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PRELIMINARY DRAFT. PLEASE DO NOT CITE OR DISTRIBUTE

Abstract: Popular narratives attribute poverty on Native American reservations today to historical resource expropriation and the resulting dearth of high quality land, but the analysis here shows the narrative is incomplete. Combining data on rainfall, soil quality, and income shows that reservations with small shares of prime agricultural land generated higher incomes than reservations with larger shares over 1970 to 2010. This relationship is not present across U.S. counties, where higher land quality is monotonically associated with higher incomes. We attribute this anomaly to the way in which land privatization legislation was implemented on reservations from 1887 to 1934. Reservations with the poorest land were not allotted, whereas reservations with higher quality lands were partially privatized such that allotted lands remained under federal trusteeship. The hypothesis that land quality indirectly reduced income generation, through its effects on land tenure, is supported by our finding that land quality positively affects income after accounting for land tenure. We conclude that reservation poverty is, at least in part, due to top-down land policies.

1. Introduction

Much of the literature in economics attributes the modern poverty of the world's least advantaged groups to historical events. Often, this literature documents the persistent effects of historical trauma inflicted by European colonists on indigenous societies. Historical episodes may have had lasting effects through the destruction of indigenous human and physical capital, as in regions of Africa targeted for slave trade (Nunn 2008) or through colonization that installed bad institutions which have persisted over time (Acemoglu, et al 2001).

The research connecting modern poverty to historical episodes emphasizes the indirect effects of natural resources. In some cases, inhospitable land turned out to be a blessing for indigenous populations because it attracted less attention from colonizers. This was the case with

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rugged land in Africa, which protected inhabitants from the slave trade (Nunn and Puga 2012). In other cases, land well-suited for agriculture was a curse because it attracted expropriation by colonizers, thus reducing the long-run growth potential for indigenous populations (Sokoloff and Engerman 2000).

These explanations of indigenous poverty also apply to Native Americans.[2] The dominant explanation focuses on repeated and systematic expropriation of tribal resources by the U.S. government. As Cornell and Kalt (1992, 225) note, this narrative emphasizes cases in which non-Indians expropriated valuable indigenous resources, leaving Indians with few ways to generate income. One example of this, documented by Dippel (2014), shows that tribes were forcibly relocated to reservations thought to be devoid of gold and silver. Another, documented by Feir et al. (2017), shows how the slaughter of bison from the American plains removed a vital source of tribal wealth. The transfer of productive farmland on many reservations from Indians to non-Indians continued through the allotment era between 1887 to 1934. It ended when the Indian Reorganization Act (IRA) stopped the process (Stuart 2005, Anderson et al. 2016). These narratives presuppose a positive relationship between resources and income and suggest that the poorest tribes are those that retained the least and lowest quality land.

This paper demonstrates that the relationship between land endowments and income is actually negative for many reservations. We quantify the amount of prime agricultural land on reservations during 1885 and assemble a new panel data of American Indian per capita income on reservations from 1915 to 2010. The data reveal a U-shaped relationship between modern income and endowments of prime land. As the amount of productive land increases across reservations, incomes decline up to a point, after which having more productive land increases per capita incomes. This relationship is not present across U.S. counties, where higher land quality is associated with higher incomes, and it contrasts with simple narratives that attribute modern reservation poverty to poor land quality.

Using a series of empirical tests, we explain why Native Americans on reservations comprised of medium quality land have the lowest incomes today. The explanation has two parts. The first is that land quality affected the mix of land tenure on reservations today, because

[2] Overall, Native Americans on reservations experience rates of poverty that are more comparable to Cameroon or Zimbabwe than to the non-Indian U.S. population. In 2015, average household income on reservations was 68 percent below the U.S. average.

land quality determined if, when, and how much of each reservation was allotted during 1887 to 1934. The second is that the mix of land tenure affects modern income generation by affecting the transaction costs of resource use. The hypothesis that land quality affected income indirectly, through its effects on land tenure, is supported by our finding that the negative relationship between land quality and income vanishes once we control for land tenure. This implies that some tenure institutions are so costly that reservations earn lower incomes per capita despite having more productive land.

We quantify the features of tenure associated with low incomes and provide new evidence of their emergence across and within reservations. The key issue is that mid quality lands were most often partially privatized, via federal policy, whereas low quality lands were not privatized and high quality lands were fully privatized. Partially privatized parcels, called allotted trust, are held in trust by the federal government and cannot be transferred to non-Indians. Allotted trust parcels also cannot be designated to a single heir in wills, which has led to fractionalized ownership as heirs are granted land interests over time. These constraints raise the transaction costs of land use and are predicted to reduce investment and economic activity relative to full privatization, and, according to the evidence, they also reduce economic activity relative to systems of tenure devised by tribes, from the bottom up.

The findings contribute to the literature on indigenous history, property rights, and natural resources in two main ways. First, they show that trustee restrictions on property rights, which were promoted as a means of preventing exploitation of Indians in land markets and to slow land transfers to non-Indians, have had the undesirable effect of lowering incomes on reservations today.[3] This finding is consistent with a broader literature emphasizing the incompatibility of promoting income generation from natural resources through resource privatization programs that also seek non-economic goals, in this case keeping resources in Indian ownership.[4] Second, because reservations with low quality land were not allotted, but generated higher incomes than reservations with medium quality land, our analysis suggests that bottom up and tribally-devised systems of land tenure can promote income growth while at the

[3] As we describe below, reservations with mid-quality land were caught in the crossroads of a political economy compromise between efforts to privatize land on one hand and to protect Native Americans (and the Indian bureaucracy), on the other.

[4] Add citations about constraints on ITQs, water ownership, etc.

same time keeping land in Indian ownership. This finding is consistent with Elinor Ostrom's (1990) work that has identified cases in which top-down formalization of informal property rights has reduced rents from natural resources such as land.

2. The Dawes Act and the Allotment Era

The Dawes Act, also known as the General Allotment Act of 1887, implemented a massive privatization scheme that allotted plots of reservation land, typically 160 acres, to individual Indian families. In so doing, it served the interests of two main coalitions, one seeking to "make Indians into farmers" and thus assimilating them into non-Indian society (Carlson 1981a),[5] and a the other wanting to make prime farmland on reservations available for white settlement. (Carlson 1981a, 1981b, Banner 2005).

When a reservation was selected for allotment, agents from the Office of Indian Affairs allocated 160 acres to each family on the reservation. If reservation acreage exceeded what was necessary to fulfill the allotments, the balance was declared "surplus" land and opened for homesteading, satisfying the desires of the land-hungry congressional coalition by transferring hundreds of thousands of acres to non-Indians. Allotment was compulsory at both the reservation and the individual level, and assignment of parcels was at the discretion of local Indian agents (Carlson, 1981a).

Allotment occurred on a more-or-less state by state basis. Most reservations in the northern Plains, Rocky Mountains, and Pacific Northwest states were allotted, while some of those in the Southwest were not. Figure 1, which is based on our digitization of a historical map from 1885, shows which and when reservations were allotted and which were not.. Carlson (1981b) provides evidence that reservations in states with higher rates of population growth and more rainfall were targeted for earlier allotment.

After land was allotted to individual Indians, it was held in trust by the federal government for 25 years or until the Indian agent declared an allottee "competent" to hold a fee simple title (Carlson 1981a). Lands remaining in trust are referred to as allotted trust. One rationale for trusteeship was that it would prevent non-Indians from taking advantage of Indians

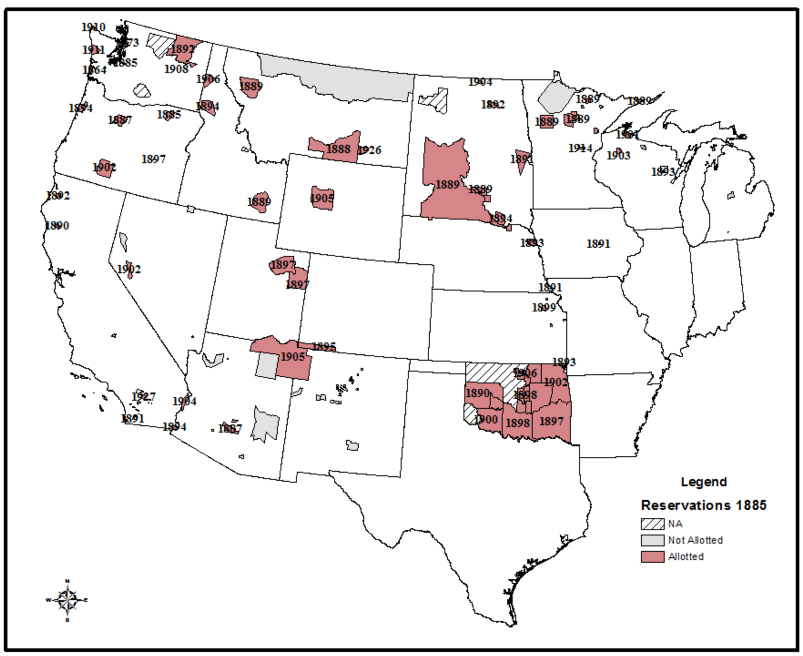
[5] Senator Dawes argued that under communal ownership Indians had not "…got as far as they can go because they own their land in common, and under that [system] there is no enterprise to make your [lnd] any better than that of your neighbors." The quote is cited from Ambler (1990, p. 10).

who might not have understood the value of their allotments and therefore might have sold their land to whites at unfavorable contractual terms for the allottee.[6]

By the 1920s, allotment received strong criticism for the pace with which Indian lands were either sold or leased to non-Indians or homesteaded by non-Indians. The “Meriam Report” concluded in 1928 that the Dawes Act was a failure having not promoted farming by Indians on reservations, not alleviated poverty, and not prevented Indian land from being transferred to non-Indians (Meriam 1928).

Ultimately these concerns led to the end of allotment with the passage of the Indian Reorganization Act (IRA) in 1934. Importantly, the IRA declared that all Indian land, either allotted trust, retained by the tribe, or not released from trusteeship by 1934, would remain in trust by the Bureau of Indian Affairs (BIA).

Figure 1: Distribution and Timing of Allotment



Notes: The large reservation in Northern Montana was split into several reservations, which were subsequently allotted. These appear as separate observations in our panel.

