Stranded: The Effects of Inaccessible Public Land on Local Economies in the American West

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Abstract

Historical land disposal policies created a mosaic of land ownership that can limit access to public lands. We quantify the amount of “stranded” inaccessible public land in 400 counties across the western United States. We estimate the effects of public land on county rents and wages and diagnose the extent to which selection into public vs. private land may affect these estimates. Our results show that accessibility is crucial to understanding the effect of public land on local economies: on net, inaccessible public land is a disamenity to consumers that may raise or lower costs for firms, while accessible public land is an amenity to consumers that may be productive for firms.

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1. Introduction

Economists have long recognized that environmental conservation generates non-rival and non-excludable benefits, suggesting a role for government ownership of land to safeguard a variety of public uses that private landowners may under-supply, including recreation, open space, watershed and habitat protection, and other non-use values (Krutilla, 1967; Krutilla et al., 1983). Even when efficient, the allocation of land to public uses can be perceived as inequitable because the benefits of withholding land from private ownership are often enjoyed nationally (or even globally), whereas the costs are typically borne by local residents. Tension over public land ownership is especially salient in the western United States, where over 50% of the land is owned by federal and state governments (Loomis, 1993), and where disputes over management have resulted in armed confrontations between law enforcement and some users of public lands.¹

At the heart of controversies over public land ownership is the question: from the perspective of the local economy, are public lands an amenity or disamenity relative to private land? Public lands may generate consumption amenities if they give local residents better access to non-market goods (e.g., recreation, water quality) than would be provided by private lands. However, public land could be either an amenity or a disamenity for firms. On the one hand, public ownership may curtail the production of natural resources such as minerals and timber relative to private ownership (e.g., because of greater regulation). On the other hand, proximity to protected areas and recreational sites may benefit firms associated with the burgeoning outdoor recreation economy (Walls et al., 2020). If public lands are amenities for both consumers and firms, then the Roback (1982) model implies that equilibrium land rents would be higher in markets with more public land, whereas the effect on equilibrium wages is uncertain. If public lands are a net...
disamenity for firms, but an amenity for local residents, then more public land should decrease wages but have an ambiguous effect on land rents. Thus, how public lands affect local economic indicators such as rents and wages, and what this implies for amenities from public lands, is an empirical question.

The previous empirical literature on the local economic impacts of public land focuses on aggregate measures of public land abundance that do not account for key characteristics such as access. The federal land disposal policies of the 19th century created a mosaic of private and public lands that left significant areas of public land physically inaccessible to federal land managers and the public (Loomis, 1993; Libecap, 2018). Many tracts of public land cannot be accessed by road and so are effectively stranded, preventing resource development, recreation, fire prevention, and maintenance (General Accounting Office, 1992). Despite a growing awareness of the importance of access in the popular press and among policymakers, no previous studies have explicitly accounted for access when estimating the economic effects of public land.²

In this paper, we examine the effects of public land in the western U.S. on county average land values and per capita income. We develop a comprehensive measure of the area of physically inaccessible “stranded” public land for each county using GIS data on ownership, easements, and roads. We estimate that there are 6.02 million acres of stranded public lands in the eleven western states, representing 1.5% of all public lands available for public use.³ We provide the first estimates of the effects of public lands on local economies that explicitly account for access. We find negative effects of stranded public lands on land values: a 10 percent (0.07 percentage point) increase in the share of total county land that is stranded public land
decreases the average 2017 land value per acre in a county by 0.72%. Conversely, stranded land is associated with small increases in per capita income.

The majority of previous studies treat public land ownership in a county as an exogenous determinant of local economic indicators (e.g., Duffy-Deno (1998); Deller et al. (2001); Lewis et al. (2002); Pugliese et al. (2015)). Most western federal lands are a residual of 19th century Westward Expansion, when settlers were able to claim any land not previously reserved by the government (Loomis, 1993). Lands that were either unclaimed initially or repossessed by the government when homesteads failed form a large part of the federal lands now managed by the U.S. Forest Service (USFS) and Bureau of Land Management (BLM). Thus, the share of public land in a western county depends on the characteristics of land in the county because this determined which lands entered into and remained in private ownership. As a result, there is the potential for ownership measures to be correlated with unobserved determinants of local economic performance.

We address the potential endogeneity of ownership and access by controlling for a large set of land characteristics and by including fixed effects based on the USDA Natural Amenities Scale and U.S. EPA Ecoregion classification, thus providing a more plausible causal estimate of the effect of public ownership within geographically comparable areas. We also use the techniques suggested by Oster (2019) to assess the extent of potential bias due to selection on unobservables.

Finally, we identify each square mile of land that was part of a planned historical land grant to form instruments for present-day shares of stranded and non-stranded public land. The instrumental variables estimates are significantly larger than our preferred OLS estimates,
suggesting a 3.3% decrease in land value for a 10 percent (0.07 percentage point) increase in stranded land. However, we caution that these larger estimates are likely specific to the relatively small, fragmented tracts of public land associated with the historic land grants that provide the identifying variation in our instruments.

Our study offers new insights into the debate on the local economic impacts of public land. By differentiating between accessible and inaccessible public land, we can indirectly address the contribution of recreation to the amenities generated by public land. Whereas all public land potentially provides non-excludable public goods such as scenic views and existence values, only accessible land affords recreational opportunities. We ground our results in the theory of Roback (1982) to interpret the net effect of public lands with and without access. Within the Roback framework, our results imply that stranded, inaccessible public land is a disamenity for consumers, with an ambiguous impact on firms. In contrast, our results for accessible public lands suggest that these lands are an amenity for both consumers and firms, emphasizing the importance of accessibility in determining effects of public lands on local economies.

The paper proceeds as follows. In section 2, we review the literature on public land ownership and local economies. Section 3 provides additional institutional background on the origins of public lands in the western U.S. and details on the construction of our strandedness measure. Section 4 presents the conceptual framework for our econometric model and discusses our identification strategy. Section 5 presents our main empirical results along with a series of robustness checks. Section 6 provides discussion and interpretation of our results from the perspective of the Roback (1982) model. Section 7 concludes.
2. Literature Review

Roback (1982) provides the theoretical foundation for most empirical analyses of amenities and their impact on local economies. In Roback’s model with mobile labor and fixed land, wages and rents are determined in spatial equilibrium as functions of locally-provided amenities. Building on this insight, empirical studies such as Blomquist et al. (1988) and Albouy (2016) investigate the role of amenities in determining local equilibrium wages and rents, whereas other authors model population and employment as endogenously-determined variables (Greenwood and Hunt, 1984; Carlino and Mills, 1987). A number of studies use data on U.S. counties to estimate effects of amenities and other local factors on population, employment, and income (Clark and Hunter, 1992; Clark and Murphy, 1996; Deller et al., 2001).

The earliest studies of the local economic effects of public land ownership adopt the framework of Carlino and Mills (1987) to examine whether public land shares are significant determinants of county population and employment. Duffy-Deno (1998) finds that shares of total county land in the western U.S. managed by the National Park Service (NPS) or the USFS or designated as wilderness do not significantly affect local economic indicators. In a similar analysis, Duffy-Deno (1997) finds that state parks have a positive but relatively small effect on local economies.

Lewis et al. (2002) follow in the tradition of Greenwood and Hunt (1984) and estimate the effects of public land shares on employment growth and net migration rates in the northeastern U.S. They find that public conservation lands increase migration to a county and provide evidence that the effects come primarily from state and USFS lands. In a follow-up study, Lewis et al. (2003) find no effects of public lands on local wage growth. A recent study by Pugliese et
al. (2015) finds no significant effect of National Forest acreage on employment growth in the western U.S., but Rasker et al. (2013) find that areas of protected federal lands are positively associated with several income measures.

The studies referenced above find mixed evidence that public lands have significant effects on local economies. One explanation could be that the studies incorrectly assume public lands are exogenous determinants of local economic indicators. In reality, the process by which public lands in the western U.S. were established raises the possibility that county public land shares are endogenous to current economic performance. Jakus et al. (2017) find that federal lands are concentrated in counties that are more rugged, have less arable land, and have less potential for energy development.

Several recent studies address the potential endogeneity of federal lands protected under the Northwest Forest Plan (NWFP). Eichman et al. (2010) study the effects of the NWFP on employment growth and net migration rates in the northwestern U.S. The variables of interest are the county share of federal land set aside for habitat under the NWFP and the share still available for timber production. The authors instrument for these variables using ecological factors used to determine habitat set-asides under the NWFP (e.g., number of spotted owl nesting pairs). They find large negative effects of protected land shares on county employment growth, but no effects on net migration. In another study of the NWFP, Chen et al. (2016) measure the effects of proximity to protected federal lands on changes in median income, population, and property values, using community-level fixed effects and post-matching regression to address endogeneity concerns. The authors find positive and highly localized amenity effects of protected lands on community-level economic indicators. Finally, Frank (2018) uses difference-in-differences and
synthetic control methods to model effects of the NWFP on county-level employment in the wood products sector.

