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Local Effects of Stranded Public Lands

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Cover photo: Beaverhead-Deerlodge National Forest, Montana. USDA photo by Preston Keres.

Abstract

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A large share of the land in the United States is public. Public and government access to these lands have major implications for their management and recreational use as well as surrounding privately owned lands. Because of historical policies related to the distribution of public land, the government manages countless areas of inaccessible land that are commonly referred to as "stranded public lands." This stranded public land has been shown to decrease county-level property values and has resulted in a higher risk of wildfire. However, past studies have focused on county-level information. In this study, we constructed and used a novel, parcel-level database of property values for Montana. We expanded the scope of past work and found that, although there was a negative correlation between property values and the presence or amount of adjacent public land, stranded public land had less magnitude effect on adjacent land values than did nonstranded public land. We also found that stranded land managed by the U.S. Department of the Interior Bureau of Land Management had a greater effect on adjacent land values than stranded land managed by the U.S. Department of Agriculture Forest Service.

KEYWORDS:
Accessibility
Economic valuation
Hedonic model
Land management

Summary

Public land accounts for a large proportion of lands across the United States, especially in the western portion of the country. There are several factors that drove the distribution of public land, including the development of the railroads. As land was given to private owners through programs associated with rail line development, the government often selected lands in a checkerboard pattern that ultimately resulted in some public land being surrounded by private land. As a result, those public lands, commonly referred to as "stranded public lands," cannot be directly accessed by the public or government agencies responsible for managing them. Past studies have examined the effects of county-level quantities of this stranded public land on land values, finding a negative effect. Other studies have found that accessibility issues stemming from stranded public land result in a higher likelihood of wildfires. However, these studies are limited by county-level analyses, which prevent them from examining mechanisms that might be driving this effect. In this study, we developed a novel dataset from parcel-level property data that was publicly available for Montana. Using the Protected Areas Database of the United States from the U.S. Department of the Interior (USDI) Geological Survey, along with the TIGER/Line® shapefiles for roads, we identified all the stranded public parcels of land in Montana, and using regression analysis, we examined the effects that these stranded public parcels had on property values. We found that, in general, adjacency to public land diminished property values; however, if the public land was stranded, this negative effect was not as large. We also found differences between stranded public land managed by different federal agencies; stranded U.S. Department of Agriculture Forest Service-managed land had a smaller negative effect on adjacent private land values than stranded USDI Bureau of Land Management-managed land. We performed several regression analyses to test whether this effect was robust and found that it was robust to various specifications, including a high-resolution, fixed-effects specification.

Contents

Introduction

Public lands account for a substantial share of the total land in the Western United States, and the way they are managed has major implications for recreation, other ecosystem services, and wildfire risk. About half of all land across the 11 Western continental United States (Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming) is under federal or state management and is therefore potentially open for public access[1] (Leonard and Plantinga 2021). Nevertheless, in practice, not all these lands are available to the public or even accessible by the agencies responsible for managing them. Because of a variety of historical factors, some public lands are surrounded by private land and not accessible from public roads (see fig. 1). Leonard and Plantinga (2021) refer to these as "stranded public lands" and estimate that they account for about 6 million acres, or 1.5 percent of all federal and state (hereafter, public) lands in the Western United States.[2]

Strandedness might diminish the ability of public lands to provide ecosystem services. Stranded public lands are not only inaccessible to the general public; they are also more difficult to establish public access to other lands that agencies may wish to open, reducing their value as a recreational resource. Nevertheless, recreational values will not be completely lost if adjacent private landowners use the land for hunting, fishing, and other activities. Stranded lands are also largely inaccessible to public land managers, which can limit management activities, such as control of invasive species, fuels management to reduce wildfire hazard, and habitat management for desired wildlife species, or at least make management prohibitively expensive and logistically cumbersome. Leonard et al. (2021) found that wildfires that started on public lands in the Western United States tended to be larger when those lands were stranded and present evidence that this was because of a lack of fuels management as well as slower response times.

These examples highlight the effect of strandedness on the provision of public benefits from public lands. Stranded public lands can also affect private values by reducing traditional extractive uses of land (e.g., timber harvest), limiting efficient use of private land by preventing consolidation of land parcels, and increasing trespassing through private land by people seeking access to stranded public lands. Although stranded public lands are a small share of all public lands, Leonard and Plantinga (2021) found that they can have significant effects on local economies. For counties in the Western United States, Leonard and Plantinga (2021) found that a 10-percent increase in stranded public land would result in a 2-percent reduction in the county average value of private land. Stranded public lands can reduce the local value of private lands by reducing wealth-generating activities in the local economy. For example, if resource extraction is lower in a county with a lot of stranded public land, there may be lower demand for private lands for residential, commercial, and industrial uses. Thus, compared to an otherwise identical county without stranded public lands, the average value of private land would be lower. Leonard and Plantinga (2021) show that there is a negative causal relationship between the amount of stranded land in a county and average land values; however, nothing is known as to what occurs at higher resolutions, or how heterogeneous this effect might be. Although the effect of stranded public lands on private land values is likely to result from a reduction in private goods, such as timber harvests, it can also arise from a decrease in public benefits, such as recreational opportunities on public lands that are increasingly important to rural economies in the U.S. West (White et al. 2016). For additional statistics regarding national-level trends in stranded public land, we encourage readers to see Leonard and Plantinga (2021).

The goal of this study was to document a new, fine-scale dataset on stranded public lands in Montana and to characterize the relationship between private land values and adjacency to stranded public lands. Unlike the analysis by Leonard and Plantinga (2021) that used county data, we developed a parcel-level dataset for private land. In addition to an estimate of 2020 real market value and a variety of covariates, we determined whether a parcel

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[1] We define public access lands as federal and state lands that, in principle, can be accessed by the public. This excludes, for example, large parts of military bases, U.S. Department of Defense Army Corps of Engineers-managed lands, and American Indian reservations.

[2] The U.S. federal government is legally required to provide access to private lands that would otherwise be stranded by inaccessible public lands. We do not consider lands that are both private and surrounded by inaccessible private lands. We assume that private lands are accessible.

was adjacent to stranded or accessible public land. These fine-scale data allowed us to estimate the effects of public lands that were not observable in the aggregate data used by Leonard and Plantinga (2021). Although Leonard and Plantinga (2021) found that the **average** effect in a county was negative, some stranded public lands could have localized positive effects, particularly on adjacent private land parcels that are granted exclusive access to stranded lands for grazing, recreation, and other potential uses.

Understanding the local effects of stranded public lands can help to shape policy priorities. Stranded public lands have long been of concern to agency managers, recreation advocates, and legal scholars (Center for Western Priorities 2013, Chavez 1987, U.S. General Accounting Office 1992) but has received little systematic treatment by economists. In 2020, the U.S. Congress passed the Great American Outdoors Act, which provides funding to address public access issues on federal lands, and in 2022, President Joe Biden signed into law the Modernizing Access to our Public Land Act, which enhances public information about accessibility to federal lands. The Great American Outdoors Act includes funds for private-public land swaps that could be deployed to reduce strandedness. Our dataset can be used to understand the consequences of such land swaps on local economies, as reflected in private land values. Moreover, there is the potential to identify which types of landowners are likely to be affected and why. Although reducing strandedness may generate public benefits not captured by private land values, such as enhanced biodiversity (Powers et al. 2022), the effects on the local economy are likely to play a central role in determining political acceptability.

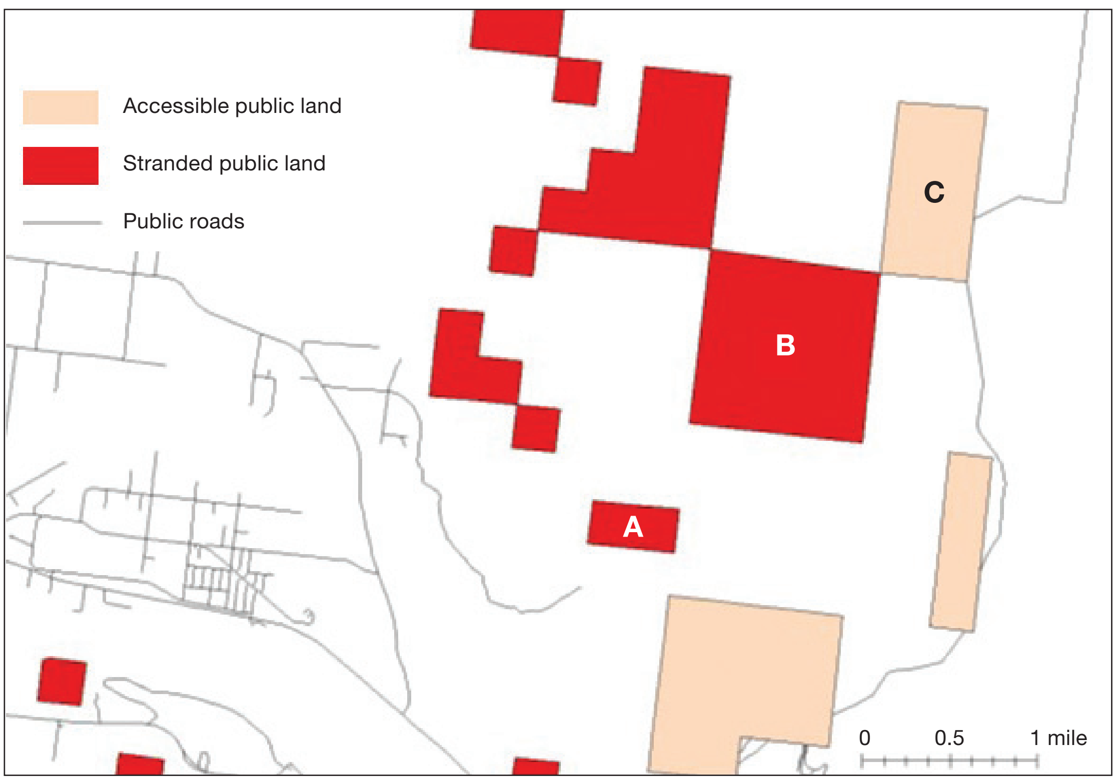

Figure 1—Stranded public land without direct public access and accessible public land in Douglas County, Washington. Unshaded white areas are privately owned land; tan shading is public land that is accessible by public road; red shading is public land that is “stranded” because it lacks public road access. While parcel C has public access, parcel A does not because it is surrounded by private land and has no public road access. Parcel B is not accessible to the public, although the corners of parcels B and C are touching. This is because crossing the corners of properties requires entry to adjacent private land, which constitutes trespassing if no permission is given. Public land files were obtained from the U.S. Department of the Interior Geological Survey’s Protected Areas Database of the United States; road files were obtained from the U.S. Census Bureau.