During the allotment era the Indian land base shrank considerably due to the declaration of surplus lands and to conversion of allotted trust to fee simple. Within reservations, 29,481,685

[6] McChesney (1990) notes that trusteeship kept work for the Indian Affairs bureaucracy, and argues that this also helps explain why land was kept in trusteeship.

acres were retained by tribes as tribal trust land 17,829,414 acres were remained as allotted trust, and 22,277,342 acres were declared fee simple, with much of it owned by non-Indians by 1933 (Flanagan et al., 2010).[7]

The large transfer of land from Indians to non-Indians has been the focus of most accounts of allotment, but the institutional legacy of the Dawes Act may be as consequential in terms of its effects on modern reservation economies. The end to allotment under the IRA left allotted reservations with a mix of tribal trust, allotted trust, and fee simple tenures.[8] Variation in the timing of when and where individual plots were allotted and alienated resulted in a mosaic of all three tenure types within a reservation rather than tenure being divided into contiguous blocks of tribal, individual trust, and fee simple land. Some surplus lands were never sold and were retained by tribes after 1934. The mosaic pattern varies across reservations due to differences in how land was initially allotted, and what was ultimately claimed.[9]

Though retaining land in trust halted the transfer to non-Indians, it also increased the transaction costs associated with land use. Allotted trust lands could not be used as collateral on loans, could not be leased or transferred without approval from the BIA, and could not be willed to a single heir (Carlson 1981). The first two restrictions immediately increased the cost to allottees of leasing or changing land use, and the third increased the transaction costs over time because trust lands were passed in equal shares to heirs, leading to multiple owners of single parcels (Shoemaker 2003).

Other studies of estimated the causes and effects of allotment. Carlson (1981b) finds that states with higher population growth rates were allotted sooner and argues this was because settlers wanted more Indian lands opened for homesteading. Carlson (1981a) finds a gap in farming activity between Indians and non-Indians, which increased over the allotment period, particularly after 1915, arguing that trusteeship undermined pre-existing systems of informal property rights. Anderson and Lueck (1992) find evidence that agricultural productivity on 39 reservations was highest on fee simple lands during the 1980s. Akee (2009) finds that allowing

[7] Add footnote with statistics from Jessica Shoemaker on how much land is held by non-Indians.

[8] Some reservations—particularly those in present-day Oklahoma—were so quickly and completely allotted that 100 percent of their land was converted to fee simple tenure.

[9] Appendix Figure A1 provides an example of the surface tenure mosaic on the Pine Ridge Reservation in South Dakota. There is also variation in the degree to which mineral rights are fragmented and scattered, depending on when a given reservation was allotted. See Ambler (1990) for details.

long-term leasing to non-Indians on lands in trust increased the value of trust lands on the Aqua Caliente reservation, because this is a work-around the constraint on alienation. Russ and Stratmann (2015) analyze 12 reservations and find that fractionation correlates with lower per capita incomes at the reservation level, and with reduced lease income from farming at the parcel level. Russ and Stratmann (2016) also find that efforts to reduce fractionation have been unsuccessful.[10]

Our study connects the research on the causes of allotment (e.g., Carlson 1981a, 1981b) with the research on the effects of allotment (e.g., Anderson and Lueck 1992, Russ and Stratmann 2015) to understand the effects of land quality on reservation economies. The analysis focuses on how reservations' pre-Dawes agricultural land endowments shaped land tenure and ultimately economic development over the 20th and early 21st century. Analyzing the long-term relationship between pre-Dawes endowments and long-run income growth provides a simple way to assess the success or failure of the Dawes Act in converting potential productivity into wealth. Understanding how land quality affected allotment within and between reservations is essential for making legitimate comparisons of economic outcomes across tenure types.

3. Initial Agricultural Land Endowments and Long Run Income

Before analyzing the determinants of allotment at the reservation and parcel level, we begin with a broader question—did the Dawes-Era experiment in privatization increase long-run income for tribes? To answer this question, we analyze whether reservations that were better endowed with agricultural resources before the Dawes Act have higher incomes today. If the Dawes Act created a uniform system of well-defined property rights, encouraging more efficient use of labor and capital , there should be a positive relationship between the quality of agricultural land and per capita income.[11]

3.1 Data on Land Quality and Income

To measure pre-Dawes endowments of reservation land bases prior to 1887, we geo-reference and digitize an 1885 map of reservation boundaries and then use geographic

[10] Using data on oil drilling on the Fort Berthold Reservation during 2005-2015, Leonard and Parker (2017) find that scattered ownership patters and fractionation substantially reduced potential income from oil development.

[11] This is true in an economy reliant on agriculture, but the link may be weaker in urban areas.

information on rainfall and soil quality to construct a measure of prime agricultural land.[12] We use PRISM climate data over the years 1895 to 1935 to estimate long-term trends in spring and summer precipitation during the allotment era by calculating total rainfall in each 800-meter by 800-meter cell from March to August of each year and then averaging over 1895 to 1935.[13] Figure 2a shows rainfall across our sample of reservations, aggregated into 5-inch rainfall bins.[14] The soil data come from Schaetzl et al. (2012), who developed a 21-point soil productivity index to measure soil quality. The index is an ordinal ranking from 0 to 20 of potential productivity of the soil based primarily on its structural characteristics and not its water or nutrient content, making it a plausibly exogenous measure of soil quality circa 1880. Figure 2b depicts the spatial variation in the index into low, medium, and high-quality soil.[15]

Importantly for our purposes, the Schaetzl et al. (2012) index is based on the geologic and structural characteristics of the soil and was designed to be invariant to nutrient, fertilizer, and moisture measurements (Schaetzl et al. 2012). This means that it does not reflect differences in management practices during 1885 to 2012, and is therefore predetermined with respect to land tenure arrangements created by the Dawes Act.

Because there is not a quantitative measure of what was considered "prime farmland" during the Dawes Era, we have combined the information just described to create a measure. "Prime farmland" receives at least 15 inches of Spring/Summer rain and has a soil productivity index ranking of at least 13 and calculate the share of each reservation that is covered with prime farmland. This is the measure that best explains farm productivity off of Indian Reservations. Data in the appendix show that this measure of prime farmland predicts about 40 percent of the

[12] Lionel Pincus and Princess Firyal Map Division, The New York Public Library. "Map showing the location of the Indian reservations within the limits of the United States and territories" *The New York Public Library Digital Collections*. 1885. http://digitalcollections.nypl.org/items/510d47e2-0b69-a3d9-e040-e00a18064a99

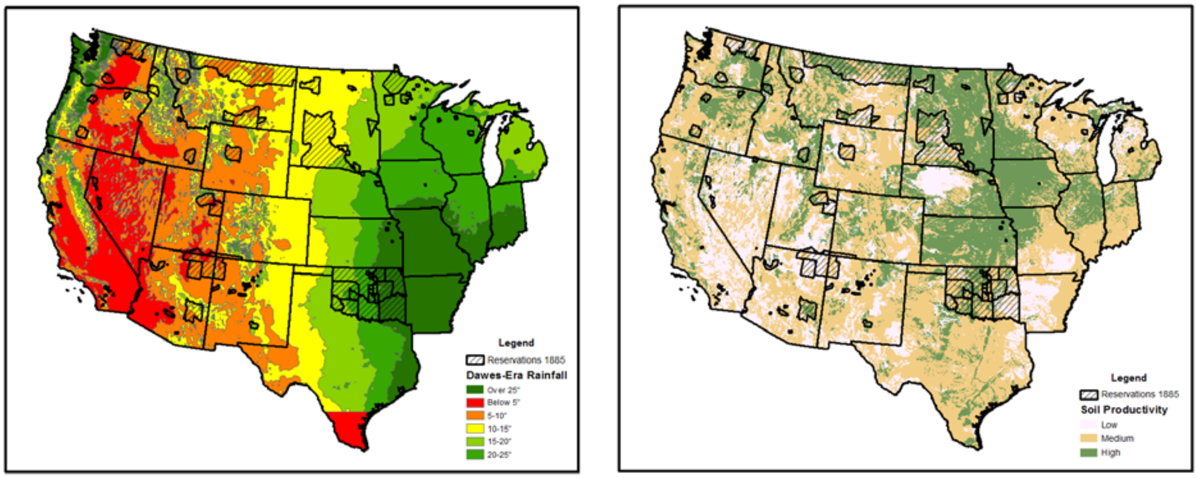
[13] 1895 is the first year for which the PRISM climate data is available.

[14] We aggregate in this way so that we can compare our measure to a rainfall map in the 1880 Statistical Atlas of the United States, which may better reflect on-the-ground knowledge at the time. Appendix Figure A5 provides a comparison.

[15] We compute the spatial intersection of our long-term precipitation measure and the soil quality index to measure the number of acres that fall into each rainfall-soil category on each reservation (resulting in a total of 126 rainfall-soil bins).

within-year variation in farm value per acre at the county level in census years spanning 1890 to 1930.[16]

Figure 2: Reservation Rainfall and Soil Productivity in 1885



The panel data set on reservation incomes span 1915 to 2010, and are estimates of the per capita incomes for Native Americans although non-Indians also live on reservations. The 1915, 1938, and 1945 data come from reports of the Bureau of Indian Affairs.[17] The 1969, 1979, 1989, 1999 data come from decadal U.S. Census reports, and the 2010 data from American Community Surveys.[18] We present income in 2010 dollars, adjusted by the national CPI.[19]

[16] Appendix Figure A2 depicts prime land and farm value per acre by county in 1890 and 1930 and Appendix Tables A1 and A2 asses the relationship between % Prime and farm value per acre.

[17] For 1915-1918, we are reporting the mean incomes over 1915, 1916, 1917, and 1918 based on income data from Bureau of Indian Affairs reports available online at http://digicoll.library.wisc.edu/cgi-bin/History/History-idx?type=header&id=History.AnnRep90&isize=M. The 1938 and 1945 means are calculated from data contained in Bureau of Indian Affairs reports located at the U.S. National Archives in Washington D.C. Because the 1945 reservation income estimates do not report reservation populations, we calculate per capita income by dividing 1945 aggregate income by the populations on reservation in 1943, which is the closest year to 1945 for which we have comprehensive Indian population data.

[18] The 2010 data come from the American Community Survey (ACS) which differs from the earlier decennial reservation census reports in certain ways. For geographic areas with populations less than 20,000, the ACS reports 5-year estimates (i.e. 2006-2010 averages). Because of this, the only data available for most reservations are the 5-year estimates which are what we use in our analysis.

[19] The census income does not include income in the form of noncash benefits such as food stamps, health benefits, subsidized housing, and goods produced and consumed on farm.

3.2 Relationship between Income and Prime Land

A tribes' agricultural land endowment is likely to have a direct "wealth" effect on income by increasing rent-generating potential, but it is also likely to have affected land tenure. Because these two effects may have different signs and magnitudes, the net effect of resources on income may not be linear. For this reason, the following regression model includes a quadratic term on the prime land variable.

$$(1)\ lnPCI_{irt} = \beta_0 + \beta_1\%Prime1885_i + \ \beta_2\%Prime1885_i^2 + \theta\vec{X}_{i,r,1885} + \alpha\vec{Z}_{i,s,t} + \lambda_{r,t} + \varepsilon_{i,r,t}.$$

The unit of observation is reservation *i* in BIA region *r* in year *t*={1915, 1938, 1945, 1969, 1979, 1989, 1999, 2010}. $X_{i,r,1885}$ is a vector of resource endowment and population pressure measures circa 1885, $Z_{i,r,t}$ are contemporaneous controls including log population and log per capita income in adjacent counties, casino gaming activity, and reservation governance and $\lambda_{r,t}$ are BIA region-by-year fixed effects. Appendix Table A4 gives summary statistics of all covariates, and Figure A3 illustrates a subset of the historical resource endowments variables.

