Online Appendix OA of "State Trust Lands and Natural Resource Use in the US Northwest" (Alston and Smith):

Data and Variables Description

Here we describe the variables and underlying sources for all data surrounding the analysis as well as additional figures and tables.

OA.1 Raw Data Sources:

Atack, Jeremy "Historical Geographic Information Systems (GIS) database of U.S. Railroads for 1826-1911" (May 2016)

Bureau of Land Management (BLM). General Land Office Records. 2022. [accessed June 2022] https://glorecords.blm.gov/BulkData/default.aspx

Bureau of Land Management (BLM). *PLSS First Division.* 2016. [accessed June 2016] http://www.blm.gov/co/st/en/BLM_Programs/geographical_sciences/gis/GeospatialData/gcdb_mm_2005_polygon.html

ESRI database. *USA Railroads.* 2016. [accessed August 2016] https://services.arcgis.com/P3ePLMYs2RVChkJx/arcgis/rest/services/USA_Railroads/FeatureServer

Idaho Department of Water Resources (IDWR). *Place of Use: Water Rights.* 2021. [downloaded April, 2022] https://maps.idwr.idaho.gov/arcgis/rest/services/BP/_WaterRights/FeatureServer/9

Montana Department of Natural Resources and Conservation (MTDNRC). *Montana Water Rights.* 2017. Montana State Library Services. [downloaded July, 2017] https://mslservices.mt.gov/Geographic_Information/Data/DataList/datalist_Details.aspx?did={0303D17E-BD0F-4180-A345-359C61E586F0}

National Atlas of the United States. *1:1,000,000-Scale Hydrographic Geodatabase of the United States—Conterminous United States: Vector digital data*. Rolla, MO, 2014. http://nationalatlas.gov/atlasftp-1m.html

North Dakota Department of Water Resources. *Water Permit Information Place of Use: Water Rights.* 2020. [downloaded February, 2020] https://mapservice.dwr.nd.gov/index.phtml?active=Permits

PRISM Climate Group (2004). PRISM Climate Data.

USDA NRCS. *Digital General Soil Map of U.S.: Tabular digital data and vector digital data.* Fort Worth, Texas, 2006. http://websoilsurvey.nrcs.usda.gov

USDA-NASS. *USDA National Agricultural Statistics Service Cropland Data Layer.* 2019. [downloaded February, 2020] https://nassgeodata.gmu.edu/CropScape/

USGS EROS Data Center. *GTOPO30 global digital elevation model: raster data tiles.* Sioux Falls, South Dakota, 1996. https://lta.cr.usgs.gov/GTOPO30

USGS Gap Analysis Project. *Protected Areas Database of the United States (PAD-US) 2.1.* Lakewood, Colorado 2021. https://doi.org/10.5066/P9IVLRSS

Washington State Department of Ecology. *The Water Resources' GWIS database.* 2019. [downloaded February, 2020] https://fortress.wa.gov/ecy/gispublic/DataDownload/wr/GWIS_Data/

OA.2 Variables in Analysis:

OUTCOMES:

Irrigated: An indicator equal to 1 if any portion of the 640-acre unit has any irrigation water rights. Measure is calculated in ArcGIS using water right shape files from Idaho (IDWR 2021), Montana (MTDNRC 2017), North Dakota (NDDWR 2020), and Washington (WSDE 2020) and the BLM PLSS data (BLM 2016). The indicator variable is set to 1 if the fraction of the PLSS unit contained in an irrigation water right point of use greater than 0.01.

Irrigated[year]: Same as *Irrigated*, but the indicator is replaced by zero if the earliest irrigation water right is after the indicated year.

Priority Year: Year of the ***earliest*** water right irrigating the 640-acre unit.