Historical Background

The spatial distribution of public and private land is a key element of this study. The current pattern of public and private lands in the Western United States is largely the result of 19th century policies that focused on the privatization of public land holdings to incentivize land development and settlement (Gates 1968, Hibbard 1939, Libecap 2018). Policy priorities slowly shifted toward natural resource preservation, beginning with federal designation of the first national parks in the 1870s, followed by designation of forest preserves in the 1880s, and eventually culminating with the end of most homesteading under the Taylor Grazing Act of 1934 (Loomis 1993).

Development and settlement of the Western United States occurred in three stages. The first stage started with the government incentivizing private development of western lands with the Homestead Act of 1862. The Homestead Act granted 160 acres of free land to settlers with the condition that they would make land improvements and occupy the homesteads for at least 5 years. Claimants could select any available land that had been surveyed and not previously set aside for another purpose. After this period of privatization, land was set aside and placed under management by federal agencies. Much of the land managed by the U.S. Department of Agriculture (USDA) Forest Service was set aside between 1890 and 1920 after the first wave of homesteading. Most land managed by the U.S. Department of the Interior (USDI) Bureau of Land Management consisted of federal land unclaimed prior to the Taylor Grazing Act in 1934 (Libecap 2018, Loomis 1993), while failed homesteads reverted back to public ownership. The result was a patchwork of public lands scattered amid private land holdings across much of the West.

Some land in the Western United States has also passed from federal to state management, further fragmenting ownership. A total of 71 million acres in 11 Western United States was transferred from federal to state management as grants to support public education (Loomis 1993). States were granted specific 1 × 1-mile (1.6 × 1.6-kilometer) sections of land within each township of the Public Land Survey System (PLSS) (e.g., sections 16 and 36), resulting in a scattered pattern of state land holdings (Gates 1968, Hibbard 1939, 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.

Railroad land grants are the largest source of stranded land and comprise about 10 percent of the land privatized by the federal government (Loomis 1993). The federal government used land grants as subsidies for the construction of transcontinental rail lines during the 1860s. As the track was constructed, land adjacent to track construction was given to the railroads.

However, to avoid giving railroads monopoly control over valuable land, the grants were given to alternating sections in a 20- to 40-mile (32- to 64-kilometer) checkerboard along each of the land grant railroads. The government attempted to fund these subsidies by selling the land it had retained from the railroad grant program. The sale price was double the going cash rate (thus recovering the full value of the land it either granted or sold); however, these lands often didn't sell (Hibbard 1939, Paul 2006). Furthermore, although some homesteading occurred within these lands, homesteading was made illegal to further promote the sale of land, which further contributed to large numbers of plots going unsold or unoccupied (Allen 1991). Because many federal sections were never purchased, these checkerboards of private and public land persist today throughout the Western United States.

Methods

We developed a parcel-level database for Montana using data from a variety of sources (table 1). Our novel database is centered around the Montana Cadastral online application (table 1: row 1), which contains information about county and township, property type, assessed land value, owner name, and land use for 925,969 private and public parcels. The first step was to classify parcels as public or private based on owner name. This exercise was complicated by multiple spellings for the same owner names (e.g., state-owned parcels were alternatively labeled "State" or "Montana," among other names). The procedure we used to arrive at a consistent set of names is described in appendix 1. The final list of public land management agencies included names for the state of Montana ("STATE"), Forest Service ("USFS"), Bureau of Land Management, hereafter BLM ("BLM"), USDI Bureau of Reclamation ("USBR"), USDI Fish

Table 1—Data sources for the parcel-level database on stranded public lands without direct public access in Montana

Data	Description	Source
Montana Cadastral	Montana parcel-level assessed land values and other data	Montana State Library (2021)
Montana boundaries	Montana state and county boundaries	U.S. Census Bureau (2021)
Reservation boundaries	American Indian reservation boundaries	U.S. Census Bureau (2020)
National Hydrology Dataset	Water drainage network	USDA NRCS (2021a)
TIGER/Line® shapefiles for roads	Public road network and classification	U.S. Census Bureau (2017)
Protected Areas Database of the United States	Protected area locations and other related data	U.S. Geological Survey (2021)
Precipitation	Annual average precipitation from 1981 to 2010; 800-meter scale	PRISM (2018)
Temperature	Mean temperature from 1981 to 2021; 800-meter scale	PRISM (2018)
National Elevation Database	Elevation; 30-meter scale	USDA NRCS (2021b)
Soil	Productivity index for 2020; 240-meter scale	USDA NRCS (2018)
National Land Cover Database	Land cover type; 30-meter scale	MRLC Consortium (2016)
Net Primary Production	Annual net primary production; 1-kilometer scale	NASA (2017)
Ecoregion	U.S. Environmental Protection Agency ecoregion boundaries	U.S. EPA (2014)
Grazing allotment	U.S. Department of the Interior Bureau of Land Management grazing allotment boundaries	USDI BLM (2021)

and Wildlife Service ("FWS"), and USDI National Park Service ("NPS"). American Indian reservations and U.S. military installations, which comprise 9 and 2 percent of the land in Montana, respectively, were excluded (Lopach 2020).[3] For ease of exposition, in this section we refer to the aforementioned agencies as "public owners."

We used the Protected Areas Database of the United States (PAD-US) and data on easements and roads to identify stranded and accessible public lands. We focused on public access lands, which we defined as publicly owned lands that are open to the public. This excludes, for example, many parts of military bases that are closed to the public. We provide details on the criteria we used to identify public access lands in appendix 2. Public parcels were combined with data on easements to allow for the possibility that a public land parcel without public road access could be reached indirectly through an easement. Specifically, if an easement touched a public access parcel, we defined the public access parcel and the easement as one parcel. We defined these parcels, along with public access parcels that were not adjacent to easements, as stranded if they did not intersect any public roads; otherwise, we considered them to be accessible public access lands. The PAD-US also provided owner names that matched the final names used for parcels in the Montana Cadastral.[4]

We used the PAD-US and data on American Indian reservations and water bodies to curate the Montana Cadastral database and produce a final set of public and private parcels for analysis. This included all parcels that intersected American Indian reservations (see footnote 1) and all parcels with more than 20 percent of their surface area classified as water. Calculations of the average

[3] Statistics for the acreage of military bases was calculated by dividing the acreage of U.S. Department of Defense lands by the total acreage of the state of Montana. However, within a federal body, military bases are excluded from the analysis.

[4] There were technically other ways in which these lands could be accessed, such as on foot or by air; however, we assumed that these types of access were time- or cost-prohibitive for most of the public.

parcel value can be overstated if there are large amounts of surface area covered by water because this will overstate the overall surface area compared to the acreage of land.[5] We estimated 20 percent to be the correct cutoff; however, future work would benefit from examining sensitivity to this assumption. We defined a parcel as public if (1) 50 percent or more of it was within public land boundaries, or (2) if it overlapped public land by 20 to 50 percent and had a public owner. We excluded parcels (1) with a public owner name, (2) that we identified as tax exempt, or (3) that had a missing land value. This step excluded about 9 percent of the parcels (80,642 of 925,966). All remaining parcels were classified as private. We conducted a robustness check on our classification scheme and found that the rate of misclassification would likely be low (appendix 3).

We merged the final set of public and private parcels in the Montana Cadastral with a suite of additional data (table 1). The final dataset included information about ownership, accessibility, hydrology, roads, precipitation, temperature, elevation, soil, land cover, net primary production, ecoregion, and grazing allotment. We also identified which private parcels were adjacent to public lands using the Montana Cadastral and the following criteria for adjacency: (1) the parcels must not overlap, (2) the parcels must share a border, and (3) the parcels must not touch only at their corners. A given private parcel of land may be adjacent to more than one public landowner.

The final dataset included 736,781 parcels that were summarized by ownership, adjacency, and accessibility. The statistics included area, number of units (parcels), net primary production, elevation, roughness (the standard deviation of elevation), land value, and land cover. We obtained these statistics from the Montana Cadastral dataset, and the resolution of these data is similarly at the level of tax lot. We also created maps for stranded and accessible public lands, ownership, and adjacency. In addition, we used statistics to summarize the distance of private land to stranded public land (fig. 2) and accessible public lands (fig. 3).

To estimate the effects of adjacency to stranded public land on private land values, we estimated a set of fixed effects ordinary least squares (FE-OLS) models using land value per acre of privately owned parcels as the dependent variable. The land value was the appraised value used for assessing property taxes. The disadvantage of this measure is that it may not accurately reflect the market price. Its advantage relative to a dataset of transactions prices is that it provides comprehensive coverage of private land parcels in Montana, including many observations of parcels adjacent to public lands. In our FE-OLS models, the key variable of interest was an indicator variable for whether a private parcel was adjacent to stranded public land. We estimated preliminary models with the cross-sectional data of the Montana Cadastral that is described in the previous section. Although it is technically possible to construct a dataset that varies over both time and space using the Montana Cadastral dataset, the lack of variation in land ownership over the availability would not have enough temporal variation in the variable of interest to add statistical power to the identification. The main advantage of a dataset that also varies over time would be the ability to estimate a model with parcel-level fixed effects. However, due to the lack of variation through time with respect to land ownership, we would be unable to estimate the effects of stranded public land in a model with parcel-level fixed effects. Many studies that use hedonic models take the log transformation of land values (e.g., Bigelow et al. 2020); however, we did not. The interpretation of the variables is easier when the dependent variable is not log-transformed. For example, the coefficient on a dummy variable indicating whether a neighboring parcel is stranded is simply the level change in land value. The empirical specification is presented in the following equation:

$$p_i = \beta_0 + \beta_1 Public_i + \beta_2 Stranded_i + \gamma_j X_{ji} + \delta_i + \varepsilon$$

Where the land value is given by p_i, and the right-hand side is composed of the constant (β_0), an indicator variable indicating whether a parcel is next to public land ($Public_i$), an indicator variable indicating whether a parcel is next to stranded public land ($Stranded_i$), a set of j control variables that control for landscape characteristics (X_{ji}), fixed effects (δ_i), and the error term (ε). The indices i and j stand for an individual tract and a given control variable, respectively. The coefficients are β_1, β_2, and γ_j,

[5] Many of the homesteaded parcels were located near water bodies. In future work, we plan to investigate whether there is a systematic relationship between present-day accessibility and proximity to water.

