Gold Mining Districts and Path Dependence*

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Abstract

This paper applies a quantitative spatial analysis for the long-term impact of Western gold rushes, studying the effect of 19th century US mineral districts on modern (2010) population density. OLS regression estimates show positive effects for areas adjacent to historic mining districts. Census tracts within 15 miles of a mineral district but not containing one are 29.8% more dense than other tracts in the West. Additionally, capital-intensive/large-scale mining was more persistent than labor-intensive/small-scale methods, and path dependence is achieved mainly through agglomeration. This research corroborates historical arguments focusing on the development of Western infrastructure for long term growth, and also contributes to the growing economic literature on path dependence.

Keywords: Gold, Mineral, Western Development, Path Dependence, Spatial, Population Density, Urbanization, Aglommeration, GIS

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1 Introduction

Nineteenth Century US western history was largely defined by a series of gold rushes that attracted unprecedented levels of migration (Maggor, 2017; Limerick, 1988; Isenberg, 2005). These rushes had somewhat ambiguous economic effects and outcomes. Within the historical discipline, scholars have argued over the costs, benefits, and overall impact of these phenomena. Some works focus on the increases in immigration, demand, urbanization, transportation, communication, and nationalization (Brands, 2010; Hahn, 2016; West, 1999) while others look to its non-sustainability, environmental degradation, and rationales for imperialism (Curtis, 2013; Andrews, 2008; Isenberg, 2006; Lecain, 2009; Rohe, 1986; Immerwahr, 2019; Meinig, 2000; Frymer, 2017).

This study aims to bring quantitative spatial analysis to the ongoing discussion of the persistence of historical gold rushes in the US West. I observe trends in economic development by looking at population density as a general indicator for growth.[1] The main findings show significant positive effects for areas near mineral districts relative to those farther away. Regression analysis with various mining factors suggest that capital-intensive and large-scale practices led to more persistence in economic development than labor-intensive and small-scale methods. Persistence of population density to the modern day is due mainly to agglomeration. The study provides new insights on geographical and natural resource advantages and its role in path dependence, while also supporting the notion that institutional development is important in promoting long term economic growth.

This study speaks to many different strands of literature, including economic history, development, labor, and industrial organization. Most directly, this paper studies path dependence and the persistence of place. Lin (2015) provides a survey of the field that explains spatial persistence through natural geography (e.g., hills and coasts/rivers), agglomeration economies (e.g., urbanization and transportation), and sunk factors (e.g., physical infrastructure and housing). The basic premise, as is explored in other literature as well (e.g. Nunn, 2014), is that historical events, traits, and institutions can have an impact on current economic development. The use of "history" can be broadly defined, as some papers look as far back as the pre-Columbian (Maloney and Caicedo, 2015) and prehistoric eras (Olsson and Hibbs, 2005).[2] One paper finds biologically and culturally transmitted traits to play a

[1] As I will note later, population density is measured as the natural log value of total population over total land area.

[2] Maloney and Caicedo (2015) find persistent clusters of population density and income per capita in the modern Americas dating back to pre-Columbian American empires, while Olsson and Hibbs (2005) find geography to be a strong determinant of the transition speed and location of hunter-gather communities to

role in persistent long-run development (Spolaore and Wacziarg, 2013).

Recent work has engaged with the first channel of path dependence, natural advantage. Krugman (1991) first introduced economic geography to the theory of industrial organization, arguing the interaction of economies of scale with transportation costs leads to spatial allocation dependent on geographic features. Studies later that decade quantitatively confirmed the importance of natural advantage, finding that it explains one-fifth of industry concentration (Ellison and Glaeser, 1999; Redding and Rossi-Hansberg, 2017). Other work in this subfield explores the influence of geography on housing supply and settlement (Saiz, 2010), the coastal concentration of the US (Rappaport and Sachs, 2003; Gallup et. al., 1999), and the nonrandom distribution of cities worldwide (Bosker and Buringh, 2015; Ellison and Glaeser, 1997).

Extending from first nature advantages in path dependence are the human advantages of "second nature," or agglomeration and transport networks. The most common research focus within this context has been exploring the impact of railroads on development, from the US and Sweden to colonial Kenya and India (Atack et. al. 2009; Berger and Enflo, 2013; Jedwab et. al. 2015; Donaldson, 2018). Another rich area of study includes Swedish town development affecting the persistence of place through historical sunk costs and investments (Cermeno and Enflo, 2019). One of the seminal case studies in path dependence that guides research in this area finds the persistence of population density through agglomeration in areas around portage sites, whose natural advantages are now obsolete (Bleakley and Lin, 2012). These studies also interact with first nature advantages, as town and railroad placements and other forms of human coordination often act in accordance with the discovery and perception of natural advantages. My analysis of gold rushes in the US West tests whether the initial advantages of largely obsolete mineral locations led to path dependence in economic development.

Speaking more generally to the 19th century US West, Atack (2009) finds that railroads had no causal effect on population density, but a positive causal effect on urbanization in the emerging Midwest. In areas farther West than the Ohio River Valley, gold rushes attracted settlers and infrastructure, and that is an additional context my study addresses. Clay and Jones (2008) used 1850 and 1852 Censuses of populations for their study and find that California miners generally had extremely small or even no economic profits, while nonminers, such as merchants or other service providers, were the individuals that often saw large positive outcomes. This underscores the variability of success at the individual

agricultural societies.

level, as well as commercial growth from positive shocks in mining activity. My study looks at more long-term, aggregate measures of growth from these outcomes. As a somewhat underdeveloped field in the economic literature, this paper contributes additional insight into US Western development from gold rushes.[3]

There has also been extensive work on the property rights of the developing US West, with economic data suggesting that the rush at the Nevada Comstock Lode increased land competition and structured property rights in association with mineral output levels (Libecap, 1978). Libecap (2007) studies the long-run path persistent implications of property rights in the 19th century US West, finding these allocations to be very influential on current environmental issues of resource scarcity. As a study within the 19th century US West, my research has interesting relations to this discussion. The West was so undeveloped at the time that it operated similar to a developing country, but also had existing and strong legal and financial systems from the East coast. The findings of this work can reveal more insight to the extent of legal and financial strength in the US West at this time despite such limited physical infrastructure.

Research on mineral extraction has had ambiguous results in the existing literature. Economists have not found definitive trends with respect to natural resource endowments and path dependence. Sachs and Warner (1999) find that resource booms led to declining GDP per capita in seven Latin American countries. In southern US counties, oil mining initially raised income per capita by 20 to 30 percent relative to neighboring counties, but over time actually fell behind in growth due to the crowding out of other manufacturing sectors that were more conducive to long-term growth (Michaels, 2011). A synthesizing work in reaction to these findings attributes this ambiguity in the effects of natural resource endowments to the varying volatility of countries (van der Ploeg, 2011). Natural resource booms can typically lead to exchange rate appreciations, deindustrialization, and unsteady growth. Countries must have strong laws, robust financial systems, and low corruption rates to benefit from these endowments, and exhaustible resources need to be converted into productive assets for longer-term growth.

[3] Multiple economic studies have also engaged with gold and mining in the US and around the globe. This includes an analysis from a global perspective (Reeves et. al., 2010) focusing on the gold supply increase and its implications for trade and investment, as well as positive spillovers in development from attracting entrepreneurial, managerial, and technical skills. Other studies look at household income benefits from gold in Peru (Aragon and Rud, 2013) and evaluations of per capita levels, investment, output, and confidence in Australia (Battellino, 2010; McLean, 2007). My study will enter into a dialogue with these existing works, and its results can be particularly telling of the different environments in countries as they grapple with natural endowments.

This paper explores these channels of path dependence within the context of US Western gold mining. I find the positive persistence of population density in areas around historical mining districts, despite the growing obsolescence of the mining industry in the West.[4] I find the most significant (and positive) effects in spatial rings surrounding mineral districts, where the area is close enough to the districts to benefit from their past resource extraction but also far enough to develop without hindrance from mountains or mining activity. Partitioning into multiple measurements of mining, I find that more capital-intensive deposits of gold are associated with greater population density today. Conducting the traditional path dependence analysis suggests that persistent effects have mainly occurred through agglomeration. These findings reveal new insights into the importance and influence of geography, natural resources, and investment in influencing economic concentration. In regard to the historical argument, it also bolsters the importance of infrastructural and institutional development for the long term economic growth of the West.

2 Historical Background

The 19th century US West experienced a diverse and vibrant history of mineral rushes, migration, and development. In dialogue with expanding notions of the Frontier and Manifest Destiny, gold functioned as a catalyst for expanding American ambitions and investment (Curtis, 2013; White, 2012). Before the gold rushes, the US West was populated by mostly nomadic Native American powers and self-subsisting Mexican farmers (Belich, 2009). Only a few Europeans penetrated the area before 1845, the few being through the military, exploration expeditions, or the fur trade (West, 1998). In 1848, when James Marshall discovered gold in Sutter's Mill, California, news spread throughout the world, and soon California was receiving emigrants from the American Midwest and East Coast as well as Australia, China, and South America (Mountford and Tuffnell, 2018). Along with the rushes, the US federal government made concerted efforts to promote Western settlement, including the Pacific Railway Act, Mineral Resources Act, and Homestead Act, incentivizing infrastructure, industry, and settlement into the area (Paul, 1974). Additionally, eastern financial markets went through a series of financial panics in the latter half of the 19th century, decimating individual wealth and encouraging people to start anew in the promising frontier (West, 1998).

[4]The historical mining districts and bonanzas are no longer associated with significant levels of mineral extraction, as I will show later in the paper.

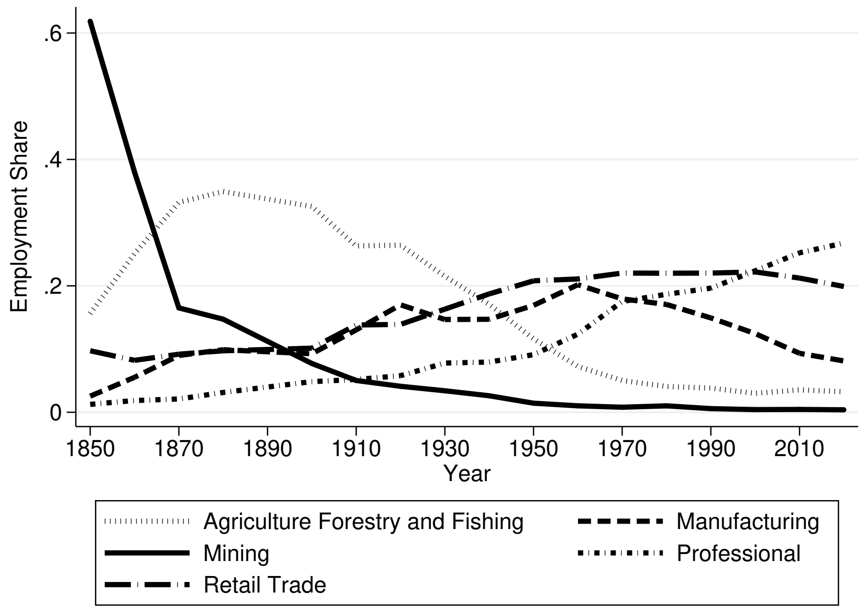
Similar to the California Gold Rush, all Western rushes attracted a large influx of people, leading to increased demand and auxiliary markets.[5] Rushes also called for the laying of infrastructure such as railroads, telegraphs, ditches, and houses (Mountford and Tuffnell, 2018). While not every rusher stayed, these states never returned to their previous levels of population, and continued to exhibit high economic concentrations (Curtis, 2013). Mining was too uncertain and unstable an endeavor to remain as the preeminent industry of the Western economy, and well before the turn of the 20th century, agriculture and cattle ranching had far surpassed mining in terms of significance (Belich, 2009; White, 1993; West, 1998). As shown in Figure 1, the mining share of employment in the US West was at its peak in the 19th century, and has gradually declined over time. Despite this emerging obsolescence within the large scheme of the Western economy, patterns of population density have persisted around historical mining districts (Shown in Figure 2). This can in part be attributed to the actions during these rushes, in which people settled close to each other and laid down legal and physical infrastructure that would prove to be advantageous in the future. Despite its limited role in the modern day, the Western Gold Rushes are essential for understanding the spatial economic allocation of the modern US West.[6]

The general arc of mineral rushes started with placer mining, or sifting for gold flakes in a flowing river. Frenzies began with a large influx of individuals who were typically of low income and limited skills with respect to mining. Placer mining was ideal for this demographic as it required very little prior knowledge or capital. As placer deposits waned, however, the majority of minerals left were stuck in lodes and veins within the mountains themselves. Extraction of this nature required extensive capital and knowledge, influencing the centralization and corporatization of the mining industry. This arc was generally followed throughout all the rushes of the US West (Isenberg, 2005; Belich, 2009; Curtis, 2013; Limerick, 2006).

[5] For rough start dates on mining in many of the Western states explored in this study, see Table 1.

[6] For more detailed information on state-specific gold rushes, including California, Nevada, Colorado, and Montana, see Appendix.