As discussed above, the main goal is to test for the existence of a positive relationship between prime land endowments and long-run income. The tests are credible if the model adequately controls for factors, other than prime land endowments, that have also affected income. For this reason, we include a suite of controls for i) resource endowments such as gold, silver, coal, timber, oil, and stream density; ii) regional economic conditions as accounted for by adjacent county per capita income and population density[20]; iii) presence and intensity of casino gaming[21]; iv) and tribal governance and institutions studied elsewhere in the empirical literature

[20] Population density and the per-capita income are for non-reservation residents living in any county adjacent to the county or counties containing the reservation. Because the census did not collect the county-level data in 1938 and 1945, we include state-level measures of per capita income as a control for regional economies in those years.

[21] Casino gaming activity on reservations is measured by the number of slot machines per American Indian in 1999 and 2010. The casino variable is zero prior to 1999 because reservations in the samples did not have casinos prior to 1999.Prior to the Indian Regulatory Gaming Act of 1988, casino gaming on reservations was virtually non-existent (Cookson 2010). The slot machines variable takes on a value of zero for all reservations prior to the 1989 Census. The data on slot machines for 1989 and 1999 were compiled by Anderson and Parker (2008) and also used in Cookson (2010). The data on slot machines in 2010 were compiled by the authors from www.500nations.com/Indian_Casinos.asp. This site provides the number of slots/gaming machines for all American Indian casinos in the U.S. Each casino can be tied to a reservation by looking at which tribe owns the casino and where the casino is located. We downloaded gaming machine data from the site in 2013, so our measure may include casinos built after 2010.

on reservation economies.[22] The model also allows for BIA region-specific time effects to account for the possibility that unobserved, time variant factors that affect income growth are clustered into particular reservation regions. BIA-specific time effects also control for regional differences in federal policy towards Native Americans over time. Note that, because reservation incomes fluctuated over time – e.g., during the decadal census reports – the empirical analysis pools data across all years rather than focusing on income during one particular year. This helps smooth some of the periodic noise and identifies stable, long-term relationships.

Table 1 reports the results of estimating Equation 1 separately in 1915 (Column 1), 1938/1945 (Column 2), and 1969 onwards (Columns 3-6). The set of control variables are described in the table notes but not shown here to save space. During allotment in 1915 and just after allotment ended in 1938 and 1945, the linear and quadratic terms on prime land are statistically indistinguishable from zero. This pattern does not persist over time, however.

For the post-1945 period, there is a U-shaped relationship between tribes' pre-allotment agricultural endowments and long-run income. Beginning with Column 3 of Table 1, the coefficient for the linear effect of % Prime is negative and statistically significant, while the quadratic term is positive and statistically significant, suggesting an initially downward-sloping, convex relationship. The results in column 4, which includes more controls, are similar.

[22] Third, we control for institutional variables that other research has identified as important. To control for differences in political organization of tribes, we include an indicator variable for Institutional controls include whether a tribe opted to reorganize under the Indian Reorganization Act (IRA) during the 1930s (see Cornell and Kalt 2000, Akee et al. 2015, Frye and Parker 2016), and whether the reservation is under state court jurisdiction through the application of Public Law 280 for the post 1945 years (Anderson and Parker 2008, Dimitrova-Grajzl et al. 2014, Brown et al. 2017). We also control for whether multiple tribes were forced to co-integrate on a single reservation, based on Dippel (2014). We do not include this variable in every specification because doing so limits sample size, as the variable is not coded for every reservation.

Table 1: Agricultural Endowment and Long-Run Income

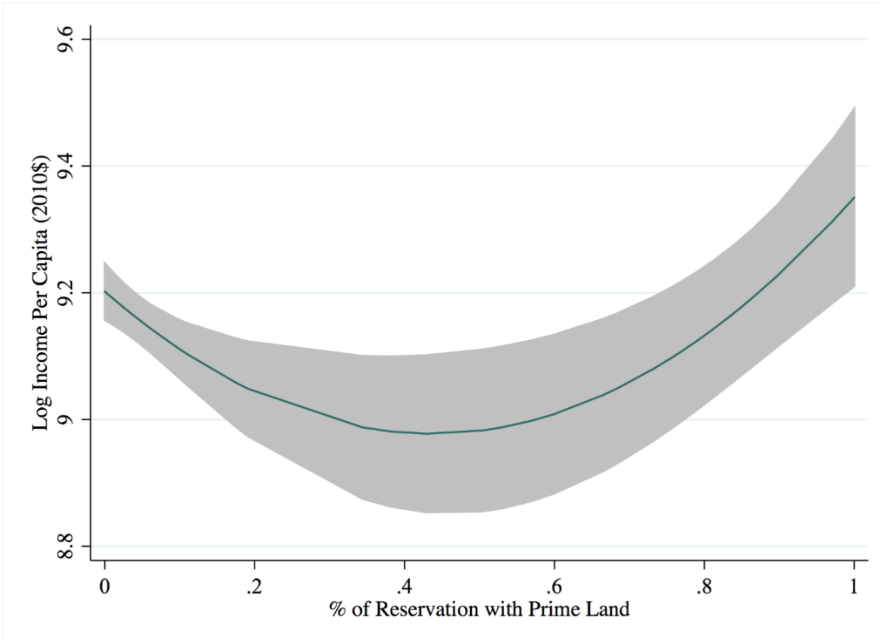
	1915	1945 & 1938	Post-1945	Post-1945	Post-1945	Post-1945
	(1)	(2)	(3)	(4)	(5)	(6)
% Prime Land	1.345	0.183	-1.053***	-1.028***		
	(1.593)	(0.519)	(0.298)	(0.302)		
% Prime Land^2	-2.286	-0.232	1.097***	1.176***		
	(1.873)	(0.532)	(0.327)	(0.313)		
PrimeT1					0.208**	0.162**
					(0.0831)	(0.0808)
PrimeT3					0.134	0.203**
					(0.0972)	(0.0870)
Controls						
Other Resource Endowments	x	x	x	X	X	X
Reservation Pop.	x	x	x	X	X	X
Adj. County PCI				X		X
Slot Machines per Capita				x		X
Political and Legal Oversight				x		X
Dippel's FC variable				x		X
BIA by Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	64	139	443	391	443	391
Adjusted R^2	0.277	0.438	0.573	0.660	0.560	0.648

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ Standard errors are clustered by reservation. Resource endowments controls are time invariant and include timber, coal, stream density, ruggedness, acres, railways, population growth from 1880-1890, and an indicator for energy resources. Controls for adjacent county conditions are time variant and include population density and per-capita income, both logged. The political and legal oversight variables are controls for tribes that opted into the IRA, and who had state jurisdiction imposed upon them by P.L. 280. Dippel's (2014) variable is a measure of forced co-integration (FC). The number of observations declines with its inclusion due to incomplete reservation coverage. The designation of BIA regions has changed over time, but here we rely on a division prevalent during the mid-1900s. Under that division, there are eight BIA regions, named after the headquarter city, which are: Aberdeen, Albuquerque, Billings, Eastern, Minneapolis, Phoenix, Portland, and Sacramento. The years in the post-1945 sample are 1969, 1979, 1989, 1999, and 2010.

Figure 3 shows the "U" shaped relationship, based on the Column 4 coefficients. Long-run incomes are lowest where the prime land makes up about 44 percent of the reservation. On average, for reservations with less than 44 percent prime land in 1885, an increase in the share of prime land is associated with lower income today, whereas reservations with at least 44 percent prime land exhibit a positive relationship between their initial endowment and modern per capita income. This means that for the average reservation in our sample with 24 percent prime land in 1885, prime agricultural land was a curse.[23]

[23] Other research suggests that good soil may be an economic curse for African countries (see Wantchekon and Stanig 2016).

Figure 3: Prime Land and 1970-2010 Income on Reservations



The "U" shape implies that reservations with relatively low or relatively high agricultural endowments in 1885 have higher incomes today than reservations with median endowments. As a non-parametric test for whether these differences are statistically significant, we create indicators for whether reservations have less than 33 percent prime land or greater than 66 percent prime land and treat reservations with between 33 percent and 66 percent prime land as the omitted category. The results, reported in Columns 5 and 6 of Table 1, show that low-endowment reservations earn about 16 percent more than medium-endowment reservations, while high-endowment reservation earn 20 percent more.

3.3 The Effect of Prime Land off Reservations

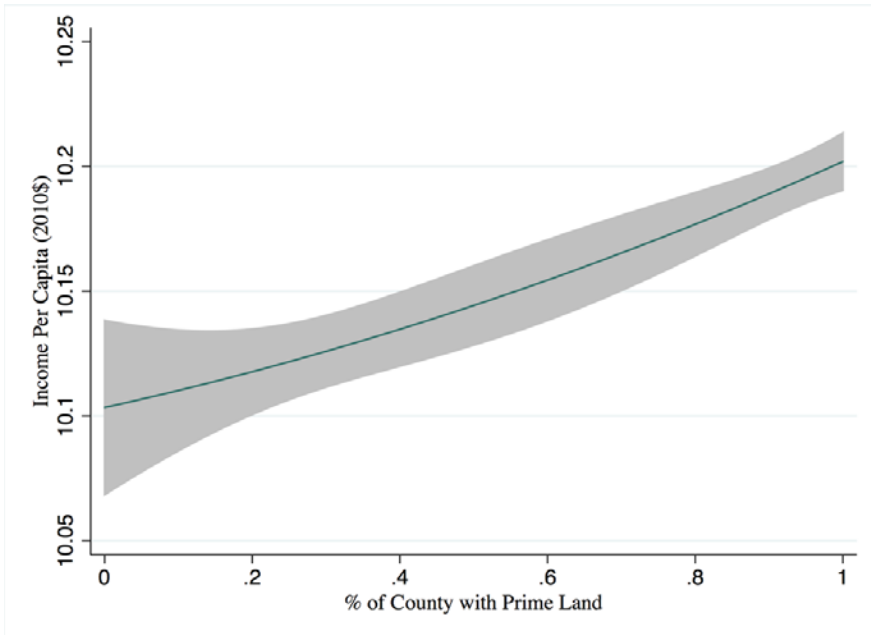
Estimates of the relationship between the share of prime land in 1890 and per capita income over 1970-2010 for U.S. counties presented in Table 2 provide a test for whether the U-shape relationship is unique to reservations. Column 1 allows for the basic quadratic formulation on reservations, controlling only for the covariates that are also available at the county level. Column 2 tests for a quadratic effect of prime land on modern per capita income in counties, and Figure 4 depicts the marginal effects. The figure indicates that the relationship off of reservations is effectively positive and linear.