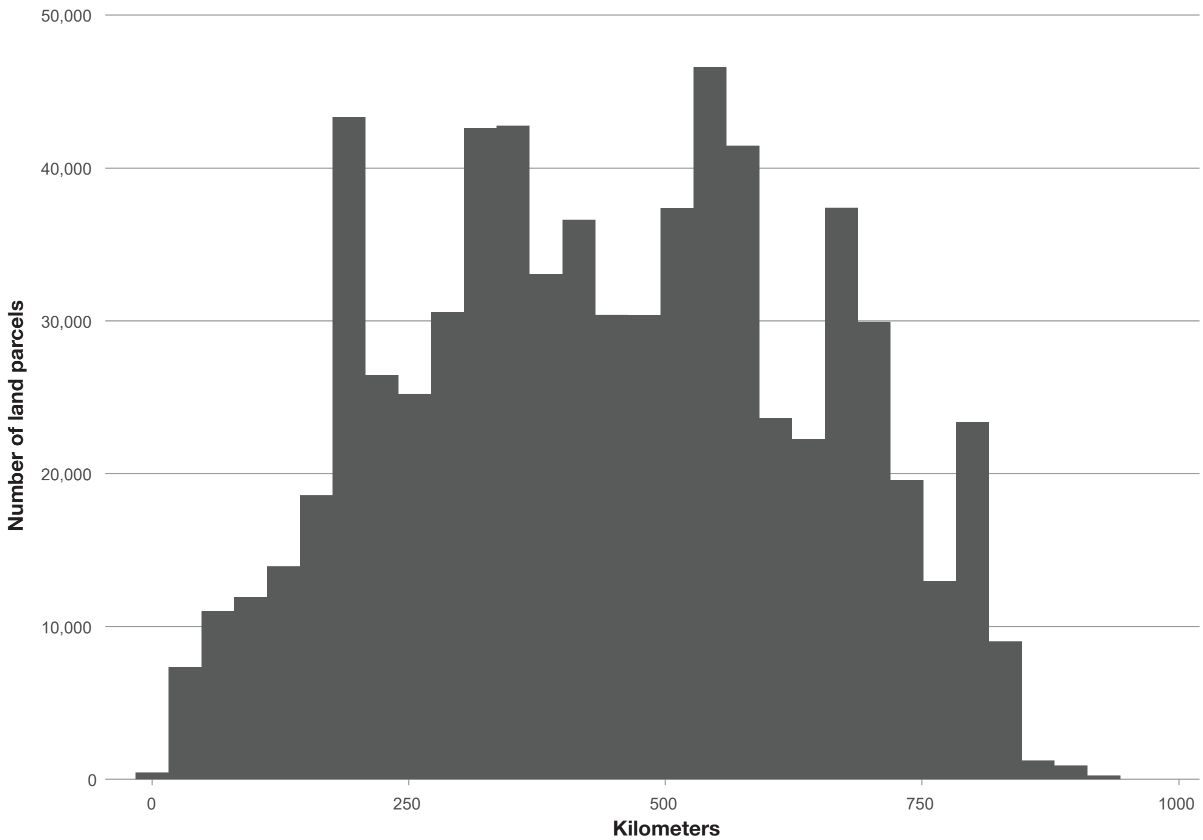

Figure 2—Distance of private land parcels to nearest stranded public land (public land without direct public access) in Montana.

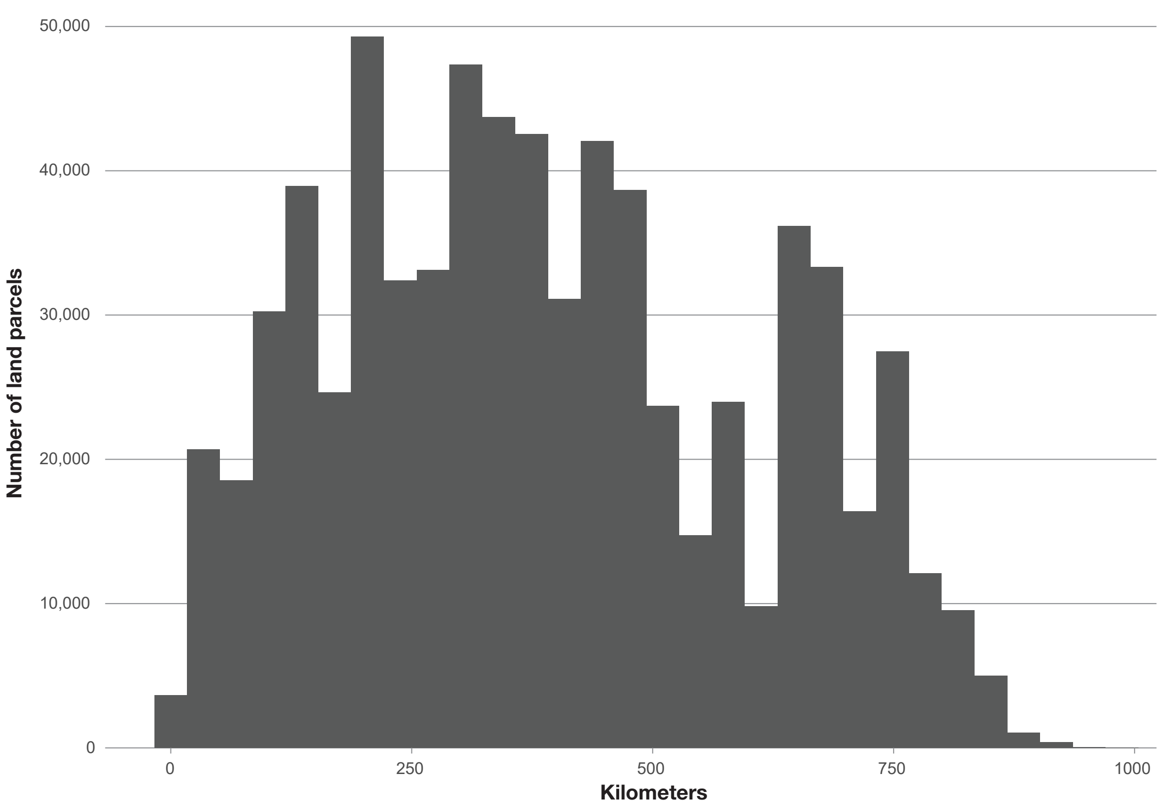

Figure 3—Distance of private land parcels to accessible public land (public land with direct public access) in Montana.

which are the coefficient on adjacency to public lands, adjacency to stranded public land, and a vector of coefficients for the other control variables, respectively. For further discussion regarding the variables used in the regression, see appendix 4 and table A4.

We used the empirical model presented in the equation to test several hypotheses regarding the effects of stranded public land on land values. First, we investigated the composition of private land in Montana to see what proportion of these lands were adjacent to public lands or stranded public lands. We then used the equation to test whether public land had an effect on land values and whether stranded public land, in particular, had an effect on land values separate from the effect of public land. Next, we hypothesized that there were heterogenous effects among agencies.

Data processing and analysis was performed using a combination of R version 4.1.3 (R Core Team 2022) and R Studio (RStudio Team 2022). Spatial processing was accomplished using the rgdal package (Bivand and Rowlingson 2022), and regression analysis was performed using the lfe package (Gaure 2013).

Results

The total land area of Montana was about 94.03 million acres (38 054 246 ha), 53 percent of which was privately owned and 36 percent of which was managed for public access by state and federal agencies (table 2).[6] The Forest Service is the federal agency managing the most public land in Montana, responsible for 51 percent of public lands in the state, followed by the BLM, which is responsible for 24 percent of federal public lands in Montana. Forest Service lands were mostly in the western part of the state, whereas BLM lands were concentrated in eastern Montana (fig. 4). Public land parcels tend to be much larger, be at higher elevations, and have greater variability in elevation than private land parcels. The average net primary production of public lands was higher than that of private lands in Montana. As measured by net primary production, lands under Forest Service and other agency management were much more productive, on average, than those that were under BLM management, which were less productive than those of private owners. This is primarily because of the different types of lands that the Forest Service and BLM manage, with the former primarily managing forested ecosystems in the west and the latter primarily managing sagebrush in the east. About 43 percent of private parcels were adjacent to public lands and tended to be much larger than parcels that were not adjacent to public lands.

There were more than 800,000 acres of stranded public land in Montana, representing about 6 percent of the total area of public land and 2 percent of total lands in the state. Stranded public lands were scattered throughout the state (fig. 5), but the greatest concentration of stranded public lands was in eastern Montana. In contrast, nonstranded public lands were mostly found in the western and north-central parts of the state. Distributions of distances from private parcels to the nearest stranded and nonstranded public lands were roughly similar (figs. 4 and 5). Almost all stranded public lands were under BLM (48 percent) or state (49 percent) management. Most of the Forest Service lands were nonstranded. Stranded public lands tended to be smaller, less productive, lower in roughness, and at lower elevations than nonstranded lands.

The average value of private land in Montana was $29,245 per acre (table 3). The land value distribution appeared to be bimodal, with concentrations at low (lower than $1,000 per acre) and high (greater than $100,000 per acre) values (fig. 6).