Figure 1: Mining Share of Total Employment in Western States



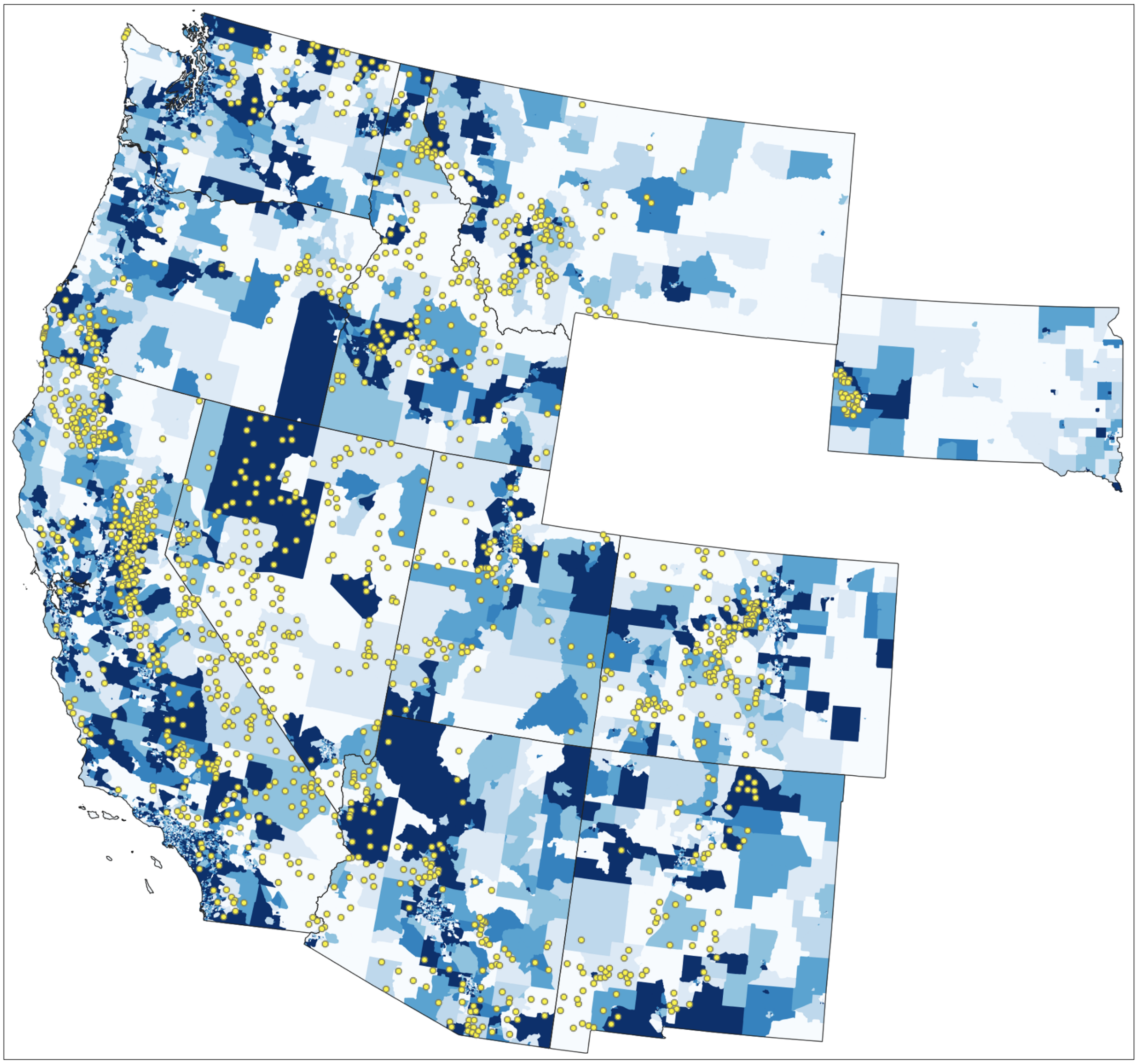
Notes: This aggregate is of the 11-state sample I use for my analysis, which is discussed in the Data section.

Table 1. Western Mineral Rushes

(1)	(2)
State	First Mining Year
California	1848
Nevada	1859
Colorado	1859
Idaho	1860
Montana	1862
South Dakota	1875
Arizona	1877
Alaska	1896

Information from (Paul et. al., 1998)

Figure 2: 2010 Census Tract Population



Notes: Population maps by 2010 Census Tract. This is suggestive of density clusters surrounding mineral districts (yellow symbols). The color symbology scale ranges from 0 to 6,000 people per Census Tract.

3 Data and Methods

This study analyzes modern data that relates to the economic characteristics in the Western region of the United States. The majority of data is taken from the IPUMS NHGIS website (Manson et. al., 2020), which compiles data from decennial Federal Censuses. The unit of analysis is the 2010 census tract level.[7] This information is available both numerically for statistical analysis, as well as on GIS files for spatial analysis. I conduct the study on the following 11 states: Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, Oregon, South Dakota, Utah, and Washington.

3.1 Variables

3.1.1 Population Density

The main outcome variable of interest in this study is total population density, which is measured as people per square mile and is transformed into logarithmic form.

The selection of this outcome variable makes an important statement to the perspective and scope of the main findings. Scholars of history have debated the effect of gold rushes on economic development. Previous findings, for example, show that in the California Gold Rush, the profit to individual miners was small or even nonexistent, while merchants and other service providers profited greatly (Clay and Jones, 2008). If this is the case, then these benefits should have led to greater population density for the area at large, evident in modern spatial clusters.

Urban and regional economists typically tend to use one of three measures as indicators of growth: gdp/income, real estate prices, and population density. At the 2010 census tract level, population density is the only available proxy of the three, so that remains the primary measure of analysis. The focus on the density of people for local growth is a standard practice in the urban economic literature.

3.1.2 Mineral Districts

The independent variable of focus is the presence of gold and mineral extraction.[8] I measure this variable in multiple ways, including continuous valuations of output as well as binary

[7] Additionally, for the supplemental historical analysis, I repeat the same methodology using 1900 Census Counties.

[8] To focus on measuring *realized* natural advantage, I have chosen to focus on gold and mineral extraction rather than the true presence, as that is also readily available through historical sources.

indicators of mineral activity.

For the main analysis, I use historical mineral districts as an indicator for past mining activity. Throughout the early mining development of the US West, mineral districts formed in places where a significant amount of mineral deposits were discovered. These areas formed to establish laws on mining claims and protect property rights. Miners often elected their own president, secretary, judge, treasurer, and recorder to carry out various administrative duties. Districts also established stipulations and regulations surrounding common goods such as water and timber. Districts were typically about 12 to 36 square miles in size, fully encompassing a group of staked mining claims, and founding documents describe the legal boundaries of their domain using natural landmarks, including mountain ridges and rivers (Paullin, 1932).

These data on historical mineral districts are available online as a map plate of gold, silver, and copper mining districts through the Atlas of the Historical Geography of the United States (See Figure 3). The plate was digitized from a print version of the Atlas that was originally published in 1932 by Charles Oscar Paullin (Paullin, 1932). He drew on the original work of James Hill, who made a report in 1912 through the Department of the Interior and the United States Geological Survey on "The Mining Districts of the Western United States" (Hill, 1912). Note that this map plate contains information not only on gold districts, but also locations for silver and copper mining districts. I have chosen to focus solely on gold mineral districts, although including silver and copper districts as well does not significantly change the results.[9]

To establish a mineral district, a location would have to have a discernible amount of mineral wealth that would warrant settlement at least permanent enough to necessitate laws and organization. For this reason, mineral districts are a fairly good indication of a satisfactory amount of mineral success, and proxy well for these variables in the analysis. The source on Mineral Districts used in this analysis draws from statistics of the Denver, Salt Lake City, and San Francisco Geological Surveys. The sole Western state that did not officially organize into mining districts was California, so the mapmakers decided to subdivide the mineral range in California to allow for the most uniformity in their source.[10] Across 14 states, there were a total of 1,479 districts (Hill, 1912; Paullin, 1932).[11]

[9]Of the roughly 1000 districts included in our 11 state sample, about 900 are gold districts.

[10]This source contained no information on mineral districts in Wyoming, so I exclude it from my analysis.

[11]Note that in my analysis I proceed with only about 1000 districts. Some are excluded from the original Hill source, as districts in Wyoming are not geospatially digitized, and I exclude Michigan, Texas, and districts in the Southeastern US from my Western analysis.

Another important aspect of these mineral districts are their ability to partially proxy for institutional development. As van der Ploeg (2011) argues in his comparative analysis, strong institutional legitimacy, through laws and financial institutions, are essential in developing positive outcomes from natural resource endowments. Libecap (1978) studies property rights in the Nevada Comstock Lode, finding their timing to be in direct association with increases in mineral output. These findings also extend broadly to most mining areas of the US West. These mining districts functioned as small communities with explicit and written law codes, and had strong developing institutions.

3.1.3 Bonanza Rushes

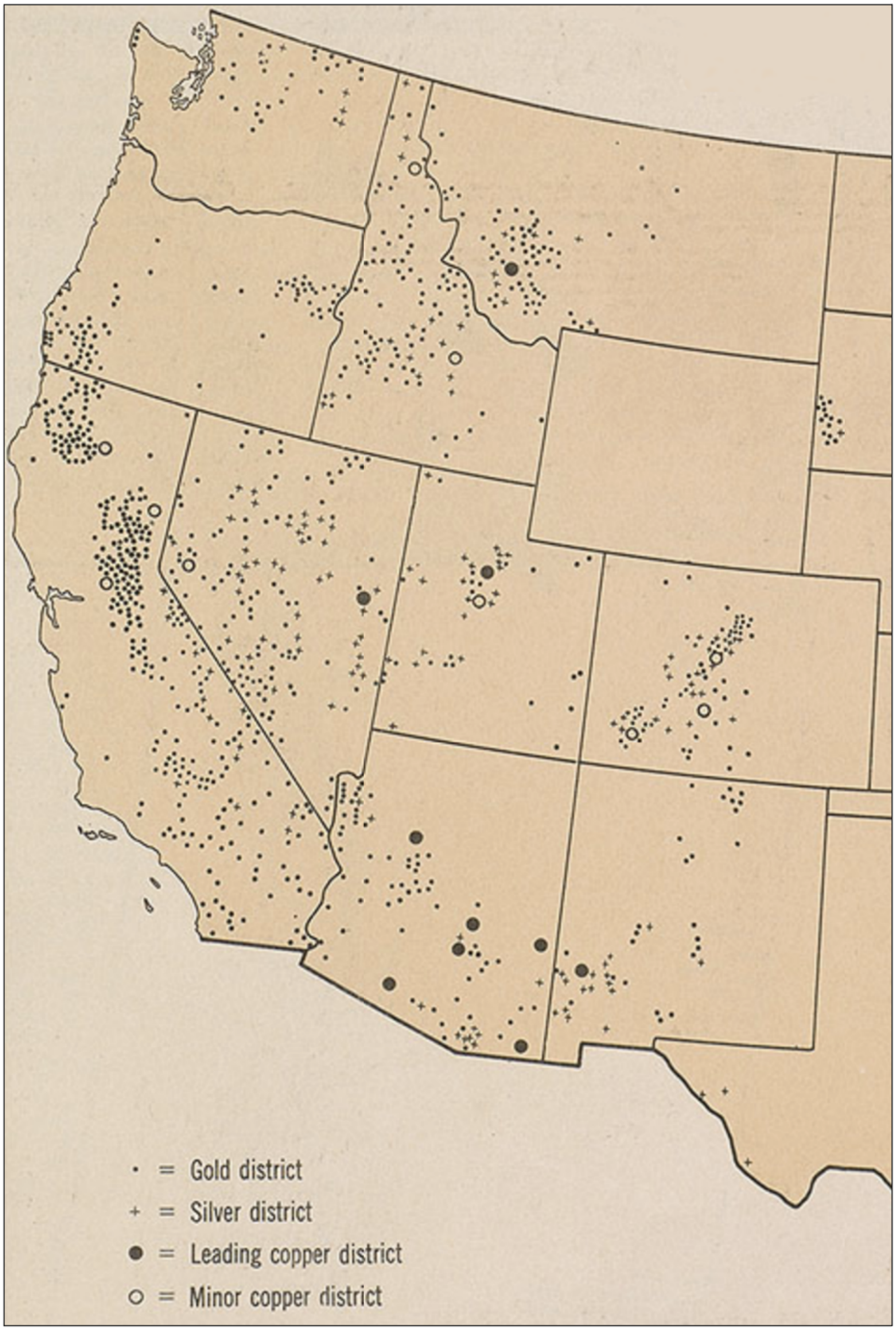
The Beck and Haase Atlas (1989) provides an additional account of 19th century Western mining, in which they only include the large Bonanza Gold and Silver Rushes to the Western states.[12] This results in only a total of 29 identified locations for rushes (See Figure 4), as opposed to the 1,479 mineral districts accounted for in the Paullin Atlas. While providing information on nearly the same topic, this Bonanza source provides nuanced results in the spatial analysis, as it focuses on the more frenzied Western rushes promoted by boosterism and speculation (Beck and Haase, 1989). They also find similar results to the mineral districts, adding robustness to the analysis by showing the results are not dependent on a particular data source.

3.1.4 1890 Mining Statistics

Alternative data I use to understand the main mining factors of persistent development come from the Eleventh Census Report on Mineral Industries (Day, 1892). This document contains county-level data on various mining factors for every state used in the sample of this project. The variables I use as independent variables in the analysis are valuation of total gold output, valuation of ore gold output, valuation of placer gold output, number of mechanics employed, number of miners employed, total mine expenditure, valuation of mining machinery, proper mine valuation, mill valuation, total number of mines, railroad valuation, and plant valuation. I run similar regressions to the baseline with these factors to evaluate which played especially important roles in long-term population density patterns. These variables allow for a more varied and nuanced measurement of mining in the West that add depth to the analysis.