To our knowledge, no existing study of the economic effects of public land accounts for whether or not land is physically accessible to the public. Explicitly accounting for access can significantly improve our understanding of the effects of public lands by separately identifying effects of the potential amenities and disamenities associated with public land. Some of the hypotheses analyzed in the previous literature implicitly assume access (e.g., the effects of recreation and natural resource production) whereas others do not require access (e.g., scenic views and many ecosystem services). Hence, differentiating between accessible and inaccessible public land can offer new insights into the economic impacts of public lands.

3. Defining and Quantifying Stranded Land

Roughly 341 million acres of land in the eleven western States are managed by the BLM, USFS, NPS, Fish and Wildlife Service (FWS) and designated as publicly accessible for recreation.\textsuperscript{9} States manage an additional 42 million acres of public access land.\textsuperscript{10} These lands have varying levels of access—some are free, some require permits or entry fees—and compete to different degrees with other uses such as mineral development or timber extraction. Nevertheless, these lands are legally designated as accessible to the public and available for hiking, camping, and other forms of recreation.

Land that is legally designated as public access may actually be inaccessible to most of the public for two reasons. First, some public land is completely surrounded by private land on all sides and lacks connectivity to public roads. Second, many lands are in fragmented mosaics of
private and public land. These checkerboards impair access because it is not possible to “cross corners” without legally trespassing on private lands (General Accounting Office, 1992). Figure 1 depicts both forms of limited access, which we refer to as “stranded” land, in an example from Douglas County, Washington. Darker parcels are stranded because they lack road access. Parcel A is an example of a public inholding that is completely surrounded by private land. Parcel B is a parcel that is legally inaccessible because the public cannot cross corners from Parcel C, which does have road access.

[FIGURE 1 HERE]

In principle, both barriers to access could be resolved by an easement with the adjacent private landowner(s) to grant right-of-way across their land, usually via a designated trail. These easements are common throughout the West for securing access to public land and waters, but they usually require payment from public agencies to landowners (General Accounting Office, 1992). Moreover, easements become more costly to secure as land becomes increasingly stranded. Pure in-holdings that are farther from public roads would require crossing more and more private land, increasing the total cost of securing easements. Checkerboards of public and private land often involve many individual landowners, making contracting difficult (Fitzgerald, 2000).

Sources of Stranded Land

The spatial distribution of public land ownership in the western U.S. is more an accident of history than the result of careful resource management and planning. Land policy focused on disposal and privatization for most of the 19th century and originally most of the western U.S.
was intended for private ownership and opened for settlement (Hibbard, 1939; Gates, 1968; Libecap, 2018). Policy priorities slowly shifted towards preservation beginning with the first National Parks in the 1870s and Forest Preserves in the 1880s, and eventually culminated in the end of most homesteading under the Taylor Grazing Act in 1934 (Loomis, 1993).

The Homestead Act of 1862 set the terms for much of the settlement in the West, granting 160 acres for free to parties that made improvements to the land and occupied it for 5 years. Claimants could select any available land that had been surveyed and not previously set aside for another purpose. Much of the land managed by the USFS was set aside between 1890 and 1920 after the first wave of homesteading had passed through. Similarly, most land managed by the BLM is what was leftover and never claimed prior to the Taylor Grazing Act in 1934 (Loomis, 1993; Libecap, 2018). In some cases, homesteads failed and the land reverted back to the government. The result is public land scattered among private land holdings across much of the West.

The federal government’s policy for granting land to states is a second source of fragmented and inaccessible land in the West. The eleven western States received a total of 71 million acres from the federal government as grants to support funding for public education (Loomis, 1993). States were granted specific 1×1-mile sections of land within each township of the Public Land Survey System (e.g., sections 16 and 36), resulting in a scattered pattern of state land holdings (Hibbard, 1939; Gates, 1968; Loomis, 1993). As a result, most states own scattered square-mile sections that are often surrounded by private land, although they are sometimes adjacent to federally owned land.
The final and most significant source of stranded land is the system of railroad land grants, which comprised roughly 10% of the land privatized by the federal government (Loomis, 1993). The government subsidized the construction of seven transcontinental railroads beginning in the 1860s by granting land adjacent to the track as it was completed. In an effort to avoid monopoly control of valuable land by the railroad, grants were given to alternating square-mile sections in a 20 to 40-mile checkerboard along each of the land grant railroads.\textsuperscript{13} The government hoped to recoup its losses by selling the land it retained within the checkerboard at a “double minimum” price that was twice the going cash rate, but often the land did not sell (Hibbard, 1939; Paul, 2006).\textsuperscript{14} Because many of the federal sections were never purchased, these checkerboards of private and public land persist today in many places.

\textbf{Measuring Stranded Land}

We combine GIS data on public land ownership and easements from the Protected Areas Database of the United States (PAD-US) with data on public roads from the U.S. Census TIGER/Line shape-files to quantify the extent of stranded public land in each county in the eleven western States.\textsuperscript{15} We focus on land that is designated as public access and managed by a state government, the BLM, USFS, FWS, NPS, or Bureau of Reclamation (BOR).\textsuperscript{16} We aggregate the public land layers so that each contiguous unit of public land is a unique feature and then determine which of these land units is intersected by a public road or accessible via an easement across private land. From TIGER/Line roads data, we include all primary, secondary, local neighborhood, and rural roads; city streets; and vehicular (4wd) trails. Forest Service roads are retained, but private roads are excluded.
We call a tract of public access land “stranded” if it does not touch a public road or easement. After determining which larger tracts of public land lack direct or indirect road access, we disaggregate them into tracts managed by individual agencies (or states) and quantify the total acreage of stranded land by agency in each county in the eleven western States. Table 1 reports state-level totals of our estimates for total public access acres, stranded (inaccessible acres), and share of stranded land managed by the BLM, USFS, NPS, FWS, or states. The information presented in Table 1 and the underlying data represent the first systematic measure of access for public land in the academic literature.17

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Our approach, which estimates fine-scale differences in accessibility across a large area, may understate the number of stranded public acres for two reasons. First, landowners may attempt to restrict access to adjacent public lands by blocking roadways or other access points that show up in our data as unrestricted (Center for Western Priorities, 2013). Second, our approach treats land as accessible as long as it is in some way connected to another tract of public access land with road access. In practice, some areas that are indirectly accessible via other public landholdings may be so remote so as to be functionally inaccessible.

On the other hand, there are two reasons why our estimates may overstate actual stranded land. First, some public lands may have access via private roads that are in reality used by the public. Second, there may exist informal arrangements or prescriptive easements across private land that grant access to public lands but are not recorded in our data. While these caveats are important, we emphasize that our estimates are the first systematic attempt to quantify public access at the county level and for the western U.S. as a whole.
The Distribution of Stranded Land

We estimate that 6,019,305 acres of public access land in the West are inaccessible. Figure 2 depicts a map of western counties shaded by the total share of the county that is stranded public land. Darker counties have larger shares of stranded land. Strandedness varies substantially within and between states. The average share of county land that is stranded is 0.73%. Only seven counties have no stranded land, and some counties have stranded percentages as high as 10%.

[FIGURE 2 HERE]

Table 1 also reports the share of stranded land managed by each agency in each state. In most states, the majority of stranded land is managed by the BLM. Notable exceptions include Arizona and Washington, where most stranded land is owned by the state. The patterns in Table 1 illustrate the legacy of uncoordinated 19th century land policies. In contrast to the National Parks that were always intended for access, public land initially intended for other purposes—homesteads, railroad grants, or state trust lands—now faces barriers to accessibility.

We also calculate and report stranded land as a share of public land in each county. Figure A1 depicts the results, which reveal interesting contrasts to Figure 2. Some counties have a relatively large amount of stranded land despite the fact that the share of public land that is stranded is relatively low, owing mostly to the large federal land holdings in some western counties. 4.6% of public access land in the average county is inaccessible to the public. Some counties lack access to as much as 75% of their public lands.