Overall, private land adjacent to public land was worth much less ($110 per acre) than private land that was not adjacent to public land ($52,661 per acre) because nonadjacent lands were much more likely to be within the boundaries of cities and towns. Private parcels adjacent to public lands were found throughout the state but were concentrated in central and eastern Montana where public land was more fragmented (fig. 7).

There were premiums associated with private land parcels that were next to Forest Service-managed lands (an added $548 per acre compared to the mean value of $110 per acre), state-managed lands ($968 per acre), and especially National Park Service-managed lands ($87,950 per acre). Montana is home to Yellowstone and Glacier National Parks as well as others, which undoubtedly provide tremendous amenity value to adjacent landowners. On average, adjacency to BLM lands was associated with a decrease in value of $60 per acre. BLM-managed lands were concentrated in eastern Montana and more

[6] The remaining 11 percent of the land area was tribal, U.S. military bases, or managed by the U.S. Department of Defense Army Corps of Engineers.

Table 2—Summary statistics for land type (ownership, adjacency, and public accessibility) in Montana

Land type	Area	Total units	Median size[a]	Average NPP	Average roughness	Average elevation
	Hectares	Number of parcels	Hectares	Grams of carbon/meter^2/year	SD of elevation	Meters
All land	38 054 246	1	38 054 246	3348	12	384
All private land	20 354 152	710,851	1	2924	7	338
Private land, adjacent[b]	8 747 477	96,920	64	2790	8	340
Private land, nonadjacent	11 606 675	613,931	<1	3025	6	336
All public land	13 549 028	25,930	45	3827	20	469
All USFS land	6 953 019	5,353	<1	4400	28	582
All BLM land	3 247 931	10,046	32	2287	10	331
All NPS land	484 980	26	18	4439	32	545
All other federal land	570 912	308	81	8251	8	2532
All state land	2 292 185	10,917	179	3036	9	363
All stranded public land[c]	820 805	8,846	32	2528	9	315
Stranded USFS land	19 317	586	1	5134	25	529
Stranded BLM land	396 751	5,065	32	2242	10	2952
Stranded NPS land	106	8	<1	3395	12	377
Other federal stranded land	2414	44	14	4486	5	2478
Stranded state land	402 217	3,142	97	2672	8	3264
All nonstranded public land	12 728 223	17,084	53	3911	20	479
Nonstranded USFS land	6 933 702	4,767	<1	4398	28	582
Nonstranded BLM land	2 851 181	4,981	49	2294	10	336
Nonstranded NPS land	484 874	18	72	4439	32	545
Other federal nonstranded land	568 498	264	127	8267	8	2532
Nonstranded state land	1 889 968	7,054	227	3114	9	371

Area and total units (properties) are reported as totals for each class. Median size is the median number of hectares. Average net primary production (NPP) is unitless and reported in the cadastral data. Average roughness is the standard deviation of elevation across the landscape, and the average elevation is the mean elevation level for each class respectively. BLM = Bureau of Land Management, NPS = National Park Service, SD = standard deviation, USFS = Forest Service.

[a] Median sizes are very small in some cases as an artifact of combining different datasets in geographic information systems.

[b] Private adjacent refers to public lands that are next to private lands.

[c] Stranded refers to public lands that lack direct public access because of surrounding private lands.

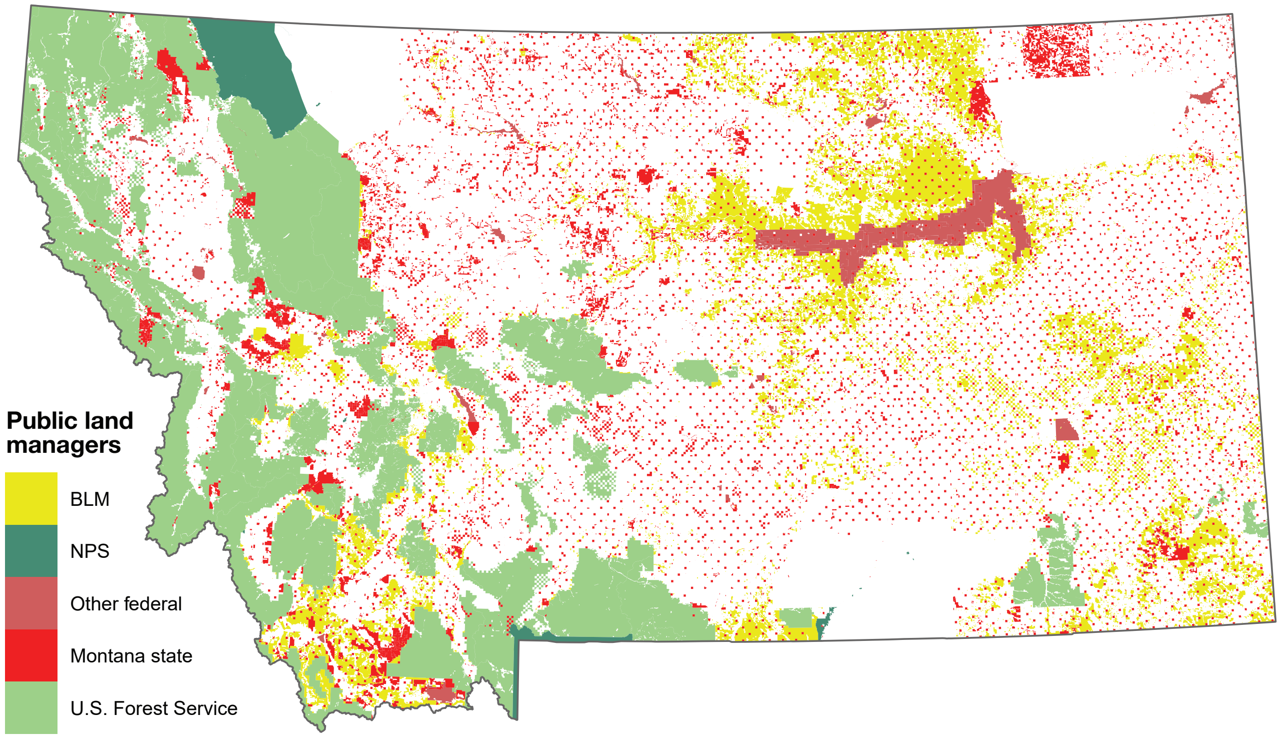

Figure 4—Federal and state land in Montana by managing agency. State and federal lands account for about 35 percent of total land area in Montana. The Forest Service manages the most public land, with 51 percent of federal land in the state; followed by the Bureau of Land Management (BLM), with 24 percent; the state of Montana, with 16 percent; and other federal, with 7 percent. NPS = National Park Service.

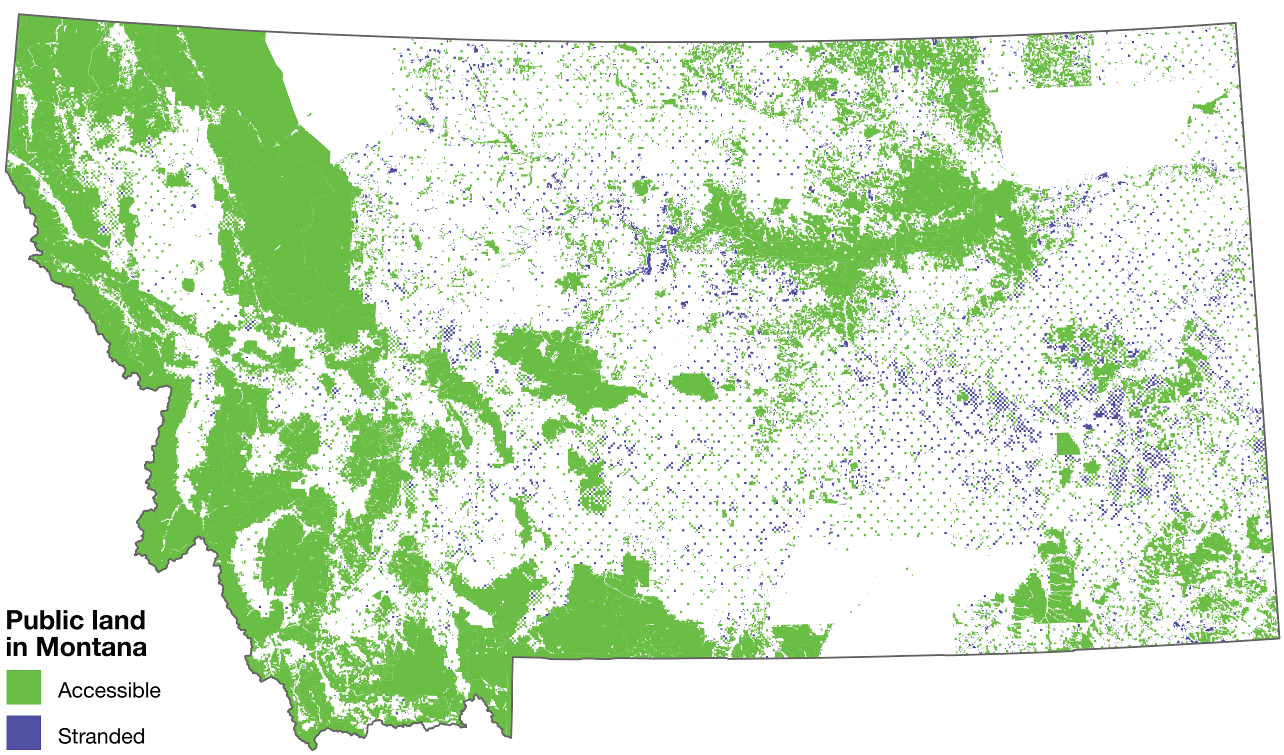

Figure 5—Stranded and nonstranded (accessible) public land in Montana. Most public land in Montana is directly accessible to the public; however, there are stranded public land parcels that lack direct public access throughout the state, especially in eastern Montana, because they are surrounded by private lands. Nonpublic land (private, tribal, military) is shown in white.