Table 2: Prime Land and Income on Reservations vs. Counties

	Reservations	Counties	Linear DD	Pct. Prime < 0. 5	Pct. Prime >0.5	Tritiles
	(1)	(2)	(3)	(4)	(5)	(6)
% Prime Land	-0.816***	0.0650	0.106***	0.0234	0.0609*	
	(0.300)	(0.0707)	(0.0164)	(0.0593)	(0.0329)	
% Prime Land^2	0.734**	[illegible]				
	(0.335)	(0.0567)				
PrimeT1						-0.0521***
						(0.0160)
PrimeT3						0.0384***
						(0.0116)
Reservation Indicator			-1.071***	-1.126***	-1.181***	-1.325***
			(0.0556)	(0.0697)	(0.311)	(0.0829)
Res × % Prime			-0.260***	-0.620**	-0.0394	
			(0.0828)	(0.292)	(0.390)	
Res × PrimeT1						0.249***
						(0.0825)
Res × PrimeT3						0.0690
						(0.0975)
Controls	x	x	x	x	X	x
BIA by Year FE	x	x	x	x	X	x
Observations	518	6208	6726	2556	4165	6726
Adjusted R^2	0.277	0.438	0.573	0.660	0.560	0.648

Notes: Standard errors are clustered by county/reservation and reported in parentheses* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. All specifications control for population, ruggedness, acres, and stream density. The years included in the sample are 1970, 1980, 1990, 2000, and 2010.

Figure 4: Prime Land and Long-Run Income for Counties



Column 3 provides linear difference-in-difference estimates which indicate the effect of prime land on income is positive off reservations, but may actually be negative for reservations. Columns 4 and 5 provide linear difference-in-difference estimates for counties and reservation with less than or more than 50 percent prime land, respectively. Column 6 affirms that the differences between reservations and counties also persist when using a tritile estimation. Across all estimation procedures, we reject the null hypothesis that the relationship between historic prime land and modern income is the same for counties and reservations.

To summarize the findings, American Indian income per capita, average over 1970 to 2010, declines as the share of prime land increases from 0 percent to about 44 percent. This declining relationship is not present in 1938 and 1945, and it is the inverse of the relationship found in 1915. Finally, the relationship on reservations is also distinct from the positive relationship between historic prime land and modern income for counties.

4. Prime Land and Privatization during the Allotment Era

To better understand the relationship between pre-Dawes prime land and post-Dawes income, we analyze the effect of agricultural land on the implementation of the Dawes Act and, hence the mosaic of land tenure, both across and within reservations. Information on which reservations were allotted and date of first allotment were obtained from a 1934 Land Planning Report and supplemented with information from a report by the Indian Land Tenure Foundation (ILTF) that reports the date of allotment as well as total allotted and "alienated" (fee simple) acres circa 1934.[24] Information on the percent of land that is owned by the tribe, held in allotted trust, or held in fee simple title as of 2003 are from Anderson and Parker (2008). Fractionation data from a 2013 report by the U.S. Department of Interior, provide the count of fractionated acres and fractionated tracts, the number of unique owners of fractionated interests, and the number of purchasable fractionated interests. Summary statistics for the allotment dataset are provided in Appendix Table A5.

4.1 The Probability and Timing of Allotment

Whether allotment was truly motivated by an altruistic desire to increase agricultural productivity for tribes or by a drive to open prime agricultural land for white settlement, reservations with more valuable resource endowments should be more likely to be allotted and more likely to be allotted sooner. Table 3 presents three sets of regressions testing whether the share of prime land on a reservation in 1885 affected the probability and timing of allotment. Columns 1 and 2 report the estimated marginal effects obtained from a logit regression where the dependent variable is an indicator equal to one if a reservation was allotted between 1877 and 1934 and zero otherwise. Columns 3 and 4 show a censored tobit regression where the dependent variable is the number of years elapsed between 1887 when the Dawes Act was passed and the date a reservation was first opened for allotment.[25] Finally, Columns 5 and 6 report hazard ratios from a Cox Proportional Hazard model where the time until allotment is the measured duration.

Identification in these models relies on cross-sectional variation in land quality between reservations. The fixed nature of the resource endowment rules out simultaneity and reverse causality. Here the chief identification concern is unobserved heterogeneity across reservations that is correlated with reservations' share of prime land and affects the probability and timing of allotment. Our approach for addressing this concern is to control for the distance to the nearest

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[24] The Land Planning Report lacks information on some reservations, but the ILTF has undergone efforts to fill in these gaps where possible.

[25] This variable is censored from above at 47 years for reservations that were not allotted prior to the end of the allotment era in 1934.

military outpost in 1885, adjacent county population growth in 1890, miles of rails that were operable by 1890 within 10 miles of a reservation, overall size of the reservation, ruggedness, stream density, and other resource abundance measures. Columns 2, 4, and 6 also control for the geographic coordinate of each reservation's centroid to account for possible spatial patterns in the rollout of allotment that are not captured by population growth. Our coefficient estimates do not change significantly with the inclusion of controls, implying either that the estimates are well-identified or that our controls are uncorrelated with some unobserved factor that is highly correlated with the share of prime land.

Table 3: The Probability and Timing of Allotment

	(1)	(2)	(3)	(4)	(5)	(6)
	Pr(Allotted)	Pr(Allotted)	Timing (Tobit)	Timing (Tobit)	Cox Prop. Haz.	Cox Prop. Haz.
% Prime Land	0.429^{***}	0.215^{*}	-21.17^{***}	-26.71^{***}	2.302^{***}	2.031^{**}
	(0.130)	(0.112)	(6.660)	(8.241)	(0.523)	(0.715)
Fort Dist.		-0.0000253		-0.00935		1.0009
Adj. Cty. Pop. Growth, 1890		0.00389^{**}		-0.0926		1.002
Rail Density 1890		0.00217^{*}		-0.0446^{*}		1.002^{**}
Acres (100,000s)		0.00107		-0.0657		1.007^{***}
Ruggedness		-0.153		18.29		0.732
Stream Density		-70.19		8697.0		0.0009
% High-Yield Timber		-0.122		13.37		0.505^{**}
Gold & Silver		0.000295		-0.0351^{**}		1.001^{**}
X Coordinate (1000s)		-0.0000818^{*}		0.00617		0.999
Y Coordinate (1000s)		0.000237^{***}		-0.0184^{***}		1.009^{***}
Constant			32.09^{***}	44.94^{***}		
Observations	142	142	142	142	133	133

Robust standard errors in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The estimates show that the share of prime land within reservation boundaries in 1885 significantly increased the probability of allotment and reduced the time between the passage of the Dawes Act and the allotment of a reservation. The marginal effect of prime land reported in Column 2 implies that a change from 0 to 100 percent prime land would increase the probability of allotment by over 20 percent. This implies that the allotment process targeted reservations thought to have the most rent-generating potential. These were the reservations with prime land, near fast-growing counties and with greater railroad access .

Columns 3 and 4 indicate that reservations with a larger share of prime land in 1885 were opened for allotment earlier. Moving from 0 to 100 percent prime land reduces the time between the passage of the Dawes Act and initial allotment by 26 years—over half the total duration of the allotment era. Column 4 also indicates that reservations were allotted more quickly in areas with greater rail access by 1890. Reservations with higher-value gold and silver mines were also allotted earlier.

Columns 5 and 6 confirm these results using a Cox Proportional Hazard model. Here, the coefficients report the relative change in the probability of being allotted in a given year, conditional on having not been allotted yet. A coefficient greater than one indicates that allotment is more likely as the variable increases. Column 6 suggests that reservations with 100 percent prime land were twice as likely to be allotted in a given year than reservations with no prime land.

4.2 Prime Land and Tenure Outcomes across Reservations

The combination of earlier allotment of reservations with higher land quality and the 25-year trust period on allotted lands suggests that the mix of tenure on a given reservation may be a product of its pre-Dawes endowments. Reservations with very little prime land were unlikely to be allotted at all remained in complete tribal tenure. Reservations with the most prime land were allotted the earliest, providing ample time for the mandatory trust window to expire. On these reservations, much of the allotted land would have passed into fee simple ownership. It is the reservations with mid-quality endowments that were allotted late in the Dawes Era that are most likely to have large shares of allotted trust land today due to the abrupt end to allotment in 1934.

Therefore, we predict a negative relationship between a reservation's share of prime land and the modern share of the reservation owned by the tribe , but a positive relationship between prime land and the share of the reservation held in fee simple tenure . The relationship between prime land and allotted trust tenure is ambiguous for two reasons. First, an increase in the share of prime land increases the probability of allotment and therefore increases the share of allotted trust land relative to non-allotted reservations. Second, an increase in the share of prime land also decreases the expected date of allotment, reducing the share of land that was frozen in trust status in 1934.

Table 4 reports the results of a series of tobit regressions—ccensored from below at 0 and from above at 1—that assess the effect of the share of prime land in 1885 on the modern share of tribal, allotted trust, and fee tenure.[26] Columns 1-3 report the results estimated on the full sample of reservations for which there are overlapping covariates, and Columns 4-6 report the results for only those reservations that were allotted.

Table 4: Resource Endowment and Tenure

	All Reservations			Allotted Reservations		
	(1)	(2)	(3)	(4)	(5)	(6)
	Tribal	Fee Simple	Allotted Trust	Tribal	Fee Simple	Allotted Trust
% Prime Land	-0.348**	0.495***	-0.126	-0.218*	0.525***	-0.238**
	(0.169)	(0.169)	(0.0831)	(0.129)	(0.161)	(0.0947)
Fort Dist.	-0.000244	-0.000134	0.0000320	0.000712	-0.000194	-0.000638
Adj. County Pop. Growth, 1890	-0.00305	0.00476**	0.00000628	-0.000746	0.00336	-0.00132
Rail Density 1890	-0.00108	-0.0000212	0.00101*	-0.0000248	-0.00112	0.000793
Acres (100,000s)	-0.000394	-0.00100	0.000789	-0.000400	-0.000641	0.000722
Ruggedness	0.816*	-0.494	-0.335	1.440***	-0.679	-0.686**
Stream Density	92.70	-115.2	13.83	-1.546	-120.2	91.73
% High-Yield Timber	-0.263**	0.111	0.173**	-0.0678	-0.0125	0.0928
Gold & Silver	-0.00130***	0.00138***	0.000155	-0.000941**	0.00105**	0.00000138
Coal 1890	-0.199	0.0846	-0.0254	-0.137	0.0948	-0.0572
IRA Indicator	0.362***	-0.275***	-0.104*	0.171*	-0.181*	-0.0111
Constant	0.474***	0.354**	0.120	0.152	0.548***	0.272***
Observations	110	110	110	73	73	73

Notes: Robust standard errors in parentheses* $p < 0.1$, ** $p < 0.05$, *** $p < 0.0$

The reduced form relationships between prime land and tenure reported in Table 4 are consistent with our predictions. Column 1 demonstrates that reservations with larger shares of prime land ultimately have less tribally owned land after 1934 . Similarly, Column 2 shows that more prime land leads to more fee simple ownership after 1934 . The effect of prime land on allotted trust tenure is not distinguishable from zero in the full sample. Reservations that adopted the IRA have larger shares of tribal land, which is consistent with buyback provisions associated with the IRA.