4. Identifying the Economic Impact of Strandedness
Conceptual Framework

Our empirical estimation is based on the Roback (1982) model, which characterizes the equilibrium sorting of workers and firms. Each location in the model is a separate land and labor market with a fixed set of unpriced amenities. These amenities affect the utility of workers as well as the production costs of constant-returns-to-scale firms. In equilibrium, land rents and wages adjust to make mobile workers and firms indifferent to locations. Using Roback’s notation, the equilibrium conditions for each location are:

\[ V(w, r; s) = k \]  

\[ C(w, r; s) = 1 \]

where \( w \) is the wage rate, \( r \) is the land rent, \( s \) is the amenity level, \( k \) is the equilibrium utility level, and 1 is the normalized price of the firm’s output. The equilibrium conditions imply, respectively, that the utility of workers \( V \) and the marginal costs of firms \( C \) are equalized across local economies. The power of the Roback model is that it predicts how land rents and wages will differ between markets with different local amenities. In particular, the conditions in Equations 1 and 2 can be used to derive the following comparative statics results:

\[ \frac{dr}{ds} = \frac{1}{\Delta} (-V_w C_s + V_s C_w) \]  

\[ \frac{dw}{ds} = \frac{1}{\Delta} (-V_s C_r + C_s V_r) \]
where $\Delta > 0$ and $V_i$ and $C_i$ are partial derivatives of the indirect utility and cost functions with respect to the $i$th variable. In general, the marginal effect of the amenity on rents and wages is of ambiguous sign, as it depends on whether it increases or decrease the utility of workers (the sign of $V_s$) and whether it is productive or unproductive for firms (the sign of $C_s$).

The Roback model provides a useful framework for understanding the estimated effects of public lands on local economies. In our empirical application, we treat public lands within a county as an unpriced amenity (or disamenity) that affects the utility of residents and the productivity of firms in the respective county. Table A1 summarizes the four possible sets of comparative statics results from the Roback model, based on whether public land is an amenity for consumers ($V_s > 0$) and productive ($C_s < 0$) for firms. As discussed below, public lands can produce a variety of amenities, which can affect rents in different ways and may differentially affect the value of individual land parcels (e.g., if the effects are moderated by distance to public lands). We assume that counties define distinct land and labor markets, a designation that we acknowledge is imperfect, but argue is the best available alternative.

We measure the overall average effect of public lands on rents within a county by specifying the dependent variable as the county average farmland value per acre in our main empirical model. Farmland value proxies for the average price of undeveloped private land in the county. An advantage of farmland values is that they reflect not only current effects of public lands but also expected changes in future rents. There is evidence from previous studies that farmland value capitalizes the expected growth in rents from higher future demand for urbanization (Plantinga et al., 2002; Isgin and Forster, 2006) as well as benefits from proximity.
to recreation and natural amenities (Bastian et al., 2002; Wasson et al., 2013; Borchers et al., 2014).

Figure 3 illustrates the empirical approach. Panel (a) shows a county with only private land. The essence of our empirical strategy is to compare this county to otherwise identical counties with stranded and non-stranded public land to determine the effect on per-acre farmland value. The panels in Figure 3 are deliberately drawn to be the same size, as we control for total county area in the empirical model. However, because the dependent variable is defined as the total value of farmland divided by total farmland area, not total county area, our estimates capture amenity effects of public lands but not the acreage effect of a smaller private land base.

[FIGURE 3 HERE]

In Panel (b), a positive share of the county’s land base is in stranded public land, which for several reasons is likely to be a disamenity relative to private land. Although public access to private lands is often restricted, private lands may nevertheless offer more recreational opportunities to residents and visitors than stranded public lands. Regional managers from the USFS and BLM indicate that strandedness can be especially problematic for recreational activities such as hunting, hiking, and off-road vehicle use (General Accounting Office, 1992). Accordingly, a county with stranded public land would be less attractive to residents compared to an otherwise identical county with only private land. Holding wages constant, equilibrium rents would have to be lower to compensate residents for the disamenity. These effects are captured in farmland values because they capitalize rents from future uses of the land (e.g., housing). In contrast to these market-wide effects on farmland values, stranded public land could have offsetting positive effects on the value of adjacent land parcels if landowners are afforded
exclusive access to stranded lands for grazing, recreation, and other activities, or if they obtain easement payments from others seeking access. This could make stranded land a consumption (or a production) amenity for some landowners. More broadly, the amenities associated with open space may capitalize at a variety of spatial scales (Abbott and Klaiber, 2011). Thus, the net effect of stranded lands on rents that comes through the utility channel is of ambiguous sign.

Stranded public land may be unproductive for firms relative to private land. First, strandedness may limit traditional extractive resource uses such as timber harvest or oil and gas development. Although these activities may be allowed on stranded lands, resource developers would need to contract with adjacent private landowners for access. This is likely to raise costs for firms because these landowners do not benefit directly from production on adjacent public lands and may hold up development. As with disamenities, lower rents would be needed to induce firms to locate in the county with stranded public lands (holding wages constant). Second, stranded public lands may limit efficient use of private land (e.g., by preventing consolidation of land parcels), especially in checkerboarded areas. Third, stranded lands may be associated with higher rates of trespass by members of the public seeking access to public lands. This may lead to under-investment in the land itself due to less secure property rights, further dampening land values (Hornbeck, 2010).

The inability of public agencies to access and manage stranded land may also adversely affect landowners. The U.S. Supreme Court held in *Leo Sheep Co v. United States* in 1979 that government officials cannot utilize eminent domain to cross private land without permission, even to access land under their jurisdiction (Chavez, 1987). This makes management activities such as invasive species control and fire prevention difficult or impossible (General Accounting
Office, 1992). In all these cases, stranded land raises costs for firms and private landowners, putting downward pressure on farmland values.

The county in Panel (c) has a positive share of accessible public land (but no stranded land). There are numerous hedonic price studies that find a positive effect on housing value of proximity to federal lands such as National Forests (e.g., Stetler et al., 2010; Liu et al., 2013; Wasson et al., 2013). However, these studies typically measure the marginal effect of distance to federal lands within a given land market, which is not directly comparable with our approach. Rather, the comparison of the county in Panel (c) to the county in Panel (a) measures the land market effects of shifting land from private uses to accessible public uses. Several of the studies reviewed in Section 2 (e.g., Duffy-Deno (1998); Lewis et al. (2002); Eichman et al. (2010)) are designed in the same way, but measure effects on employment and migration rather than on rents.

As with stranded lands, we expect accessible public land to affect recreational opportunities of residents and the production costs of firms. When easily accessed, public lands are more likely to provide better recreational activities than private lands and, thus, be an amenity for residents and visitors. Finally, a comparison of the county in Panel (d) to the county in Panel (a) measures the combined effect of stranded public and accessible public lands on per-acre farmland values. We also estimate alternative models with per-capita income as the dependent variable. Given the estimated effects on farmland values and income, results from the Roback model provide insights into whether public lands are amenities or disamenities to residents and whether they are productive or unproductive for firms. We explore these implications of our results in Section 6.
For firms, costs of extractive resource uses may be higher on accessible public land than on private land due to greater regulation, but still lower than on stranded land because of easier access. Accessible public land may be a net amenity for firms if it forms the basis for a local recreation economy, as discussed in Walls et al. (2020). Moreover, the accessibility of public lands limits trespass on private lands and negative spillovers from unmanaged stranded lands. In sum, accessible public lands are more likely to be an amenity for consumers than stranded public lands. Whether accessible public lands raise costs for firms relative to private lands depends on the relative importance of resource extraction vs. recreation in the local economy.

Econometric Framework

We begin with the empirical model of farmland value per acre. Farmland value is from the Census of Agriculture and represents the average owner-estimated per-acre value of private farm land in a county. The use of county data has the advantage that we can measure effects of public lands that are common to all properties within the market (e.g., lower rents in an area that are the result of higher costs for natural resource extraction). As with all aggregate data, a disadvantage is that we cannot characterize within-county heterogeneity (e.g., we measure the average of spatially-varying effects of public lands). In addition, counties may not accurately represent distinct land and labor markets. Studies of urban amenities have used cities, or metropolitan statistical areas, as the definition of a market area (Roback, 1982; Albouy, 2016). This is not appropriate for this application because it would exclude rural areas where most of the stranded lands are found. In the end, counties are a convenient way to define markets because so much other data is reported at this scale. This likely explains why many previous studies have
used this designation (Carlino and Mills, 1987; Chay and Greenstone, 2005; Mendelsohn et al., 1994).

We focus on farmland value in 2017 for counties within the 11 western states. The estimating equation is:

\[
\ln(LandVal_{2017i}) = \beta_0 + \beta_1TotalAcres_i + \beta_2%NonStranded_i + \beta_3%Stranded_i + \tilde{X}_i\theta + \epsilon_i
\]

where \( i \) indexes counties, \( %NonStranded_i \) is the percentage of total county acres inaccessible public land, \( %Stranded_i \) is the percentage of total county acres in inaccessible public land, and \( \tilde{X}_i \) is a vector of geographic and economic controls. Although land value data are available for multiple years, we do not estimate Equation 5 using panel data because our public land measure is time-invariant, making county fixed effects infeasible. As described below, we also estimate a version of Equation 5 with per capita income as the dependent variable.