Developed Share: Based on the tabulate area tool in ArcGIS, this is the share of the section (BLM 2016) classified as either low, medium, or high development in the Cropscape Data Layer (USDA-NASS 2019)

Grassland Share: Based on the tabulate area tool in ArcGIS, this is the share of the section (BLM 2016) classified as grassland pasture in the Cropscape Data Layer (USDA-NASS 2019)

Cropland Share: Based on the tabulate area tool in ArcGIS, this is the share of the section (BLM 2016) classified as a crop in the Cropscape Data Layer (USDA-NASS 2019)

Forest Share: Based on the tabulate area tool in ArcGIS, this is the share of the section (BLM 2016) classified as either deciduous, evergreen, or mixed forest in the Cropscape Data Layer (USDA-NASS 2019)

CONTROLS:

State Section: An indicator equal to one if section is numbered 16 or 36 (BLM 2016).

State Claimed: An indicator equal to one if section is either patented under the "Idaho Territory Act", ""MT-ND-SD-WA Enabling Act", "State Grant-School Sec Patent", "State Grant-Agri College", "State Grant-University Land", "Indemnity Selections", of the "Washington-Lieu Selection" Acts and the state is listed as the patentee (BLM 2022) or if the section has greater than 24 percent contained in State Fee Land (USGS 2021).

State Indemnity: An indicator equal to one if section is "State Claimed" but is not numbered section 16 or 36 (BLM 2022, BLM 2016, USGS 2021).

State Owned: if the section has greater than 24 percent contained in State Fee Land (USGS 2021). Ownership was determined independently for each state based on data: WA, Loc_D=Trust Land; ID, Own_name="SDOL"; MT, Loc_Own=Montana State Trust Lands; ND, Loc_own=State Land Board.

State Sold: An indicator equal to one if section is "State Claimed" but not "State Owned" today (BLM 2022, USGS 2021).

Land Grant Buffer: This is an indicator equal to 1 if the centroid of the 640-acre unit lies within the statutorily defined extent of the relevant railroad based on the distance from the Northern Pacific Line calculations. In our analysis we consider all sections within the primary grant area (40 miles) (BLM 2016; Atack 2016)

Distance to Railroad: This is the distance in miles from the nearest railroad. Distances were calculated in ArcGIS with the near table tool using Atack (2016) historic shape files and PLSS shape files (BLM 2016) Distances based on 1911 railroad networks in operation are utilized.

Odd Section: This is an indicator equal to 1 if the 640-acre unit odd (1, 3, …, 35) numbered (BLM 2016) to indicate sections reserved for the Northern Pacific.

Distance to Stream: The distance to the nearest stream from the centroid of the 640-acre unit given in meters. Calculated in ArcGIS with PLSS data (BLM 2016) and stream data (National Atlas 2014) using the near table tool. Stream locations are contemporary.

Strahler Stream Order: The strahler order of the nearest stream to the 640-acre unit. This information was linked to the near table calculated for the distance to the nearest stream in order to identify the nearest stream's strahler order (National Atlas 2014). Strahler order is discretely measured 1-7 and is based on the number of tributaries that have been combined. When two order 1 streams come together, it becomes an order 2 stream. If another order 1 stream joins the order 2, the joint stream remains order 2. When two order 2 streams combine, it becomes order 3. This process continues through order 7.

Soil Quality: Spatial average of the soil classification within the 640-acre unit. Classification is discrete from 1 (high suitability) to 8 (low suitability) We calculated the spatial average of niccdcd (USDA 2006) for PLSS units (BLM 2016) by tabulating the intersection of the layers in ArcGIS.

Elevation (mean): Spatial average of the elevation in meters for the 30 degree grid (USGS 1996) calculated for the 640 acre sections of the PLSS system (BLM 2016) using the zonal statistics tool in ArcGIS.