Columns 4-6 focus on tenure shares only on those reservations that were allotted. Unlike Columns 1-3, these estimates do not include effects associated with a change in the baseline probability of allotment. Within this subset of reservations, we expect more prime land to be

[26] The pattern and statistical significance of the results is unchanged when OLS is used instead. Additionally, we control for whether a tribe voted to adopt the rules associated with the Indian Reorganization Act—the legislation that formally ended allotment—in 1934. Tribes that adopted the IRA may differ systemically from those that did not, and the IRA did contain provisions for purchasing back some fee simple land for tribes.

associated with more fee land and less allotted trust land because reservations with more prime land are allotted sooner and therefore allotted parcels are less likely to be frozen in trust status.

Columns 5 and 6 confirm that an increase in the historical share of prime land increases the modern share of fee land and decreases the share of allotted land. The negative relationship between percent tribal and prime land, conditional on allotment, is consistent with low-quality land being designated as surplus land, but not being claimed by non-Indian settlers and therefore left in tribal ownership.

The primary hypothesis for why allotted trust tenure might be a mechanism for the relationship between prime land and income is that allotted trust lands are heavily fractionated and subject to BIA oversight today. The results in Tables 3 and 4 suggest that reservations with either little or abundant prime land would be least exposed to fractionation problems because they are comprised primarily of tribal and of fee simple tenure, respectively. Accordingly, we test for a non-linear relationship between prime land and several measures of fractionation on allotted reservations in Table 5—the number of unique owners of fractional interests (Column 1), the total number of purchasable interests (Column 2), the number of highly fractionated tracts (Column 3), and the average number of purchasable interests per fractionated tract (Column 4). Here we rely on the same assumptions for identification as in Table 4.

Table 5: Resource Endowment and Fractionation

	(1)	(2)	(3)	(4)
	Unique Owners	Purchasable Interests	Highly Fractionated Tracts	Avg. Interests per Tract
% Prime Land	14438.8^{***}	74661.0^{**}	277.8^{**}	92.02^{**}
	(2830.3)	(28890.1)	(111.3)	(37.58)
% Prime Land^2	-15204.6^{***}	-90387.7^{**}	-318.9^{**}	-79.62^{*}
	(3007.0)	(36869.6)	(140.7)	(43.11)
Fort Dist.	-6.926	-101.8	-0.402	0.00918
Adj. County Pop. Growth, 1890	-25.58^{**}	-352.1^{*}	-1.171	-0.0267
Rail Density 1890	10.60	301.9^{**}	1.043^{**}	-0.0641
Acres (100,000s)	58.13^{***}	476.0^{**}	1.908^{**}	0.00495
Ruggedness	-4003.8	15001.9	9.409	-26.74
Stream Density	-913231.1	-7144465.3	-26214.5	-14076.0^{*}
% High-Yield Timber	-451.2	3891.6	18.57	-5.288
Gold & Silver	-1.567	0.705	0.0620	0.0150
Coal 1890	1148.1	10399.8	27.68	9.985
IRA Indicator	-1536.9^{*}	-10791.9	-36.17	1.890
Constant	4545.5^{***}	31046.4^{***}	107.3^{***}	41.07^{***}
Observations	77	77	77	77
Adjusted R^2	0.517	0.390	0.381	0.083

Notes: Robust standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

The results in Table 5 indicate a statistically significant inverted U-shape relationship between prime land and fractionation. Initial increases in prime land lead to more fractionation, but after % prime exceeds 40-50 percent, further increases in the share of prime land on a reservation decrease the extent of fractionation.[27]

4.3 Within-Reservation Determinants of Tenure

GIS parcel-level data on land tenure for 15 reservations in the Great Plains Region show modern individual parcel boundaries and tenure—tribal, allotted trust, and fee simple for over 124,000 parcels. Appendix Table A6 provides a list of these reservations and the number of parcels and tenure breakdown on each reservation.

Geographic data described above allow us to calculate parcel-level measures of resource quality. Most parcels fall into a single rainfall and soil category, from which we sort parcels according to the soil indexes—low (0-6), medium (7-13), and high (14-20) quality. The parcels fall into 10-15, 15-20, and 20-25-inch rainfall bins. To identify whether approximately 100,000 of the parcel meets our definition of prime land, we calculate elevation and ruggedness the 30-by-30 meter data from the NED.[28]

From this dataset we can estimate the within-reservation relationship between prime land and tenure. Focusing on within-reservation variation in tenure overcomes the obstacle of unobserved heterogeneity across reservations. Relative to cross-reservation analysis, assessing the relationship between resource quality and land that was actually selected for privatization provides a more precise test of the hypothesis that higher quality land was targeted for allotment under Dawes, which is crucial to our interpretation of the "U" shape presented in Section 3. The interpretation of our results implies that high-quality parcels are more likely to be allotted and less likely to remain in tribal ownership and that higher quality parcels are more likely to become fee simple, conditional on being allotted.

To account for factors that may affect the selection of parcels into different tenure types, other than prime land, we control for distance to the nearest stream, distance to the nearest railroad (operable by 1930), and distance to the reservation border. Reservation fixed effects allow us to isolate within-reservation variation in land quality and tenure.

[27] We refer the reader back to Figure 3 to note that those same reservations have the lowest per capita incomes.
[28] Appendix Table A7 gives summary statistics.

Table 6 reports the estimated marginal effects of land quality on the probability that a parcel became fee simple (Columns 1-3) and the probability that a parcel became fee simple, conditional on it having been allotted initially (Columns 4-6). The dependent variable in Columns 1-3 is equal to one if a parcel is either allotted trust or fee simple and zero if it is tribal. The dependent variable in Columns 4-6 is equal to one if a parcel is fee simple and zero if it is allotted trust.[29] Columns 1 and 4 measure land quality using an indicator for parcels that meet our definition of prime land. Columns 2 and 5 control linearly for soil quality and for rainfall where the indicators are one for all rainfall bins except the 10-15 inch bin which is the omitted category. Columns 3 and 6 include the same rainfall indicators in addition to indicators for whether a parcel is the middle or top third of the soil quality index with the bottom third of the index being the omitted category

Table 6: Parcel-Level Outcomes of Dawes

	(1)	(2)	(3)	(4)	(5)	(6)
	Pr(Allotted)			Pr(Fee| Allotted)		
Prime Indicator	0.112***			0.176***		
	(0.00702)			(0.00907)		
Rain_15_20		0.0562***	0.0609***		0.172***	0.186***
		(0.00685)	(0.00692)		(0.00952)	(0.00965)
Rain_20_25		0.284***	0.280***		-0.601***	-0.639***
		(0.0199)	(0.0199)		(0.0186)	(0.0187)
Soil Index		0.00705***			0.00801***	
		(0.000258)			(0.000402)	
Medium Quality Soil			0.0252***			0.0313***
			(0.00359)			(0.00508)
High Quality Soil			0.0818***			0.156***
			(0.00338)			(0.00499)
Controls						
Dist. to Rail	-0.000702***	-0.000463***	-0.000360***	-0.00623***	-0.00620***	-0.00589***
Dist. to Stream	0.00235***	0.00201***	0.00205***	0.00424***	0.00479***	0.00492***
Dist. to Res. Border	-0.00163***	-0.00217***	-0.00183***	-0.00749***	-0.00831***	-0.00815***
N	124366	124357	124357	79297	79290	79290

Notes: Robust standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

[29] Tribal parcels are excluded from the models in Columns 4-6.

The results in Columns 1 through 3 are consistent with the intuition that the highest quality land was targeted for privatization. Column 1 shows that prime parcels are 11 percent more likely to be privatized than non-prime parcels. As shown in Column 2, parcels with 15 to 20 inches of spring and summer rain are 5 percent% more likely to be privatized than parcels with only 10 to 15 inches, and parcels with 20 to 25 inches are nearly 30 percent more likely to be privatized. A one-unit increase in the soil quality index increases the probability of privatization by just under 1 percent. Column 3 indicates that relative to parcels with low-quality soil, medium-quality parcels are 2.5 percent more likely to be privatized while high-quality parcels are 8 percent more likely to be privatized.[30]

Columns 4 through 6 show that higher quality allotted parcels are more likely to have become fee simple. Prime parcels are 17 percent more likely to be converted from trust to fee simple status than non-prime parcels. Increases in soil quality are monotonically associated with increases in the probability of becoming fee simple (Columns 5 and 6). Though parcels with 15 to 20 inches of rain are about 17 percent more likely to have been converted to fee simple than parcels with 10 to 15 inches, parcels with 20 to 25 inches are 60 percent less likely to be converted to fee simple, conditional on soil quality. Consistent with Carlson (1981a, 1981b), these results provide the first definitive empirical evidence that the pattern of allotment was driven by land quality, even within reservations.

5. Allotment, Tenure, and Long-Run Outcomes

To assess the extent to which allotment outcomes explain the U-shaped relationship between prime land and income, we add four variables to the model described in equation (1). The first is an indicator for whether a reservation was allotted. For our main sample, the mean of this variable is 0.81, indicating that the majority of reservations were allotted. The second variable measures the proportion of modern reservation acreage held in allotted trust status. Conditional on a reservation being allotted, the mean proportion in allotted trust is 0.18 with a

[30] The other estimated marginal effects in Columns 1 through 3 also conform to intuition. Parcels are less likely to be privatized if they are farther from existing rail networks. This is consistent with the idea that parcels with better market access would be targeted for privatization. Parcels that lie further inside the reservation boundary are also less likely to be privatized, which is consistent with the notion that part of the motivation for Dawes concerned making land available for white settlers from outside the reservation. Parcels near streams were less likely to be privatized, again consistent with the fact that many stream-adjacent lands are too rugged for agriculture in the Western U.S. (Leonard and Libecap 2017).

standard deviation of 0.17. The third variable measures the extent to which land in allotted trust status is fractionated.[31] Conditional on a reservation being allotted, the mean number of interests per tract is 33.6 with a standard deviation of 21.3. The forth variable is the proportion of land remaining in tribal trust. Conditional on a reservation being allotted, some land may remain in tribal trust because not all surplus and allotted land were claimed, because not all of the reservation was allotted, or because of idiosyncratic circumstances that converted allotted trust and fee simple land to trust lands after 1935. Conditional on being allotted, the mean proportion of a reservation held by the tribe is 0.41 with a standard deviation of 0.31.

5.1 Land Tenure, Prime Land, and Income

Table 7 presents estimates that utilize the panel of income from the 1970-2010 decennial census reports. Columns 1-3 do not control for 1915 per capita income, but Columns 4-6 do, which reduces the sample size from 437 to 294 observations. Including 1915 income is important because it helps control for differences in prosperity before land on reservations became fractionated and before much of it was freed from trust and alienated.[32] Columns 7-9 also control for Dippel's (2014) indicator for whether multiple tribes were forcibly co-integrated (FC) onto a single reservation. Co-integration is important because it leads to lower incomes, but including FC reduces the sample size from 294 to 255 observations.