Table 3—Mean private land values by land type (adjacency to public lands and managing agency) in Montana

Land type	Land value
	U.S. DOLLARS PER ACRE
All private land	29,245
All nonadjacent to public land	52,661
All adjacent to public land	110
Adjacent to USFS land	658
Adjacent to BLM land	50
Adjacent to NPS land	88,060
Adjacent to other federal land	203
Adjacent to state land	1,078
All adjacent to stranded public land[a]	61
Adjacent to stranded USFS land	225
Adjacent to stranded BLM land	48
Adjacent to stranded NPS land	88,789
Adjacent to other federal stranded land	150
Adjacent to stranded state land	1,024
All adjacent to nonstranded land	133
Adjacent to nonstranded USFS land	669
Adjacent to nonstranded BLM land	50
Adjacent to nonstranded NPS land	88,789
Adjacent to other federal nonstranded land	199
Adjacent to nonstranded state land	886

BLM = Bureau of Land Management, NPS = National Park Service, USFS = Forest Service.

[a] Stranded refers to public lands that lack direct public access because of surrounding private lands.

likely to be grasslands, which plausibly had lower amenity value compared to Forest Service-managed lands, which were concentrated in western Montana and more likely to be forested. Parcels adjacent to stranded public land were worth less on average ($61 per acre) compared to parcels adjacent to nonstranded public land ($133 per acre). This difference likely reflected the preponderance of stranded BLM-managed lands and the low value of private land adjacent to them. Considering differences among public land management agencies, the average value of private parcels was lower when adjacent to stranded Forest Service-managed or other federal land compared to nonstranded counterparts. For example, parcels adjacent to stranded Forest Service-managed lands had an average value of $225 per acre, compared to $669 per acre for parcels adjacent to nonstranded Forest Service-managed lands. There was little difference with BLM- and National Park Service-managed lands, and only for state lands did strandedness convey a premium. Private parcels adjacent to stranded state lands had an average value of $1,024 per acre, compared to $886 per acre for nonstranded state lands.

A larger share of private land was in developed use compared to public access land, and more public land was forested compared to private land (table 4). About 86 percent of stranded public land was in shrubland or herbaceous land covers, followed by forest at 8.6 percent. In contrast, nonstranded public lands were 45-percent forested, with about 50 percent in shrubland or herbaceous. As above, this reflected the fact that many stranded lands were under BLM management. For Forest Service- and BLM-managed lands, there was little difference in land covers between stranded and nonstranded lands. However, compared to nonstranded state lands, stranded state lands were less likely to be in forest and shrubland and more likely to be in herbaceous and wetlands.

To provide information about model sensitivity to assumptions regarding regressors and fixed effects, we used three different FE-OLS models (table 5). Land value per acre was the dependent variable in each case, and bounds on parcel size and per-acre value were used to remove extreme outliers that arose from very small parcels (i.e., based on the distribution, values greater than $1 million per acre and less than 1 acre were removed). Adjacency to public land was associated with about a $7,351 decline in value per acre in Model 1, after controlling for land that was in developed use, which added a large premium. It is likely that, in part, this variable was capturing remoteness (e.g., distance to city centers). The key finding was that adjacency to stranded public land was associated with a statistically significant $4,555 premium in Model 1, which may have reflected the value of exclusive access to public land. Nonetheless, the net effect of adjacency to stranded public land was

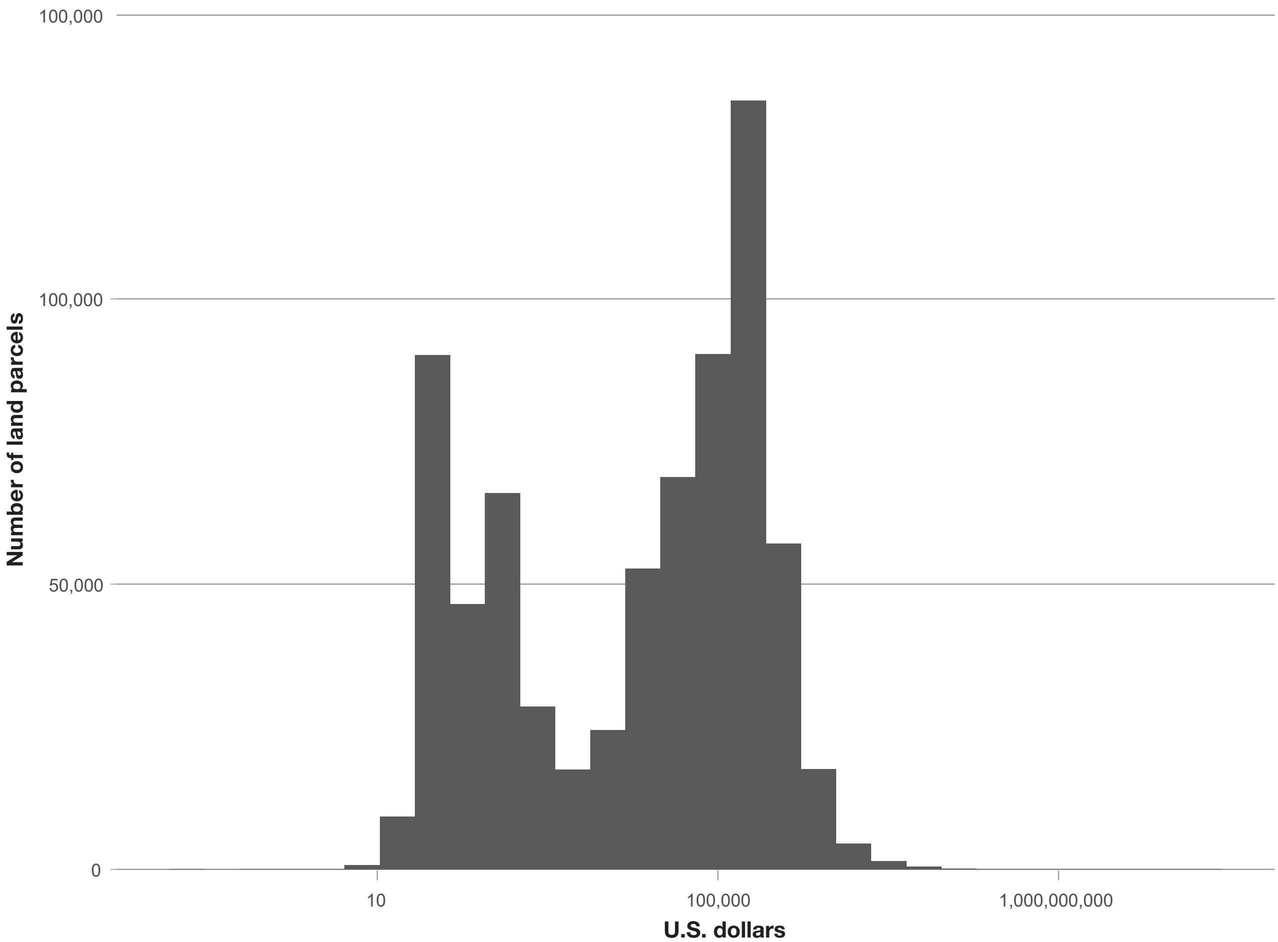

Figure 6—Per-acre land value of private land parcels in Montana.

negative in Model 1 (−$2,800).[7] Model 2 added county fixed effects and a distance index—the population-weighted distance to the nearest population center—designed to measure remoteness. Finally, Model 3 retained the distance index but replaced the county fixed effects with more granular township-level fixed effects from the Public Land Survey System (PLSS). With these controls, the negative net effect of stranded land adjacency remains, but is lower (−$2,257 per acre in Model 2 and −$1,044 per acre in Model 3).

From the descriptive statistics, we found that adjacency to stranded public land was correlated with a decrease in private land values, on average; the exception was National Park Service land, which conveyed a small premium relative to adjacency to nonstranded land (table 3). The regression results showed that adjacency to stranded public land reduced private land values; however, the effect was smaller (in absolute value) compared to adjacency to nonstranded public land. This indicated that controlling for physical characteristics of the land was important for determining the effect of strandedness and hinted that the effects of stranded land could be the result of one or more mechanisms (e.g., benefits of exclusive access, negative spillovers such as higher wildfire hazard). Moreover, the coefficient for adjacency to stranded public land was greatly diminished with the inclusion of fixed effects—a 67-percent decrease in magnitude moving from Model 1 to Model 3, indicating the effects of a variety of location-specific unobservable factors.

Finally, we used a model with interaction terms to estimate how effects of public lands vary across land management agencies (table 6). We replaced the two public land

[7] We calculated the net effect on land value for a private parcel adjacent to stranded public land by adding the coefficients for adjacency to public land and adjacency to stranded public land: −$7,400 + $4,600 = −$2,800. The net effect of adjacency to nonstranded public land was −$7,400.

