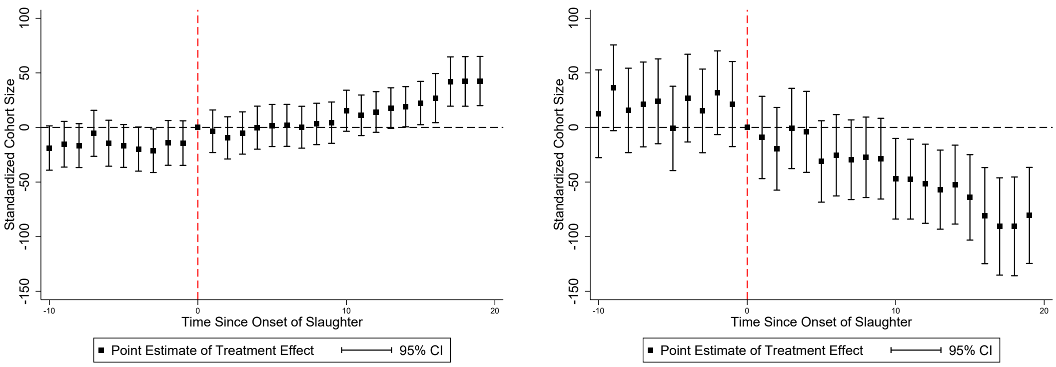


Figure 3: Coefficients on indicators for each two-year of birth before and after the slaughter interacted with the share of their terrority historically overlapping the bison range. The dependent variable is height in cm and conditions on age fixed effects, a dummy for "full blood", the tribe being located in Canada, whether a railway entered the traditional territory of the tribe and the number of years since your year of birth the railway had been present, and for whether the respondent had been born during a period of war. Data is from Franz Boas' 1889 to 1903 sample, N=7,602 (males).



(a) Full sample (b) Bison-reliant: gradual vs. rapid

Figure 4: Coefficients on indicators for each two-year of birth before and after the slaughter interacted with whether the tribe obtained most of its calories from bison at least during part of the year. The dependent variable is the weighted number of people observed in that cohort and conditions on age fixed effects. Data is from the IPUMS 1900 and 1910 Census Over-sample. Given that some tribe-birth year combinations have no observations, we impute a population size of zero.

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Online Appendix: "The Slaughter of the Bison and Reversal of Fortunes on the Great Plains" by Donna Feir, Rob Gillezeau, and Maggie Jones

A Additional Tables

Table A1: Share of Lands Ceded Over Time by bison-reliance

	$\leq$ 60% Bison	$\geq$ 60% Bison	Difference
Ceded Share 1784-1840	0.05	0.05	-0.00
	(0.17)	(0.13)	
Ceded Share 1840-1860	0.43	0.34	0.09
	(0.42)	(0.37)	
Ceded Share 1860-1870	0.16	0.32	-0.16
	(0.33)	(0.33)	
Ceded Share 1870-1880	0.09	0.15	-0.06
	(0.24)	(0.29)	
Ceded Share 1880 to Present	0.18	0.25	-0.07
	(0.36)	(0.37)	
Observations	125	72	197

Notes: Mean values are reported with the standard deviations in parenthesis. Source: Hilliard (1972).

Table A2: Summary Statistics 1900, 1910, 1930: Communities with Traditional Territories Overlapping the Original Bison Range Less than and More than 60 Percent

	Men			Women		
	Not Bison-Reliant	Bison-Reliant	Diff	Not Bison-Reliant	Bison-Reliant	Diff
				1900		
Std Occupational Score	-0.01	-0.14	0.13***			
	(0.76)	(0.71)				
Proportion of Children Ever Born Still Living				0.81	0.78	0.02***
				(0.25)	(0.25)	
Age	25.61	22.79	2.82***	41.05	39.57	2.15***
	(20.96)	(18.77)		(17.18)	(1486.44)	
Literate	0.26	0.35	-0.09***	0.16	0.32	-0.11 ***
	(0.44)	(0.48)		(0.37)	(0.47)	
Observations	9728	7029	16757	4609	3262	16345
				1910		
Std Occupational Score	-0.08	-0.21	0.13***			
	(0.74)	(0.74)				
Proportion of Children Ever Born Still Living				0.78	0.77	0.01*
				(0.26)	(0.25)	
Age	24.71	23.01	1.70***	41.01	40.24	1.18***
	(20.48)	(19.20)		(17.24)	(16.26)	
Literate	0.37	0.45	-0.09***	0.29	0.46	-0.10***
	(0.48)	(0.50)		(0.45)	(0.50)	
Observations	11085	8070	19155	5008	3523	18439
				1930		
Std Occupational Score	-0.17	-0.19	0.02			
	(0.68)	(0.71)				
Proportion of Children Ever Born Still Living						
Age	24.08	23.28	0.80			
	(19.78)	(19.46)				
Literate	0.48	0.58	-0.10***			
	(0.50)	(0.49)				
Observations	3221	2843	6064			

The means are reported with the standard deviations in parenthesis. The percentage of the male population between the ages of 20 and 65 and all women who ever had children. "Bison-Reliant" are all individuals who belong to tribes whose territories overlapped the bison range by at least 60 percent. Data is from the IPUMS 1900 and 1910 Census 1.4 percent samples with the over-sample of Native Americans and the 1930 Census 5 percent sample. The occupation codes are from the 1950 consistent occuptiona codes produced from by IPUMS. Steven Ruggles, Sarah Flood, Ronald Goeken, Josiah Grover, Erin Meyer, Jose Pacas, and Matthew Sobek. IPUMS USA: Version 8.0 [dataset]. Minneapolis, MN: IPUMS, 2018. https://doi.org/10.18128/D010.V8.0 Significance stars: * 0.05 ** 0.01 *** 0.001

Table A3: The Loss of the Bison on Male Native American Height: Alternative Bison-Dependency Measure

	(1)	(2)	(3)
Bison-Dependency	3.352***	1.077	0.960
	(0.671)	(3.110)	(2.956)
I(Still had bison in 1870)	-0.939	-2.384	-4.119
	(4.170)	(4.557)	(4.273)
I(Born After 1883)	1.749**	1.403	1.955
	(0.820)	(1.995)	(1.937)
Bison-Dependency X I(Still had bison in 1870)	0.720	2.791	4.577
	(4.809)	(5.490)	(5.172)
I(Born After 1886) X Bison-Dependency	-2.062	-3.392	-4.892
X I(Still had bison in 1870)	(1.793)	(2.548)	(2.929)
Year of Birth	-0.151***	-0.136***	-0.132***
	(0.036)	(0.003)	(0.012)
Year Sampled	-0.0415	-0.0875	0.0558
	(0.111)	(0.108)	(0.127)
Canada	-1.087	-0.316	0.0921
	(0.830)	(0.385)	(0.442)
Only Native American Ancestors	-1.127***	-0.439	-0.425
	(0.326)	(0.396)	(0.402)
Years since rail			-0.00145
			(0.012)
Born after railway			-0.298
			(0.662)
Years born after rail			-0.118**
			(0.053)
Born During War			1.637**
			(0.790)
Observations	9239	2975	2975
Adjusted R^2	0.872	0.860	0.862

Notes: Clustered standard errors at the tribe level in parentheses. There are 133 clusters at most and 48 clusters at least. The columns (2), (3), are for only bison-reliant nations (i.e. our measure of bison-reliance is greater than 0.4 which indicates that a significant portion of calories obtained from bison).

Table A4: The Impact of the Loss of the Bison on Female Native American Height

	(1)	(2)	(3)	(4)	(5)	(6)
I(Born After 1870)X Shr lost btw 1730-1870	-0.498			-0.560		
	(0.753)			(0.864)		
I(Born After 1886)X Shr lost btw 1870-1889		1.370	-10.69**		1.095	-8.037**
		(1.896)	(4.243)		(1.970)	(3.448)
I(Born After 1870)	-0.245			-0.0760		
	(0.896)			(0.863)		
Share lost btw 1730-1870	1.274			0.923		
	(0.955)			(0.962)		
I(Born After 1886)		-2.181	-1.568		-4.139	-4.839*
		(3.127)	(3.764)		(2.770)	(2.821)
Shr lost btw 1870-1889		1.480	1.586		0.613	0.348
		(0.891)	(0.995)		(1.030)	(1.087)
Year of Birth	-0.816***	-0.605***	-1.641***	-0.800***	-0.585***	-1.591***
	(0.030)	(0.033)	(0.056)	(0.035)	(0.032)	(0.062)
Year Sampled	0.616***	0.267	1.421***	0.595***	0.705***	1.842***
	(0.084)	(0.326)	(0.410)	(0.089)	(0.165)	(0.197)
Canada	-0.627	0.436	0.460	0.405	0.484	-0.323
	(0.660)	(0.608)	(0.749)	(0.702)	(1.143)	(1.682)
Only Native American Ancestors	-0.424	0.0609	-0.0202	-0.265	0.00924	-0.0863
	(0.335)	(0.530)	(0.488)	(0.278)	(0.480)	(0.476)
# Yrs Since Rail				-0.0108	0.0376***	0.0596**
				(0.017)	(0.012)	(0.028)
Born After Rail				1.198**	0.0687	0.0438
				(0.563)	(0.664)	(0.770)
# Yrs Born After Rail				-0.0376	-0.105***	-0.131***
				(0.027)	(0.021)	(0.029)
Born During War				1.863*	1.615	1.493
				(0.944)	(1.118)	(1.155)
Observations	5386	2001	1498	5386	2001	1498
Adjusted R^2	0.858	0.839	0.831	0.860	0.843	0.836

Notes: Clustered standard errors at the tribe level in parentheses. There are 123 clusters at most and 45 clusters at least. The columns (2), (3), (5) and (6) are for only bison-reliant nations (i.e. only includes only those tribes whose traditional territories overlap with the historic bison range by at least 60%). Columns (3) and (6) restrict the age of the sample to be between 5 and 35 and the last three columns are for American tribes only.