Equation 5 is directly linked to the conceptual model in Figure 3. The coefficient on accessible public land (\( \beta_2 \)) is estimated by comparing counties with different shares of private and accessible public land, holding all other factors constant (e.g., Panel (a) and Panel (c) in Figure 3), whereas the coefficient on stranded public land (\( \beta_3 \)) is estimated by comparing counties with different shares of private and stranded public land (e.g., Panel (a) and Panel (b)). We test several hypotheses. The first is whether the effects of public land are significantly different from zero: \( \beta_2 = 0, \beta_3 = 0 \). The second is whether the effects are different for stranded and non-stranded land: \( \beta_2 = \beta_3 \). The comparison of \( \beta_2 \) to \( \beta_3 \) provides insight about whether access has an impact on the amenities associated with public land. If access is important, then we predict \( \beta_2 \neq \beta_3 \).
There are several concerns for identifying $\beta_2$ and $\beta_3$ in Equation 5. First, the extent and configuration of public land in each county is likely endogenous to a variety of unobservable factors that influenced settlers’ decisions about where to establish homesteads as well as decisions about which lands to set aside as National Forest or Parks. In particular, the amenity value of public land itself may be confounded by the fact that public lands tend to be highly correlated with high elevations, rugged terrain, and other geographic features that are themselves consumption amenities.

Second, given some initial configuration of public land, there may be factors that affect the selection of land into stranded vs. non-stranded status. Whether or not a specific tract of public land is stranded ultimately comes down to ability to access that land by road. Hence, stranded land is likely endogenous to factors that affect the construction of public roads. Moreover, the accessibility of public land as measured in 2017 is endogenous to past attempts to improve public access through land exchanges and acquisitions, which were especially common in the 1990s (General Accounting Office, 2000). If the USFS or BLM targeted acquisitions in counties with relatively high gains from improving access, OLS estimates of $\beta_3$ will be biased toward zero. Selection on the potential benefits of access would lead to lower strandedness in high-value areas relative to areas that received few or no exchanges, as of 2017. Moreover, counties that received more land exchanges may have experienced an artificial increase in land values if land deeded to private parties was systematically worth more than the land conveyed to the government during the 1990s, as opponents of land exchanges have claimed (General Accounting Office, 2000).
We address these selection concerns using the approach developed by Oster (2019) to diagnose potential selection on unobservables. Specifically, Oster (2019) shows how to calculate the proportional degree of selection on unobservables that would have to be present for $\beta_2$ or $\beta_3$ to be zero, based on the selection on observables estimated from the data. For example, if Oster’s $\delta = 5$, this means that selection on unobservables would have to be five times as large as the selection on observables measured in the data for the true $\beta$ to be equal to zero. Hence, a larger value of $\delta$ implies that selection on unobservables is relatively less likely to undermine a statistically significant result because it would have to be larger relative to the measured selection in the data. We characterize the potential for different types of selection by estimating the Oster $\delta$ across the following sets of control variables:

**Geographic Controls**: elevation, ruggedness, soil quality, precipitation, and stream density. These controls are the most clearly exogenous, and are likely to strongly affect selection into public vs. private ownership. They may also affect the selection into stranded vs. non-stranded public land.

**1934 Economic Controls**: the total number of manufacturers in a county in 1934 and the percentage of the population living in urban areas in 1934. These controls capture how developed and populous a county was when the process of selection into private and public ownership became fixed with the passage of the Taylor Grazing Act in 1934. Importantly, these controls are measured prior to the subsequent development of major road infrastructure that could have affected which lands became stranded or non-stranded.
**New Deal Controls**: total spending in a county by the Public Works Administration, the Works Progress Administration, and the Public Roads Administration. These are direct measures of funding for building roads post-1934. Although much of this spending was driven by national political factors (Fishback et al., 2005), they may be endogenous to the existing distribution of public land.

**Modern Controls**: modern railroad miles, road density, and an indicator for the presence of a major urban area. These controls capture key determinants of land value that may be mechanically related to stranded land, though they are the least likely to be exogenous.

We also use several sets of spatial fixed effects to non-parametrically absorb unobserved differences between counties. In all models, we include fixed effects for the Amenity Index Ranking assigned to a county by the USDA. The USDA’s Amenity Ranking is based on a variety of factors including winter sun and temperature, summer temperatures and humidity, topography, and water area. Figure A5 in the Appendix depicts the Amenity Ranking for each county. We then report results that add either state fixed effects or state-by-Ecoregion fixed effects, using Level 2 Ecoregions obtained from the Environmental Protection Agency (EPA). According to EPA, ecoregions are regions where the type, quality, and quantity of environmental resources are generally similar and reflect “similarity in the mosaic of biotic, abiotic, terrestrial, and aquatic ecosystem components with humans being considered as part of the biota.”

Finally, we conduct a variety of robustness checks by including other individual control variables: Native American reservations, land exchanges, universities, net primary productivity, and irrigation. We then assess the potential for selection on unobservables across different sets of controls and fixed effects. We describe the data used to construct our controls in the next section.
Data for Covariates

For our geographic controls, we collect elevation data at 30x30 meter resolution from the National Elevation dataset and calculate the mean and standard deviation of elevation for each county. The latter serves as our measure of topographic roughness (Ascione et al., 2008). We also calculate average precipitation and temperature over 1980-2010 using the PRISM climate dataset. We use a soil quality index from Schaetzl et al. (2012) to calculate acres of high-quality land in each county.\(^{24}\) We use the National Hydrography Dataset to calculate the density of perennial streams in each county (stream miles per sq. mile).

For the 1934 economic controls, we obtain data on total population, urban population, and the number of manufacturers from the U.S. Census. For the New Deal controls, we obtained county-level measures of total infrastructure expenditures during the New Deal by the Public Works Administration, Works Progress Administration, and the Public Roads Administration (Fishback et al., 2005). For the modern controls, we obtain data on urban areas from the U.S. Census Tigerline shapefiles. We use the Tigerline transportation database to measure the miles of railroad track and roads in each county in 2017.

Additionally, we create an indicator for the presence of a Native American reservation in a county using U.S. Census Tigerline shapefiles. We also count the number of higher education institutions with at least 5,000 students using U.S. Census data. We measure the share of farmland irrigated in 2017 based on the Census of Agriculture, as well as average Net Primary Production (NPP).\(^{25}\) Finally, we estimate the total acreage of land that changed hands as a part of land exchanges or federal acquisition in each county using recently digitized patent data from the General Land Office.\(^{26}\) Appendix Table A2 provides summary statistics and variable definitions.
5. The Effects of Public Land on Land Values and Incomes

OLS Results for Land Values

Table 2 presents the results of estimating Equation 5 using OLS, where the dependent variable is the natural log of land value per acre in 2017. Panel A uses state fixed effects, while Panel B uses state-by-Ecoregion fixed effects. Both panels also include USDA Amenity Ranking fixed effects. Column 1 reports the baseline results with no controls, column 2 adds the geographic controls, column 3 adds the 1934 economic controls, column 4 adds the New Deal spending controls, and column 5 adds the modern controls. Standard errors are clustered by arbitrary 150 square-mile grid cells (N=62) and reported in parentheses.

Across all specifications in both panels, stranded land has a negative and statistically significant effect on land values. In Panel A, the effect of stranded land is much larger without the inclusion of controls, but falls by 25% after including just geographic controls and continues to fall as additional controls are included. The estimates are more stable to the inclusion of controls in Panel B, which includes the finer spatial fixed effects in all specifications.

Consistent with the coefficient stability, the Oster δ for stranded land is significantly larger in the Panel B specifications. In Panel A, selection on unobservables would need to be roughly twice the magnitude of selection on observables for the true effect of stranded land to be zero. In contrast, in Panel B, selection on unobservables would need too be 7 to 24 times as severe as selection on observables to fully explain the estimated effect of stranded land (depending upon the specification). The upshot is that including state-by-Ecoregion fixed effects substantially helps address potential selection on unobservables.
The results for non-stranded land in Table 2 also reveal important effects of including covariates. When no controls are included, the effect of non-stranded land on land values is not statistically distinguishable from zero. However, adding basic geographic controls causes the effect of non-stranded land to triple (Panel A) or double (Panel B) in magnitude. Across columns 2 through 5, which include various sets of controls, the effect of non-stranded public land is positive and statistically significant. The Oster δs for non-stranded land tell a slightly different story, peaking in column 2 with only geographic covariates and then declining as additional, potentially endogenous, controls are added. Consistent with this, the estimated effect of non-stranded land is less stable across specifications in Panel B than the effect of stranded land.