Certain patterns are evident across all Columns of Table 7. First, inclusion of the tenure variables causes the U-shape to flatten and become statistically insignificant. This is especially apparent when comparing Column 5 to 6, and when comparing Column 8 to 9. With the inclusion of the tenure controls, there is actually a positive, linear relationship between income and land quality in Column 9.[33] These results demonstrate that the U-shaped relationship is a direct result of land tenure institutions.

[31] This variable is the number of separate purchasable land interests divided by the number of allotted trust land tracts with at least two owners.

[32] Ideally we would like to control for 1885 per capita income but 1915 is the first year for which income data are available for a large number of reservations.

[33] When we omit the squared term from the column 9 specification, the coefficient on %prime land is positive and statistically significant at $p < 0.01$.

Table 7: OLS Estimates of Logged Native American Income Per Capita, 1970 to 2010

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Land Tenure									
Allotment Indicator	0.2403***		0.1909***	0.1983**		0.1209	0.2745***		0.1778**
	(0.067)		(0.0664)	(0.0780)		(0.0807)	(0.0801)		(0.0816)
Land Interests per Parcel	-0.0033***		-0.0026***	-0.0028***		-0.0021**	-0.0027**		-0.0016*
	(0.0009)		(0.0009)	(0.0009)		(0.0010)	(0.0011)		(0.0009)
Pct of Land in Allotted Trust	-0.0891		-0.0786	-0.2704**		-0.2466*	-0.2867		-0.1537
	(0.1124)		(0.1063)	(0.1309)		(0.1253)	(0.1790)		(0.1593)
Pct of Land in Tribal	-0.0088		0.0033	0.0264		0.0669	-0.0473		0.0053
	(0.0777)		(0.0739)	(0.0806)		(0.0815)	(0.1162)		(0.1046)
Land Quality									
Pct Prime Land		-1.0759***	-0.7603***		-0.6759**	-0.4678		-0.7868**	-0.3010
		(0.2871)	(0.2753)		(0.3235)	(0.3165)		(0.3341)	(0.3367)
Pct Prime Land Squared		1.1294***	0.8151***		0.8096**	0.5675		1.0549***	0.5519
		(0.3115)	(0.3027)		(0.3598)	(0.3576)		(0.3423)	(0.3367)
Controls									
Reservation Pop. & Acres	x	x	X	x	x	x	x	x	X
Resource Endowments	x	x	X	x	x	x	x	x	X
Adjacent County Conditions	x	x	X	x	x	x	x	x	X
Slot Machines per Capita	x	x	X	x	x	x	x	x	X
Political and Legal Oversight	x	x	X	x	x	x	x	x	X
Per Capita Income in 1915				x	x	x	x	x	X
Dippel's (2014) FC Variable							x	x	X
BIA Region-by-Year FE	x	x	X	x	x	x	x	x	X
Observations	437	437	437	294	294	294	255	255	255
Adj. R-square	0.635	0.628	0.646	0.725	0.714	0.730	0.745	0.754	0.760

Notes: * p<0.1, ** p<0.05, *** p<0.01. Standard errors are clustered by reservation. Resource endowments controls are time invariant and include timber, coal, stream density, ruggedness, acres, railways, population growth from 1880-1890, and an indicator for energy resources. Controls for adjacent county conditions are time variant and include population density and per-capita income, both logged. The political and legal oversight variables are controls for tribes that opted into the IRA, and who had state jurisdiction imposed upon them by P.L. 280. Dippel's (2014) variable is a measure of forced co-integration (FC). The number of observations declines with its inclusion, and with the inclusion of the income in 1915, due to incomplete reservation coverage. The designation of BIA regions has changed over time, but here we rely on a division prevalent during the mid-1900s. Under that division, there are eight BIA regions, named after the headquarter city, which are: Aberdeen, Albuquerque, Billings, Eastern, Minneapolis, Phoenix, Portland, and Sacramento. The years in the sample are 1969, 1979, 1989, 1999, and 2010.

Estimates in Table 7 control for land quality and correct for otherwise biased estimates of land tenure effects. [34] As shown in Columns 4 and 6, the coefficient on the allotment indicator decreases from a significant 0.19 to a marginally significant 0.12 because some of the effects of higher land quality (of the allotted reservations) were otherwise being attributed to the allotment policy. The coefficients on the fractionation and allotted trust variables become less negative after controlling for land-quality because fractionated lands and allotted trust are of lower quality.

The coefficients on the land tenure variables suggest the effects of allotment on long-run income depend critically on whether the process was completed on a particular reservation.[35] They imply that, if all land had passed to fee simple, income per capita would have increased by 12 percent (p value of 0.14). For the mean reservation that was allotted, the effects are indistinguishable from zero.[36] For an allotted reservation with two standard deviations more fractionation and allotted trust land above the mean, the effects of allotment were negative, reducing long-run income by about 15 percent (p value of 0.09).[37] Table A8 in the appendix provides a series of robustness checks and shows that this general conclusion holds with alternative specifications, such as those that employ state-by-year effects and control for ethnic assimilation.

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[34] In separate regressions estimates, not shown here, we find that the differences between column 6 and column 9 are driven by the changing sample size, rather than the inclusion of the FC variable.

[35] To estimate the effects of tenure and fractionation on income, conditional on land quality, we must rely on residual variation in tenure and fractionation that is not explained by prime land and the other controls. Some of this variation results from other dimensions of land quality that are unobserved by the econometrician, or from idiosyncratic differences in the timing of allotment and differences in family sizes across reservations. However, some of the residual variation may be endogenously determined; for example, perhaps tribes that are well-suited for income generation in modern times were also able to prevent land from later becoming fractionated. We control for this possibility, in part, by including 1915 income in the regressions. Still, we recommend caution in interpreting the tenure coefficients. To us, they represent suggestive patterns rather than precise causal estimates.

[36] Using the coefficients in Column 6, we can estimate the effect of allotment on income as follows: 0.12 + 33.6(-0.0021) + 0.18(-0.246) + 0.41(0.066) = 0.033. This estimate is not statistically distinguishable from zero, as the p value of the F-test for joint significance is only 0.59.

[37] This is based on the following calculation: 0.12 + 76.3(-0.0021) + 0.51(-0.246) + 0.24(0.066) = -0.151. This calculation assumes that the two standard deviation increase in the proportion of allotted trust land – which is an increase of 0.32 - is reallocated and split equally between tribal and fee simple lands.

5.2 Allotment and the Number of Native Americans on Reservations

Income per capita may not be the best barometer of the effect of allotment and IRA, especially if tribal members transferred their land to non-Indians and moved off the reservation. To assess the broader impacts of allotment and the IRA, we estimate the relationship between Indian populations on reservations and allotment.

Table 8 estimates the log of reservation Indian population as a function of land tenure controls and American Indian population in 1890 The -0.646 coefficient on the allotment indicator implies that there would have been a 64 percent decline in American Indian populations if all land had been converted to fee simple. In other words, though full privatization may have led to higher incomes per capita, it would have also reduced the number of American Indians on reservations.[38]

Table 8: Estimates of American Indian Population

	Y = ln(American Indian Population), 1970-2010
	(1)
Land Tenure	
Allotment Indicator	-0.6460**
	(0.299)
Land Interests per Parcel	-0.0077*
	(0.004)
Pct of Land in Allotted Trust	0.2740
	(0.495)
Pct of Land in Tribal	0.8791***
	(0.293)
Controls	
Same as baseline	X
1890 Am. Indian Population	X
Observations	294
Adj. R-squared	0.730

Notes: * p<0.1, ** p<0.05, *** p<0.01. Standard errors are clustered by reservation. All regressions included the same set of controls and fixed effects as in Column 3 of Table 7, unless otherwise noted. The observations are for 1970, 1980, 1990, 2000, and 2010.

[38] For the mean allotted reservation, the effects on Indian population size was about a 50 percent decrease, relative to not being allotted, based on the following calculation: -646 + 33.6(-0.0077) + 0.18(0.274) + 0.41(0.879) = -0.538. This estimate is statistically different from zero with a p value of 0.04 on the F-test for joint significance. The positive sign on the percent of land in tribal ownership indicates that this tenure type is associated with sustaining higher levels of Native populations over time. The negative sign on land interests per parcel indicate that fractionation is associated with fewer American Indians living on reservations in recent decades.

5.3 Discussion

To summarize, there are three main findings that affect how one evaluates the long-run economic legacy of allotment. The first is that an appropriate assessment requires controlling for systematic differences in land quality under different tenure arrangements. This is a point emphasized by economists who study land-tenure impacts in other settings (see, e.g., Besley 1995, Galiani and Schargrodsky 2010), and who study North American indigenous tenure systems in particular (see Akee 2009, Akee and Jorgensen 2015, Aragón 2015, Pendakur and Pendakur 2017, Aragón and Kessler 2017).

The second finding is that the economic legacy of allotment, for any particular reservation, depended critically on how much land was left in allotted trust and fractionated. Reservations that were largely privatized or largely left in tribal ownership, have in general, had better long-run outcomes as measured by the total and per capita incomes of American Indian populations over 1970 to 2010. This finding suggests that blanket statements like "allotment was a failure" have little meaning unless considered in the context of individual tribes and their pre-1887 land endowments.

The third finding is that the evaluation of allotment depends on how one prefers to measure success. If one prefers an outcome of small, prosperous Native American populations living on modern reservations, then allotment into 100 percent fee simple lands dominates individual trusteeship with the associated fractionation and is about equivalent to complete tribal ownership. If one prefers an outcome of large Native American populations, then full tribal ownership dominates allotment into either fee simple or into individual trusteeship with fractionation. The impact of fractionation has been negative by either metric.

6. Conclusion

Popular narratives attribute modern poverty on Indian reservations to the dearth of high quality land, but the data here show the narrative is, at best, incomplete. Reservations with small shares of prime agricultural land actually generate higher incomes per capita for Native Americans when compared to reservations with medium shares of prime land. Because reservations with poor quality land were never allotted, they remained mainly in tribal tenure and were spared the drawbacks of allotted trust and fractionation.

These findings are consistent with Elinor Ostrom's (1990) work which emphasized that top-down formalization of informal property rights can reduce rents from natural resources. In fact, tribes on many reservations created relatively well-developed systems of informal property that encouraged productive use of the land (Carlson 1981a). Allotment undermined existing informal property rights by imposing a top-down system of bureaucratic management over a bottom-up system of social coordination. This system increased the transaction costs of coordinating land use relative to tribal control or private ownership.

As it was, allotment undermined existing informal property rights by imposing a top-down system of bureaucratic management over a bottom-up system of social coordination. By scattering land holdings and interspersing whites among tribal claimants incomplete property rights raised the transaction costs of coordinating land use on reservations by requiring individuals to seek approval from BIA officials for changes in land use and ownership and by destroying tribes' ability to serve as a coordinating institution. In other words, incomplete privatization undermined tribes' capacity for informal governance while simultaneously preventing them from fully capturing the benefits of privatization.