Table A5: Summary Statistics from Historical Statistics Population Data

	N	Pop 1907	Pop 1780	Pop Change
Non-bison-reliant	45	224.42	1137.78	-913.36
		(40.20)	(112.80)	(121.75)
Bison-reliant	20	1199.00	4592.25	-3393.25
		(262.94)	(990.77)	(890.58)
Difference	65	974.58	3454.47	-2479.894
		(59.10)	(222.18)	(199.97)

Notes: Bison-reliant communities are those whose traditional territories overlapped with the original bison range by more than 60%. Non-bison-reliant communities are those whose territories overlapped with the original range by less than 60%. Means are reported with standard deviations in parenthesis.

Table A6: Correlation between Share of Bison Covering Traditional Territory and GDP per capita by Reserve in Canada in 2001 (CAD)

	(1)	(2)	(3)	(4)
Original Share	-5400.4	-3951.2	-4290.4	-2964.6
	(417.02)	(1154.54)	(1089.23)	(1120.23)
Geographic Controls		X	X	X
Historic Controls			X	X
Modern Controls				X
Constant	12632.5	29537.6	23088.5	33779.6
	(317.19)	(5215.69)	(5084.07)	(6678.65)
Observations	341	341	341	341
Adjusted R^2	0.270	0.547	0.572	0.632

Notes: Robust standard errors at the tribe level in parentheses. Geographic controls are fixed effects for the province in which the census subdivision (csd) is currently located, and the latitude and longitude of the csd. The historic controls include the share of the traditional territory covered by the primary beaver range, the share of traditional territory covered by the secondary beaver range, the historic population at the nearest trading post, the log of distance to the closest trading post, the log of distance to the closest railway station, historic centralization, calories from agriculture, wealth distinctions, and levels of jurisdictional hierarchy. Modern controls include the log of distance to the closest city and population.

Table A7: Correlation between Alternative Bison Measures and Income Per Capita by Reservation in 2000

	(1)	(2)	(3)	(4)	(5)
Original share	-938.1				
	(833.971)				
Share left by 1870	-2188.5***				
	(801.336)				
Anthropological dependence		-622.8			
		(1037.104)			
Anthro dependence x Share 1870		-2823.5***			
		(1015.989)			
Short grasses share			-1679.8		
			(1319.669)		
Short grasses share x Share 1870			-945.4		
			(1244.875)		
Log cattle density in traditional territory				-67.82	
				(381.622)	
Log cattle density x Share 1870				-1058.5***	
				(312.526)	
Member of ITBC					-394.2
					(675.874)
Member of ITBC x Share 1870					-2506.9***
					(807.383)
Constant	1994.5	1167.0	1452.9	1323.7	1418.9
	(2967.796)	(2774.803)	(2951.636)	(2815.008)	(2903.225)
Observations	195	195	195	195	195
Adjusted R^2	0.151	0.148	0.143	0.147	0.147
# of Clusters	99	99	99	99	99

Notes: Clustered standard errors at the tribe level in parentheses. "Anthropological dependence" is a measure from 0 to 1 of the degree of bison-reliance collected from Waldman (2009). "Share left by 1870" measures the degree to which a tribe's traditional territory was still covered by bison in 1870, indicating that a nation still potentially relied on the bison at the time of the slaughter. "Grassland share" is the share of ancestral territory that overlaps with temperate grassland ecosystems which was generated by data from the World wildlife foundation. "Log cattle density in traditional territory" is the logarithm of the number of cattle per square kilometre in 2012 within the borders of a tribe's traditional territory. All columns controls for the full set of controls in Table 6.

Table A8: Correlation between the Share of Bison Covering Traditional Territory and Income Per Capita by Reservation in 2000: Full Result Robustness Checks

	(1)	(2)	(3)	(4)	(5)
Share lost as of 1870	-1249.0*	-902.2	-1459.9*	-450.7	-701.1
	(735.960)	(707.064)	(832.472)	(1011.925)	(1076.371)
Share lost between 1870-1889	-4058.7***	-4187.5***	-4551.2***	-1927.3*	-1754.4
	(1446.637)	(1462.013)	(1488.201)	(1150.910)	(1188.295)
Historic Centralization	1033.5	1139.9	842.0	411.2	109.0
	(861.512)	(970.689)	(970.936)	(805.041)	(869.060)
EA Calories Agriculture	240.2	160.3	237.4	-120.1	-61.67
	(453.356)	(459.265)	(481.554)	(320.486)	(287.397)
EA Sedentary	-39.20	30.19	32.32	-0.755	-40.54
	(308.581)	(326.135)	(323.869)	(257.852)	(250.910)
Jurisdictional Hierarchy	-503.3	-455.9	-463.0	469.6	25.44
	(1019.522)	(1029.158)	(1044.599)	(839.627)	(681.027)
Wealth Distinctions	37.51	-22.50	-18.36	213.7	510.6
	(867.471)	(882.843)	(894.210)	(892.214)	(751.799)
Population in 1600	-49.63	-50.40	-52.94	-19.92	-29.07
	(94.217)	(88.913)	(88.151)	(94.429)	(114.785)
Log Ruggedness	667.5	547.7	555.4	715.2**	636.6
	(404.089)	(389.885)	(390.631)	(353.387)	(427.501)
Great Basin	-1474.4	-1346.4	-1297.2	-652.0	-556.8
	(2192.134)	(2170.289)	(2206.315)	(1785.605)	(1482.214)
Northeast	-444.6	316.7	-665.9	149.9	997.1
	(1945.243)	(1997.893)	(2112.601)	(1921.333)	(1992.655)
Northwest	-2238.0	-1350.7	-1130.4	-3755.5*	-2841.7
	(1470.100)	(1787.727)	(1842.913)	(2053.423)	(1921.893)
Plains	-1956.3	-808.1	-782.4	379.2	-213.0
	(1582.837)	(1721.793)	(1693.714)	(1910.805)	(1885.699)
Plateau	-3191.7**	-2083.8	-2314.5	-1611.3	-757.7
	(1411.240)	(1710.383)	(1803.984)	(1432.783)	(1271.279)
Southeast	-2307.5	-1390.5	-881.0	-1033.2	554.2
	(2029.973)	(1992.753)	(2235.974)	(1901.898)	(1708.097)
Southwest	-4119.4	-4114.4	-4116.2	-1767.6	-735.9
	(2498.817)	(2533.133)	(2584.133)	(1836.979)	(1709.953)
Treaty Signed post-1880		-1928.4**	-1977.6**	-840.9	-906.7
		(906.467)	(898.754)	(710.787)	(739.520)
Treaty Signed 1870-1880		0	0	0	0
		(.)	(.)	(.)	(.)
Treaty Signed 1860-1870		-1369.7	-1316.4	-546.5	-562.3
		(833.742)	(825.149)	(774.683)	(824.688)
Treaty Signed 1850-1860		-1263.3	-1420.5	-1295.1	-1140.2
		(1447.425)	(1396.207)	(1165.138)	(1041.483)
Treaty Signed pre-1850		-1554.9	-1400.2	304.9	64.38
		(1113.291)	(1107.125)	(789.795)	(849.847)
Beaver Share of Territory			1214.4	1221.6	996.2
			(1428.029)	(1199.237)	(1140.217)
Log Reservation Square KM				-186.9	-307.4
				(220.540)	(246.056)
Nearby Income Per Capita				0.420**	0.375**
				(0.179)	(0.180)
Mobility of Surrounding County				-87.03	-58.73
				(105.542)	(92.369)
Log Distance to Nearest City				-789.4*	-574.0
				(472.476)	(458.029)
Presence of a Casino				3304.6**	3359.0**
				(1278.370)	(1308.899)
Log population				-378.8	-334.2
				(319.896)	(304.818)
Adult Population Share				156.6**	167.6**
				(65.680)	(73.981)
Constraint: excess salt					2124.4**
					(1041.278)
Constraint: nutrient availability					-144.5
					(1198.052)
Constraint: nutrient retention					2156.6
					(1591.801)
Constraint: rooting conditions					-1437.9
					(1733.877)
Constraint: oxygen					12.15
					(1473.287)
Constraint: toxicity					-3274.7
					(2449.248)
Constraint: workability					3123.8**
					(1517.689)
Constant	13880.7***	13791.4***	13678.2***	1518.7	-1557.7
	(2010.410)	(2027.207)	(2112.460)	(6862.684)	(6653.931)
Observations	195	195	195	195	195
Adjusted R^2	0.077	0.071	0.068	0.284	0.292

Notes: Clustered standard errors at the tribe level in parentheses. All columns includes cultural region fixed effects which include: California, the Great Basin, the Northeast, the Northwest, the Plains, the Plateau, the Southeast and the Southwest. Omitted treaty category is 1870-1880, and omitted railway category is 1830-1840.