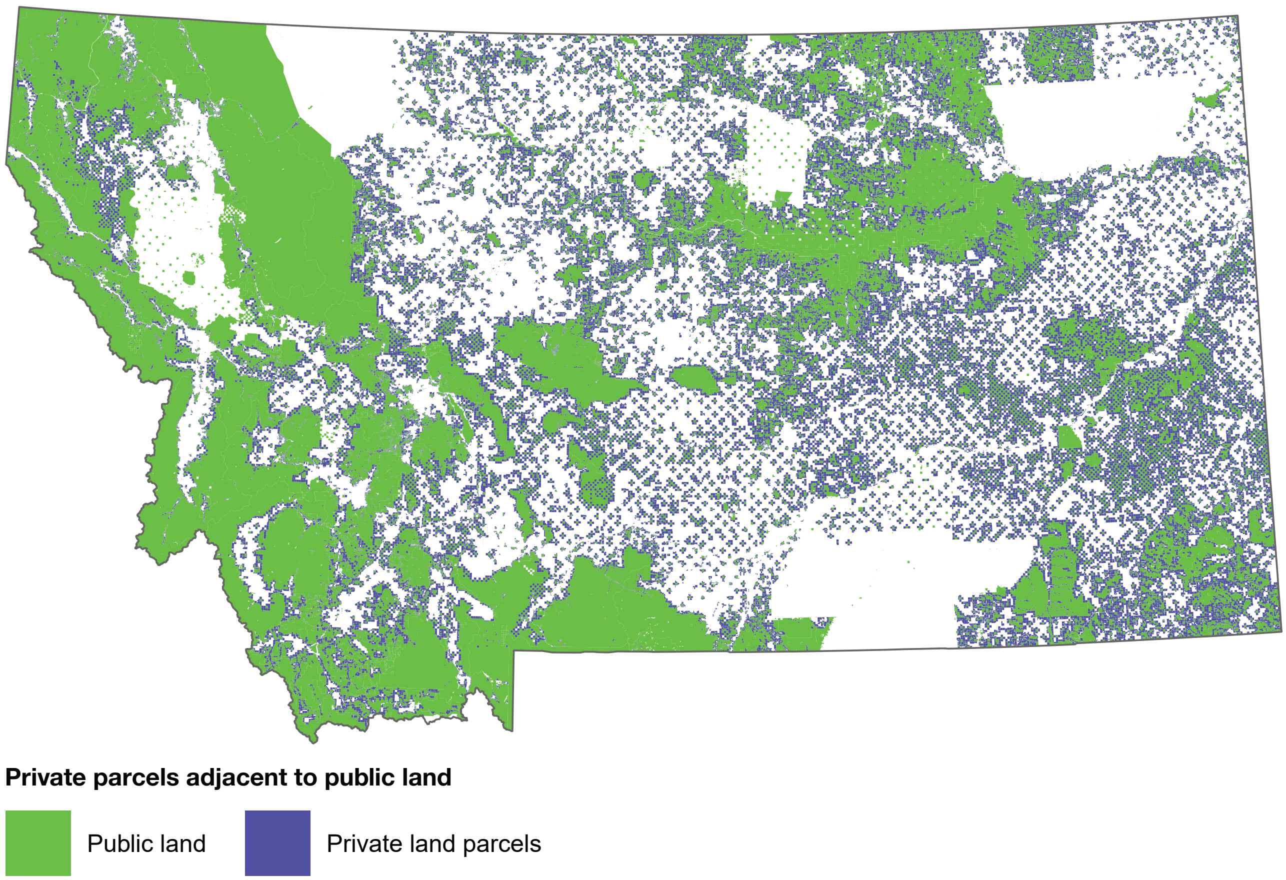

Figure 7—Private land parcels adjacent to public lands in Montana. Private land parcels that are adjacent to public lands are distributed throughout the state, though they are concentrated in central and eastern areas where public land is more fragmented.

variables with interactions between the adjacent-to-public land or adjacent-to-stranded-public land variables and agency indicator variables (Forest Service, BLM, other federal, state, and multiple public agencies). Model 4 (table 6) included county fixed effects, and Model 5 included PLSS fixed effects.[8] Interactions allowed the effects of public lands on the value of adjacent private land to vary by agency. In models 4 and 5, the results showed that Forest Service land had the largest negative effects on adjacent private parcels. Compared to nonadjacent parcels, adjacency to Forest Service-managed land reduced land values by about $13,117 per acre (Model 4) or $6,880 per acre (Model 5). If the Forest Service land was stranded, the per-acre value decreased by another $4,692 (Model 4) or $2,671 (Model 5). In both models, negative effects were found for all other agency categories, with larger negative effects found in Model 4, which had coarser fixed effects. If the public land was stranded, these negative effects were more than offset in the cases of the BLM and multiple public agencies. These preliminary results suggested that the model, despite including county or PLSS fixed effects and a distance index, was not controlling adequately for remoteness. Parcels adjacent to Forest Service-managed land were likely to be in more rural areas and therefore had considerably lower per-acre land values compared to urban parcels within the same county or PLSS unit.

[8] Except for the interaction terms, Model 4 in table 6 is identical to Model 2 in table 5, and Model 5 in table 6 is identical to Model 3 in table 5. We report only the estimated coefficients on the interaction terms for brevity.

Table 4—Land cover distribution by land type (ownership, adjacency, and public accessibility) in Montana

Land type	Land cover							
	PERCENT							
	Water	Developed	Barren	Forest	Shrubland	Herbaceous	Planted/ cultivated	Wetland
All land	1.0	1.0	0.5	20.4	24.1	36.5	14.9	1.6
All private land	0.2	1.2	0.1	7.7	24.6	42.0	22.7	1.6
Private land, adjacent[a]	0.1	0.6	0.1	9.8	28.2	45.9	13.9	1.3
Private land, nonadjacent	0.2	1.6	0.1	6.1	21.9	39.0	29.3	1.8
All public land	1.4	0.3	1.1	42.5	25.1	27.3	1.6	0.7
All USFS land	0.5	0.1	1.4	69.5	17.6	10.7	0.0	0.2
All BLM land	0.2	0.2	0.1	9.5	37.3	52.1	0.1	0.5
All NPS land	2.8	0.2	10.3	51.3	23.4	11.1	0.2	0.6
All other federal land	21.5	0.3	0.1	7.0	34.8	30.0	0.8	5.5
All state land	4.5	1.0	0.3	35.1	30.7	21.9	2.0	4.4
All stranded public land[b]	0.4	0.1	0.2	8.6	30.2	55.5	3.9	1.1
Stranded USFS land	4.0	0.1	0.6	65.9	13.3	15.0	0.3	0.8
Stranded BLM land	0.3	0.0	0.2	7.9	32.0	58.6	0.2	0.7
Stranded NPS land	3.9	0.0	0.0	25.9	43.8	23.5	0.8	2.1
Other federal stranded land	14.8	0.6	2.4	0.3	11.4	52.3	4.3	13.9
Stranded state land	8.5	2.5	0.2	11.4	16.9	27.4	7.0	26.2
All nonstranded public land	1.5	0.3	1.2	44.6	24.7	25.5	1.4	0.7
Nonstranded USFS land	0.5	0.1	1.4	69.5	17.6	10.6	0.0	0.2
Nonstranded BLM land	0.2	0.2	0.1	9.8	38.0	51.1	0.1	0.4
Nonstranded NPS land	2.8	0.2	10.3	51.3	23.4	11.1	0.2	0.6
Other federal nonstranded land	21.5	0.3	0.1	7.0	34.9	30.0	0.7	5.5
Nonstranded state land	4.5	0.9	0.3	35.6	31.0	21.8	1.9	4.0

BLM = Bureau of Land Management, NPS = National Park Service, USFS = Forest Service.

[a] Private adjacent refers to public lands that are next to private lands.

[b] Stranded refers to public lands that lack direct public access because of surrounding private lands.

Table 5—Private land value per acre regression results (Models 1–3), interactions with land characteristic and ownership variables for the effect of adjacent stranded land on private land values

Variable	Model 1		Model 2		Model 3	
	Estimate	SE	Estimate	SE	Estimate	SE
Adjacent to public land	−7,351.224***	211.972	−5,718.334***	212.205	−2,555.652***	207.336
Adjacent to stranded public land[a]	4,555.621***	343.876	3,461.602***	341.842	1,511.446***	323.973
Net primary production	1.969***	0.02	1.995***	0.02	1.742***	0.019
Elevation	1.725***	0.395	11.947***	0.97	−13.133***	1.959n
Roughness[b]	−792.722***	12.968	−727.500***	13.339	−590.420***	14.39
Precipitation	63.545***	1.03	38.995***	1.302	57.249***	2.997
Temperature	1,180.844***	90.967	626.641***	179.81	2,879.239***	444.716
Soil class 0	41,488.820***	919.108	42,069.610***	905.891	29,503.750***	855.112
Soil class 2	1,803.859**	730.599	2,250.251***	723.248	−1,954.145***	690.669
Soil class 3	887.574	719.98	1,691.567**	712.588	−2,831.188***	682.879
Soil class 4	1,444.479*	741.013	1,456.233**	733.926	−2,117.050***	701.935
Water	8,709.799***	2022.152	6,247.853***	1984.482	1,786.69	1,783.70
Developed	51,602.850***	338.194	46,666.110***	340.879	31,679.640***	328.061
Barren	−3,721.45	2892.65	795.025	2840.62	−239.694	2,601.74
Herbaceous	495.457**	221.264	1,336.292***	223.353	−1,078.435***	221.185
Forest	5,271.709***	271.998	5,380.312***	272.208	2,071.486***	264.555
Planted/cultivated	−1,699.105***	255.113	−2,772.497***	256.419	−6,051.578***	258.785
Wetlands	−4,669.552***	502.558	−4,703.699***	495.9	−5,586.380***	458.997
Grazing	127.035	238.903	405.458	260.172	5,954.315**	2,373.04
Idaho Batholith Ecoregion	5,081.426***	1126.682	16,081.120***	1460.1	917.958***	301.069
Middle Rockies Ecoregion	16,824.860***	320.987	22,391.680***	936.745	9,675.927***	1,541.13
Wyoming Basin Ecoregion	2,393.91	1477.745	18,932.460***	1828.509	6,072.933*	3,369.37
Canadian Rockies Ecoregion	−6,990.019***	732.435	−7,268.610***	748.571	1,656.09	1,564.77
Northwestern Glaciated Plains Ecoregion	4,286.847***	312.381	21,328.810***	1071.667	7,204.326***	1,772.70
Northwestern Great Plains Ecoregion	4,547.062***	314.518	20,241.440***	1051.357	7,174.888***	1,704.28
Size	−13.673***	0.454	−13.523***	0.463	−8.901***	0.481
Distance index	—	—	−156.305**	77.915	−149.099**	69.54
Constant	−32,970.620***	1241.095	—	—	—	—
County fixed effects?		No		Yes		No
PLSS fixed effects?		No		No		Yes
Observations		392,354		392,354		392,349
Adjusted R^2		0.201		0.231		0.403

Model 1 is the preferred model. Models 2 and 3 have additional control variables, and provide robustness checks against different assumptions. Models 2 and 3 both include a distance index, whereas model 1 does not. Model 3 includes a set of fixed effects, whereas models 1 and 2 do not.