Often, policymakers create constrained, incomplete property rights in an attempt to generate efficiency gains while guarding against particular outcomes that are politically undesirable. Restrictions on the use or transfer or prior appropriation water rights, tradable development rights, and individual fishing quota offer just a few examples. The danger with this approach is that it reduces the rent-generating potential of formal property rights while simultaneous destabilizing preexisting informal arrangements. The lesson from the allotment era is that poorly designed, formal property rights can be worse than informal rights.

Data presented here suggest important lessons for renewing indigenous economies in the United States. First, reservation poverty today is, at least in part, a story of poorly designed land tenure institutions that have reduced Indian incomes over time. There are two main avenues for reforming tenure. One possibility is to restore tribal ownership and governance of allotted trust lands. Another is to finish the process that was frozen in 1934 and pass allotted trust lands into fee simple ownership. Either alternative would be an improvement on the status quo if improving economic conditions is the goal.

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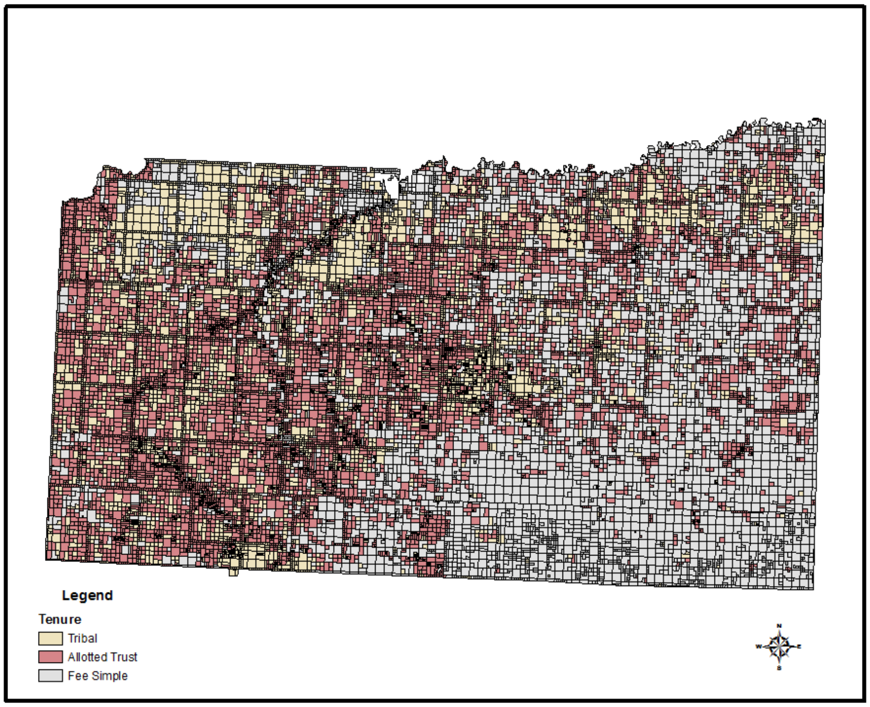
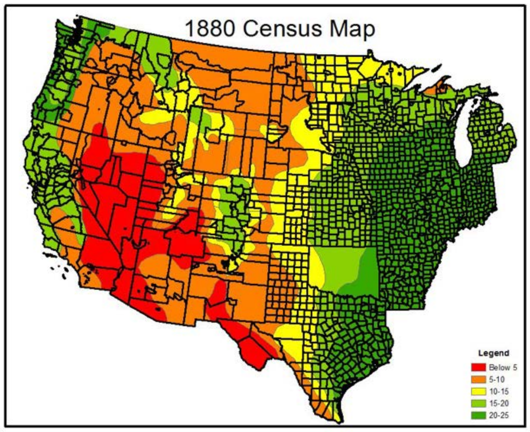
Appendix

Figure A1: Surface Tenure Mosaic on Pine Ridge Reservation



Source: Shape files from Bureau of Indian Affairs.

Figure A2: 1880 Census vs. 1985-1935 PRISM Rainfall



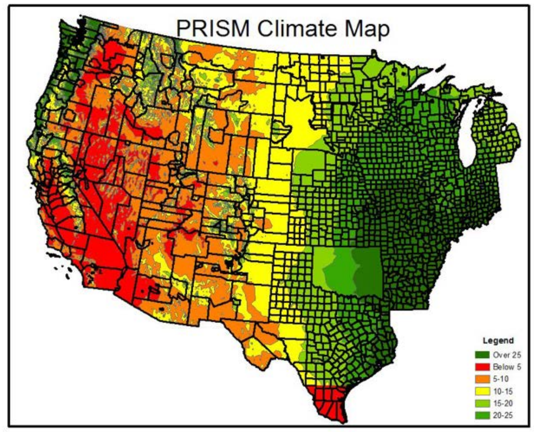
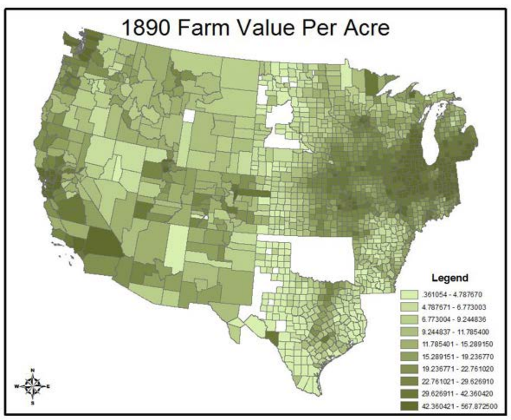
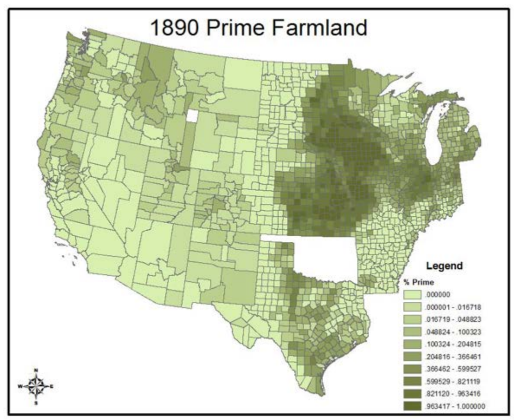
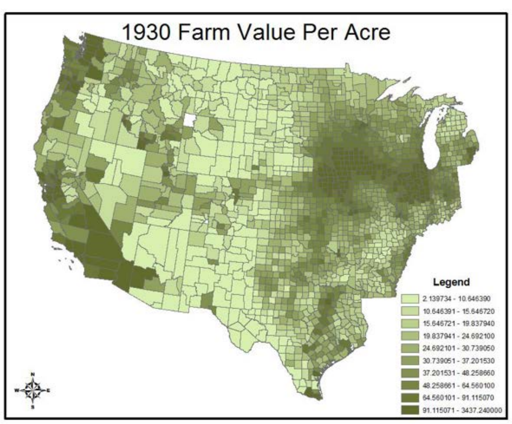


Figure A3: Farm Value Per Acre vs. Prime Land







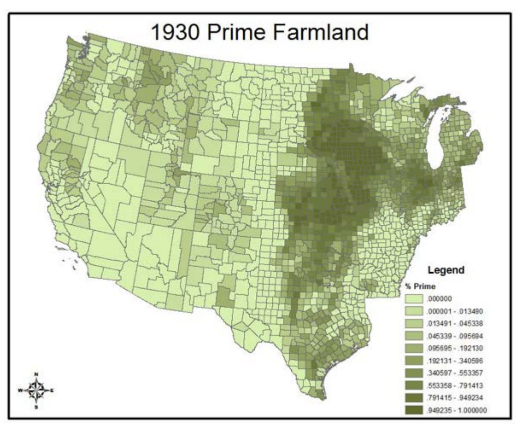
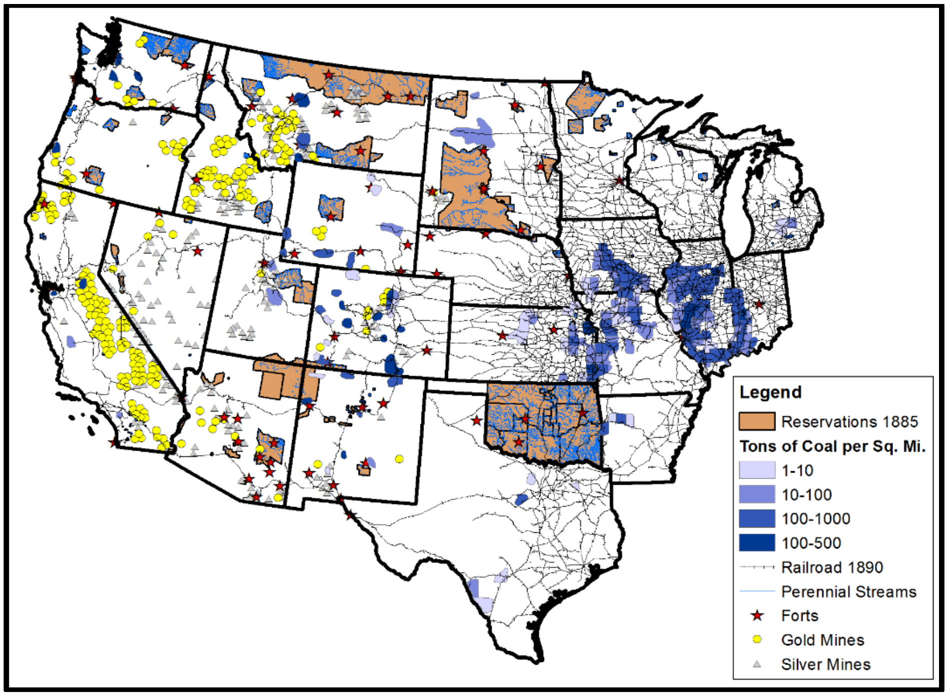


Figure A4: Non-Agricultural Resource Endowments Prior to the Dawes Act



Prime Land and County-Level Farm Value Per Acre

We assemble a panel dataset of counties over the period 1890 to 1930 to assess the validity of our measure of prime farmland. We use county shapefiles for 1890, 1900, 1910, 1920, and 1930 provided by NHGIS to estimate the share of each county covered with prime farmland—our geographic measures are time-invariant, so temporal variation only come from changes in county boundaries over time. We combine this geographic information with agricultural census data compiled by Haines et al. (2015). We use their measure of total farm value and acres in farms to create the variable "Farm Value Per Acre" and assess the degree to which our measure of prime farmland predicts farm value per acre over the period 1890 to 1930, which roughly corresponds to the Dawes Era. County-level summary statistics are available in Appendix Table A3.