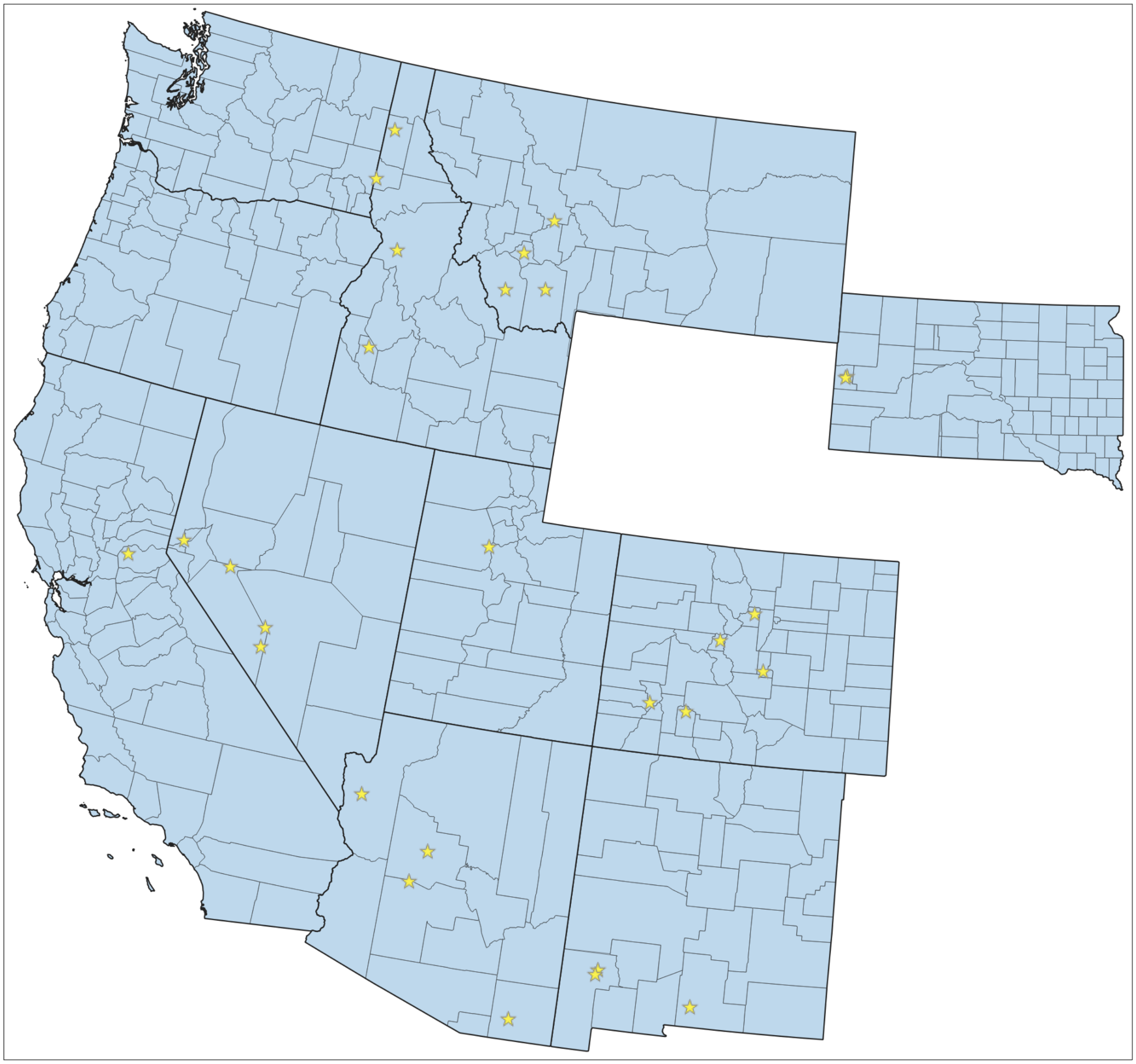
[12]Bonanzas are, broadly speaking, the more "frenzied" rushes to particular places in the West; they are those most often remembered in the popular history of Western mining.

Figure 3: Mineral District Allocation



19th Century Mineral Districts, as presented in *The Atlas of the Historical Geography of the United States* (Paullin, 1932).

Figure 4: Gold and Silver Bonanzas



Gold and Silver Bonanzas that occurred throughout the 19th Century US West. Taken from a plate of the *Historical Atlas of the American West* (Beck and Haase, 1989).

3.2 Methods

The main regression of this study focuses on the natural log of total population density as its outcome variable. It is regressed against a proximity dummy variable that captures a spatial relation to historical mining activity. I then incorporate geographic and state-fixed effect control variables.

3.2.1 Identification Strategy and Control Variables

The identification strategy is a standard treatment-control regression, comparing groups of census tracts with spatial proximity to mineral districts with others in the region, while including geographic and state-fixed effect controls. It is important to note that mining districts are exogenous geographic features, so endogeneity is not a major concern in this methodology.

Geographic controls (χ_i) include a logged distance of each census tract to the West Coast and log-linearized net elevation range and average percent slope. The latter two variables function as proxies for land usability, and particularly mountain ranges, which significantly affect the population density because land can be too steep to settle.[13] This is an important factor to account for when considering how mineral districts affect settlement.

I also include state fixed effects ($State_s$) in the regression. This helps account for any significant differences by state, such as laws or demographics, that would influence population density.[14] For more information on the measurement and sourcing of these variables, refer to the Data Appendix.

3.2.2 Spatial Analysis

I overlaid the mineral district file from the *Atlas of the Historical Geography of the United States* onto a GIS shapefile of 2010 census tracts from the IPUMS NHGIS website. From GIS spatial software I constructed a proximity dummy (within 15 miles) to mineral districts ($Proximity_i$).[15] This spatial analysis is based closely off of the work done by Bleakley and Lin (2012) observing the persistent spatial effects around portage sites, who also use the 15 mile distance for spatial proximity.[16] As a distinction from this previous work, my

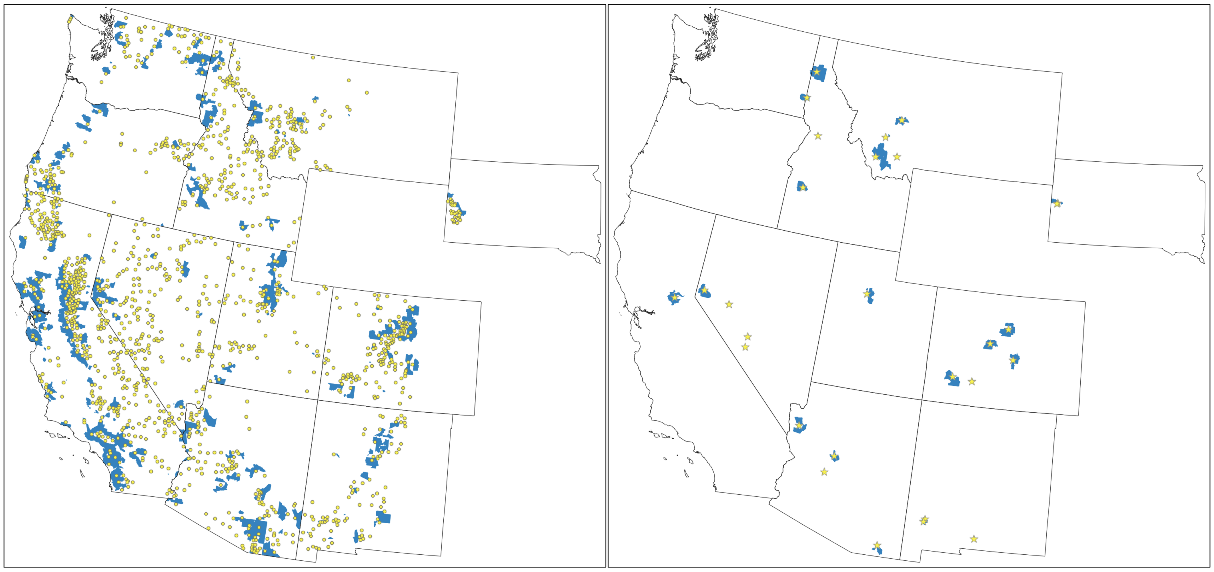
[13] The use of elevation range and mean slope also function on the precedent of Saiz (2010).

[14] In the alternative bonanza analysis, I also include a bonanza-fixed effect, which clusters the sample for each individual bonanza.

[15] I run similar analysis with continuous distance to mining district as the independent variable.

[16] To provide robustness to this methodology, I also conduct my analysis with a discrete variable of the number of mining districts within 15 miles of a census tract, and obtain similar results.

Figure 5: 2010 Census Tracts within 15 miles of Mineral Districts and Bonanzas



Shows the control (light blue) and treatment (dark blue) groups for the spatial methodology implemented as a dummy variable in the main analysis. The treatment group is census tracts within 15 miles of mineral districts that do not contain mineral districts themselves (left) and census tracts within 15 miles of a bonanza that does not contain one itself (right). Note that from a graphic perspective, the treatment group appears small, but this is due to the nature of settlement around these mineral clusters. Populations there are most dense, so the census tracts there are most difficult to see visually. As shown in the summary statistics of Table 2, the treatment group for mineral districts is comprised of over 4,000 census tracts, which is over 25% of the sample.

analysis excludes census tracts containing a mineral district itself from the treatment group.[17] This isolates the effects of the mineral districts from the confounding geographic factor of mountains and excessively steep land, where it is especially difficult to settle.

$$lnPopDense_i = \beta_0 + \beta_1 Proximity_i + \beta_2 \chi_i + \beta_3 State_s + \epsilon_i \quad (1)$$

[17]These tracts are included in the control group, with a binary indicator to differentiate between them and tracts outside of the proximity. Excluding census tracts containing a mineral district from the sample altogether obtains similar results.

3.2.3 Channels/Explanations for Path Dependence

After establishing a relationship between the spatial proximity variable and population density, I look to the various channels that can help explain this association. The first of these methods involves looking at different mining factors, as taken from the Eleventh Federal Census. To identify the effects of each individual mining factor, I construct interaction variables between the spatial proximity dummy and each mining variable. I then run regressions with each interaction variable as the independent variable, and population density remaining the outcome variable of interest.

Constructing an interaction variable with my spatial proximity variable in this manner would alone produce values of zero, as census tracts near a mining area did not have mining data themselves. To address this, I use GIS spatial analysis to determine the closest mining county to each 2010 census tract, and assign it the mining statistics of that 1890 mining county.

A second method of analysis I implement to explore the channels of path dependence works to disaggregate between the persistent effects of agglomeration and sunk costs. The first regression is with modern population density as the dependent variable and the spatial proximity variable as independent, conditional on both historical (1900) population density and one of the historical factors. This regression compares the proximity dummy coefficient in the baseline with those that include sunk cost factors. The extent to which the original coefficient changes determines the importance of sunk costs in the current spatial allocation of economic activity.

The other two regressions are with modern economic factors as the dependent variables and the spatial proximity dummy as the independent variable, the latter regression conditional on modern population density. These regressions note any significant current differences in infrastructural and institutional factors, even when accounting for population density.

The modern and historical factors implemented in this analysis are as follows:

Infrastructure variables, which include log-linearized values of the total length of railroads, interstates, major roads, and highways in each census tract. I also include logged distances from the centroids of each census tract to airports of varying sizes as well as current ski resorts.

Housing variables, which contain measures of housing stock, median values, and median rents. Bleakley and Lin (2012) implement these in their analysis, and they are important contributing factors in previous studies of path dependence. I also include the proportion of federally owned land in each census tract and the valuation of agricultural output at the county level. These factors can contribute to modern population density clusters regardless of mineral districts.

Table 2 below displays the summary statistics of the data, partitioning between census tracts within 15 miles of a mineral district (without containing one) to those over 15 miles away. The decision of 15 miles as the threshold cutoff distance is based off the precedence of Bleakley and Lin (2012). The results show there to be a statistically significant difference between the two groups in all variables except median housing value and federal land share.

Table 2. 2010 Summary Statistics: Partitioned by 15mi Proximity to Mineral District

	Within Proximity			Outside of Proximity			
	Census Tracts	Mean	Standard Deviation	Census Tracts	Mean	Standard Deviation	Significance of Difference in Means
Population Density (ln)	4,074	16.058	1.659	11,084	15.851	2.236	0.000
Distance from District	4,084	15,034	5819	11,113	70,004	63,309	0.000
Distance from Ski Resort	4,084	153,442	429,307	11,113	177,753	436,690	0.000
Distance from West Coast	4,084	267,722	384,744	11,113	296,317	425,137	0.000
Housing Stock	4,083	14,225	15,075	11,075	11,866	13,740	0.000
Median Housing Rent	4,000	1012	368	10,915	964	406	0.000
Median Housing Value	4,023	356,046	185,491	10,899	373,025	233,399	0.174
Distance to Big Airports	4,084	151,868	146,544	11,113	159,675	193,479	0.000
Distance to Small Airports	4,084	18,196.42	14,994.92	11,113	29,143	30,054	0.000
Distance to Medium Airports	4,084	215,947	223,775	11,113	229,121	238,675	0.000
Interstate Length	4,084	0.006	0.031	11,113	0.012	0.065	0.000
Major Road Length	4,084	0.010	0.054	11,113	0.031	0.164	0.000
Highway Length	4,084	0.004	0.027	11,113	0.019	0.113	0.000
BNSF Railroad Length	4,084	462	3068	11,113	1847	11,577	0.000
Amtrak Railroad Length	4,084	0.201	9.887	11,113	0	0	0.020
Elevation Range	4,084	153.9	305	11,113	164.4	356	0.000
Mean Slope	4,084	4.994	5.518	11,113	4.464	5.106	0.000
Farm Output	3,964	12,160	10,703	11,113	14,853	12,884	0.000
Federal Land Share	4,084	0.04	0.143	10,886	0.04	0.149	0.901

Notes: This table compares the 2010 summary statistics of the sample partitioned between census tracts whose centroid is within 15 miles of a mineral district and census tracts with centroids over 15 miles from a mineral district (Census tracts containing a mineral district are dropped from this partition). Columns 1-3 show the statistics for census tracts whose geometric centroid is within 15 miles of mineral districts without containing a mineral district itself, while Columns 4-6 show the statistics for census tracts with a geometric centroid over 15 miles away from a mineral district. Column 7 displays the p-value for a hypothesis test on the difference in means between the two groups.