PLSS = Public Land Survey System (township-level effects), SE = standard error, – = variable excluded from the model.

Note: Dependent variable is land value per acre in all models.

[a] Stranded refers to public lands that lack direct public access because of surrounding private lands.

[b] Standard deviation of elevation.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 6—Private land value per acre regression results (Models 4 and 5), interactions with land ownership variables for the effect of adjacent stranded land on private land values

Variable	Model 4		Model 5	
	Estimate	SE	Estimate	SE
Adjacent to public land × USFS land	−13,117.420***	376.626	−6,880.775***	392.94
Adjacent to stranded public land × USFS land	−4,692.070***	1379.761	−2,671.975**	1291.519
Adjacent to public land × BLM land	−3,074.409***	392.544	−991.158**	386.573
Adjacent to stranded public land × BLM land	3,291.034***	546.601	1,142.376**	521.334
Adjacent to public land × other federal land	−2,963.826*	1537.142	−2,807.369*	1472.659
Adjacent to stranded public land × other federal land	−486.658	6491.675	−657.524	5903.584
Adjacent to public land × state land	−3,015.882***	306.288	−1,435.818***	287.285
Adjacent to stranded public land × state land	667.278	541.634	442.397	500.026
Adjacent to public land × multiple public land management agencies	−3,134.018***	640.07	−866.766	599.795
Adjacent to stranded public land × multiple public land management agencies	4,746.009***	969.33	1,909.408**	892.722
Observations		392,354		218,803
Adjusted R^2		0.253		0.120
County fixed effects		Yes		No
PLSS fixed effects		No		Yes

Models 4 and 5 include terms that estimate the effects of specific agencies (USDA Forest Service or USDI Bureau of Land Management) on the effect of stranded land. Model 5 includes fixed effects, whereas Model 4 does not.

BLM = Bureau of Land Management, PLSS = Public Land Survey System (township-level effects), SE = standard error, USFS = Forest Service.

Note: Dependent variable is land value per acre; the specification is the same as Model 2 in table 5, except that interaction variables are included.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Summary and Directions for Future Research

A main goal of this research was to develop fine-scale data on land values and attributes for Montana. Our final dataset included about 737,000 private and public access land parcels. The public parcels were classified by public land management agency and by whether they are accessible or stranded. About 800,000 acres of public lands (6 percent of Montana's total public land area) were stranded, and most were managed by the BLM or the state. For private lands, we determined whether parcels were adjacent to accessible and stranded public land. By area, about 45 percent of private lands were adjacent to public lands.

Summary statistics indicated that the average value of private land in Montana was $29,245 per acre. The subset of private land parcels that were adjacent to public lands had, on average, substantially lower land values ($110 per acre). This was likely because of adjacent parcels being more remote from cities and towns. Among different public land management agencies, private land adjacent to BLM-managed lands had the lowest average value, whereas private land adjacent to Forest Service-managed land was worth about $548 per acre more than the average adjacent parcel. Parcels adjacent to stranded public lands had an average land value of $61 per acre, compared to $133 per acre for parcels adjacent to nonstranded public lands. Adjacency to stranded and accessible Forest Service-managed lands provided a premium relative to the average adjacent parcels. A private parcel adjacent to stranded Forest Service-managed lands had an average value of $225 per acre, increasing to $669 per acre if the Forest Service land was directly accessible to the public.

We estimated the effect of adjacent public lands on private land values using three regression models that controlled for a variety of parcel attributes. In all models, the effect of adjacent public lands on private land values was negative. One drawback of these models was that they explained relatively little of the variation in land values in the cadastral dataset, which is indicated by the low adjusted R^2 values. This was likely because of the absence of available data on structure characteristics. It is important to note that in this study, we were concerned with the identification of marginal effects, notably the effects of land ownership and strandedness. In response to this issue, we included fine-scale fixed effects, which accounted for unobserved structure characteristics. Model 3 (table 5) included township-level (PLSS) fixed effects. Each township was 36 square miles (Wisconsin Department of Natural Resources 2023). This doubled the R^2 value, resulting in an R^2 of 0.403.

If the public land was stranded, this provided an offsetting positive effect, although the net effect remained negative in all specifications. The model with township-level fixed effects—the finest scale of the three models—indicated that adjacency to public land reduced land value by $2,555. If the public land was stranded, the reduction was by $1,044. While this finding was consistent with stranded public lands that provided amenities or other benefits to adjacent private landowners, we found that adjacency to stranded public land still had a negative net effect, even after controlling for indicators of remoteness, including parcel size, development status, a population-weighted distance index, and county or PLSS fixed effects. Exceptions were found when we estimated separate effects by management agency. The net effects of adjacency to stranded public land were positive when the land was managed by the BLM or by multiple public land management agencies.

Additional analysis is needed to better identify the effect of stranded and accessible public lands on property values, specifically to make sure that our results were not reflecting remoteness of public land parcels. One possibility would be to develop a more granular measure of rurality. This would necessitate going beyond the existing county-based measure of rural areas (e.g., Dobis et al. 2021). Another approach would be to compare neighboring parcels in cases where only one parcel is adjacent to public land. These parcels should have similar land values but for the effect of adjacency to public land. Finally, future research will explore in more depth the mechanisms underlying the different effects of accessibility and differences among public land management agencies. Further, there are possibly other metrics of strandedness that might be salient for statistical analysis, including fragmentation indices.

In the Western United States, public lands provide a large range of ecosystem services, including timber, forage, recreation, and species habitat. Federal lands provide most protected areas for species (Gergely and McKerrow 2013). Because the extent and configuration of public lands in the West is the consequence of 19th century policies focused on privatization, there is the potential to improve the provision of ecosystem services through the reorganization of public and private lands. Public-private land swaps, funding for which is provided by the Great American Outdoors Act, could improve access to public lands in the West, thus enhancing recreational activities. Such exchanges can also enhance habitat for species, especially by providing connectivity corridors for species with large ranges. Powers et al. (2022) found that substantial gains in coverage and connectivity could be achieved for key species of conservation concern in Montana through revenue-neutral public-private lands swaps.

Metric Equivalents

When you know:	Multiply by:	To find:
Miles	1.609	Kilometers
Acres	0.405	Hectares

U.S. Standard Equivalents

When you know:	Multiply by:	To find:
Kilometers	0.621	Miles
Hectares	2.47	Acres

Literature Cited

Allen, D.W. 1991. Homesteading and property rights; or, "how the West was really won." The Journal of Law and Economics. 34(1): 1–23. https://doi.org/10.1086/467217.

Bigelow, D.P.; Ifft, J.; Kuethe, T. 2020. Following the market? Hedonic farmland valuation using sales prices versus self-reported values. Land Economics. 96(3): 418–440. https://doi.org/10.3368/le.96.3.418.

Bivand, R.; Keitt, T; Rowlingson, B. 2022. rgdal: Bindings for the 'Geospatial' Data Abstraction Library. https://proj.org, https://r-forge.r-project.org/projects/rgdal/.

Center for Western Priorities. 2013. Landlocked: measuring public land access in the West. 15 p. https://westernpriorities.org/wp-content/uploads/2013/11/Landlocked-Measuring-Public-Land-Access.pdf. (March 8, 2024).

Chavez, M.J. 1987. Public access to landlocked public lands. Stanford Law Review. 39(6): 1373–1401. https://doi.org/10.2307/1228850.

Dobis, E.A.; Krumel, T.P., Jr.; Cromartie, J.; Conley, K.L.; Sanders, A.; Ortiz, R. 2021. Rural America at a glance. 2021 ed. Economic Information Bulletin EIB-230. Washington DC: U.S. Department of Agriculture, Economic Research Service. 18 p.

Gates, P.W. 1968. History of public land law development. U.S. Government Printing Office. Vol 62. 828 p.

Gaure, S. 2013. lfe: Linear group fixed effects. The R Journal. 5(2): 104–117. https://doi.org/10.32614/RJ-2013-031.

Gergely, K.J.; McKerrow, A. 2013. PAD-US—National inventory of protected areas. Fact Sheet 2013–3086. Reston, VA: U.S. Department of the Interior, Geological Survey. 2 p. https://doi.org/10.3133/fs20133086.

Great American Outdoors Act [GAOA] of 2020; H.R. 1957; Public Law 116–152.

Hibbard, B.H. 1924. A history of the public land policies. New York: The Macmillan Co.

Homestead Act of 1862; 12 Stat. 392; Public Law 37–64.

Leonard, B.; Plantinga, A.J. 2021. Stranded: the effects of inaccessible public land on local economies in the American West. Santa Barbara, CA: Donald Bren School of Environmental Science and Management, University of California–Santa Barbara. 35 p. https://doi.org/10.2139/ssrn.4047357.

Leonard, B.; Plantinga, A.J.; Wibbenmeyer, M. 2021. Stranded land constrains public land management and contributes to larger fires. Environmental Research Letters. 16(11): 114014. https://doi.org/10.1088/1748-9326/ac2e39.

Libecap, G.D. 2018. Federal lands, opportunity costs, and bureaucratic management. Working Paper 24705. Cambridge, MA: National Bureau of Economic Research. 32 p.

Loomis, J.B. 2002. Integrated public lands management: principles and applications to national forests, parks, wildlife refuges, and BLM lands. 2nd ed. New York: Columbia University Press. 544 p. https://doi.org/10.7312/loom12444.

Lopach, J.J. 2020. Tribal government today: politics on Montana Indian reservations. New York: Routledge. 214 p. https://doi.org/10.4324/9780429269592.

Modernizing Access to our Public Land Act of 2022; H.R. 3113; Public Law 117–114.

Montana State Library. 2021. Montana Cadastral [Database]. https://svc.mt.gov/msl/cadastral/?page=Map. (2021).

Multi-Resolution Land Characteristics Consortium [MRLC]. 2016. Land cover type [Database]. https://www.mrlc.gov/data?f%5B0%5D=year%3A2016. (2021).