In summary, the selection of land into non-stranded status appears to be primarily driven by fixed, geographic features that can be readily controlled for. Adding additional economic controls actually reduces the confidence that the model is adequately addressing selection on unobservables, suggesting that these measures may be “bad controls” for non-stranded land. In contrast, the coefficient on stranded land is more stable to the inclusion of these controls, which reduce the scope for selection on unobservables. This implies that the “best” model may depend on whether one is primarily interested in the effect of stranded or non-stranded land. In the discussion that follows, we focus on the estimates in column 3, which produces the largest δ for stranded land.

The estimates in column 3 of Panel B indicate that a one percentage point increase in stranded land would lead to a 10 percent decrease in land value per acre. For context, the average county has 0.7 percent stranded land, with a standard deviation of 1.1 percentage points. Hence, a one percentage point increase in stranded land represents a more than doubling of the mean
amount of stranded land in a county. Mean farm value per acre in 2017 was $4,490, with a standard deviation of $7,377. Hence, a one standard deviation increase in stranded land leads to a decrease in land value of roughly $4,490 \times 1.1 \times 0.0997 \approx 490$ per acre, or about 1/14th of the standard deviation in land value.

Turning to the effect of non-stranded land, column 3 of Panel B in Table 2 indicates that a one percentage point increase in non-stranded land leads to a 0.8% increase in land value per acre. The average county in our sample is 41% non-stranded land, with a standard deviation of 27 percentage points. For non-stranded land, a one standard deviation increase would lead to an increase in land value of $27 \times 0.00766 \times 4,490 \approx 930$ per acre, which is about 1/7 of the standard deviation in land value. Ultimately, it is difficult to interpret these effects without also understanding the impact of public land on wages, which we turn to next.

**OLS Results for Per Capita Income**

The Roback (1982) model implies that equilibrium wages, like land rents, are a function of local amenities. Uncovering the effect of public land on wages can help us distinguish among the possible scenarios described in Table A1 and draw conclusions about the net welfare effects of public land for both consumers and firms.

Table 3 presents the results of estimating Equation 5 using OLS, where the dependent variable is the natural log of per capita income in 2017. The structure of the table is analogous to Table 2. The results reveal starkly different patterns than the land value results. To begin with, the effect of stranded land is positive across all specifications and statistically significant in five (\(\alpha = 0.05\)) and nine (\(\alpha = 0.10\)) specifications. The coefficients are also fairly stable across the
specifications that include controls in columns 2–5, and across both sets of fixed effects. Finally, the Oster δs in Panel B suggest that selection on unobservables would have to be anywhere from 4.4 to 59 times the selection on observables for the effect of stranded land to be zero.

In contrast, the effect of non-stranded land is extremely small in magnitude and never statistically significant. Unsurprisingly, the Oster δs for non-stranded land are also quite small. Taken together, the results in Table 3 provide fairly clear evidence that there is not a relationship between non-stranded land and per-capita income at the county level.

Turning to magnitudes, the estimates in column 3 of Panel B of Table 3 indicate that a one percentage point increase in stranded land is associated with a 1.75% increase in per capita income. The average per capita income across our sample of counties is $27,664 with a standard deviation of $7,212. Hence, a one standard deviation increase in stranded land (1.1 percentage points), would imply an increase in income of $1.1 \times 0.0175 \times 27,664 \approx 530$ per capita, roughly 1/13th of the standard deviation in income. Before interpreting these coefficients in the context of the Roback (1982) model, we first assess the robustness of our core results and provide estimates obtained from an alternative identification strategy.

**Robustness of OLS Results**

Table A3 presents a series of robustness checks for the effect of stranded and non-stranded land on land values. Each column adds a potential confounding variable individually, and the final column includes all of the variables in combination. All models include all four sets of primary controls (geographic, 1934 economic, New Deal spending, and modern) as well as state-by-Ecoregion and USDA Amenity Ranking fixed effects.
Column 1 includes an indicator for whether there is a federally recognized Native American reservation in a portion of county, as incomes and land values tend to be lower on reservations (Leonard et al., 2020). Column 2 includes the percentage of land in a county that was part of a federal land exchange, a measure of concentrated attempts to reduce stranded land. Column 3 includes the number universities in a county with over 5,000 students because the economic development prospects may be fundamentally different in “university towns” in rural parts of the Western United States. Column 4 includes a control for Net Primary Production, a measure of agricultural suitability that could impact both land values and incomes. Finally, column 5 includes a control for the percentage of farmland in a county that is irrigated, which could also affect farm values.

Across all specifications, the effect of stranded land on land values remains negative and statistically significant. The estimates in columns 1–3 are very similar in magnitude to those in Table 2. The agricultural controls that are included in columns 4–6 do reduce the estimated impact of stranded land somewhat, though the magnitude of the Oster δs across these columns suggest that the scope for selection on unobservables is minimized when the agricultural controls, which may be endogenous, are not included. The estimated effect of non-stranded land on land values is also robust to the inclusion of the various controls, and is quite similar in magnitude to the estimates in Table 2.

Table A4 presents the robustness results for per capita income. As with land values, the effect of stranded land on per capita income is robust to the inclusion of the various controls, and the magnitudes are fairly stable across all six specifications. The estimated effects for non-stranded land remain small and statistically insignificant in 3 of 5 specifications, but including
the control for irrigation leads to a marginally significant positive coefficient on non-stranded land.

**Instrumental Variables**

An alternative approach is to instrument for the %NonStranded and %Stranded variables in Equation 5. To do this, we develop several instruments that measure the extent and distribution of public land based on pre-determined spatial variation in the original land grants to the transcontinental railroads and to states. The intuition behind our approach is to use historical variation in the *planned* land grant policies as a source of identifying variation in the modern distribution of public land. The combination of planned land grants to railroads and states leads to modern fragmentation in public lands that is pre-determined with respect to subsequent patterns of settlement and deviations from the policies as originally designed.

We create several county-level variables summarizing potential sources of strandedness. First, we calculate the total distance of land grant and checkerboard edges in a county, denoted $GrantBorders_i$. For instance, each square-mile section of state land that is not contiguous with any other public land adds four miles (6,437 meters) of land grant edges. Second, we calculate the share of county land that was comprised of land grants or retained portions of the railroad checkerboards ($%Grants_i$). Third, we create a measure of land-grant fragmentation based on the ratio of the perimeter-to-area ratio of planned public land grants in a county to the potential minimum perimeter-to-area ratio if all public land in the county was contiguous ($Fragmentation_i$).

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These three variables capture the overall extent and fragmentation of land exposed to spatially random designation. These measures should mechanically increase the amount of accessible and inaccessible land in a county because each additional parcel of checkerboarded land contributes to the total amount of public land, while the degree of fragmentation in the retained lands also drives modern access problems. Details on the development of our instruments are provided in the Appendix.

Table A5 presents the instrumental variables results for the land value (Panel A) and per capita income (Panel B) models specified in Equations A1 through A3. Because we have multiple endogenous regressors and multiple instruments, we estimate all models using Limited-Information Maximum Likelihood rather than Generalized Method of Moments. All models include state-by-Ecoregion and USDA Amenity Rank fixed effects. The different sets of controls are added sequentially as in Table 2. We report the partial F statistics for both stranded and non-stranded land in Table A5, and Table A6 provides the full first-stage results.

The estimates in Panel A of Table A5 indicate substantially larger coefficients on stranded land than in the OLS estimates. The estimates in column 3, for instance, imply that a one percentage point increase in stranded land is associated with a 47% decrease in land value per acre. These results are also much more sensitive to the different sets of controls than the OLS results. For non-stranded land, the IV estimates are negative and statistically significant across all specifications, in contrast to the positive estimates for non-stranded land in Table 2. The column 3 results suggest that a one percentage point increase in non-stranded land leads to a 3% decrease in land value per acre in a county. Turning to the per capita income estimates in Panel B, we find a negative and marginally significant effect of stranded land on per capita income (in
contrast to the positive effects in Table 3). For non-stranded land, we also find a negative and marginally significant effect (in contrast to null effects in Table 3).

Ultimately, the OLS estimates are our preferred results for two reasons. First, as we discuss in the Appendix (where we interpret the IV diagnostic tests reported in Table A5), our IV estimates may be subject to weak instrument problems. Second, differences between the OLS and IV estimates may be driven by crucial differences in the identifying variation in public land that underlies each approach. The instrumental variables estimator delivers a local average treatment effect (LATE) based on the identifying variation in the instruments. That is, we are identifying the effect of stranded land that is caused specifically by checkerboarding from historic land grant policies. That this can produce an especially severe form of strandedness may explain why the IV estimates are larger than the OLS estimates. It could also explain the sign changes. Even when it is accessible, fragmented public land is much less likely to support recreation or large-scale production, which could explain the negative impacts of non-stranded land on land values and income. Therefore, while we think the IV results help to inform the different drivers of the spatial distribution of public land, they may be less useful for quantifying the overall average effect of public land on local economies.