3.2.4 1900 County Analysis

I also run all of the aforementioned analysis on population density contemporary to the gold rushes, in 1900 counties. The findings of these regressions are less insightful, as the main aims of this paper are to evaluate persistent development from historical events. The counties are also a fairly large scale for this spatial analysis, and census tracts are much more appropriate.[18] Regardless, the results confirm trends exhibited in the 2010 analysis, but less precisely due to the crude scale of measurement.[19]

3.2.5 Strengths/Challenges/Threats to Identification

The implemented methodology relies on an authoritative historical source for mineral districts, from the 1932 US Atlas (Paullin, 2013), which serves as a robust proxy not only for mineral output, but also institutional development. I also bolster this analysis with a second source on mineral bonanzas (Beck and Haase, 1989). The included variables are relatively exhaustive of all relevant factors contributing to Western development that vary by census tract. Geographic proxies for land usability prove to be especially crucial in observing this relationship. The baseline of this research follows closely off of Bleakley and Lin (2012).

Some limitations to the data do arise. The nature of data acquisition in the developmental US West eliminates the ability to conduct a traditional difference-in-differences methodology that would disaggregate the effects of gold mining from overall growth before and after the rushes.[20] Additionally, conducting time series analysis could help in understanding the lagged effects of gold mining. Due to the developing nature of Western states at this time, counties rapidly evolved and broke down into several smaller counties throughout the course of the 19th century. Few remain the same from census to census and some are able to aggregate and line up along boundaries, but going back to even just 1870 yields county sizes too large for specificity in analysis.

The 1890 Mining Statistic analysis provides insight on the particular aspects of mining that helped promote long term development, but it is limited in that it is only collecting mining data for Western counties in 1890. This was at a different stage in the development of various states' mining industries (40 years after the California Gold Rush), so it is not a perfect measurement of the overall mineral success of a state. Still, variables such as total mines, as opposed to total operating mines, help capture this effect over time.

4 Results

The results find generally positive effects on the modern population density of census tracts in spatial relation to historical mining districts and mineral bonanzas. Capital-intensive

[18]The smallest unit of observation in 19th century federal censuses is the county.

[19]For results on the 1900 county analysis, see Table 9 in the Appendix.

[20]By the nature of data acquisition I am referring to the fact that most Western areas became territories due to the effects of a rush, so no census data is available in the area prior to the rush.

mining and agglomeration also help explain the channel for path dependence in these areas.

For the continuous distance results, population density declined as the distance from the district increased. The squared distance was also slightly negative, indicating a downward parabolic trend in the outcome variables. Population density was largely restricted to areas outside the mountains due to their geographic constraints, so people would situate nearby the mountains to benefit from the minerals but in areas of land capable of fostering density. The spatial proximities situated around mineral districts then become a useful method of analysis for isolating the effects of mineral districts.

4.1 Proximity to Mining District

Table 3 shows estimates of β_1 from Equation 1 that relate the proximity of mining districts of census tracts to their measures of population density.

Table 3. 15 Mile Proximity Results (2010 Census Tracts)

Modern Population Density	Baseline	Geography/State
	(1)	(2)
Panel A: Mineral Districts		
Spatial Proximity	0.207***	0.261***
	(0.034)	(0.018)
Panel B: Bonanzas		
Spatial Proximity	0.335**	0.434***
	(0.158)	(0.071)
Sample Size	15,611	15,611

Notes: The regression implemented in the table follows from equation (1) in the text, which has (ln) population density as the dependent variable and the 15 mile spatial proximity dummy as the independent variable. The sample implemented is of all census tracts in the 11 state sample in 2010. The coefficients are OLS estimates. Column 1 conducts a baseline regression of this analysis while column 2 incorporates state-fixed effects and geographic controls, including (ln) mean slope, (ln) elevation range, and (ln) distance to West Coast. For more information on variable definitions, see the main text and data appendix. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

From these results, I find positive associations with population density in census tracts within 15 miles of mining districts and bonanzas that did not contain the mineral districts (bonanzas) themselves. These results are statistically significant throughout. From Table

3, column 2, using the transformation ($e^{0.261}$-1), census tracts within 15 miles of a mining district (but not containing one) are about 29.8% more dense in population than those outside 15 miles (or containing a district) in the 11-state sample.[21] These results are even greater in magnitude for bonanzas (54.3%), which is intuitive as those tended to be the larger mineral events of the West.[22]

As further support for the declining population density away from mineral districts and bonanzas, Table 4 shows the results of a regression on three mutually exclusive distance bins, for census tracts whose geometric centroids are within 0 to 15, 15 to 30, and 30 to 45 miles of a mineral district or bonanza, respectively. These results confirm the above findings, with the greatest effect on population density in the baseline model being in the 15 to 30 mile range (removed from the mountains) and a declining effect once controlling for geography.

[21] To differentiate in the control group between census tracts outside of the proximity and census tracts containing a mineral district/bonanza, I include a District/Bonanza dummy variable as a control in all regressions. Similar results uphold when removing census tracts with mineral districts/bonanzas from the regression.

[22] As an addendum to the main core of analysis, I implement the initial proximity regressions (Table 3) in 2010 on a finer scale than census tracts, in blocks, for the state of Colorado (See Table 10 in Appendix). The results in this case are consistent with the broad outcomes of the 11 state census tract sample. Colorado blocks within 15 miles of a historic mining district (but not containing one) are about 63.1% more dense in population than those outside 15 miles (or containing a district) in the sample. The results for the bonanzas are interesting, as they are significant and negative. This may be due to the limited amount of bonanzas, and within the 15 mile radius the spatial proximity did not include many blocks in Denver, for example. Each state's specific results are likely not as prominent as in Colorado, which had an especially enduring mineral industry, but this provides an even closer view into the persistent effects in economic development arising from these mining endeavors.

Table 4. Distance Bin Proximity Results (2010 Census Tracts)

Modern Population Density	Baseline	Geography/State
	(1)	(2)
Panel A: Mineral Districts		
0-15 mi	0.771***	0.359***
	(0.053)	(0.025)
15-30 mi	0.991***	0.171***
	(0.052)	(0.023)
30-45 mi	0.415***	0.031
	(0.063)	(0.028)
Panel B: Bonanzas		
0-15 mi	0.532***	0.547***
	(0.161)	(0.072)
15-30 mi	0.812***	0.342***
	(0.080)	(0.034)
30-45 mi	0.362***	0.092***
	(0.072)	(0.032)
Sample Size	15,611	15,611

Notes: The regression implemented in the table follows similarly to equation (1) in the text, with has (ln) population density as the dependent variable and spatial proximity dummies for census tracts whose geometric centroids are within 0 to 15 miles of a mineral district (but not containing one), 15 to 30 miles of a mineral district, and 30 to 45 miles of a mineral district. A dummy is also included to differentiate between census tracts containing a district and those outside the range of proximity. Panel B repeats the same analysis but for mineral bonanzas. The sample implemented is of all census tracts in the 11 state sample in 2010. The coefficients are OLS estimates. Column 1 conducts a baseline regression of this analysis while Column 2 incorporates state-fixed effects and geographic controls, including (ln) mean slope, (ln) elevation range, and (ln) distance to West Coast. For more information on variable definitions, see the main text and data appendix. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

4.2 Mining Factors

Various channels and methods of mining can help explain the relation of modern population density to historical mineral districts and bonanzas. The general findings of the individual mining factors support that expenditures (total, machinery, proper mine, mills, railroad, plant, etc.) had positive associations with the outcome of population density, with more capital intensive (and corporate/large scale) and skilled aspects of mining having stronger positive effects than labor intensive (and small scale) aspects.

As the exact values of each variable in this exercise is less pertinent, I focus on the magnitudes relative to each other, most notably comparing ore gold (a highly capital-intensive extract/large-scale) with placer gold (labor intensive/small-scale), as well as mechanics (skill-based) with miners (labor).

Table 5. 2010 Spatial Dummy Interaction with with Historical Mining Factors (15mi)

Historical Factor	(1) Total Gold	(2) Gold Ore	(3) Placer Gold	(4) Mechanics	(5) Miners	(6) Total Mines
Panel A: Mineral Districts						
Spatial Interaction	0.017***	0.015***	-0.001	0.056***	0.045***	0.053***
	(0.001)	(0.001)	(0.003)	(0.007)	(0.004)	(0.005)
Panel B: Bonanzas						
Spatial Interaction	0.024***	0.023***	0.028***	0.089***	0.046***	0.072***
	(0.006)	(0.006)	(0.011)	(0.022)	(0.013)	(0.019)
Sample Size	15,167	15,167	15,167	15,167	15,167	15,167

Notes: The regression implemented in the table uses for an independent variable an interaction term between the spatial proximity dummy and each factor included at the head of each column. The sample implemented is of all census tracts in the 11 state sample in 2010. The coefficients are OLS estimates. All regressions include controls for housing, infrastructure, geography, and state-fixed effects. The variables in the respective columns are all information from the 1890 mining census and contain county-level information on (ln) dollar valuation of total gold output, (ln) dollar valuation of ore-mined output, (ln) dollar valuation of placer-mined output, number of mechanics employed, number of miners employed, and (ln) total number of existing mines. For more information on variable definitions, see the main text and data appendix. Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Note that gold ore has a larger effect on modern population density clusters than placer gold, and mechanics have a larger effect than miners. These trends also hold true for the bonanza analysis, except placer gold has a larger effect on population density than ore gold. This is likely due to the nature of more frenzied rushes and the massive influx of placer miners it brought.[23] Overall, these results suggest that capital-intensive and skill-based factors were more important for long term development than labor-based and unskilled. Additionally, expenditure in general, and on railroads, mills, and plants, all had positive effects on modern population densities.[24] This helps to illustrate the narrative that infrastructural and institutional development helped influence long term economic growth in the region.

[23] As opposed to ore lode mining, which required extensive machinery and capital, placer mining only involved panning for gold flakes in a flowing river. For this reason, the earlier parts of rushes exhibited a lot of placer mining with incoming poor people, while later capitalists took over the process with mechanized lode mining.

[24] For brevity these results are not included, as their comparative magnitudes are less insightful than the other variables in focus.

4.3 Channels for Path Dependence

The results for path dependence suggest that agglomeration played the primary role in population persistence near mineral districts and bonanzas.[25]

Shown in Table 6, it appears that current population density patterns are influenced by both historical sunk factors and agglomeration, as the spatial dummy and historical factor variables are both significant. This implies that both the spatial relation and historical factors are associated with modern levels of population density. However, the value and significance of the spatial proximity variable changes little when including each historical factor, suggesting that this spatial association, and the agglomeration therein, is the primary driving force behind path persistence.

As the spatial proximity variable captures all elements not relating to the historical factors, it is likely that a major part of this persistence was achieved through the institutions surrounding mineral rushes. Mineral districts serve as indirect proxies for increased property rights and institutional legitimacy. These legal structures likely functioned as attractive incentives for migration and agglomeration (See van der Ploeg, 2011).

Table 6. Density Historical Factors and Modern Population Densities (15mi)

Historical Factor	(1) Baseline	(2) Railroad Length	(3) Farming Output	(4) Manufacturing Output	(5) Housing Stock Stock	(6) Manufacturing Establishments	(7) Irrigated Acres
Outcome Variable: Modern Population Densities							
Panel A: Mineral Districts							
Spatial Dummy	0.279***	0.270***	0.197***	0.278***	0.271***	0.257***	0.248***
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
Historical Factor	-	-0.020***	-0.003***	0.000	2.734***	34.859***	-0.037***
	(-)	(0.004)	(0.000)	(0.000)	(0.491)	(4.935)	(0.004)
Panel B: Bonanzas							
Spatial Dummy	0.382***	0.361***	0.363***	0.400***	0.415***	0.394***	0.339***
	(0.071)	(0.070)	(0.070)	(0.071)	(0.071)	(0.071)	(0.072)
Historical Factor	-	-0.023***	-0.001***	0.000***	-2.486***	2.610	-0.046***
	(-)	(0.005)	(0.000)	(0.000)	(0.563)	(5.572)	(0.004)
Sample Size	15,572	15,572	15,572	15,364	15,572	15,435	13,165

Notes: The sample implemented is of all census tracts in the 11 state sample in 2010. The coefficients are OLS estimates. Columns (1) through (7) each show the outcome of regressions with modern population density as the dependent variable against the 15 mile spatial dummy proximity and the historical factor for that column. All regressions include controls for geography and state-fixed effects. The baseline regression includes no historical factor. The respective column variables are total historical railroad length per capita, dollar valuation of 1900 agricultural output per capita, dollar valuation of 1900 manufacturing output per capita, total 1900 housing units per capita, 1900 manufacturing establishments per capita, and 1900 irrigated acres per capita. For more information on variable definitions, see the main text and data appendix. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

[25] For comparison, the Berger and Enflo paper find statistically significant coefficients on their dummy variable, but insignificant coefficients on the factors (generally speaking), and their conclusion determines agglomeration as the primary channel of path dependence.

The modern factor analysis shows complementary results to the previous table's findings. Most factors are statistically significant in Panel A as well as in Panel B, once modern population densities are included as a control. This suggests that regardless of a census tract's population density, proximity to these historical mineral districts (and bonanzas) typically exhibits differences in modern density factors of infrastructure and development. Modern factors thus matter in determining the spatial distribution of economic activity in the US West beyond historical agglomeration.