Table A9: Correlation between Share of Bison Territory Lost and Log Mean Light Density in 2013

	(1)	(2)	(3)	(4)	(5)	(6)
Share lost as of 1870	-0.445**	-0.629**	-0.678***	-0.389**	-0.325*	
	(0.192)	(0.242)	(0.234)	(0.184)	(0.188)	
Share lost between 1870-1889	-1.232***	-1.214***	-1.217***	-0.573**	-0.452*	
	(0.221)	(0.264)	(0.263)	(0.235)	(0.233)	
Popultion in 2015 (in 1000s)	-0.0398	0.111	0.167	0.0681	0.0953	
	(0.450)	(0.483)	(0.502)	(0.226)	(0.213)	
federal_res	-0.895***	-0.450	-0.551*	-0.616**	-0.562*	
	(0.263)	(0.284)	(0.288)	(0.274)	(0.286)	
Log of Ruggedness Index		-0.274***	-0.271***	-0.301***	-0.270***	
		(0.062)	(0.062)	(0.067)	(0.070)	
Historic Centralization		-0.316*	-0.389**	-0.180	-0.239	
		(0.160)	(0.164)	(0.151)	(0.168)	
EA Calories Agriculture		0.0803	0.0804	-0.0535	-0.0751	
		(0.052)	(0.052)	(0.043)	(0.053)	
EA Sedentary		-0.0489	-0.0369	0.104**	0.0946**	
		(0.055)	(0.058)	(0.042)	(0.045)	
Jurisdictional Hierarchy		-0.141	-0.155	-0.150	-0.112	
		(0.163)	(0.162)	(0.119)	(0.122)	
Wealth Distinctions		0.0477	0.0486	-0.106	-0.116	
		(0.126)	(0.129)	(0.075)	(0.072)	
Population in 1600 (in 1000s)		-0.00442	-0.00543	0.00124	0.000488	
		(0.011)	(0.011)	(0.008)	(0.008)	
Never Railroad		-0.132	-0.167	0	0.435	
		(0.268)	(0.274)	(.)	(0.275)	
Rail b/w 1830-1840		1.348**	1.258**	-0.386	0.275	
		(0.565)	(0.556)	(0.361)	(0.373)	
Rail b/w 1840-1850		0.801**	0.745*	-0.0660	0.528	
		(0.387)	(0.405)	(0.326)	(0.321)	
Rail b/w 1850-1860		0.743**	0.747**	-0.193	0.520*	
		(0.304)	(0.304)	(0.294)	(0.265)	
Rail b/w 1860-1870		0.340	0.286	-0.192	0.275	
		(0.234)	(0.246)	(0.246)	(0.225)	
Rail b/w 1870-1880		0.598**	0.569**	-0.0945	0.402*	
		(0.251)	(0.252)	(0.230)	(0.233)	
Rail b/w 1880-1890		0.489**	0.468**	-0.0220	0.439**	
		(0.224)	(0.226)	(0.204)	(0.208)	
Rail after 1890		0	0	-0.391	0	
		(.)	(.)	(0.253)	(.)	
Indian War		-0.272*	-0.305**	0.0721	0.00942	
		(0.142)	(0.148)	(0.116)	(0.113)	
Distance Displaced		-0.00222	-0.00254	-0.00113	-0.000663	
		(0.002)	(0.002)	(0.001)	(0.001)	
Beaver Share			0.212	0.344**	0.383**	
			(0.191)	(0.147)	(0.146)	
Log of Ruggedness Index				0		
				(.)		
Log distance to city				-0.406***	-0.410***	
				(0.064)	(0.064)	
Log PC Income surr counties				1.158**	1.234***	
				(0.455)	(0.457)	
Abs mobility surr counties				0.0241	0.0262	
				(0.020)	(0.021)	
Log mean lights in surr area				0.340***	0.383***	
				(0.087)	(0.082)	
Log of Ruggedness Index					0	
					(.)	
Shr land no excess salts					-0.113	
					(0.224)	
Shr land nutrients avail					-0.226	
					(0.268)	
Shr land nutrient retention					0.0868	
					(0.313)	
Shr land good rooting cond					0.959***	
					(0.276)	
Shr land oxygen					0.234	
					(0.176)	
Shr land non toxic					0.253	
					(0.350)	
Shr land workable					-1.147***	
					(0.337)	
Constant	2.833***	3.617***	3.718***	-7.665*	-9.346**	
	(0.276)	(0.575)	(0.590)	(4.492)	(4.589)	
Observations	338	338	338	338	338	
Adjusted R^2	0.090	0.183	0.183	0.449	0.463	

Notes: Clustered standard errors at the tribe level in parentheses.

Table A10: Robustness: IV First Stage

	(1)	(2)
Cost to Chicago in 1870	1.004**	1.051***
	(0.396)	(0.227)
Cost to Fort Leavenworth in 1870	0.210	0.226
	(0.276)	(0.266)
Cost to New York in 1870	-0.431	-0.385***
	(0.337)	(0.118)
Cost to St. Louis in 1870	-0.869	-0.897*
	(0.521)	(0.503)
Cost to Montreal in 1870	0.0798	
	(0.582)	
Cost to Baltimore in 1890	6.569**	6.564***
	(2.438)	(2.396)
Cost to New York in 1890	-6.548**	-6.544***
	(2.438)	(2.396)
Historic Centralization	-0.169	-0.169
	(0.169)	(0.167)
EA Calories Agriculture	-0.0957	-0.0987
	(0.085)	(0.074)
EA Sedentary	0.0216	0.0251
	(0.096)	(0.089)
Jurisdictional Hierarchy	0.0457	0.0490
	(0.064)	(0.060)
Wealth Distinctions	-0.733	-0.720*
	(0.442)	(0.423)
Population in 1600	-0.0674*	-0.0679*
	(0.040)	(0.037)
Log Ruggedness	0.0407	0.0392
	(0.030)	(0.029)
Forced Co-existence	-0.0615	-0.0564
	(0.081)	(0.082)
Indian War	-0.293*	-0.285
	(0.174)	(0.197)
Distance Displaced	0.230***	0.227***
	(0.064)	(0.068)
Nearby Income Per Capita	0.0000172*	0.0000176*
	(0.000)	(0.000)
Constant	3.316	4.065**
	(5.265)	(1.866)
Observations	72	72
Adjusted R^2	0.678	0.683
# Clusters	37	37

Notes: The dependent variable is the share lost as of 1889. Clustered standard errors at the tribe level in parentheses. All specifications restrict the sample to tribes whose traditional territory was at least 60 percent overlapping with the bison range.

Table A11: Robustness: IV Reduced Form

	(1)	(2)
Cost to Chicago in 1870	4618.2	976.8
	(4914.672)	(2521.926)
Cost to Fort Leavenworth in 1870	1063.6	-207.8
	(3439.301)	(3234.125)
Cost to New York in 1870	1375.7	-2163.0
	(4940.496)	(1689.830)
Cost to St. Louis in 1870	-788.7	1421.2
	(6489.408)	(6097.198)
Cost to Montreal in 1870	-6237.5	
	(7846.300)	
Cost to Baltimore in 1890	-1483.4	-1112.1
	(22499.050)	(22703.272)
Cost to New York in 1890	1406.8	1032.6
	(22496.330)	(22699.108)
Historic Centralization	2103.4*	2067.1*
	(1164.394)	(1159.967)
EA Calories Agriculture	-189.0	45.04
	(1050.488)	(1002.398)
EA Sedentary	-1156.4	-1425.9
	(1316.941)	(1255.199)
Jurisdictional Hierarchy	-1083.1	-1339.3
	(1241.084)	(1174.896)
Wealth Distinctions	4138.2*	3124.4*
	(2371.118)	(1670.541)
Population in 1600	-182.5	-142.4
	(279.277)	(271.243)
Log Ruggedness	-238.0	-126.4
	(637.286)	(577.792)
Forced Co-existence	-6904.7	-7297.3*
	(4422.766)	(4163.976)
Indian War	-4.170	-621.3
	(1414.988)	(1123.004)
Distance Displaced	-248.7	-79.69
	(1226.233)	(1184.659)
Nearby Income Per Capita	0.410	0.379
	(0.262)	(0.255)
Constant	80686.4	22198.5
	(70143.805)	(21248.951)
Observations	72	72
Adjusted R^2	0.304	0.309
# Clusters	37	37

Notes: The dependent variable is per capita income. Clustered standard errors at the tribe level in parentheses. All specifications restrict the sample to tribes whose traditional territory was at least 60 percent overlapping with the bison range.