6. Public Land, Amenities, and Productivity

Given our preferred estimates for land values and per-capita income (column 3, Panel B in Tables 2 and 3), we can use the results from Roback (1982) summarized in Table A1 to gain insights into whether public lands are amenities or disamenities for residents and firms relative to private lands. For stranded public lands, we find negative effects on land values and small, marginally significant positive effects on per-capita income, which is most consistent with
stranded lands being a consumption disamenity that is unproductive for firms. In this case, \( V_s < 0 \) and \( C_s > 0 \), and Equations 3 and 4 imply \( \frac{dr}{ds} < 0 \) and \( \frac{dw}{ds} \geq 0 \), consistent with our results. We cannot rule out the possibility that stranded lands are a disamenity for consumers but productive for firms (from Table A1, this obtains when \( \frac{dr}{ds} \leq 0 \) and \( \frac{dw}{ds} > 0 \)), although the evidence for this is less compelling because the positive coefficient associated with \( \frac{dw}{ds} \) is only marginally significant. However, our results make clear that stranded lands are not a consumption amenity, as this requires effects on rents and wages that we do not find. Therefore, the most plausible interpretation of our results is that stranded land is a disamenity for consumers and firms, relative to private land.

Our results for accessible public lands reveal small but positive and significant effects on land values, and insignificant effects on income. In the context of the Roback model, these results are most consistent with accessible public lands being a consumption amenity and productive for firms (Table A1). This may be because accessible lands offer more opportunities for recreation and natural resource production than stranded lands. Nevertheless, the magnitude of the effects is small relative to the negative effects of stranded lands. Our results allow us to rule out the possibility that accessible public lands are a disamenity to consumers and costly to firms \((V_s < 0 \text{ and } C_s > 0)\) because that scenario implies a negative effect of public land on land values, which we can statistically reject.

The comparison of the implied amenity affects between stranded vs. accessible public land underscores important differences in the impact of each on local economies. Specifically, we can conclude from our results that stranded land is a consumption disamenity, and the evidence is most consistent with this amenity raising costs for firms. In contrast, our results
imply that accessible public land is most likely a consumption amenity for consumers that lowers costs for firms. Hence, future work that explores the impact of public land on local economies should be careful to differentiate between accessible and inaccessible land.

7. Conclusion

Controversy over public lands in the western U.S. often stems from the perception that benefits are dispersed nationally, but costs are concentrated locally. This paper examines an issue at the heart of public land debates: the effects of public lands on local economies. Relative to earlier literature, a key innovation is to estimate the extent and economic impact of inaccessible “stranded” public lands that were created by 19th century land disposal policies. Strandedness has long been of concern to agency managers, recreation advocates and legal scholars, but has not as yet received a systematic treatment from economists (Chavez, 1987; General Accounting Office, 1992; Paul, 2006; Center for Western Priorities, 2013). We quantify strandedness for every county in the American West and find that about 1.5% of public land in the region is stranded, most of it managed by the BLM, USFS, and state governments.

We estimate the effect of both stranded and non-stranded public lands on county land values and per-capita income. Our results indicate that, relative to private land, accessible public land has limited effects on local economies, a finding that is consistent with earlier studies. Our key finding is that the effect of public land depends critically on whether or not that land is accessible. Inaccessible public land has robust negative effect on private farmland values, amounting to a 0.72% county-wide reduction in land value per acre for a 10% increase in the mean county share of stranded public land. The effect of inaccessible public land on incomes is much smaller, but positive.
We also find significant differences in the effects of stranded and accessible public lands on land values. This has two important implications. First, it suggests that the value of public land has changed since the designation of federal and state lands. The principal intent of the federal land disposal policies was to transfer land to homesteaders, railroads, and other private interests. Lands that remained in or reverted back to the public domain were likely to have been less productive than lands that were claimed by private owners (Jakus et al., 2017). If the productivity of public lands had remained the same over time, we would not expect any differences in their effects on modern day land values: if private parties did not want to claim these lands before 1935, it should not matter whether or not they are accessible today. However, recreational use of federal lands has increased significantly over time and is expected to grow more in the future (White et al., 2016), providing one reason why accessible public lands may be valued differently from stranded lands today. Second, accessible public lands may provide some offsetting amenities not supplied by stranded lands. The negative effect of stranded lands on land values (combined with the positive effect on income) suggests these lands are a consumption disamenity. However, if some amenities are provided by accessible public lands (e.g., recreational opportunities and local businesses that support this), the negative effects of public lands may be offset, which is consistent with our finding of small positive effects of accessible public lands on consumer amenities.

Our results imply potential benefits from consolidating fragmented public and private landholdings. Although our findings do not indicate large gains to local economies from privatizing accessible public land, they do suggest value from reducing the extent of stranded land, either by eliminating (e.g., privatizing) it or increasing its accessibility. This can be achieved through exchanges of stranded public parcels for private parcels that are contiguous.
with accessible public lands, or through purchases of private parcels that increase accessibility. In the past, land exchanges have been criticized for benefiting local landowners at the expense of the public (General Accounting Office, 2000), but our finding that stranded lands depress the local economy suggests that the beneficiaries of consolidation are not limited to landowners adjacent to public lands. Additional research is needed to better understand how the effects of stranded public lands vary over space, both within and between distinct land markets. One approach would be to employ parcel-level price data to identify distance-mediated effects of stranded lands within individual land markets.
Acknowledgements

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References


### Table 1: Stranded Land by State and Agency

<table>
<thead>
<tr>
<th>State</th>
<th>Public Access Acres</th>
<th>Stranded Acres</th>
<th>% BLM</th>
<th>% USFS</th>
<th>% NPS</th>
<th>% FWS</th>
<th>% State Land</th>
</tr>
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<tbody>
<tr>
<td>Arizona</td>
<td>36,856,477</td>
<td>533,452</td>
<td>17.3</td>
<td>2.4</td>
<td>0.06</td>
<td>0.001</td>
<td>80.2</td>
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<tr>
<td>California</td>
<td>46,937,725</td>
<td>677,609</td>
<td>57.5</td>
<td>20.2</td>
<td>0.5</td>
<td>5.6</td>
<td>16.1</td>
</tr>
<tr>
<td>Colorado</td>
<td>24,774,784</td>
<td>201,447</td>
<td>71.2</td>
<td>17.7</td>
<td>1.3</td>
<td>0.1</td>
<td>9.6</td>
</tr>
<tr>
<td>Idaho</td>
<td>33,076,207</td>
<td>162,613</td>
<td>76.5</td>
<td>10.8</td>
<td>0</td>
<td>1.6</td>
<td>10.2</td>
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<tr>
<td>Montana</td>
<td>32,636,509</td>
<td>1,913,156</td>
<td>47</td>
<td>1.9</td>
<td>0.01</td>
<td>0.3</td>
<td>50.7</td>
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<tr>
<td>Nevada</td>
<td>56,615,729</td>
<td>707,448</td>
<td>97.3</td>
<td>0.5</td>
<td>0.001</td>
<td>1.3</td>
<td>0.9</td>
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<tr>
<td>New Mexico</td>
<td>32,522,370</td>
<td>636,337</td>
<td>32.8</td>
<td>0.7</td>
<td>0.2</td>
<td>0.1</td>
<td>66.2</td>
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<td>Oregon</td>
<td>34,158,255</td>
<td>271,729</td>
<td>83.4</td>
<td>3.7</td>
<td>0.001</td>
<td>2.1</td>
<td>10.9</td>
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<tr>
<td>Utah</td>
<td>37,124,598</td>
<td>211,999</td>
<td>75.2</td>
<td>3.8</td>
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<td>0.1</td>
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<tr>
<td>Washington</td>
<td>15,662,520</td>
<td>252,577</td>
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<td>0.09</td>
<td>2.2</td>
<td>72.6</td>
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<tr>
<td>Wyoming</td>
<td>32,891,162</td>
<td>799,731</td>
<td>67.5</td>
<td>2.7</td>
<td>0.01</td>
<td>0.02</td>
<td>29.7</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>383,256,394</strong></td>
<td><strong>6,019,305</strong></td>
<td>55.3</td>
<td>3.7</td>
<td>0.1</td>
<td>0.1</td>
<td>40.1</td>
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</table>

**Notes:** This table reports the total acreage of publicly owned land designated as open for public access in each state based on the Protected Areas Database of the United States. Land designated as “Open Access” or “Restricted Access” (requires a fee and/or permit) is included as public access. Of this land designated for access, we report how many acres are legally inaccessible via road (directly and indirectly). The percentages indicate what share of these “stranded” acres are managed by each agency in each state. Our calculations also include land managed by the Bureau of Reclamation, which we omit from the agency breakdowns for brevity.
Table 2: OLS Estimates of the Effect of Public Land on Land Values