Table 7. Modern Density Factor Comparison (15mi)

Modern Factor	(1) House Stock	(2) House Value	(3) Railroads	(4) Interstates	(5) Roads	(6) Highways	(7) Poverty	(8) Employment	(9) School	(10) Commute	(11) Plumbing	(12) Income
Panel A: Modern Outcomes												
Mineral Districts	0.084***	-0.078***	-0.027***	-0.552***	0.002	0.318***	0.054***	-0.004***	0.007	-0.003	0.004***	-0.036***
	(0.020)	(0.009)	(0.008)	(0.098)	(0.095)	(0.066)	(0.013)	(0.001)	(0.008)	(0.005)	(0.001)	(0.009)
Bonanzas	-0.170***	0.097***	-0.137***	-0.375***	0.911**	0.004	0.144***	0.003	0.011	0.027*	0.011***	0.114***
	(0.059)	(0.033)	(0.037)	(0.338)	(0.363)	(0.378)	(0.050)	(0.003)	(0.026)	(0.014)	(0.002)	(0.027)
Sample Size	15,651	15,372	15,651	15,651	15,651	15,651	15,536	15,555	15,651	15,651	15,548	15,580
Panel B: Conditional on Modern Population												
Mineral Districts	0.122***	-0.089***	-0.004	-0.548***	-0.133	0.254***	-0.002	-0.004	0.005	-0.005	0.002***	-0.037***
	(0.020)	(0.009)	(0.008)	(0.098)	(0.095)	(0.066)	(0.013)	(0.001)	(0.008)	(0.005)	(0.001)	(0.009)
Bonanzas	-0.098*	0.079**	-0.104***	-0.370	0.694*	-0.093	0.053	0.003	0.009	0.025*	0.008***	0.111***
	(0.059)	(0.032)	(0.036)	(0.340)	(0.358)	(0.379)	(0.044)	(0.003)	(0.025)	(0.014)	(0.002)	(0.0.027)
Sample Size	15,651	15,372	15,651	15,651	15,651	15,651	15,536	15,555	15,651	15,651	15,548	15,580

Notes: Panel A regresses the 15 mile proximity dummy variable (as the independent variable) against the variable of each column as the outcome variable. Controls for geographic variables and state-fixed effects are also included. In Panel B, the same analysis follows, but the 2010 population density of each census tract is also included as a control. The respective column variables are (ln) per capita total housing units, (ln) median house value, (ln) total railroad length per capita, (ln) total interstate length per capita, (ln) total major road length per capita, (ln) total highway length per capita, the poverty rate, the employment rate, (ln) per capital school enrollment, (ln) per capita commute time, the plumbing rate, and (ln) per capita income. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

The findings of this analysis suggest that both historical and modern factors of infrastructure and development play a role in the current allocation of population density in the US West, in addition to a spatial relation to historical mining districts and bonanzas. The primary channel for historical path dependence in this instance, however, is through agglomeration.

5 Discussion

This paper found generally positive effects on modern population density in spatial relation to historic mining districts and bonanzas. Findings support the persistence of spatially allocated economic activity and concentration from historically motivated events. This research displays the importance of historical phenomena in shaping modern economic outcomes. It also shows specifically the importance of physical and institutional infrastructure in the long term development of the American West.

Much of the path dependence literature discusses the possibility of multiple steady state equilibria, which are determined by the initial conditions set in place in history and the environment.[26] This theory naturally begs the question: can areas become "stuck" in otherwise undesirable equilibria? Within this framework, it is possible that initial conditions, whether it be some geographic endowment or seemingly arbitrary decision, can place an area on the path toward a long run equilibrium that would otherwise be undesirable. One may argue that gold rushes in the US West influenced people to migrate, settle, and become embedded into lands less desirable for long term development and growth. A slower, more gradual path of development for Western settlement without rushes may have had a very different modern spatial outlook. This study dealt with the limited information of the 19th century US, and counterfactuals to this detail cannot be constructed for that time. These are still very important considerations to have when observing individual studies of path dependence, and invite further research into the topic of gold rushes.

Though gold mining and production generally waned from the end of the 19th century to the present day, there was a noticeably large spike in output in the mid-1980s. New technological processes developed to extract gold out of the Carlin Trend in Elko, Nevada that rivaled even the output of California gold in the 1850s. This innovation extracted microscopic amounts of gold by crushing up low-grade ore with cyanide. This newfound value in microscopic gold inspired open pit mining throughout the West. Interestingly enough, despite the new massive proliferation of gold through this process, the revival of gold mining in the mid 1980s garnered no frenzy or media near what can be observed in the Western rushes of the 19th century.[27] This spike in revenue and extraction combined with a lack of historical enthusiasm could have differing effects on the lasting economic development of the Western US. The 1980 Tracts also display positive spatial effects for population density for mineral districts, but there is no significance with respect to bonanzas.[28] Overall, the findings of this exercise are inconclusive, but considering the dependent mining variables of my analysis are from 19th century rushes, they are not correlated with the rushes in the 1980s, so that could be accounted for by state fixed effects. The evolving nature of US Western mining through the course of the 20th century nonetheless has important implications for the current allocation of economic activity in the region.

Cultural notions distinct to the Western region of the US are also important elements

[26]In their literature review, Jedwab et. al. (2015) provide an extremely insightful survey of this aspect of path dependence.

[27]Limerick (2006) discusses this phenomenon toward the close of her book.

[28]For results, see Table 11 in Appendix.

to consider in this developing history. The idea of the American frontier was first posited by 19th century historian Frederick Jackson Turner, in a speech he presented at the 1893 Columbian Exposition. Turner argued that the American West in the 19th century was a frontier of individuality and ruggedness that allowed for Americans to become distinctly American, shedding their European roots and becoming enmeshed in the nature of the continent. At the time of his speech, the US Census declared there to be the end of the frontier, defined as a Western line marking the areas where population densities fell below two people per square mile. Turner marked this as a crisis in American identity formation, as he believed it was essential for the American spirit to pioneer into the frontier.

Two twin papers work with the American Frontier from an economic framework, finding that there are long-run persistent effects from total frontier experience, the time spent near the frontier line.[29] The research found that areas with longer exposures to the frontier exhibited higher levels of individualism, defined as the occurrence of infrequent names. They also displayed higher levels of antipathy toward government intervention, and found there to be causal effects from living in the frontier beyond selective migration, using exogenous migratory shocks. These cultural traits have persisted to the present, manifesting in low levels of taxation, public spending, and infrastructure (Bazzi et al, July 2020). In a later paper in light of the Covid-19 pandemic, the writers found that frontier culture contributed to a poor public health response. Longer frontier exposure was associated with less mask use, less social distancing, a mistrust in science, and anti-statism (Bazzi et al, August, 2020). These papers underscore the persistent effects of the American frontier in history, and show how the 19th century West has had effects on the country even to the present day. My paper complements this work on the cultural persistence of the West by incorporating the persistence of its more physical aspects.

The work of this paper also fits into a broad scholarly view referred to as material history. First posited by Fernand Braudel and the Annales School is the *longue duree* argument, that "material forces of geography and climate shaped the broad outlines of human history" (Lecain, 2017). The influence of mineral deposits on the spatial allocation of economic activity is just one example of geographical action in the human network. An acknowledgement of this natural, nonhuman power in the human economy can help to reorient the importance of the environment in economic considerations.

Beyond the scope of this project, more research could be done tracing the evolution of

[29] These authors follow the same definition of the frontier as is set in the 19th century censuses, as areas with population densities below 2 people per square mile.

the environment and its interaction with humans through the course of history from an economic framework. Specifically, the long-term environmental effects of this 19th century mining could provide valuable insights, as historians have already confirmed ecological outcomes from these events (Rohe, 1986). This could make crucial contributions to the field of environmental economics as it develops to make arguments for sustainable enterprises. Libecap (2007) has already engaged in extensive work on the long run environmental effects of property right allocation in the 19th century US West, finding these historic local laws to be extremely influential in current environmental affairs. Understanding, acknowledging, and engaging with ecological history has become essential in being able to deal with and address modern problems with the environment and climate change (Foltz, 2003).

6 Conclusion

The findings of this study confirm the long term importance of Gold Rushes in Western US economic development. Regardless of its *success*, as is fought over so ardently in the historical literature, this quantitative exercise asserts the *importance* of these events. More specifically, this research shows the importance of physical and institutional development in promoting long term growth in the region. This can have important policy implications to local and state funding initiatives in their considerations for long-term growth.

More broadly speaking, the gold rushes can be observed as a stimulus in investment and consumer confidence. The power and allure of gold had the ability of attracting large populations and projects that would not have otherwise come so quickly. This does not necessarily imply that these migratory patterns and investments were imprudent, but rather gold rushes helped capitalists realize the far-ranging economic potential of the Western frontier. Individuals came largely for the prospect of striking it big with gold, but when many people arrived, they saw potential in other livelihoods, from farming and cattle ranching to merchandising and professional careers. It is in this way that gold acted as a catalyst in Western development, promoting the use of the West as an economy in various industries.

Alternate considerations as to why negative effects are seen significantly in the mineral districts themselves beyond mountains should also be explored. One important factor to consider in relation to these extraction points is environmental change. The mining industry has always been intimately tied to the environment from which it extracts, cutting down inordinate amounts of timber for drills and fires, diverting water through artificial channels and sluices, and leaving behind debris in the surrounding air, water, and land. Widespread ecological effects have already been found as a result of this industry (Rohe, 1986). One important consideration in light of these findings is that negative population outcomes in the mining districts themselves may be one indication that those areas have become so environmentally degraded that they are beginning to be uninhabitable by large-scale human populations. This could be another explanation for the spatial ring phenomenon surrounding these districts, where people are close enough to benefit from resource revenue but far enough from the environmental decay taking place to not be profoundly affected by it. This is an aspect of the mining industry that certainly warrants further research quantitatively, and results in this field could yield extremely important implications not only for mining and extractive industries, but human development and agglomeration with the environment in general.

This paper continues to build on the existing work underlining the importance of path dependence. It can seem somewhat serendipitous to observe clusters of human networks surrounding mountains and mineral districts in the US West, both now and over 150 years ago, but this continuity is no coincidence. These events were guided by mineral characteristics exogenous to human decision making. Human coordination and behavior is influenced by geographic boundaries and stipulations far more than many acknowledge. Work in this field helps to uncover the deep-seated historical factors that shape the way we live and cohabit with the world today. Recognition of this shaping force can help policy makers and current world leaders make better-informed decisions on the future outlook of the envirotechnical human network.

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8 Appendix

8.1 Case Study Historical Backgrounds

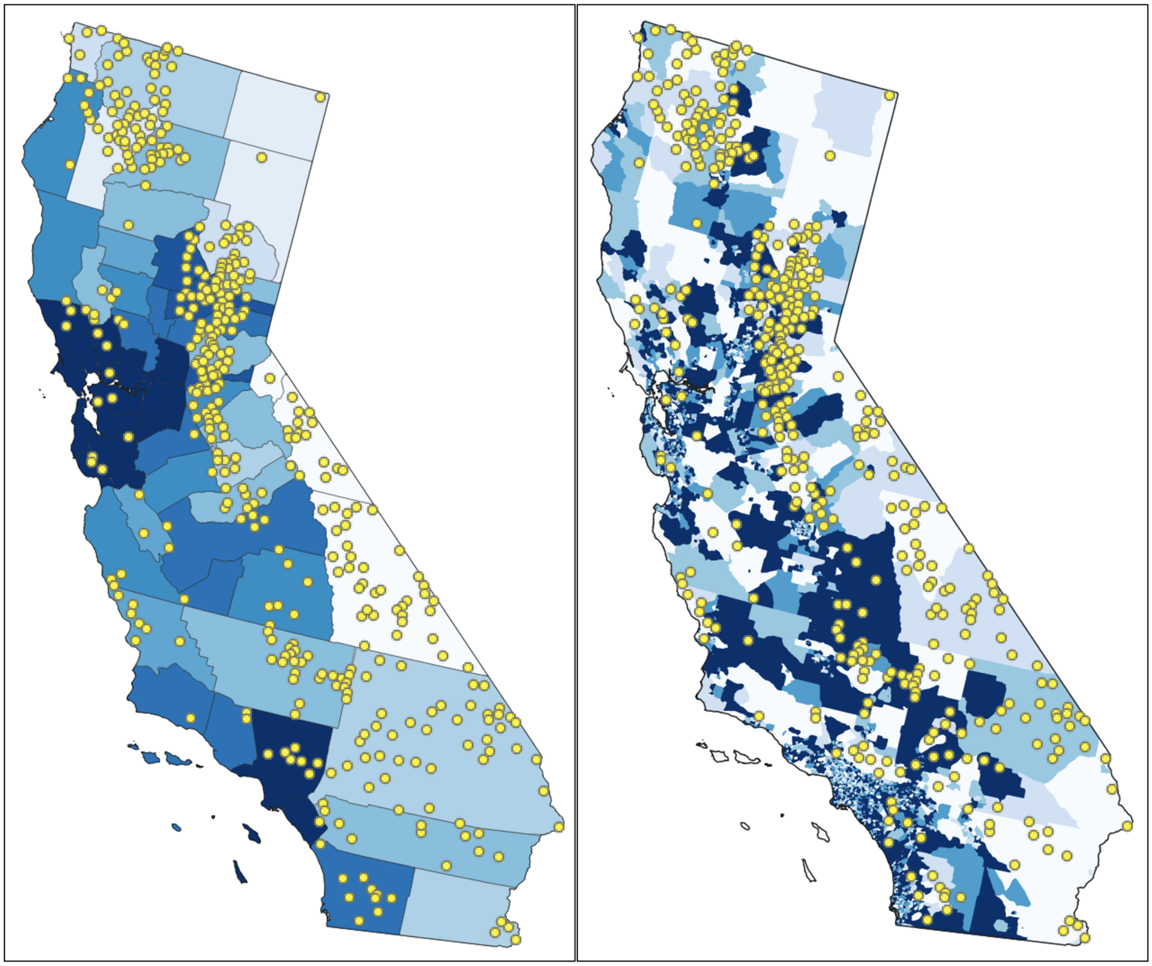
8.1.1 California Gold Rush

The era of American Western gold mining began at Sutter's Mill on January 24th, 1848. James Marshall was leading a group of laborers in blasting out land to develop a water-powered saw mill when he saw shining specks of gold dust in the debris. What started as discreet information quickly ballooned into a massive frenzy, and boosted international fervor. Upon arrival of the news to the coast, San Francisco became essentially deserted as everybody made their way for the hills in search of fortune. Eastern Americans began to make the journey over either in wagons on the Oregon Trail or in ships around Cape Horn. Part of the reason for the rush regardless of the gold were the developing transportation routes of railroads and ocean steamship travel. The gold mines of California were soon filled with immigrants from the Pacific Islands, Oregon, British Columbia, Mexico, Peru, China, and Chile.