Table A12: Top Five Occupations by Share of the 20 to 65 Population by Race and Year

Rank by Share	White Men	
	1900	1930
1	Farmers (owners and tenants)	Farmers (owners and tenants)
2	Laborers (n.e.c.)	Laborers (n.e.c.)
3	Farm laborers, wage workers	Managers, officials, and proprietors (n.e.c.)
4	Managers, officials, and proprietors (n.e.c.)	Operative and kindred workers (n.e.c.)
5	Operative and kindred workers (n.e.c.)	Salesmen and sales clerks (n.e.c.)
N	353,556	3,091,819
	NAI Men	
	1900	1930
1	N/A (blank)	Farmers (owners and tenants)
2	Farmers (owners and tenants)	Farm laborers, wage workers
3	Other non-occupational response	N/A (blank)
4	Farm laborers, wage workers	Laborers (n.e.c.)
5	Laborers (n.e.c.)	Farm laborers, unpaid family workers
N	14,851	5,150

The percentage of the male population between the ages of 20 and 65 in each occupation. They are ranked by the share of the North American Indian population greatest to smallest. Data is from the IPUMS 1900 and 1910 Census 1.4 percent samples with the over-sample of Native Americans and the 1930 Census 5 percent sample. The occupation codes are from the 1950 consistent occupational codes produced from by IPUMS. Steven Ruggles, Sarah Flood, Ronald Goeken, Josiah Grover, Erin Meyer, Jose Pacas, and Matthew Sobek. IPUMS USA: Version 8.0 [dataset]. Minneapolis, MN: IPUMS, 2018. https://doi.org/10.18128/D010.V8.0

B Additional Figures

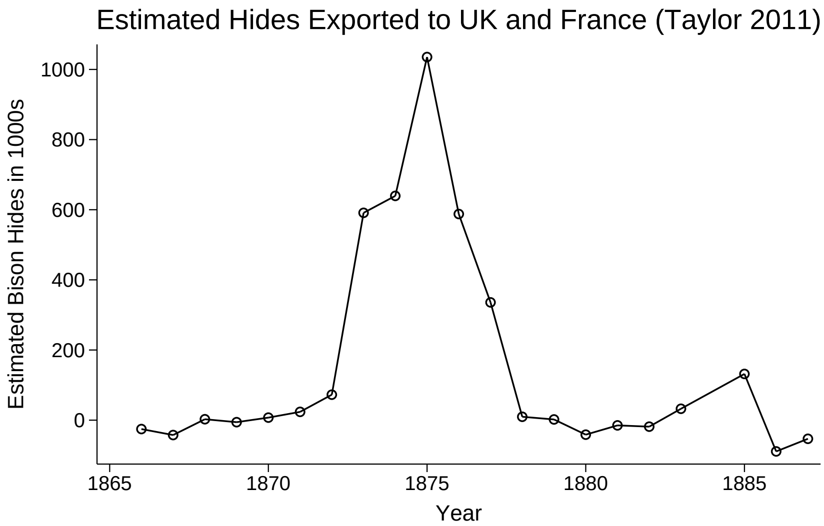

Figure A1: Meaures of hide exports to England and France from Taylor (2011). See Taylor (2011) for details.

Figure A2: This map illustrates the timing and original range of the North American bison and is found in Hornaday 1889, Extermination of the North American Bison with a Sketch of its Discovery and Life History. In the Report of the National Museum under the direction of the Smithsonian Institution, pp. 367-548. Washington: Government.

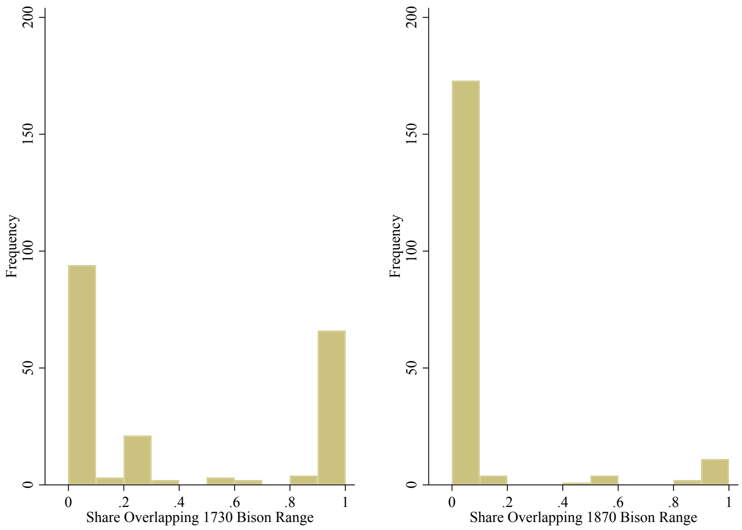

Figure A3: This figure focuses on the tribal sample of Dippel (2014) and displays histograms of the share of ancestral lands overlapping the original (left) bison range and the bison range as of 1870 (right). It is analogous to figure 2, which uses the full sample.

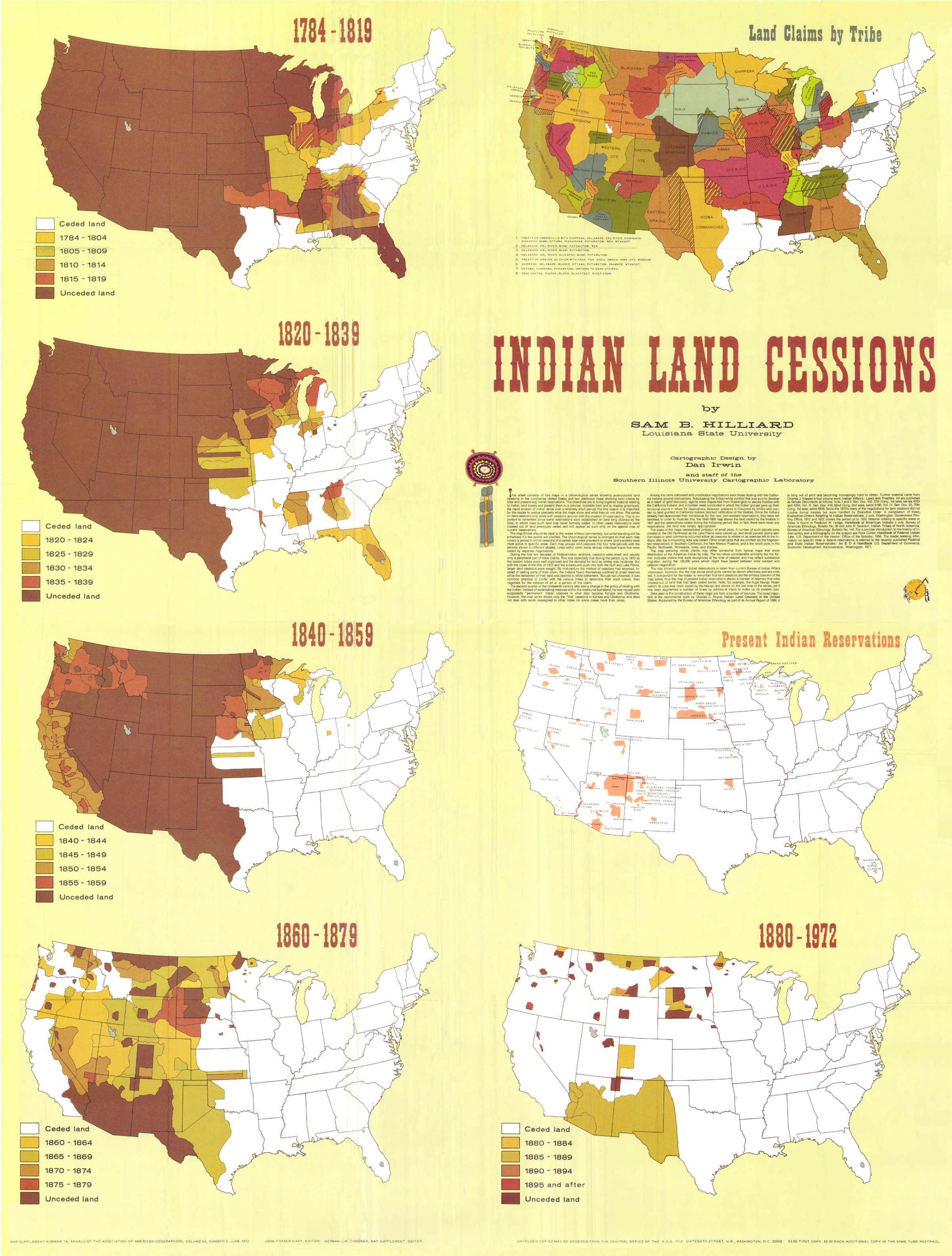

Figure A4: This map illustrates the timing of land succession and can be found as Map supplement number 16, Annals of the Association of American Geographers, Volume 62, Number 2, June 1972