National Aeronautics and Space Administration [NASA]. 2017. MODIS gross primary production (GPP)/net primary production (NPP [Database]). https://modis.gsfc.nasa.gov/data/dataprod/mod17.php. (2021).

Paul, B. 2006. Statutory land exchanges that reflect appropriate value and well serve the public interest. Public Land & Resources Law Review. 27: 107.

Powers, L.C.; Larsen, A.E.; Leonard, B.; Plantinga, A.J. 2022. Reconnecting stranded public lands is a win-win for conservation and people. Biological Conservation. 270: 109557. https://doi.org/10.1016/j.biocon.2022.109557.

PRISM Climate Group, Northwest Alliance for Computational Science and Engineering, Oregon State University [PRISM]. 2018. 30-year normals [Database]. https://prism.oregonstate.edu. (2021).

R Core Team. 2022. R: a language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing. https://www.R-project.org.

R Studio Team. 2022. RStudio: integrated development for R. Boston, MA: RStudio, PBC. https://posit.co/download/rstudio-desktop.

Taylor Grazing Act of 1934; 48 Stat. 1269; 43 U.S.C. s/s 315 et seq.

U.S. Census Bureau. 2017. 2017 TIGER/Line® shapefiles: roads [Database]. https://www.census.gov/cgi-bin/geo/shapefiles/index.php?year=2017&layergroup=Roads. (2021).

U.S. Census Bureau. 2020. TIGER/Line® shapefile, 2020, nation, U.S., American Indian tribal subdivisions [Database]. https://catalog.data.gov/dataset/tiger-line-shapefile-2020-nation-u-s-american-indian-tribal-subdivisions. (2021).

U.S. Census Bureau. 2021. State boundaries [Database]. https://data.census.gov. (2021).

U.S. Department of Agriculture, Natural Resources Conservation Service [USDA NRCS]. 2018. Web soil survey [Database]. https://www.nrcs.usda.gov/resources/data-and-reports/web-soil-survey. (2021).

U.S. Department of Agriculture, Natural Resources Conservation Service [USDA NRCS]. 2021a. National Hydrology Dataset [Database]. https://datagateway.nrcs.usda.gov. (2021).

U.S. Department of Agriculture, Natural Resources Conservation Service [USDA NRCS]. 2021b. National Elevation Database [Database]. https://datagateway.nrcs.usda.gov. (2021).

U.S. Department of the Interior, Bureau of Land Managemen [USDI BLM]. 2021. Livestock grazing on public lands. https://www.blm.gov/programs/natural-resources/rangelands-and-grazing/livestock-grazing. (2021).

U.S. Environmental Protection Agency [US EPA]. 2014. Ecoregions. https://www.epa.gov/eco-research/ecoregions (2021).

U.S. General Accounting Office. 1992. Federal lands: reasons for and effects of inadequate public access. Briefing Rep. GAO/RCED-92-116BR. Washington, DC. 34 p. https://www.gao.gov/assets/rced-92-116br.pdf. (July 9, 2024).

U.S. Geological Survey. 2021. PAD-US data download [Database]. https://www.usgs.gov/programs/gap-analysis-project/science/pad-us-data-download. (2021).

White, E.M.; Bowker, J.M.; Askew, A.E.; Langner, L.L.; Arnold, J.R; English, D.B.K. 2016. Federal outdoor recreation trends: effects on economic opportunities. Gen. Tech. Rep. PNW-GTR-945. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Station. 46 p. https://doi.org/10.2737/PNW-GTR-945.

Wisconsin Department of Natural Resources. **2023.** Tutorial on the Public Land Survey System descriptions. 5 p. https://dnr.wisconsin.gov/sites/default/files/topic/ForestManagement/PLSSTutorial.pdf. (February 17, 2023).

APPENDIX 1
Identification of Owner Names in the Montana Cadastral

The Montana Cadastral (see table 1) contains information about the name of the owner for each parcel. We used this information at several points in the analysis, including the process of defining parcels as public or private. The cadastral data contains about 436,000 individual owner names. There were several challenges in determining whether an owner that was named was public or private. First, there is no public or private classification in the cadastral data itself. Second, the encoding is very inconsistent. For example, the name for the U.S. Department of the Interior, Bureau of Land Management is spelled almost 50 different ways in the dataset. We needed to definitively distinguish between public and private parcels, and we could not find an applicable reference in the literature; as a result, we found it was necessary to create our own methodology. Our method used the following steps to determine whether an owner named in the cadastral was public or private:

1. As a first pass, we listed the owner names that were associated with parcels contained within public lands. This yielded a list of 2,316 individual names.
2. From this list, we manually identified the owner names that represented a public owner.
3. We used the names in the above list as insight to define a set of terms to include in a string search: "USA," "STATE," "MONTANA," "DEPT," "FOREST SERVICE," "UNITED STATES," "USDI," "USDA," "BUREAU," "LAND MANAGEMENT," " AGRICUL," "BLM," "CITY," "RECLAMATION," "GOVERNMENT," "AGRICULTURE," "US A," "COUNTY," "DEPARTMENT," "DEFENSE," "ARMY CORPS," "NATIONAL FOREST," "DOI," "FWP," "USFS," "BIA," "DNRC." This search yielded 2,949 unique owner names.
4. We manually went through this list and added names that appeared to belong to public owners to the original list of public owner names.
5. We identified owner names in parcels that overlapped public land (i.e., they were partly inside and partly outside) and were tax exempt, and manually determined which ones were public. We then added these names to the list of public owner names.
6. We repeated the preceding procedure for parcels that overlapped public lands and that had missing property values.

This method provided a list of owner names that appeared in the Montana Cadastral and that represented public owners. This is not a complete list, but because all owner names of parcels that overlapped public lands matched various string searches, were tax exempt, or were missing property values, we believe it was a comprehensive list of public owner names in the state.

Using this full list, we identified those owner names that corresponded to federal and state owners, and then classified them into the following categories: BLM, USFS, USBR, NPS, FWS, USDA, USDI, USDOD, USDOE, and USHUD, federal unspecified, federal American Indian reservation, uncategorized public, and state. The state category excluded all public owner names that represented the Montana Department of Transportation. The final list of public owner name categories for the purposes of our analysis was BLM, STATE, USFS, USBR, NPS, and FWS. These are the ones that best matched the public owners in the Protected Areas Database (PAD-US). Finally, private owner names are defined as those that are not public (using the full list including all agencies and owners other than federal and state), and that are not missing.

APPENDIX 2
Identification of Public Access Lands

The Protected Areas Database (PAD-US) 2.1 contains information about protected areas, both private and public, across the United States. Data on federal lands is provided directly from the managing agencies through the Federal Geographic Data Committee Federal Lands Working Group. This dataset was processed as follows. The public lands included in the analysis were only from the fee category. The analysis was further limited to those public lands that intersected Montana. The descriptive statistics only applied to those parts of public lands that were inside Montana. Hence, if a public land unit was partly inside and partly outside Montana, only the part inside was included.

We were only interested in federal and state public lands that were open to the public. This filtering was achieved in two steps. First, owner classes "regional agency special district," "joint," "local government," "non-governmental organization," "private," and "tribal" were eliminated. This left "federal," "state," and "unknown" under owner type. There were many observations of unknown owner type, whereas there were no observations of unknown manager types. Second, after filtering out the above owner types, we selected, among the remaining observations, those with federal and state managers.

APPENDIX 3
Potential Error Rate in Classifying Public and Private Parcels

We used four classifications for public land access: restricted, open, closed, and unknown. We filtered out public lands that were classified as closed, so that only public lands that were available in some way to the public were included. We can look at some statistics to get a sense of the possible error rate in the above classification scheme.

We excluded parcels that were more than 20 percent water and that did not intersect with American Indian reservation lands. Parcels that are fully contained in public lands are public, and those not contained in public lands are not public. So any ambiguity in classification arises from nonpublic parcels that overlap public lands (i.e., have some part inside and some part outside).

Assume that, among overlapping parcels, we have correctly classified parcels with >80 percent overlap as public, and those with <20 percent as not public. This leaves 1,866 ambiguous parcels out of a total of 133,396 overlapping parcels. Among these, 451 have public owner names, so we can assume that these belong to public lands. That leaves only 1,415 parcels that were still ambiguous. If these are the only ones we risk misclassifying, the upper bound for the misclassification rate among overlapping parcels is about 1.1 percent. Visual inspection of the data suggests that the remaining ambiguous parcels are unavoidably indeterminate.

APPENDIX 4
Variable Classifications

To further clarify the nature of each variable used in our regression, we provide a list of those variables with the type of data to which they belong in table A4.1. The variables can be one of three different data types—continuous, binary, and proportion. Continuous variables are numerical variables that have some real number value. Binary variables can have a value of 0 or 1. Proportion variables are continuous but constrained between 0 and 1. The proportion variables are typically scaled up to between 0 and 100, such that a unit change represents a change by 1 percent as opposed to 100 percent.

Table A4.1—Classification of regression variables used to analyze the effects of public lands on adjacent private property values

Variable	Data type
Adjacent to public land[a]	Binary
Adjacent to stranded public land[b]	Binary
Net primary production	Continuous
Elevation	Continuous
Roughness[c]	Continuous
Precipitation	Continuous
Temperature	Continuous
Soil class 0	Binary
Soil class 2	Binary
Soil class 3	Binary
Soil class 4	Binary
Water	Proportion
Developed	Proportion
Barren	Proportion
Herbaceous	Proportion
Forest	Proportion
Planted/cultivated	Proportion
Wetlands	Proportion
Grazing	Proportion
Idaho Batholith Ecoregion	Binary
Middle Rockies Ecoregion	Binary
Wyoming Basin Ecoregion	Binary
Canadian Rockies Ecoregion	Binary
Northwestern Glaciated Plains Ecoregion	Binary
Northwestern Great Plains Ecoregion	Binary
Size	Continuous
Distance index	Continuous

[a] Adjacent to public land refers to proximity of private land parcels.
[b] Stranded public land refers to land that lacks direct public access because of surrounding private lands.
[c] Standard deviation of elevation.

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