The Rush brought a massive surge in population to the region. With only 14,000 inhabitants in 1848, California held a population of 100,000 in 1849, 250,000 in 1852, and 380,000 in 1860. About half of the population was not explicitly involved in mining affairs, but instead provided goods and services to the newly created market, including lawyers, tradesmen, lumbermen, ranchers, and mechanics. This is the time in which eventual railroad magnate Leland Stanford made the first beginnings of his fortune, operating a dry-goods store in Cold Springs and later Michigan Bluff to supply miners with their outfits. Like occupations, various businesses emerged alongside the mining industry, from banks, newspapers, postal services, and hotels, to bars, casinos, theatres, and law firms. Gold production itself was still significant, peaking at over 81 million dollars in 1852, and 1.4 billion dollars in total. In the 1860 census, gold manufacturing accounted for 60 percent of all total manufacturing in the state, employed 56 percent of the manufacturing workforce, and attracted 40 percent of all capital invested.

Both town and governmental structures were rather haphazardly built during this period near the mines, as everyone's ultimate goal was to create personal wealth. People did collectively act in some instances, forming cooperative associations to makes dams and ditches to control water for extraction, and developing rules for mining claims and property from ancient European mining codes. Litigation over mining claims helped develop comprehensive court and legal systems in the area. On a statewide level, California developed quickly and

Figure 6: California Population Density 1900 to 2010 (Districts)



Population Density maps by County in 1900 and Census Tract in 2010 for California. Suggestive of density clusters surrounding mineral districts (yellow symbols) in both years. The 1900 color symbology scale ranges from 509 to 60,216 people per County while the 2010 color symbology scale ranges from 0 to 10,577.891 people per Census Tract.

was in part catalyzed by the rush, transitioning from territory to statehood in just two years. Sacramento, established as the state capital in 1854, was situated strategically between the coal mines of Contra Costa and the iron ore deposits of the Sierra. While most of the urban centers were situated along the coast, major interior towns emerged as a result of the rush, to function as supply and distribution centers for the mines. These nodes were advanced by both natural advantages and boosted by the speculators and merchants who would benefit from their prosperity.

Infrastructure was also an important outcome of the rush. Part of the finance and speculation brought on to enact the development of the first transcontinental railroads came due to the increased traffic west as people came to mine. The Federal government, San Francisco civic government, and private investors alike all contributed to the construction of wagon roads, bridges, dams, canals, and docks.

Agriculture soon developed as an important industry in the state. Much of the early water development, in ditches and other irrigation systems for mining, were crucial in developing a sustainable agricultural industry. Even by 1854, California had become self sufficient in grain production. The agriculture industry was modeled closely off of the industrial nature of the mining enterprise. Bonanza farms and specialized mass crop producing were the norm for the state.

The geologic conditions of California were highly conducive to placer mining, which made it the apt place for the beginning of sustained American mining.[30] Rushers came in with little to no prior experience in mining, and developed knowledge and insights on the go as they prospected and panned for the valuable flakes. The region for gold mining in California developed into a 120 mile strip from Sutter's Mill to Mariposa, and was given the name "Mother Lode."

As the California mining industry matured, science and engineering helped technically develop methods that could extract gold from ores and lodes, which proved to be much more rich in minerals than placers. This included sophisticated dam and stream diverting. The method of hydraulicking was invented in the California rush, a major contribution to the field of mining. This involved dropping water from a height so steep that it could hit gravel rock sides with a pressure that would break it apart. This method required large investments in fixed capital, so it was conducive to central control. It also imposed predictability on water supplies and added much more consistency to the extraction process.[31] Rushers also

[30] Placers were shallow deposits of gold that could be found through washing and sifting in a riverbed.

[31] Hydraulicking also caused a significant amount of runoff debris in riverbeds, leading to floods affecting both farmers and city workers and still has profound environmental effects. Similarly, the use of mercury in

developed the stamp mill with such precision that their model became known around the world as the "California Stamp Mill."

The California miners for the decade of 1850 became a restless group of experienced miners, serving as a source of knowledge in all the other later Western gold rushes, save most of Colorado. This group pioneered many of the far reaches of the US West as they meandered according to the latest news of mineral strikes (Isenberg, 2005; Immerwahr, 2019; Brands, 2010; Belich, 2009; Paul, 1974; Johnson, 2001).

8.1.2 Nevada Gold Rush

Directly following the California Gold Rush in 1859 was a bonanza found in and around a single lode in the Carson River Basin of Western Nevada. Discovered by Peter O'Riley, Patrick MacLaughlin, and Henry T.P. Comstock, the Nevada Comstock Lode drew most of its ten thousand rushers from Nevada County, California, only reaching 100 miles from the existing mining towns of the '49 rush. 1859 to 1861 was a short period of speculative frenzy on the Comstock Lode, and this was followed by years of steady increases in mineral output, reaching 16 million dollars worth in 1864. The pass from these old mining towns to the Comstock became a frequently traveled route of commerce, and developed from mule trains to wagon roads and finally rails. California bankers' interests in the profits of the lode proved to be beneficial to the development of the region, as they helped to finance a railroad from the mining site to the mills along the Carson River, later connecting it to the transcontinental.

The Comstock area saw modest growth, boasting 1500 miners in 1860 and 3000 in 1870. Austin, Nevada became a major distribution center for the region, and Virginia City and Gold Hill were the twin mining towns for the bonanza, holding populations of 11,000 in 1870 and 15,000 in 1880. From 1860 to 1880, 300 million dollars worth of mineral product were extracted from the lode, 43 percent of which was gold, the rest being silver. These twin mining towns eventually faded to centers of the past, but they extracted crucial gains for nearby distribution centers and even San Francisco, the overarching distribution center of the West. Many intangible yet nonetheless enduring elements of Western mining began here as well, including the technical innovation of square set wood frames in tunneling and the first iteration of the Miners' Union, setting acceptable wage rates and working conditions (Paul, 1974).

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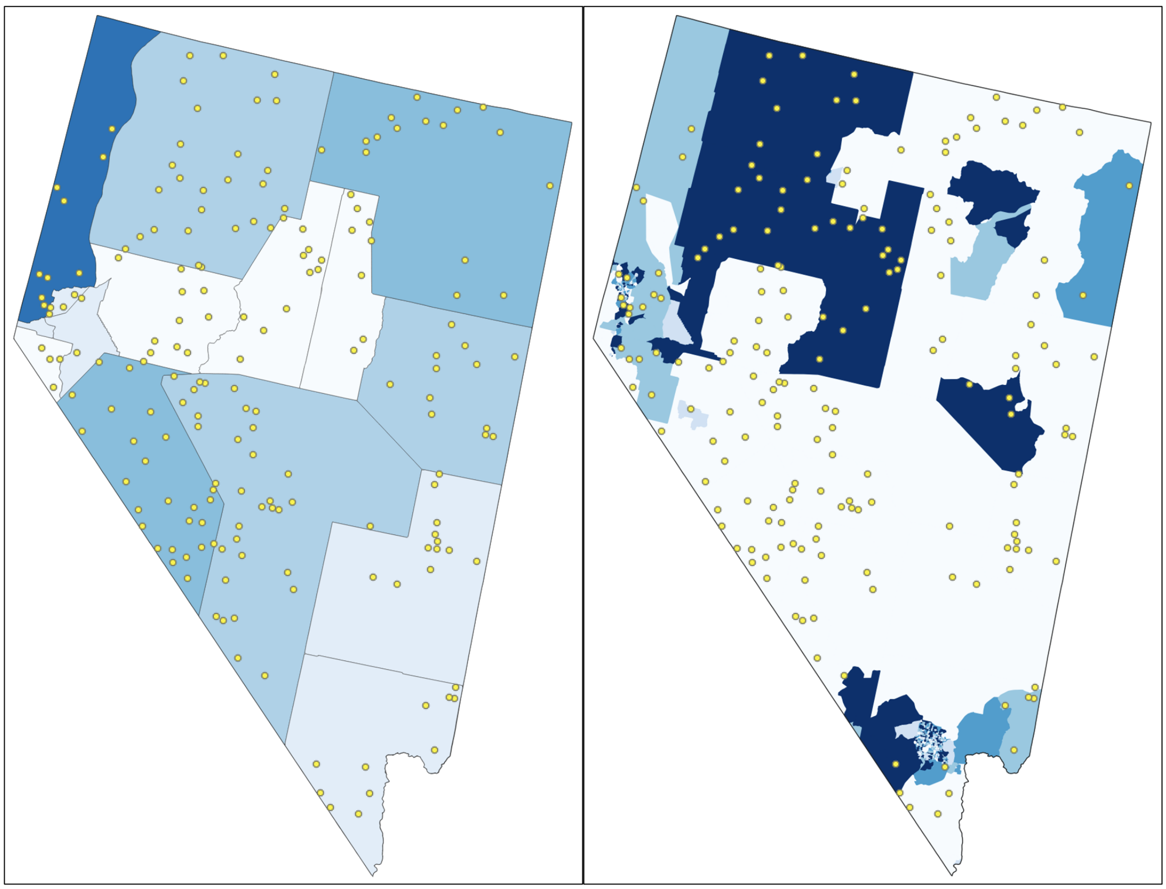
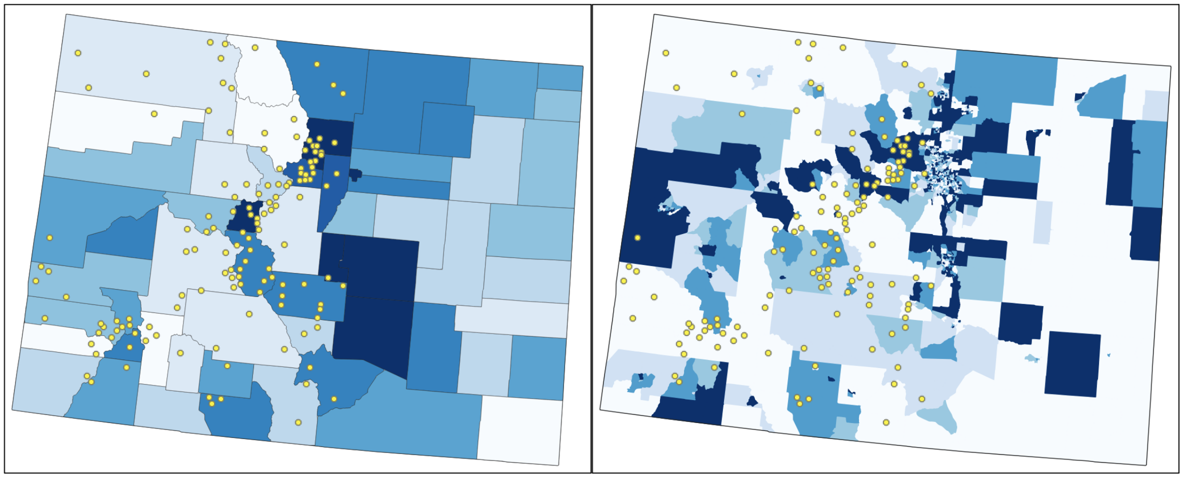
sluicing polluted rivers and killed fish ecosystems.

Figure 7: Nevada Population Density 1900 to 2010 (Districts)



Population Density maps by County in 1900 and Census Tract in 2010 for Nevada. Suggestive of density clusters surrounding mineral districts (yellow star symbols) in both years. The 1900 color symbology scale ranges from 830 to 9,141 people per County while the 2010 color symbology scale ranges from 0 to 8,614.32 people per Census Tract.

Figure 8: Colorado Population Density 1900 to 2010



Population Density maps by County in 1900 and Census Tract in 2010 for Colorado. Suggestive of density clusters surrounding mineral districts (yellow symbols) in both years. The 1900 color symbology scale ranges from 501 to 34,448 people per County while the 2010 color symbology scale ranges from 0 to 9,387.812 people per Census Tract.

8.1.3 Colorado Gold Rush

Following scatterings of reports of gold around the Rocky Mountain region of what would eventually become the Territory and State of Colorado, William Green Russell led a party out of Georgia in 1858 and found discernible traces of gold at Pike's Peak. The Lawrence Party was a somewhat contemporaneous prospecting party that had similar findings. Mania surrounding these gold strikes far exceeded their initial value as Midwest towns and speculators boosted the prospects in hopes of attracting increased amounts of travel and outfitting through their markets.