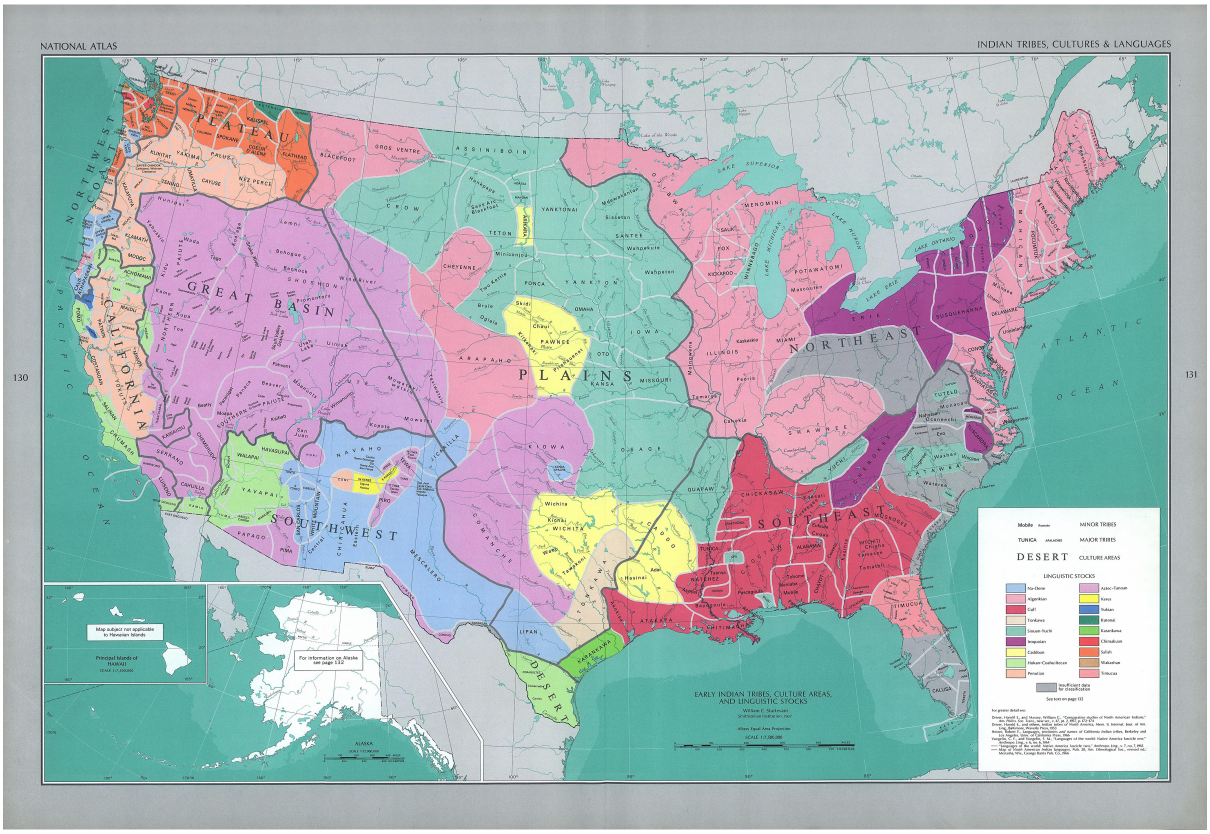

Figure A5: This map illustrates the ancestral territories from the National Atlas of the United States 1970 (Gerlach, 1970).

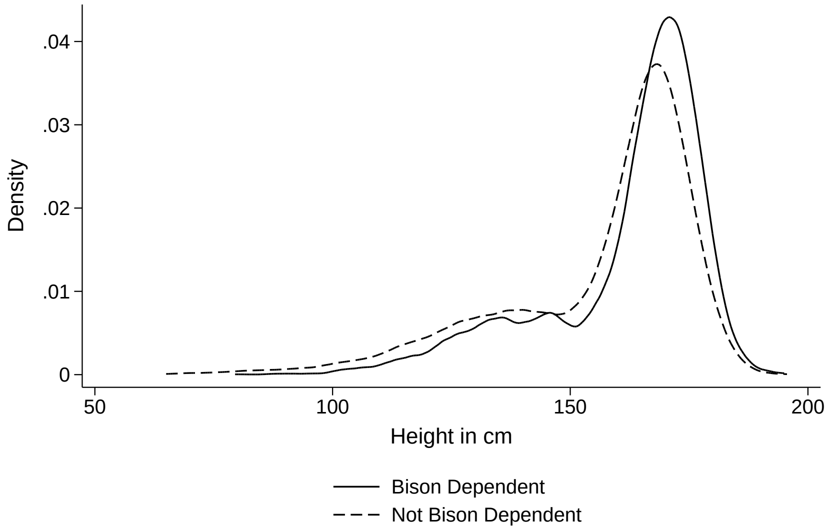

Figure A6: This figure plots the density of standing height from Franz Boas' sample 1890 to 1901. N=9,075. Societies are classified as bison-reliant when more than 60% of their ancestral territory was covered by the historic bison range and non-bison-reliant if it was less than this. A similar pattern is visible if a threshold of 80% or 40% is used.

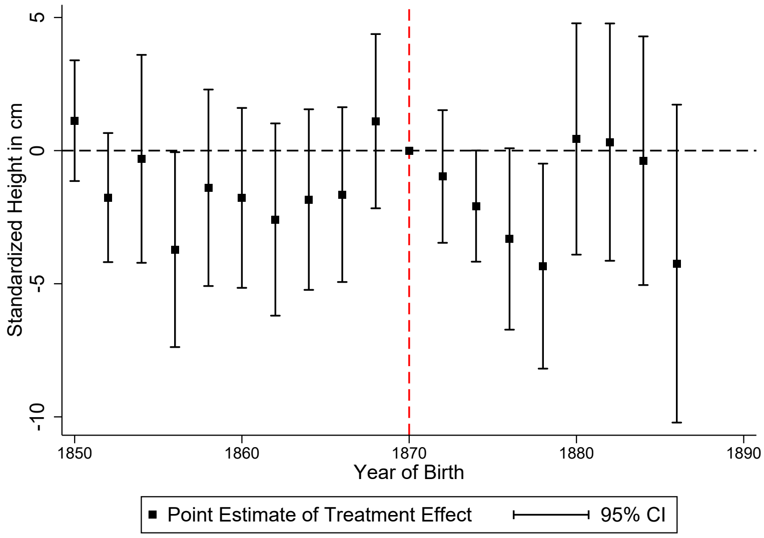

Figure A7: Coefficients on indicators for each two-year of birth before and after the slaughter interacted with whether the tribe obtained most of its calories from bison at least during part of the year. The dependent variable is height in cm and conditions on age fixed effects, a dummy for "full blood", the tribe being located in Canada, whether a railway entered the traditional territory of the tribe and the number of years since your year of birth the railway had been present, and for whether the respondent had been born during a period of war. Data is from Franz Boas' 1889 to 1903 sample, N=4,405 (males).

Figure A8: This data comes from Franz Boas' sample 1890 to 1901. These data are all for males and N=3,717 for bison-reliant societies and 5,104 for non-bison-reliant societies. Societies are classified as bison-reliant when more than 60% of their ancestral territory was covered by the historic bison range and non-bison-reliant if it was less than this. A similar pattern is visible if a threshold of 80% or 40% is used.

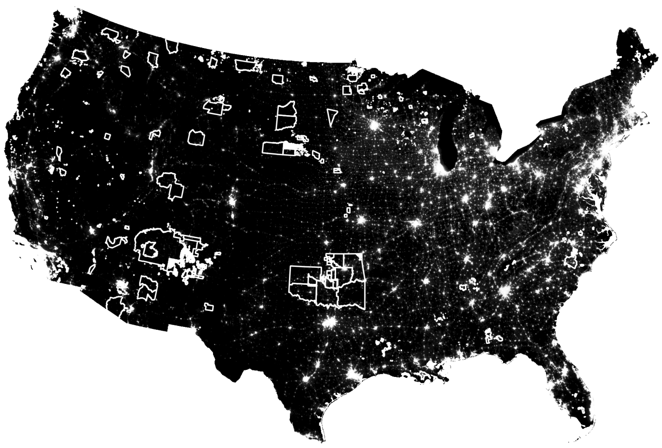

Figure A9: The distribution of nighttime lights in 2000 overlaid with Native American homelands or reservation boundaries in 2013.