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
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<tr>
<td><em>Y = ln(Land Value per Acre)</em></td>
<td></td>
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<tr>
<td><strong>Panel A: State Fixed Effects</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>% Stranded</td>
<td>-0.135***</td>
<td>-0.101**</td>
<td>-0.103**</td>
<td>-0.0967**</td>
<td>-0.0787**</td>
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<tr>
<td></td>
<td>(0.0486)</td>
<td>(0.0433)</td>
<td>(0.0405)</td>
<td>(0.0405)</td>
<td>(0.0380)</td>
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<tr>
<td>% Non-Stranded</td>
<td>0.0204</td>
<td>0.006658***</td>
<td>0.00849***</td>
<td>0.00871***</td>
<td>0.0104***</td>
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<td></td>
<td>(0.00247)</td>
<td>(0.00234)</td>
<td>(0.00207)</td>
<td>(0.00188)</td>
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<tr>
<td>Adjusted R-Squared</td>
<td>0.546</td>
<td>0.602</td>
<td>0.664</td>
<td>0.674</td>
<td>0.715</td>
</tr>
<tr>
<td># Fixed Effects</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Oster (2019) δ, % Stranded</td>
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<td>2.766</td>
<td>2.473</td>
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<td></td>
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<tr>
<td></td>
<td>(0.00244)</td>
<td>(0.00244)</td>
<td>(0.00220)</td>
<td>(0.00122)</td>
<td>(0.00225)</td>
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<td><strong>Panel B: State-by-Ecoregion Fixed Effects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Stranded</td>
<td>-0.0860**</td>
<td>-0.0871**</td>
<td>-0.0997***</td>
<td>-0.0970**</td>
<td>-0.0819**</td>
</tr>
<tr>
<td></td>
<td>(0.0393)</td>
<td>(0.0354)</td>
<td>(0.0364)</td>
<td>(0.0371)</td>
<td>(0.0370)</td>
</tr>
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<td>% Non-Stranded</td>
<td>0.00216</td>
<td>0.00511**</td>
<td>0.00766***</td>
<td>0.00779***</td>
<td>0.00998***</td>
</tr>
<tr>
<td></td>
<td>(0.00244)</td>
<td>(0.00244)</td>
<td>(0.00220)</td>
<td>(0.00122)</td>
<td>(0.00225)</td>
</tr>
<tr>
<td>Adjusted R-Squared</td>
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<td>0.651</td>
<td>0.697</td>
<td>0.704</td>
<td>0.741</td>
</tr>
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<td>39</td>
<td>39</td>
<td>39</td>
</tr>
<tr>
<td>Oster (2019) δ, % Stranded</td>
<td>7.000</td>
<td>24.56</td>
<td>18.57</td>
<td>7.594</td>
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</tr>
<tr>
<td></td>
<td>(0.00244)</td>
<td>(0.00244)</td>
<td>(0.00220)</td>
<td>(0.00122)</td>
<td>(0.00225)</td>
</tr>
<tr>
<td>Geographic Controls</td>
<td>ü</td>
<td>ü</td>
<td>ü</td>
<td>ü</td>
<td></td>
</tr>
<tr>
<td>1934 Economic Controls</td>
<td>ü</td>
<td>ü</td>
<td>ü</td>
<td>ü</td>
<td></td>
</tr>
<tr>
<td>New Deal Controls</td>
<td>ü</td>
<td>ü</td>
<td>ü</td>
<td>ü</td>
<td></td>
</tr>
<tr>
<td>Modern Controls</td>
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<td>ü</td>
<td>ü</td>
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</tr>
<tr>
<td>Observations</td>
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</table>

Notes: This table presents estimates for the effect of stranded and non-stranded land on county average land values obtained by estimating the model in Equation 5. Geographic controls include average elevation, topographic ruggedness, soil quality, average precipitation, and stream density. 1934 economic controls include the number of manufacturing firms and the percentage of the population living in urban areas. New Deal controls include spending by the Works Progress Administration, the Public Roads Administration, and the Public Works Administration (included separately). Modern controls include road density, total miles of railroad track, and an indicator for whether a county has a major urban area. All models include fixed effects for a county’s ranking in the USDA’s six-point amenity index. Standard errors are clustered by arbitrary 150-sq. mi. grid cells (N = 62) and reported in parentheses.
Table 3: OLS Estimates of the Effect of Public Land on Per Capita Income

\[ Y = \ln(\text{Per Capita Income}) \]

<table>
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<tr>
<th></th>
<th>(1)</th>
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<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
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<td><strong>Panel A: State Fixed Effects</strong></td>
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<tr>
<td>% Stranded</td>
<td>0.0170*</td>
<td>0.0224**</td>
<td>0.0223**</td>
<td>0.0230**</td>
<td>0.0273***</td>
</tr>
<tr>
<td></td>
<td>(0.00969)</td>
<td>(0.0103)</td>
<td>(0.0101)</td>
<td>(0.0101)</td>
<td>(0.00972)</td>
</tr>
<tr>
<td>% Non-Stranded</td>
<td>0.000582</td>
<td>0.000751</td>
<td>0.00103</td>
<td>0.00104</td>
<td>0.00119</td>
</tr>
<tr>
<td></td>
<td>(0.000662)</td>
<td>(0.000880)</td>
<td>(0.000858)</td>
<td>(0.000876)</td>
<td>(0.000865)</td>
</tr>
<tr>
<td>Adjusted R-Squared</td>
<td>0.254</td>
<td>0.266</td>
<td>0.293</td>
<td>0.289</td>
<td>0.323</td>
</tr>
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<td>16</td>
<td>16</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Oster (2019) (\delta), % Stranded</td>
<td>-1.263</td>
<td>-2.566</td>
<td>-2.488</td>
<td>-2.657</td>
<td></td>
</tr>
<tr>
<td></td>
<td>-8.586</td>
<td>-3.001</td>
<td>-3.091</td>
<td>-3.389</td>
<td></td>
</tr>
<tr>
<td><strong>Panel B: State-by-Ecoregion Fixed Effects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Stranded</td>
<td>0.0170</td>
<td>0.0198*</td>
<td>0.0175*</td>
<td>0.0176*</td>
<td>0.0219**</td>
</tr>
<tr>
<td></td>
<td>(0.0105)</td>
<td>(0.0111)</td>
<td>(0.0102)</td>
<td>(0.0101)</td>
<td>(0.00986)</td>
</tr>
<tr>
<td>% Non-Stranded</td>
<td>0.000236</td>
<td>0.000547</td>
<td>0.00101</td>
<td>0.00101</td>
<td>0.00107</td>
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<tr>
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<td>(0.000762)</td>
<td>(0.000911)</td>
<td>(0.000901)</td>
<td>(0.000916)</td>
<td>(0.000903)</td>
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<tr>
<td>Adjusted R-Squared</td>
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<td>0.252</td>
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<td>39</td>
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<td>39</td>
</tr>
<tr>
<td>Oster (2019) (\delta), % Stranded</td>
<td>-4.478</td>
<td>58.88</td>
<td>62.49</td>
<td>-8.926</td>
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<td></td>
<td>-0.671</td>
<td>-1.250</td>
<td>-1.266</td>
<td>-1.752</td>
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<tr>
<td>Geographic Controls</td>
<td>ü</td>
<td>ü</td>
<td>ü</td>
<td>ü</td>
<td>ü</td>
</tr>
<tr>
<td>1934 Economic Controls</td>
<td>ü</td>
<td>ü</td>
<td>ü</td>
<td>ü</td>
<td>ü</td>
</tr>
<tr>
<td>New Deal Controls</td>
<td>ü</td>
<td>ü</td>
<td>ü</td>
<td>ü</td>
<td>ü</td>
</tr>
<tr>
<td>Modern Controls</td>
<td>ü</td>
<td>ü</td>
<td>ü</td>
<td>ü</td>
<td>ü</td>
</tr>
<tr>
<td><strong>Notes:</strong> This table presents estimates for the effect of stranded and non-stranded land on per capita income obtained by estimating the model in Equation 5. Geographic controls include average elevation, topographic ruggedness, soil quality, average precipitation, and stream density. 1934 economic controls include the number of manufacturing firms and the percentage of the population living in urban areas. New Deal controls include spending by the Works Progress Administration, the Public Roads Administration, and the Public Works Administration (included separately). Modern controls include road density, total miles of railroad track, and an indicator for whether a county has a major urban area. All models include fixed effects for a county’s ranking in the USDA’s six-point amenity index. Standard errors are clustered by arbitrary 150-sq. mi. grid cells (N = 62) and reported in parentheses.</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
Figure 1: Examples of Stranded Land