The original findings of gold were on Cherry Creek, which developed into a major juncture for mines, farms, ranches, and railroads. Later discoveries were found along Clear Creek, and a mineral belt emerged along the Rockies from San Juan to Boulder County. 25 million dollars worth of ore was extracted from 1858 to 1867, with a peak of 3.4 million in 1862. The population of the area was 34,000 in 1860 and 40,000 in 1870. Following a serious mining depression in 1864 to 1869, a silver and lead rush occurred later in 1877 around Leadville, amassing a population of 15,000 in 1880 with an 11.5 million dollar output. In 1890, gold mining experienced a significant revival in Clear Creek.

Many push factors were at play to promote such a significant migration following these findings. The Panic of 1857 had just ruined eastern financial markets and individual savings.

This lowered the opportunity cost of individuals to emigrate west, as they were leaving such little prospects behind. The increased money supply from the California Gold Rush put large upward pressure on prices and heavily overextended the economy. The American Midwest, being the greatest recipient of growth through the 1850's, was also the most badly hurt by the Panic, as it had the least established regional economy. Just four years prior to the rush, Kansas and Nebraska formed as territories to promote agrarian republicanism, and they were directly adjacent to what would become Colorado. This time was also the lead up to the Civil War, and sectional tensions had already risen to a degree that were surely pushing some people away from the East.

The Colorado Gold Rush had a distinctly different nature to it, being tied more to the Midwest than the Atlantic. Pre-rush, the only inhabitants of Colorado were Native Americans, Mexicans, and eastern fur traders. The five states with the most contributing rushers to Colorado were New York, Ohio, Illinois, Missouri, and Indiana. While there weren't many, there was a small base of experienced miners that came from both the California and Georgia Gold Rushes. Of the 34,277 inhabitants of Colorado in 1860, only 2,666 were foreign born, so this rush was a largely domestic affair. Unlike San Francisco for much of the mining West, Chicago and St. Louis emerged as the major supply centers for the rush and ensuing industry. Much of the earlier settlement was seasonal, and rushers would return to their nearby homes in Kansas and elsewhere in the winter. Later, settlement became much more permanent and established.

Massive industries emerged along the way as people travelled to the mines. Those coming arrived by road, water, and rail. Railroads that had previously been overbuilt and underused were able to drum up business with the gold strike and increase their transport. River towns along the way experienced significant boosts in economic activity as travelers outfitted for their journey. Businesses, including hotels and restaurants, thrived all along the Santa Fe trail. The Pike's Peak Express assumed a federal contract to deliver mail from St. Joseph to Salt Lake City. Commercial hauling grew significantly, with three major outfitters delivering four million pounds and eight million pounds of goods in 1859 and 1860, respectively. By 1870, these freighting practices were picked up by railroads and goods became much cheaper. This transition did a great part in reviving the mining industry of Colorado.

Agriculture also developed extensively in the region as the rush progressed. Ranches helped to connect mining settlements with border towns, sometimes contracting out their animal power for travel and transport. Public works projects like ditches and dams benefited both farmers and miners. By the time mining extraction had waned, the farming and ranching economies of the region had matured to a point where the Colorado economy in general was sustainable.

Geology and mineralogy developed immensely for the world at large as the Colorado mines developed. The peculiar nature of Colorado ore, and the elements gold and other metals were attached to, was distinctly different from the California rush, and new methods of extraction had to be developed to gain a profitable amount of the material. Chemists, geologists, mineralogists, and engineers trained in world-class institutions from Harvard to Freiburg and entered the Rockies to study its contents and improve on the methods there. The US Geological Survey formed in 1879, and one of its first key areas of research was in studying the processes in Leadville. The findings of this study contributed greatly to the field and science of mining all over the world. The mineral diversity of the region supported the sustainability and longevity of the industry. As the industry matured, so too did the machinery it implemented, including long toms, sluices, machines for blasting tunnels, stamp mills, and refineries (Cochran, 1980; West, 1998; Paul, 1974; Isern, 1975).

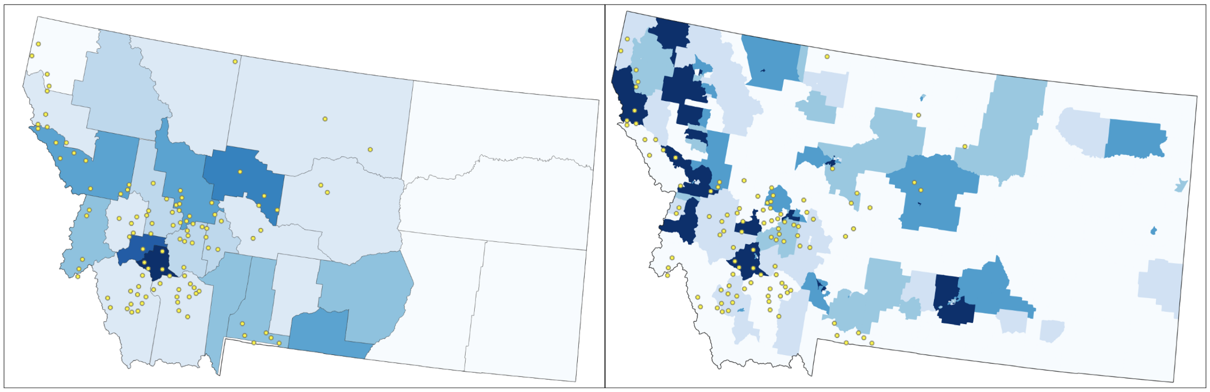
8.1.4 Montana Gold Rush

The Butte, Montana mineral rushes took place in 1864, directly following the Pike's Peak Rush in Colorado. The gold industry specifically had an extremely short period of flourishing, from 1862 to 1867. By 1870, most of the minerals were left stuck in quartz veins, and individuals were no longer able to extract it with limited equipment. Merchant-financiers bought out these quartz vein mines at cheap prices, and invested in capital to extract the ores. This move toward the capital control of gold extraction lead to specialization and the division of labor within the industry. Mass production and economies of scale limited the uncertainty of the process. Early on, daily wages were extremely promising, averaging about 20 dollars per miner per day. Though discernible gold production in Montana was somewhat short-lived, it still had an extremely valuable legacy, producing extensive knowledge of the terrain and topography of the region.

Infrastructure and town development also bloomed as a result of this rush. The Mullan Road was cleared through the Rocky Mountains to the area, and steamboat travel was federally subsidized up the Missouri River. The Fairweather Mining District in Nevada City blossomed into a large mining settlement, with streets of cabins arranged in a grid-like fashion much like that of a modern metropolis.

While gold mining petered out quickly in the Montana domain, silver and copper proved to be much more lasting enterprises. Copper eventually became the iconic mineral of the

Figure 9: Montana Population Density 1900 to 2010



Population Density maps by County in 1900 and Census Tract in 2010 for Montana. Suggestive of density clusters surrounding mineral districts (yellow star symbols) in both years. The 1900 color symbology scale ranges from 2,443 to 25,777 people per County while the 2010 color symbology scale ranges from 24 to 9,149.099 people per Census Tract.

Butte region. Arising in a time of capitalism where it was becoming extremely valuable for its contribution to heat and electricity, mining copper was an extremely fruitful endeavor. The Anaconda Mine in Butte emerged as the preeminent copper mine in the entire country, possessing its own railroad, smelter, and town. Together with the Lake Superior district in Michigan, Butte helped to produce 66 percent of all US copper. It also attracted significant investment from the east, when Henry Rogers, an executive at Standard Oil, formed the Amalgamated Copper Company in Montana in 1899 (Paullin, 1932; Curtis, 2013; Nelson, 2006; Lecain, 2017).

8.1.5 City Development and Junctures

One of the lasting and most important features of 19th Century Western Gold Rushes are not the mining towns themselves, but their adjacent supply and distribution centers. As people rushed West in the latter half of the nineteenth century, they passed through "gateway cities" before arriving at the mines, promoting the growth of those areas. These places were determined by geographic factors, including the space to expand and strategic locations next to rivers and other waterways. On the Pacific Coast the major emerging city was San Francisco, while on the interior this included Denver, Boise, Sacramento, and Stockton (Mountford and Tuffnell, 2018). These urban centers helped to funnel the natural resources of the area into the overarching American capitalist economy, much to their own benefit (Isenberg, 2005).

8.1.6 San Francisco, California

Serving as a port of goods from international markets, San Francisco became the queen city of the California Gold Rush, sending commerce through the Californian interior on steamers through the San Joaquin River. Sacramento, Stockton, and Marysville all became major inland commercial centers through this trade network. Even past the peak of gold production, as mining towns faded in population, these distribution centers remained.

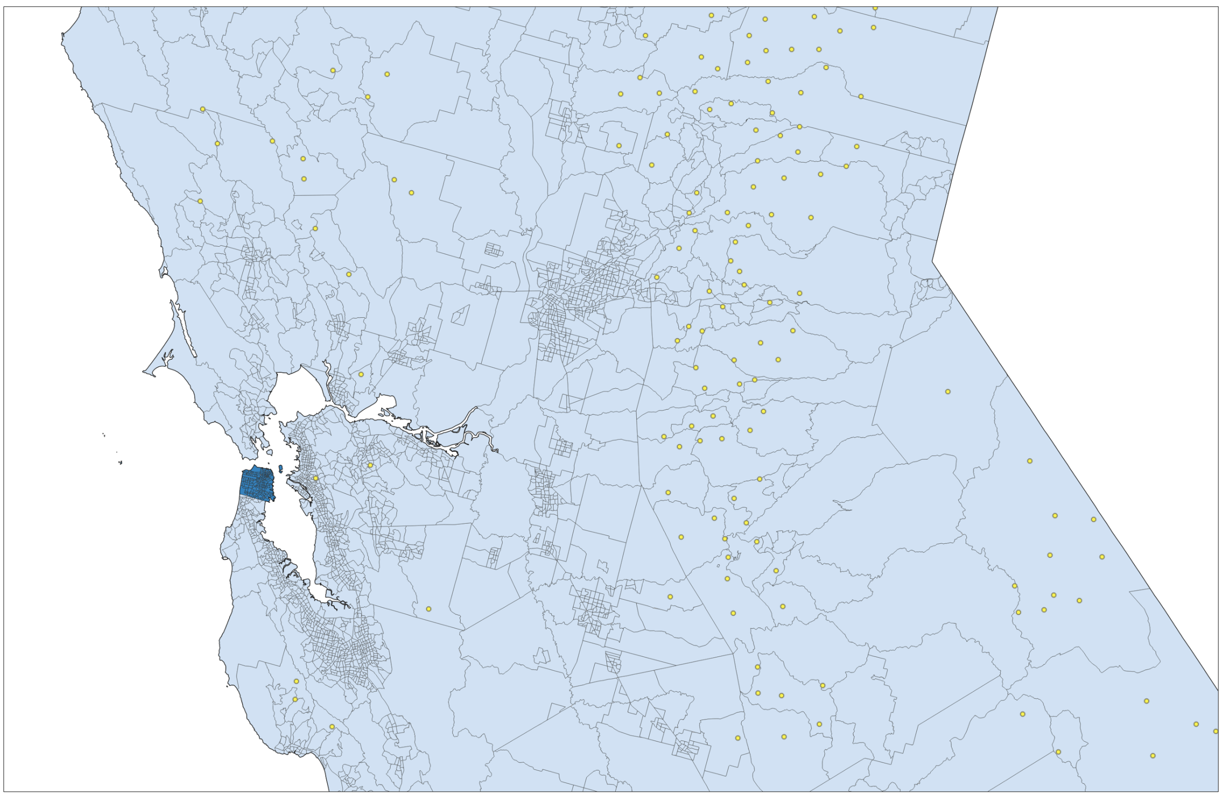
San Francisco's rise to ascendancy was in part due to its natural advantages, well beyond its spatial relation to areas with rich gold deposits. It was the most advantageous position for a Western port along the coast, with Portland, Oregon, becoming a second major point. More importantly, San Francisco was linked to the Western interior by water transportation through a series of rivers. This was the main and most important network of commerce in the West before the induction of railroads. Much like the state of California as a whole, San Francisco's population bloomed, from 1000 in 1848, to 36,000 in 1852, 56,000 in 1860, and 133,000 in 1868. One of the main values the port city grew into was as an iron foundry, supplying all of the mining frontiers of the far West with supplies, equipment, and machinery for extraction. Their foundries produced two-thirds of all the manufacturing in the state.

San Francisco also had other large industries in its early growth. By 1858, it had a large media empire, with 12 daily newspapers, 17 weeklies, 4 fortnightly journals, and 4 monthlies. Even by just 1850 the city had 7 banks and 80 manufacturing firms (Belich, 2009; Paul, 1974).