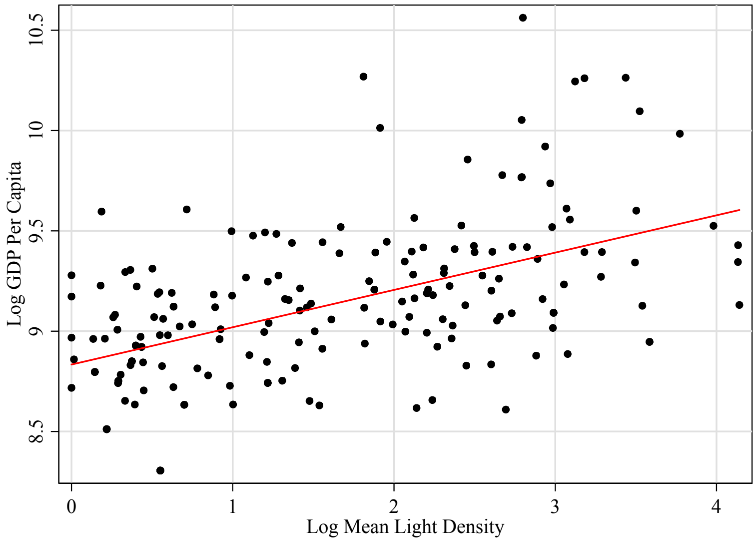

Figure A10: Log of GDP per capita and log of mean light density at the reservation level (using the sample of reservations from (Dippel, 2014) and the nighttime lights satellite data from the NCES).

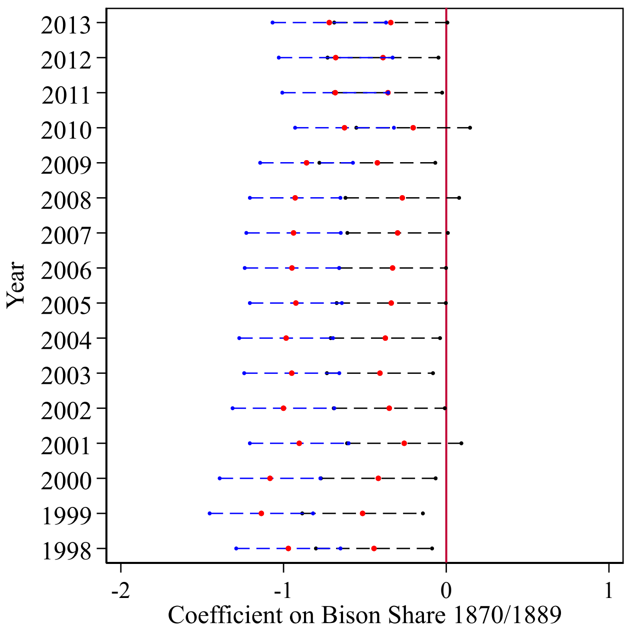

Figure A11: Coefficient estimates on "Share lost as of 1870" (black) and "Share lost between 1870-1889" (blue) using the log of mean light density as the dependent variable. All regressions include the full set of controls from Table **??**.

C Additional Data Sources

Table A13: bison-reliance Scale Generated from Anthropological Accounts

Code	Description
0	No contact at all with buffalo
0.1	Some contact with buffalo, though rare, through consumption or trade
0.2	Buffalo were occasionally hunted for food or skins
0.3	Buffalo were consumed as a non-essential food source in a diet centered around other foods
0.4	Buffalo played a small but significant part in the diet centered around other foods
0.5	Buffalo played a significant part in the diet however other food sources reduced dependence
0.6	Buffalo meat was consumed regularly but supplemented by a significant amount of agriculture
0.7	Buffalo were a seasonal staple and provided most of the calories for a significant part of the year
0.8	Buffalo were the primary source of meat and were supplemented by gathering or agriculture
0.9	Majority of calories came from buffalo meat, supplemented by small amounts of gathering or agriculture
1	Nearly all calories were derived from buffalo meat

Table A14: Sources for Anthrological Bison Index in Boas Tribal Data

Tribe Name	Band	Sample Size	Sources in Addition to Waldman 2009
ALASKA		5	http://www.native-languages.org/alaska.htm
BANNOCK	All	97	https://www.britannica.com/topic/Bannock-people; http://www.legendsofamerica.com/na-tribesummary-b.html
BILOXI		18	http://www.bigorrin.org/biloxi_kids.htm
CADDO		62	http://archeology.uark.edu/indiansofarkansas/index.html?pageName=The%20Caddo%20Indians
CARRIER	All	35	http://www.thecanadianencyclopedia.ca/en/article/carrier/
CATAWBA		50	http://catawbaindian.net/about-us/early-history/
CAYUGA		12	http://www.cayuganation-nsn.gov/Culture/Food
CAYUSE		22	http://ctuir.org/history-culture/first-foods
CHITIMACHA		31	http://www.chitimacha.gov/history-culture/tribal-history
CHOCTAW		501	http://www.aihd.ku.edu/foods/choctaw.html
COLUMBIA	All	5	https://www.britannica.com/topic/Plateau-Indian
CREEK		104	http://www.encyclopedia.com/history/united-states-and-canada/north-american-indigenous-peoples/creek
DELAWARE		28	http://www.lenapelifeways.org/lenape1.htm
HOOPA VALLEY		35	https://www.hoopa-nsn.gov/the-tribal-government
HURON		1	http://www.tolatsga.org/hur.html
KLAMATH		267	https://www.warpaths2peacepipes.com/indian-tribes/klamath-tribe.htm
KUTENAI	LOWER	54	http://www.thecanadianencyclopedia.ca/en/article/kootenay/
MENOMINI		274	https://www.mpm.edu/wirp/ICW-36.html
MODOC		1	https://www.warpaths2peacepipes.com/indian-tribes/modoc-tribe.htm
MOHAWK		95	http://www.thecanadianencyclopedia.ca/en/article/mohawk/
MOLALLA		6	http://dibblehouse.org/molala-life.html
OKANAGAN	All	101	Thomson, D. D. (1985). A history of the Okanagan: Indians and whites in the settlement era, 1860-1920 (T). 179-183. University of British Columbia.
ONEIDA	All	250	http://www.exploreoneida.com/culture-and-history/oneidas-way-of-life/
ONONDAGA		75	http://www.onondaganation.org/culture/food/
PUEBLO		43	http://native-american-indian-facts.com/Southwest-American-Indian-Facts/Pueblo-Indian-Facts.shtml
SENECA	All	114	https://sni.org/culture/
SHUSHWAP	All	477	http://www.landoftheshuswap.com/land.html
TENINO	All	138	Murdock, G. (1980). The Tenino Indians. Ethnology, 19(2), 129-149. doi:10.2307/3773268
THOMPSON		143	https://www.aadnc-aandc.gc.ca/DAM/DAM-INTER-BC/STAGING/texte-text/fnmp_1100100021018_eng.pdf
TUSCARORA		87	http://northcarolinahistory.org/encyclopedia/the-tuscarora/
UMATILLA		50	http://ctuir.org/history-culture/first-foods
UTE		10	http://www.legendsofamerica.com/na-ute.html
UTE	CAPOTE	21	http://www.legendsofamerica.com/na-ute.html
UTE	MOACHE	26	http://www.legendsofamerica.com/na-ute.html
UTE	UINTAH	50	http://www.legendsofamerica.com/na-ute.html
UTE	WEEMINUCHE	10	http://www.legendsofamerica.com/na-ute.html
WALLA WALLA		30	http://ctuir.org/history-culture/first-foods
WASHO		12	https://www.warpaths2peacepipes.com/indian-tribes/washoe-tribe.htm
WENATCHI		1	http://www.historylink.org/File/8634
YAKIMA		57	https://www.britannica.com/topic/Yakama
SPOKANE	All	18	http://www.aihd.ku.edu/foods/Spokanes.html
APACHE	COYOTERO	7	http://www.encyclopedia.com/humanities/encyclopedias-almanacs-transcripts-and-maps/western-apache
APACHE	SAN CARLOS	64	http://www.encyclopedia.com/humanities/encyclopedias-almanacs-transcripts-and-maps/western-apache
APACHE	TONTO	64	http://www.encyclopedia.com/humanities/encyclopedias-almanacs-transcripts-and-maps/western-apache
APACHE	WHITE MOUNTAIN	64	http://www.encyclopedia.com/humanities/encyclopedias-almanacs-transcripts-and-maps/western-apache
APACHE	WHITE MOUNTAIN@	1	http://www.encyclopedia.com/humanities/encyclopedias-almanacs-transcripts-and-maps/western-apache
COEUR D'ALENE		49	http://www.cdatribe-nsn.gov/cultural/ancestral.aspx
KALISPEL		12	http://kalispeltribe.com/our-tribe/land-culture
CHEROKEE		699	http://www.tolatsga.org/Cherokee1.html
CHICKASAW		217	https://www.utm.edu/departments/special_collections/wc_hist/chksaw.php
FLATHEAD		38	http://www.flatheadwatershed.org/cultural_history/pend_salish.shtml
WINNEBAGO		191	https://www.mpm.edu/wirp/ICW-52.html
POTAWATOMI		30	http://www.pbpindiantribe.com/tribal-history.aspx
SAUK & FOX		10	https://discover.research.uiowa.edu/meskwaki-culture-and-history
APACHE	MESCALERO	37	https://www.britannica.com/topic/Apache-people
ARIKARA	REE	2	http://plainshumanities.unl.edu/encyclopedia/doc/egp.na.007
MANDAN		1	http://www.ndstudies.org/resources/IndianStudies/threeaffiliated/culture_mandan3.html
MIAMI		2	https://miamination.com/node/11
QUAPAW		3	http://archeology.uark.edu/indiansofarkansas/index.html?pageName=The+Quapaw+Indians
BEAVER		1	http://www.thecanadianencyclopedia.ca/en/article/beaver-native-group/