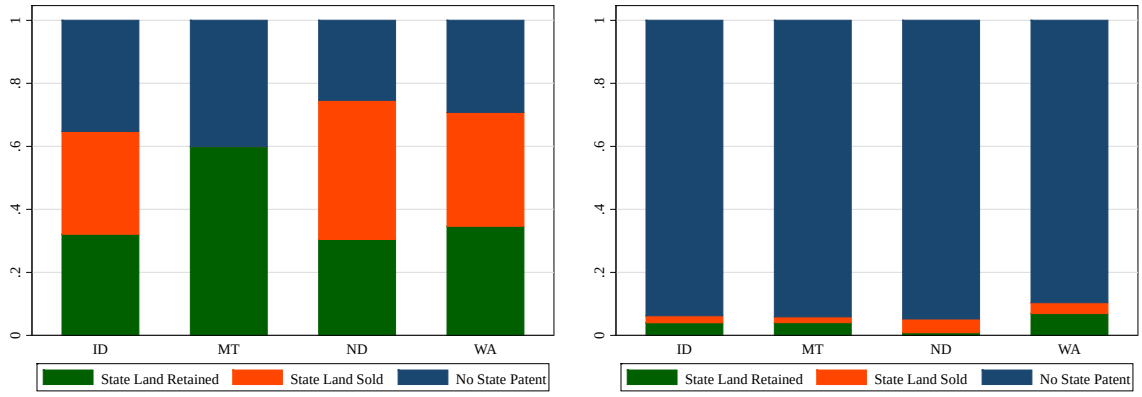
Elevation (st. dev): Spatial standard deviation of the elevation in meters for the 30 degree grid (USGS 1996) calculated for the 640 acre sections of the PLSS system (BLM 2016) using the zonal statistics tool in ArcGIS.

Average Precipitation: Spatial average of the 30-year average annual total precipitation in millimeters at the 30 x 30 meter resolution (PRISM 2004) for the 640 acre section (BLM 2016) using the zonal statistics tool in ArcGIS.

Average Temperature: Spatial average of the 30-year average monthly temperature in degrees celsius at the 30 x 30 meter resolution (PRISM 2004) for the 640 acre section (BLM 2016) using the zonal statistics tool in ArcGIS.

OA.3 Additional Figures and Tables

FIGURE A1
STATE LANDS BY STATE



Panel A: Sections 16/36 **Panel B: Other Sections**

Notes: Graphs of the percentage of sections under various ownership status across each state. "State Land Retained" is that which was patented by the state and remains owned by the state today. "State Land Sold" was patented by the state but is no longer owned by the state today. "No State Patent" is that which never had a patent by the state nor is owned by the state today. The final category may or may not be patented by others. Panel A includes only sections numbered 16/36, designated by the state in the grants. Panel B includes all other sections. Patents are from GLO land records (BLM 2022) and current ownership is from PAD-US (USGS 2021).

TABLE A1
ROBUSTNESS TO SELECTION

	(1) Irrigated	(2) Priority Year	(3) Developed Share	(4) Grass Share	(5) Cropland Share	(6) Forest Share
Panel A: Intent-to-treat						
Section 16/ 36	-0.0137***	0.918**	-0.000886**	0.0137***	-0.0180***	0.00579***
	(0.00252)	(0.401)	(0.000376)	(0.00314)	(0.00305)	(0.00139)
N	370510	77676	299591	299591	299591	299591
Adj. R-sq	0.509	0.615	0.620	0.771	0.659	0.841
Dep. Var. Mean	0.219	1921.3	0.00960	0.273	0.128	0.304
Dep. Var. Std.	0.413	35.79	0.0594	0.330	0.259	0.368
Panel B: IV Estimates						
State Owned (Today)	-0.0353***	2.257**	-0.00216**	0.0334***	-0.0439***	0.0141***
	(0.00627)	(0.956)	(0.000947)	(0.00681)	(0.00613)	(0.00347)
N	370510	77676	299591	299591	299591	299591
Adj. R-sq	0.045	-0.056	-0.017	-0.021	0.016	0.029
Dep. Var. Mean	0.219	1921.3	0.00960	0.273	0.128	0.304
Dep. Var. Std.	0.413	35.79	0.0594	0.330	0.259	0.368
Panel C: Exclude selected State lands						
State Owned (Today)	-0.0466***	2.129***	-0.00244***	0.0396***	-0.0550***	0.0110***
	(0.00474)	(0.575)	(0.000429)	(0.00663)	(0.00540)	(0.00320)
N	356540	74988	286182	286182	286182	286182
Adj. R-sq	0.514	0.620	0.624	0.769	0.664	0.840
Dep. Var. Mean	0.219	1921.2	0.00988	0.273	0.130	0.301
Dep. Var. Std.	0.414	35.84	0.0607	0.329	0.261	0.367
Panel D: Exclude selected state lands, sold state lands, and non-patented lands						
State Owned (Today)	-0.0704***	2.257***	-0.00234***	0.0385***	-0.0598***	0.0203***
	(0.00763)	(0.582)	(0.000447)	(0.00688)	(0.00540)	(0.00325)
N	252026	68986	186692	186692	186692	186692
Adj. R-sq	0.527	0.610	0.618	0.756	0.636	0.836
Dep. Var. Mean	0.286	1921.9	0.0133	0.349	0.188	0.179
Dep. Var. Std.	0.452	35.54	0.0711	0.347	0.296	0.295