8.1.7 Denver, Colorado

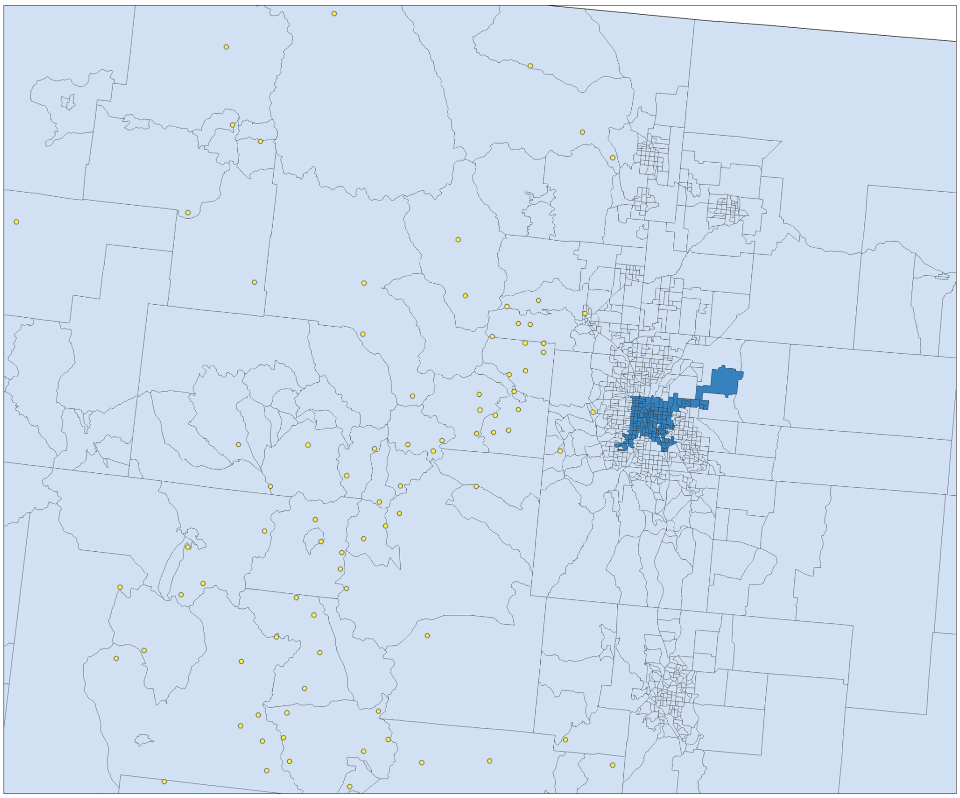
The majority of people who came to Colorado amidst the gold rush did so in hopes of making fortunes in the minefields, but some entrepreneurs saw other opportunities for wealth with this new population base. This included a class of town speculators who came out and looked to stake their claim in the nation's next bustling metropolis. One of the most successful among these capitalists in the domain of Colorado was William Larimer. Larimer chose the spot for his townsite as the east side of Cherry Creek, across the water from Auroria. He was so successful in his town placement because it functioned as an ideal transition point between the outer world and the gold mines. Larimer's town was the first to be reached by travelers coming from the East along either the Platte or Arkansas roads. It also sat along a major trade route from New Mexico to Fort Laramie. Most importantly, Larimer had made a deal with the major freighting company Russell, Majors, and Waddell that their freight route to the gold mines would go through this town (West, 1998).

Figure 10: San Francisco County and Mineral Districts/Bonanzas (2010)



Shows the census tracts of San Francisco county in 2010 (highlighted in dark blue) in relation to both mineral districts (yellow dots) and bonanzas (yellow stars).

Figure 11: Denver County and Mineral Districts/Bonanzas (2010)



Shows the census tracts of Denver county in 2010 (highlighted in dark blue) in relation to both mineral districts (yellow dots) and bonanzas (yellow stars).

The name of this town was Denver. It is of no surprise that this particular enterprise was so successful; as described above, Larimer positioned this fledgling town perfectly between advantages from the mineral lodes as well as the outer national economy. Denver was not situated directly atop the mineral districts, rather, it was placed at a threshold distance that allowed it to grow and expand while still benefiting from the natural resources. This particular anecdote is not unique, either. In the mineral rushes throughout the US West, cities flourished at these juncture points between mineral deposits and the outer economy, including Helena, Montana, Bellingham, Washington, and Carson City, Nevada, among many others.

8.2 Data Appendix

Variable	Source	Notes
Total Population Density (ln)	IPUMS NHGIS 2010 Federal Decennial Census (Manson, 2020)	The log value of population divided by land area at the census tract level.
Spatial Proximity	Calculated by author from Atlas of the Historical Geography of the United States (Paullin, 2013) and Historical Atlas of the American West (Beck and Haase, 1989)	Dummy indicator that takes a value of 1 for census tracts whose geometric centroids are within 15 miles of a mining district (or bonanzas in the alternate analysis) but don't contain one themselves.
Elevation Range (ln)	Terrain GIS Map (Nagi, 2014)	Log value of the range of elevation at the census tract level.
Mean Slope (ln)	Terrain GIS Map (Nagi, 2014)	Log value of the mean percent slope of land at the census tract level.
Total Housing Units (ln)	IPUMS NHGIS 2010 Federal Decennial Census (Manson, 2020)	Log value of total housing units at the census tract level.
Median Housing Rent (ln)	IPUMS NHGIS 2010 Federal Decennial Census (Manson, 2020)	Log value of median housing rent at the census tract level.
Median Housing Value (ln)	IPUMS NHGIS 2010 Federal Decennial Census (Manson, 2020)	Log value of median housing value at the census tract level.
Railroad Length (ln)	National Rail Network GIS Map (Wayland, 2020)	Log value of the total length of BNSF or Amtrak railroads in each census tract.
Interstate Length (ln)	USA Major Highways GIS Map (Esri, 2019)	Log value of the total length of interstates in each census tract.
Major Road Length (ln)	USA Major Highways GIS Map (Esri, 2019)	Log value of the total length of major roads in each census tract.
Highway Length (ln)	USA Major Highways GIS Map (Esri, 2019)	Log value of the total length of highways in each census tract.
Distance to Mining District/Bonanza (ln)	Calculated by author from Atlas of the Historical Geography of the United States (Paullin, 2013) and Historical Atlas of the American West (Beck and Haase, 1989)	Log value of the distance from the geometric centroid of each census tract and the nearest mineral district (or bonanza for the alternate analysis).
Distance to Big Airport (ln)	USA Airports GIS Map (Esri, 2019)	Log value of the distance from the geometric centroid of each census tract to the nearest big airport.
Distance to Medium Airport (ln)	USA Airports GIS Map (Esri, 2019)	Log value of the distance from the geometric centroid of each census tract to the nearest medium airport.
Distance to Small Airport (ln)	USA Airports GIS Map (Esri, 2019)	Log value of the distance from the geometric centroid of each census tract to the nearest small airport.
Distance to Ski Resort (ln)	Ski Resort Coordinate Data (Enzel, 1998)	Log value of the distance from the geometric centroid of each census tract to the nearest ski resort.
Distance to Coast (ln)	Calculated by author	Log value of the distance from the geometric centroid of each census tract to the nearest point on the West Coast.
Farm Output (ln)	USDA National Agricultural Statistics Service (USDA, 2020)	Log value of the dollar valuation of agricultural output at the county level.
Federal Land Share	USA Federal Lands GIS Map (Esri, 2020)	Percentage of land in each census tract that is owned by federal institutions.
1890 Gold Mining Variables	11th Census Report on Mineral Industries (Day, 1892)	Total gold output, valuation of ore gold output, valuation of placer gold output, number of mechanics employed, number of miners employed, total mine expenditure, valuation of mining machinery, proper mine valuation, mill valuation, total number of mines, railroad valuation, and plant valuation (all recorded at the 1890 county level).

8.3 Tables

Table 8. 2010 Summary Statistics: Partitioned by 15mi Proximity to Bonanza

	Within Proximity			Outside of Proximity			
	Census Tracts	Mean	Standard Deviation	Census Tracts	Mean	Standard Deviation	Significance of Difference in Means
Population Density (ln)	243	14.679	1.797	15,340	15.773	2.281	0.000
Distance from District	244	16,168	13,990	15,379	54,829	59,228	0.000
Distance from Ski Resort	244	255,467	624,533	15,379	171,080	432,639	0.724
Distance from West Coast	244	506,509	300,507	15,379	289,141	414,362	0.000
Housing Stock	244	3050	2156	15,339	12,392	14,119	0.000
Median Housing Rent	239	798	293	15,092	970	399	0.000
Median Housing Value	241	281,672	146,829	15,103	366,439	221,330	0.000
Distance to Big Airports	244	398,267	219,206	15,379	158,593	181,814	0.000
Distance to Small Airports	244	22,046	18,763	15,379	27,184	28,143	0.002
Distance to Medium Airports	244	373,552	211,090	15,379	226,920	234,902	0.000
Interstate Length	244	0.014	0.053	15,379	0.013	0.079	0.742
Major Road Length	244	0.032	0.108	15,379	0.036	0.193	0.588
Highway Length	244	0.017	0.053	15,379	0.021	0.127	0.000
BNSF Railroad Length	244	915	6228	15,379	1648	11,069	0.679
Amtrak Railroad Length	244	0	0	15,379	0.053	5.095	0.859
Elevation Range	244	375	496	15,379	196	423	0.000
Mean Slope	244	8.023	7.314	15,379	4.877	5.641	0.000
Farm Output	244	17,313	17,233	15,379	14,061	12,282	0.019
Federal Land Share	244	0.133	0.249	15,379	0.051	0.169	0.000

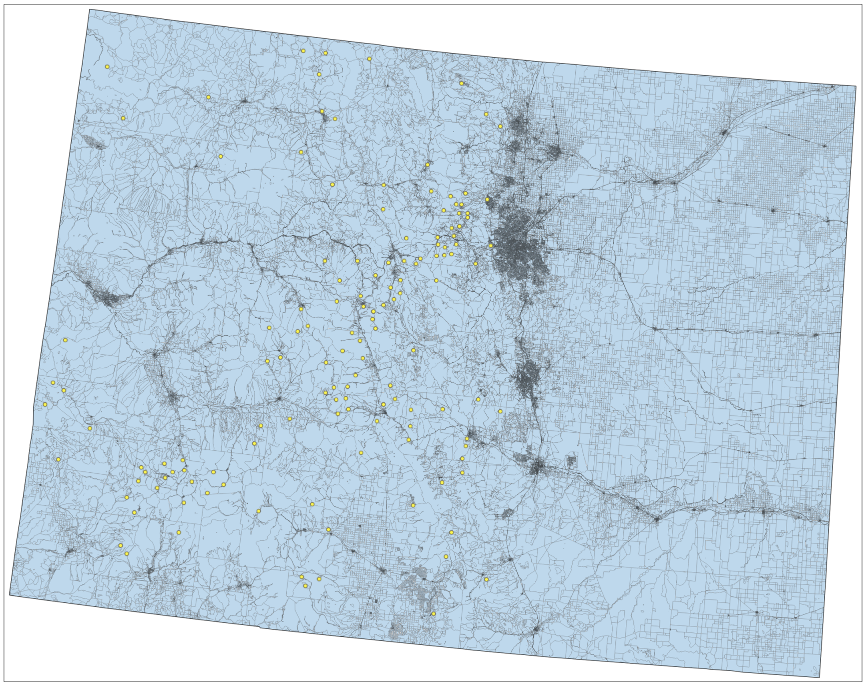
Notes: This table compares the 2010 summary statistics of the sample partitioned between census tracts whose centroid is within 15 miles of a bonanza and census tracts with centroids over 15 miles from a bonanza (Census tracts containing a bonanza are dropped from this partition). Columns 1-3 show the statistics for census tracts who geometric centroid is within 15 miles of bonanzas without containing a bonanza itself, while Columns 4-6 show the statistics for census tracts with a geometric centroid over 15 miles away from a bonanza. Column 7 displays the p-value for a hypothesis test on the difference in means between the two groups.

Table 9. 15 Mile Proximity Results (1900 Counties)

1900 Population Density	Baseline (1)	Geography/State (2)
Panel A: Mineral Districts		
Spatial Proximity	-1.348	3.000***
	(2.225)	(0.400)
Panel B: Bonanzas		
Spatial Proximity	1.306***	1.702**
	(0.380)	(0.781)
Sample Size	355	354

Notes: The regression implemented in the table follows from equation (1) in the text, which has (ln) population density as the dependent variable and the 15 mile spatial proximity dummy as the independent variable. The sample implemented is of all counties in the 11 state sample in 1900. The coefficients are OLS estimates. Column 1 conducts a baseline regression of this analysis while column 2 incorporates state-fixed effects and geographic controls, including (ln) mean slope, (ln) elevation range, and (ln) distance to West Coast. For more information on variable definitions, see the main text and data appendix. Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Figure 12: Colorado Blocks and Mineral Districts



Colorado Blocks and the historical gold mining districts in the state.
Blocks are from the 2010 Federal Census.

Table 10. 2010 Colorado Block Results (15mi)

Modern Population Density	Baseline	Geography/State
	(1)	(2)
Panel A: Mineral Districts		
Spatial Proximity	0.096***	0.489***
	(0.034)	(0.018)
Panel B: Bonanzas		
Spatial Proximity	-2.390***	-0.214***
	(0.158)	(0.071)
Sample Size	55,186	33,964

Notes: The regression implemented in the table follows from equation (1) in the text, which has (ln) population density as the dependent variable and the 15 mile spatial proximity dummy as the independent variable. The sample implemented is of all blocks in Colorado in 2010. The coefficients are OLS estimates. Column 1 conducts a baseline regression of this analysis while column 2 incorporates geographic controls, including (ln) mean slope and (ln) elevation range. For more information on variable definitions, see the main text and data appendix. Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 11. 1980 v. 2010 Census Tracts (15mi)

	(1) PopDense	(2) Distance
Panel A: Mineral Districts		
2010 Proximity	0.200***	-0.090***
	(0.015)	(0.009)
Sample Size	15,199	15,199
1980 Proximity	0.124***	-0.080***
	(0.021)	(0.014)
Sample Size	6,802	6,802
Panel B: Bonanzas		
2010 Proximity	0.228***	-0.123***
	(0.061)	(0.016)
Sample Size	15,199	15,199
1980 Proximity	-0.003	-0.059**
	(0.115)	(0.027)
Sample Size	6,802	6,802

Notes: The following table compares the effects of historical mining districts and bonanzas on 1980 and 2010 population density levels. To account for the incompleteness of 1980 census tracts, I include a dummy variable in the 2010 sample that indicates whether or not a 2010 census tract overlaps with a 1980 tract. Robust standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$