Notes: For nations where different sources were used to construct bison-reliance they are listed. This is not a complete listing of nations.

Table A15: Sources for Anthrological Bison Index in Boas Tribal Data

Tribe Name	Band	Sample Size	Sources in Addition to Waldman 2009
NEZ PERCE		132	https://www.critfc.org/member_tribes_overview/nez-perce-tribe/
OTOE		5	http://www.e-nebraskahistory.org/index.php?title=Nebraska_Historical_Marker:_Oto_Indians
PAWNEE		88	http://www.nebraskastudies.org/0300/frameset_reset.html?http://www.nebraskastudies.org/0300/stories/0301_0107.html
KICKAPOO		5	ttp://www.tolatsga.org/kick.html
KUTENAI	UPPER	43	http://www.thecanadianencyclopedia.ca/en/article/kootenay/
PONCA		83	http://www.encyclopedia.com/history/united-states-and-canada/north-american-indigenous-peoples/ponca
WICHITA	All	37	http://www.wichitatribe.com/history/people-of-the-grass-house-1750-1820.aspx
CHEYENNE		55	Grinnell, G. B. (2008). The Cheyenne Indians: Their History and Lifeways: Edited and Illustrated. 95-99. World Wisdom Inc.
OMAHA		121	http://www.encyclopedia.com/history/united-states-and-canada/north-american-indigenous-peoples/omaha-indians
OSAGE		124	http://www.encyclopedia.com/history/united-states-and-canada/north-american-indigenous-peoples/osage
SAUK		33	https://www.britannica.com/topic/Sauk
CROW		607	http://www.encyclopedia.com/history/united-states-and-canada/north-american-indigenous-peoples/crow-people
GROS VENTRE		9	http://www.encyclopedia.com/history/united-states-and-canada/north-american-indigenous-peoples/gros-ventre
KIOWA		203	http://www.encyclopedia.com/history/united-states-and-canada/north-american-indigenous-peoples/kiowa
SIOUX		1022	http://native-american-indian-facts.com/Great-Plains-American-Indian-Facts/Sioux-Indian-Tribe-Facts.shtml
SIOUX	TETON	6	http://www.nebraskastudies.org/0300/stories/0301_0108.html
ASSINIBOIN		66	http://www.thecanadianencyclopedia.ca/en/article/assiniboine/
COMANCHE		193	http://www.encyclopedia.com/history/united-states-and-canada/north-american-indigenous-peoples/comanche
BLOOD		66	http://www.thecanadianencyclopedia.ca/en/article/blood-kainai/
PIEGAN		122	http://www.thecanadianencyclopedia.ca/en/article/piikuni-peigan-pikuni/
SARCI		21	http://www.thecanadianencyclopedia.ca/en/article/sarcee-tsuu-tina/
ARAPAHO		95	http://www.colorado.edu/csilw/arapahoproject/contemporary/history.htm
BLACKFOOT		29	http://www.aihd.ku.edu/foods/Blackfeet.html
TONKAWA		44	http://www.tonkawatribe.com/meals.html

Notes: For nations where different sources were used to construct bison-reliance they are listed. This is not a complete listing of nations.

Table A16: Sources for Anthropological Bison Index: Tribes Whose bison-reliance is Proxied by Geography in the Anthropological Measure

Tribe Name	Band	Sample Size
APACHE	With no band	123
CHIPPEWA (with no band)	With no bankd	634
CREE	With no band	228
KUTENAI		16
SHAWNEE		24
AGUA CALIENTE		59
AMERICAN VALLEY		1
ANADARKO		2
APACHE	CASSLOLA	1
APACHE	CHERACOW	1
APACHE	CHIRA	1
APACHE	CHIRICAHUA	2
APACHE	MOHAVE	2
ATHIPURE		1
B.C.		13
BENITOO		1
BIG MEADOW		9
BIG MEADOW	NAKUMA	1
BIG VALLEY		1
BROTHERTOWN		1
CALIFORNIA		1
CHEROKEE	WESTERN	1
CHICO		1
CHILLUKUWEYUK		2
CHINESE		5
CHIPPEWA	CASCADES	8
CHIPPEWA	CASS LAKE	6
CHIPPEWA	GULL LAKE	3
CHIPPEWA	LAKE O WOODS	1
CHIPPEWA	LAKE SUPERIOR	1
CHIPPEWA	LEECH LAKE	43
CHIPPEWA	MISS.	38
CHIPPEWA	OTTER TAIL	38
CHIPPEWA	PEMBINA	15
CHIPPEWA	PILLAGER	6
CHIPPEWA	RED LAKE	63
CHIPPEWA	SAULTEAUX	2
CHIPPEWA	SAULTEURS	14
CHIPPEWA	TURTLE MT.	1
CHIPPEWA	VIEUX DE DENT	1
CHIPPEWA	WINNEBEGOSHISH	1
CLACLASEQALA		1
CLEAR LAKE		1
COLUMBIA RIVER		1
CONCOW		61
CONCOW	BIG BAND	1
CONCOW	BLOOMERHILL	1
CONCOW	NEVODAS	1
COTTONWOOD		1
COW		1
COW CREEK		7
COYOTERRA		1
HAT CREEK		2
HAWKWELGETT		1
HOH		2
HUMPTULIPS		1
IROQUOIS	THIC RANY	1
JACOWE		1
JOSHUA		5
KALISPEL LOWER		1
KATSEY		1
KITSAI		2
KITSOP		1
KLAHKANSYU		1
KLAMATH RIVER		18
KOGOALIK		1
KUTENAI	METIS	1
LIPAN		3
LONG TOM		1
MALISQUI		1
MARIPOSA		1
MARYSVILLE		4
MARYVILLE		1
MATSQUI		2
MEQONADINA		1
MIKSOFDO		4
MIKSOFDO	LOW CREEK	1
MISSISSAGUA		291
MOKI (ORAIBE)		8
MOLALI		1
MOORETOWN		6
MORAVIAN		13
MORAVIANTTOWN		1
MUCKLESHOT		1
MUNSEE		101
NALTUNNETUNNE		2
NAQONGYSLISALA		1
NATCHITOCHES		1
NESTUCCA		1

Notes: For Nations were different sources were used to construct bison-reliance they are listed. This is not a complete listing of nations.