Notes: This figure depicts private and public land in Douglas County, Washington. The unshaded white areas are privately owned land, while the shaded parcels are public lands meant to be accessible to the public. Tan (lighter) shading indicates public land that has road access and is therefore accessible. Red (darker) shading represents stranded public land that lacks road access. Parcel C is accessible. Parcel A is inaccessible because it is completely surrounded by private land with no road access. Parcel B is inaccessible because, although it touches parcel C, “crossing corners” constitutes trespass. Public land files obtained from the Protected Areas Database of the United States and road files obtained from the US Census.
Figure 2: Stranded Land as a Percentage of County Area

**Legend**

<table>
<thead>
<tr>
<th>PetStranded</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - .11</td>
<td></td>
</tr>
<tr>
<td>.11 - .25</td>
<td></td>
</tr>
<tr>
<td>.25 - .43</td>
<td></td>
</tr>
<tr>
<td>.43 - .63</td>
<td></td>
</tr>
<tr>
<td>.63 - .89</td>
<td></td>
</tr>
<tr>
<td>.89 - 1.27</td>
<td></td>
</tr>
<tr>
<td>1.27 - 1.95</td>
<td></td>
</tr>
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<td>1.95 - 3.17</td>
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</tr>
<tr>
<td>3.17 - 5.9</td>
<td></td>
</tr>
<tr>
<td>5.93 - 10.00</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:** This map depicts the share of all county land that is stranded public land: \( \frac{\text{Stranded Acres}}{\text{County Acres}} \) for each county in the western U.S. The map is based on authors’ calculations using PAD-US and Tiger/Line shapefiles. Our calculations involve several steps. First, we select land that is designated as Open or Restricted Public Access. Second, we dissolve public land polygons into larger contiguous polygons that also include easements recorded in the PAD-US database. Third, we intersect public land and easements with the public road shapefile. We call a tract of public land “stranded” if it does not intersect a public road or is not contiguous to another public access tract or easement that intersects a public road.

Figure 3: Illustration of the Empirical Approach
**Figure 4: Land Grants and Access in Pershing County, Nevada**

(a) Planned Land Grants

(b) Modern Stranded Land

**Notes:** Based on authors’ digitization of original land grants. Hibbard (1939) and Gates (1968) provide descriptions of which sections were designated as railroad or state land grants in each state. We combine this information with GIS data on the location of each section in the Public Land Survey System obtained from the USDA Geospatial Data Gateway. Panel A depicts land initially retained by the federal government in the railroad land grants (dark shading) and lands granted to states (light shading) in Pershing County, Nevada. Unshaded land in Panel A was open for settlement. Panel B depicts modern public land. Light tan shading indicates accessible (nonstranded) land and red shading indicates inaccessible (stranded) land. Unshaded land in Panel (b) is privately owned.
Notes

1 See, for example, a summary of the armed standoff at the Malheur Wildlife Refuge in Oregon: https://www.oregonlive.com/portland/2017/02/oregon_standoff_timeline_41_da.html

2 See, for instance, https://www.hcn.org/articles/in-a-wyoming-county-public-land-access-hinges-on-road-designation

3 This excludes public lands with restricted access, such as military bases.

4 Two exceptions are Eichman et al. (2010), who instrument for shares of federal land subject to different management regimes under the Northwest Forest Plan using ecological variables and Chen et al. (2016), who combine fixed effects with a post-matching regression to address the endogeneity of proximity to protected federal lands.

5 The latter studies are disequilibrium analyses that focus on changes in population and employment.

6 Another strand of this literature estimates the effects of federal timber harvests on local economies rather than public land shares (Daniels et al., 1991; Burton and Berck, 1996; Burton, 1997).

7 In some specifications, the share of BLM land is significant.

8 The NWFP was adopted to address declining populations of northern spotted owl and other endangered species.

9 Much of the rest is managed by the U.S. Military.

10 Authors’ calculations.

11 This notion has been put to the test recently. In May of 2023, a federal judge in Wyoming ruled in favor of four hunters who “crossed corners” from one public parcel to another and argued that doing so did not constitute trespassing on the adjacent private parcels. In all likelihood, this issue will continue to be litigated. See https://www.wyomingpublicmedia.org/natural-resources-energy/2023-06-03/wyoming-judge-sides-with-corner-crossing-hunters-in-trespassing-case

12 Cash sales were also allowed, but these also occurred in a non-uniform fashion (Anderson and Hill, 1975; Allen, 1991, 2019).

13 These include the Illinois Central, Union Pacific, Central Pacific, Sante Fe, Northern Pacific, Southern Pacific, and Texas Pacific (Allen, 2019).

14 The government also forbade homesteading within the checkerboard for this reason, although some homesteading still occurred (Allen, 1991).

15 Public land files were obtained from http://www.protectedlands.net/data/ and road data from https://www.census.gov/cgi-bin/geo/shapefiles/index.php?year=2017&layergroup=Roads.

16 We determine access designation using the “Access” variable and treat land as public access if this variable takes the value “Open” or “Restricted.” The latter refers to land that requires a permit or fee, such as many National Parks. We determine ownership using the “Own Name” variable in the public land shapefile obtained from the USDA Geospatial Data Gateway.
The closest points of comparison are a 2013 report by the Center for Western Priorities (Center for Western Priorities, 2013) and a more recent report by the Theodore Roosevelt Conservation Partnership (Partnership and OnX, 2018). Our estimates are broadly consistent with both sources, although we do find differences for certain states. There are two key differences between our methodology and these reports. First, we focus only on land designated for public access in the PAD-US database. We were unable to determine whether all public lands were included in either report. Second, we include easements (also provided by PAD-US) in our definition of access, which neither report does.

Because public lands were designated long ago, we assume that public land amenities are predetermined with respect to contemporaneous rents and wages. See Ahlfeldt et al. (2015) and Diamond (2016) for models that allow for amenities to be determined endogenously as a function of contemporaneous outcome variables such as employment density and skill mix.

Given these adverse affects, landowners may have an incentive to at least grant public agencies access for management purposes, although the literature suggests otherwise (Chavez, 1987; General Accounting Office, 1992; Paul, 2006).

Chavez (1987) also discusses a subsequent case (United States v. 82.46 Acres of Land, 1982) concerning the ability of federal agencies to expand roads on private land. This question has been a topic of ongoing litigation. Though road building may be allowed in certain instances, the associated transaction costs are high.

Although positive spillovers to adjacent private lands are also possible, they are not likely to be as large as those with stranded lands because landowners are not provided exclusive access.

An alternative to farmland values would be the median value of owner-occupied housing units by county from the American Community Survey (ACS). As with the Census of Agriculture data, these are owner-reported estimates of property values. For our purposes, these estimates would need to be adjusted for differences in the value of structures. Two further concerns are that lot sizes vary considerably between urban and rural counties (the ACS housing value estimate is for all single-family houses below 10 acres) and developed areas may be highly selected. Our assessment is that farmland values are a more reliable proxy for land rents, especially in rural counties where public lands are more commonly found.

Restricting our attention to the western U.S. means that most counties will include, or be relatively close to, public lands. We focus on 2017 farm values because that corresponds to the year in which we obtained the public land ownership data.

We calculate to total area of each county with soil that falls in the top 1/3 of the productivity index.

NPP data were obtained from https://lpdaac.usgs.gov/products/mod17a2hv006/

These data contain an observation for each piece of land that is deeded to or by the U.S. government and report the type of land transaction for each patent. We use two criteria for identifying land exchanges and acquisitions. First, we keep all patents labeled as an “Exchange” or “Acquisition.” Second, we keep all patents where a state or a branch of the U.S. Government is listed as the patentee.

This approach allows us to have a sufficient number of clusters to obtain valid inference, and has become common in county-level studies. See, for example, Bazzi et al. (2020).

For example, two non-contiguous square-mile sections would have a total perimeter of 8 miles (four miles per section) with an area of 2 square miles, which yields a perimeter-to-area ratio of \( 2 = 4 \). The minimum-sized square with an area of two square miles is \( 2 \times \sqrt{2} = 5.65 \), which would have a perimeter-to-area ratio of \( 5.65 \). Our measure of fragmentation in this case would be \( \frac{5.65}{2} = 2.83 \). 28

To ensure that our estimates are not simply measuring the presence or absence of a railroad in the county, we plot the residuals from the second stage for Column 3 of Table 6 and present them in Appendix Figure A7. As can be seen from the figure, there is no clear spatial pattern in the residuals to suggest a disproportionate railroad effect.
A possible caveat is that access may have been a problem for lands in the checkerboard even before 1935.