Table A1 presents the results of a series of regressions estimating the relationship between the share of prime land in a county and the per-acre value of farms (VPFA). We estimate the models as a pooled cross section and exclude outliers in terms of VPFA, which we define as observations exceeding the 99 percentile (Table A2 reports the results using the full sample). Columns 1 through 3 are estimated using an unbalanced panel and Columns 4 through 6 are estimated on a balanced panel that uses only counties that do not change over time. The estimated coefficient on % Prime is positive and statistically significant in all specifications. The magnitude of the coefficient is roughly equal to the mean of VPFA. Columns 1 and 4 are estimated with no fixed effects and show that % Prime explains 15% of the cross-sectional and time-series variation in VPFA. Columns 2 and 5 include year fixed effects and show that % Prime does even better within-year, explaining roughly 40% of the within-year variation in VPFA.

Table A1: Prime Land and Farm Value Per Acre

	(1)	(2)	(3)	(4)	(5)	(6)
		Unbalanced			Balanced	
% Prime	41.27***	43.22***	42.46***	41.76***	42.99***	42.65***
	(1.070)	(0.930)	(1.128)	(1.124)	(0.954)	(1.184)
Constant	25.11***	7.002***	34.87***	25.55***	7.099***	34.28***
	(0.475)	(0.803)	(1.372)	(0.514)	(0.811)	(1.392)
Year FE		X	X		X	X
State FE			X			X
Observations	8,332	8,332	8,332	7,574	7,574	7,574
Adjusted R^2	0.151	0.361	0.524	0.154	0.391	0.538

Standard errors are clustered by county and reported in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A2: Prime Land and Farm Value Per Acre (Full Sample)

	(1)	(2)	(3)	(4)	(5)	(6)
	Unbalanced			Balanced		
% Prime	43.64***	44.84***	44.78***	44.52***	44.71***	45.05***
	(1.070)	(0.930)	(1.128)	(1.124)	(0.954)	(1.184)
Constant	27.88***	7.227***	39.04***	28.22***	7.303***	38.40***
	(0.475)	(0.803)	(1.372)	(0.514)	(0.811)	(1.392)
Year FE		X	X		X	X
State FE			X			X
Observations	8,420	8,420	8,420	7,657	7,657	7,657
Adjusted R^2	0.058	0.151	0.242	0.060	0.167	0.250

Standard errors are clustered by county and reported in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Appendix Table A3: County Summary Statistics

Variable	(1) N	(2) Mean	(3) S.D.	(4) Min	(5) Max
Panel for Table 2					
Per capita Income ($ 2010)	6,290	26,890.44	7,418.95	0	83,232
ln(Per capital Income)	6,288	10.163	0.276	9.021	11.329
% Prime	6,256	0.642	0.373	0	1
% Prime <.3 Indicator	6,336	0.263	0.440	0	1
% Prime >.6 Indicator	6,336	0.577	0.494	0	1
ln(Population)	6,288	10.095	1.318	5.318	16.101
Acres (100,000s)	6,256	616,710.7	964,654.7	14.233	1,720,000
Stream Density	6,336	1.12×10^{-7}	1.09×10^{-7}	0	1.12×10^{-6}
Panel for Appendix Tables A2-A3					
Farm Value per Acre	8,504	40.10	63.54	0.0698	3,437
% Prime	10,401	0.275	0.351	0	1

Table A4: Panel Summary Statistics

Variables	(1) N	(2) Mean	(3) S.D.	(4) Min	(5) Max
Historic Resources & Controls					
% Prime Land 1885	443	0.184	0.317	0	1
% High-Yield Timber Land 1885	443	0.197	0.393	0	1.000
Value of Gold & Silver Mines 1880	443	33.56	106.4	0	547.3
Value of Coal Mines 1890	443	0.0575	0.187	0	0.740
Stream Density	443	0.000501	0.000460	0	0.00190
Elevation	443	0.915	0.689	0	2.432
Ruggedness	443	0.142	0.124	0	0.458
Acres, 1885 (100,000s)	443	26.95	63.40	0.0176	220.0
PrimeT1 1885	443	0.777	0.417	0	1
PrimeT3 1885	443	0.153	0.361	0	1
Rail Density 1890	443	58.15	84.30	0	369.2
Distance to Nearest Fort 1885	443	55.20	57.96	0	252.3
Adj. County Pop. Growth, 1890	443	32.41	35.20	-11.75	126.4
Dawes & Other Policies					
Allotted Indicator	443	0.693	0.462	0	1
% Tribal Tenure	439	0.559	0.386	0	1
% Fee Tenure	439	0.303	0.328	0	1
% Allotted Trust Tenure	443	0.141	0.184	0	0.871
Land Interests per Parcel	443	24.58	23.20	1	98.68
Forced Coexistence Indicator	392	0.594	0.492	0	1
Public Law 280 Indicator	443	0.359	0.480	0	1
Land Lost to Surplus	443	2.144e+06	6.002e+06	-2.592e+06	2.190e+07
IRA Indicator	443	0.792	0.406	0	1
Income & Res. Characteristics					
Amer. Ind. PCI ($2010)	443	10,464	4,270	3,286	36,712
Total Income	443	2.286e+07	2.266e+07	74,474	1.141e+08
American Indian population	443	2,419	2,547	10	15,827
Income in 1915 (000s)	298	2.335	1.571	0.204	7.679
Reservation Acres, 2000	443	551,196	805,021	768	4.332e+06
Road miles to nearest MSA in 1979	429	186.4	155.9	9	741
Slot Machines	443	286.3	689.5	0	5,048
Slot machines per Amer. Ind.	443	0.235	0.880	0	12.90
Energy Endowed Indicator	443	0.345	0.476	0	1
Adj. County PCI (1,000s)	437	20.83	5.215	9.717	34.79
Ln(Adjacent County Pop.)	437	3.117	1.405	-0.195	6.519

Table A5: Dawes-Era Summary Statistics

Variable	(1) N	(2) Mean	(3) S.D.	(4) Min	(5) Max
Resource Measures and Controls					
% Prime Land	146	0.257	0.343	0	1
% High-Yield Timber Lands	147	0.161	0.358	0	1
Value Gold & Silver Mines	147	26.51	99.24	0	547.3
Value of Coal Mines	147	0.0450	0.169	0	0.740
Stream Density	147	0.000540	0.000557	0	0.00423
Elevation	147	0.789	0.664	0	2.432
Ruggedness	147	0.115	0.116	0	0.458
Acres (100,000s)	147	19.61	51.34	0.0114	220.0
Rail Density 1890	147	54.37	94.06	0	558.1
Fort Dist.	147	59.32	58.17	0	252.3
Adj. County Pop. Growth, 1890	147	30.31	31.89	-11.75	126.4
Dawes Outcomes					
Allotted Indicator	138	0.298	0.458	0	1
% Tribal Tenure	129	0.793	0.366	0	1
% Fee Simple Tenure	129	0.166	0.327	0	1
% Allotted Trust Tenure	129	0.0594	0.170	0	1
% Fractionated	138	0.0412	0.114	0	0.850
Years from 1887 Until Allotted	138	35.59	18.54	-23	47

Table A6: Reservations in Parcel Dataset

Reservation	*N* Parcels	% Tribal	% Allotted Trust	% Fee
Cheyenne River	19,599	0.369	0.212	0.419
Crow Creek	3,413	0.221	0.480	0.299
Flandreau	53	0.321	0.00	0.679
Fort Berthold	17,475	0.502	0.498	0.00
Fort Totten	2,664	0.135	0.523	0.342
Lower Brule	3,939	0.452	0.286	0.262
Omaha	1,033	0.216	0.437	0.348
Pine Ridge	26,542	0.241	0.556	0.203
Ponca	200	0.01	0.00	0.99
Rosebud	17,889	0.299	0.304	0.397
Sisseton	4,201	0.103	0.501	0.396
Standing Rock	22,457	0.193	0.457	0.351
Turtle Mountain	1,770	0.097	0.818	0.085
Winnebago	1,158	0.100	0.674	0.227
Yankton	1,984	0.102	0.506	0.392

Notes: Fee parcels are not available in the Fort Berthold shapefile. However, our results include reservation fixed effects and are robust to dropping Fort Berthold

Table A7: Parcel Summary Statistics

Variable	(1) N	(2) Mean	(3) S.D.	(4) Min	(5) Max
Tribal Indicator	124,366	0.428	0.495	0	1
Allotted Trust Indicator	124,366	0.290	0.454	0	1
Fee Simple Indicator	124,366	0.281	0.450	0	1
Rain_10_15 Indicator	124,357	0.874	0.332	0	1
Rain_15_20 Indicator	124,357	0.109	0.311	0	1
Rain_20_25 Indicator	124,357	0.0176	0.132	0	1
Meters to Nearest Railroad	124,366	23,630	16,864	0	77,763
Meters to Nearest Stream	124,366	5,529	5,059	0	26,581
Main Soil Index Category	124,357	8.940	5.394	0	17
Meters to Res. Boundary	124,366	12,258	10,144	0	42,489
Low-Quality Soil Indicator	124,366	0.459	0.498	0	1
Medium-Quality Soil Indicator	124,366	0.236	0.425	0	1
High-Quality Soil Indicator	124,366	0.305	0.460	0	1
Prime Land Indicator	124,366	0.0730	0.260	0	1

Table A8: Robustness of Allotment and Land Tenure Effects

		adding and subtracting variables			*different geography and time effects*		
	Baseline (col. 6 of table 7)	Does not control for population	Drops slot machine variable	Adds ethnic assimilation	No BIA-region specific year effects	Adds state fixed effects	Adds state-by-year fixed effects
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Land Tenure							
Allotment Indicator	0.1209	0.1174	0.1302	0.2344***	0.1137	0.2833*	0.3292*
	(0.081)	(0.080)	(0.081)	(0.074)	(0.092)	(0.152)	(0.165)
Land Interests per Parcel	-0.0021**	-0.0019**	-0.0024**	-0.0035***	-0.0015	-0.0043***	-0.0045***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Pct of Land in Allotted Trust	-0.2466*	-0.2799**	-0.2054	-0.1994	-0.3193**	-0.3205*	-0.2842
	(0.125)	(0.136)	(0.125)	(0.121)	(0.130)	(0.191)	(0.202)
Pct of Land in Tribal	0.0669	0.0567	0.0649	-0.0239	0.0810	0.0134	-0.0103
	(0.081)	(0.079)	(0.080)	(0.061)	(0.076)	(0.129)	(0.139)
Observations	294	294	294	294	294	294	294
Adj. R-squared	0.730	0.730	0.711	0.711	0.713	0.746	0.742

Notes: * p<0.1, ** p<0.05, *** p<0.01. Standard errors are clustered by reservation. All regressions included the same set of controls and fixed effects as in Column 6 of Table 7, unless otherwise noted. Column 1 is the baseline specification (col. 6 of Table 7). Column 2 drops the potentially endogenous control for population size (of Native Americans) on the reservation. Column 3 adds to the baseline specification a measure of ethnic assimilation in 1938, which is constructed from BIA blood quantum data. The variable is constructed by xxxx. Column 4 drops the potentially endogenous measure of casino gaming, which is slot machines per capita. Column 5 includes country-wide year effects, rather than BIA region specific year effects. Column 6 adds state fixed effects. Column 7 adds state-by-year fixed effects.