Table A17: Sources for Anthropological Bison Index: Tribes Whose bison-reliance is Proxied by Geography in the Anthropological Measure

Tribe Name	Band	Sample Size
NHYNOOTCHIE		1
NOGOOLI		1
OJIBWA		338
OJIBWA	BATSHEWANA	1
OJIBWA	GARDEN RIVER	1
OJIBWA	OTHIPWE	15
OJIBWA (of CATLIN'S COMY)		1
OKA		5
OLOLOFA		1
OMACK		2
OREGON		1
PEND D'OREILLE		12
PITT RIVER		21
PITT RIVER	INDIAN VALLEY	3
PORT MADISON		1
PORT MEDICINE		1
PORTEUR		1
POTTS VALLEY		1
QECTIC		1
QOMOYNE		1
QUMOYUT		1
ROTOMA n. WALLIS IS.		1
ROTUMA		2
SAN JUAN		7
SAN LUIS REY		185
SANTA CLARA		11
SATUS		1
SCOOYAM		1
SCOTCH		1
SEATTLE		6
SHIPEK		9
SHOALWATER BAY		2
SINSLAW		1
SISHIALT		3
SKOATATC		1
SKOATATC	UPSIOW	1
SMELKAMEEN		1
SNAKE		1
SNOYNALUNI		1
SOFERS ID.		1
SQAEEN	(23mi. ab. FT.	1
STOCKBRIDGE		86
TAAM		1
TAOS		45
TARAHUMARA		20
TARAHUMARA	(RARAMUTCHY)	1
TARAHUMARA	GENTIL	2
TEXELIS		1
TEXELS	DOUGLAS	1
THOMPSON	All bands	277
TIETSAUT		1
TIPEHUANAS		1
TIXELIS		1
TLASANQOALA		1
TLASLASIQULA		1
TLASLASIQULE		1
TONGA		1
TOO TOO DINA		1
TOWACONIE		1
TRIAM		4
TSMISHIAN	GINNEHAUGUAK	1
TSMISHIAN	NASXA	2
TSMISHIAN	NISKA	10
TSXELIS		4
TUBAR		4
UNCOMPAGEE		4
UTAINGT		1
UTAMGT		1
UTE	APACHE	1
UTE	DUCHESNE	1
UTSINGT	All bands	3
WALAPAI		2
WALLIS IS.		2
WAPATOO LAKE		2
WAPETOO LAKE		1
WARNUCK		1
WEILACY		1
WIKWEMIKONG		1
YAM HILL		4
Total N		3074

Notes: For Nations were different sources were used to construct bison-reliance they are listed. This is not a complete listing of nations.

Table A18: Current Members of the InterTribal Bison Cooperative that Matched to Our Data

Blackfeet Nation	Nambe O-ween-ga Pueblo	Sandria Pueblo
Cheyenne and Arapaho	Nez Perce Tribe	Santee Sioux Tribe of Nebraska
Cheyenne River Sioux Tribe	Northern Cheyenne Tribe	Shoshone-Bannock
Cochiti Pueblo	Oglala Sioux Tribe	Sisseton Wahpeton Oyate
Crow Creek Sioux Tribe	Omaha Tribe of Nebraska	Southern Ute
Crow Tribe	Oneida Nation of Wisconsin	Spirit Lake Sioux Tribe
Flandreau Santee Sioux	Picuris Pueblo	Spokane Tribe
Fort Peck	Pit River Tribe	Standing Rock Sioux Tribe
Ho-Chunk Nation	Pojoaque Pueblo	Taos Pueblo
Jicarilla Apache Nation	Prairie Band Potawatomi	Turtle Mountain Band of Chippewa
Kalispel Tribe	Prairie Island Dakota Community	Ute Indian Tribe
Lower Brule Sioux Tribe	Rosebud Sioux Tribe	Winnebago Tribe of Nebraska
Leech Lake Band of Ojibwe	Salt River Pima	Yankton Sioux Tribe
Mesa Grande	San Juan Pueblo	Cherokee Nation
Tesuque Pueblo		

Notes: The InterTribal Bison Cooperative currently has 63 member tribes. The above list contains the 43 tribes that matched to our main sample. More information can be found at `http://www.itbcbuffalo.com/`

Table A19: Soil quality indicators from the Harmonized World Soil Database v 1.2

Soil Quality Indicator	Description
Nutrient Availability	"Soil texture, soil organic carbon, soil pH, and total exchangeable bases." Nutrient availability is important for low level input farming and for some intermediate input levels.
Nutrient Retention Capacity	"Soil organic carbon, soil texture, base saturation, cation exchange capacity of soil and of clay fraction." The term nutrient retention capacity refers to the capacity of the soil to retain added nutrients against losses caused by leaching, thus it is important for the effectiveness of fertilizer applications. The ability of the soil to retain nutrients is relevant for intermediate and high input cropping conditions.
Rooting Conditions	"Soil textures, bulk density, coarse fragments, vertic soil properties and soil phases affecting root penetration and soil depth and soil volume." Rooting conditions essentially measure soil depth and volume related to the presence of gravel and stoniness. Rooting conditions are of particular importance for yield formation.
Oxygen Availability to Roots	"Soil drainage and soil phases affecting soil drainage." Oxygen availability relates to the drainage characteristics of soils.
Excess Salts	"Soil salinity, soil sodicity and soil phases influencing salt conditions." Soil with a large amount of excess salts inhibits the uptake of water by crops, thus reducing yields, or in high levels killing the crops.
Toxicity	"Calcium carbonate and gypsum." The toxicity of the soil determines the acidity of the soil, which in turn affects the level of micro-nutrients available in the soil.
Workability	"Soil texture, effective soil depth/volume, and soil phases constraining soil management (soil depth, rock outcrop, stoniness, gravel/concretions and hardpans)." There are a number of factors that affect the workability of the soil, including the texture, structure, organic matter content, soil consistence, occurrence of gravel, etc. This has particular consequences for manual cultivation or light machinery.

Notes: The information in this table was taken from the Harmonized World Soil Database v 1.2 from the Food and Agriculture Organization of the United Nations. For more information please see `http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/harmonized-world-soil-database-v12/en/`

Table A20: Additional Sources Used for Controls in Lights Regressions

Variable	Source and Variable Construction
Population in 2015	Population estimates were taken from the Gridded Population of the World (GPW) database. The GPW uses numerous data sources to compute estimates of the world population distribution at a resolution of 30 arc-seconds. Source: Center for International Earth Science Information Network - CIESIN - Columbia University, United Nations Food and Agriculture Programme - FAO, and Centro Internacional de Agricultura Tropical - CIAT. 2005. *Gridded Population of the World, Version 3 (GPWv3): Population Count Grid.* Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). `http://dx.doi.org/10.7927/H4639MPP`. Accessed 05 05 2017.
Federal Reservation	We include an indicator for whether the reservation was established by the federal government or the state government. This information is available in the American Indian/Alaska Native/Native Hawaiian Areas (AIANNH) TIGER/Line Shapefile.
Distance Displaced	This variable was constructed by taking the geodetic distance between the tribal homeland centroid and the reservation centroid.
Log Ruggedness Index	We overlay elevation raster files from the U.S. Geological Survey–available at: `https://viewer.nationalmap.gov/viewer/`–with reservation boundaries and use GIS software to calculate the ruggedness index for each reservation. The ruggedness index is calculated based on the following source: Riley, S. J, S. D. DeGloria, and R. Elliot (1999). A terrain ruggedness index that quantifies topographic heterogeneity. *Intermountain Journal of Sciences 5(4)*, 23-27.

Notes: This table describes the sources and methods used to construct the additional control variables in the log lights regressions that were not described in the main text of the paper.

Table A21: Additional Information on Variable Construction for Canadian Regressions

Variable	Source and Variable Construction
bison-reliance	We digitize tribal territory maps from the the Handbook of the North American Indian and overlay them with our bison-range maps from Hornaday (1889) to construct a measure of initial bison-reliance for Canadian tribes.
Log GDP Per Capita	We obtain GDP per capita from the 2001 Community Well-Being (CWB) Database: `https://www.aadnc-aandc.gc.ca/eng/1100100016579/1100100016580`. The CWB Database provides a well-being score for each census subdivision (essentially municipality) in Canada. To construct this score, a number of component scores are used, based on housing availability, income, labor force participation, and education. We invert the income component score formula to obtain GDP per capita for 283 communities: Income Score = $\frac{\log(\text{GDP per capita})-\log(\$2{,}000)}{\log(\$40{,}000)-\log(\$2{,}000)} \times 100$.
Population at Trading Post	This variable comes from the "trading posts 1823" GIS layer from EsriCanadaEducation.
Distance to Trading Post	We calculate the distance from the reserve centroid to the closest historical trading post listed in the "trading posts 1823" GIS layer from EsriCanadaEducation.
Distance to Railway Station	We use the Canadian Historic Railways layer from ESRICanadaEd: `http://explorer.arcgis.com/home/item.html?id=89044dbd4e7a4ec288d18b2b477237d4` to calculate the distance between each Indigenous community and the closest railway station.
Population	We control for population which is also included in the Community Well-Being Database.
Cultural Controls	We also match a number of cultural controls from the ethnographic atlas to our data at the tribe level. This includes historical centralization, calories from agriculture, complexity of the community, level of sedentariness, and wealth distinctions.
Beaver Range	We overlay the digitized maps from the Handbook of the North American Indian with the beaver range maps from the Canadian Geographic `https://www.canadiangeographic.ca/article/rethinking-beaver` to calculate the share of ancestral territory covered by the beaver range.
Distance to City	We use Statistics Canada geographic boundary files to compute the geodetic distance between the reserve centroid and the closest census metropolitan area. Boundary files can be downloaded from: `http://www12.statcan.gc.ca/census-recensement/2011/geo/bound-limit/bound-limit-eng.cfm`. We also use these files to compute the latitude and longitude of each reserve.

Notes: This table describes the sources and methods used to construct the outcomes and controls for the Canadian regressions.