Notes: Coefficients from estimating equation (1) for the outcomes indicated in the column headers with township fixed effects. Each panel offers an alternative to address selection in lands selected and sold. Panel A uses sections numbered 16 or 36 as the treatment. Panel B uses an IV, instrumenting for state owned land by whether the section is numbered 16 or 36. Panel C excludes state lands not on sections 16 or 36. Panel D excludes those as well as state lands sold and any section without a patent. To address the railroad land grant, the regressions also include an indicator for whether the section is within the railroad grant, odd numbered, and the interaction term. Additional controls for distance to a railroad, distance to a stream, size of that stream (Strahler order), mean elevation, standard deviation of elevation, average precipitation, average temperature, and soil class are also included. Robust standard errors, clustered by county, in parentheses.
***p<0.01, **p<0.05

TABLE A2
ROBUSTNESS TO FIXED EFFECT SCALE

	(1) Irrigated	(2) Priority Year	(3) Developed Share	(4) Grass Share	(5) Cropland Share	(6) Forest Share
Panel A: State FE						
State Owned (Today)	-0.0428***	2.472	-0.00958***	0.0452***	-0.0616***	0.00904
	(0.0125)	(1.603)	(0.00249)	(0.0134)	(0.00838)	(0.0152)
N	370527	78405	299608	299608	299608	299608
Adj. R-sq	0.212	0.226	0.070	0.409	0.248	0.517
Dep. Var. Mean	0.218	1921.6	0.00960	0.273	0.128	0.304
Dep. Var. Std.	0.413	35.93	0.0594	0.330	0.259	0.368
Panel B: County FE						
State Owned (Today)	-0.0595***	2.019**	-0.00941***	0.0489***	-0.0648***	0.0120
	(0.0105)	(0.868)	(0.00224)	(0.0113)	(0.00665)	(0.0122)
N	370524	78405	299608	299608	299608	299608
Adj. R-sq	0.299	0.376	0.193	0.567	0.405	0.670
Dep. Var. Mean	0.218	1921.6	0.00960	0.273	0.128	0.304
Dep. Var. Std.	0.413	35.93	0.0594	0.330	0.259	0.368
Panel C: One-third Township FE						
State Owned (Today)	-0.0434***	1.848***	-0.00319***	0.0321***	-0.0417***	0.0208***
	(0.00508)	(0.517)	(0.000564)	(0.00652)	(0.00486)	(0.00528)
N	369940	75797	299034	299034	299034	299034
Adj. R-sq	0.569	0.675	0.689	0.801	0.710	0.857
Dep. Var. Mean	0.219	1920.8	0.00960	0.273	0.128	0.304
Dep. Var. Std.	0.413	35.61	0.0594	0.330	0.259	0.368
Panel D: One-fourth Township FE						
State Owned (Today)	-0.0384***	2.040***	-0.00281***	0.0334***	-0.0420***	0.0168***
	(0.00445)	(0.515)	(0.000454)	(0.00637)	(0.00495)	(0.00432)
N	369555	75018	298646	298646	298646	298646
Adj. R-sq	0.608	0.709	0.743	0.824	0.746	0.870
Dep. Var. Mean	0.219	1920.6	0.00960	0.273	0.128	0.304
Dep. Var. Std.	0.413	35.53	0.0594	0.330	0.259	0.368
Panel E: One-ninth Township FE						
State Owned (Today)	-0.0363***	1.514***	-0.00220***	0.0312***	-0.0417***	0.0174***
	(0.00487)	(0.538)	(0.000384)	(0.00642)	(0.00496)	(0.00389)
N	367123	70134	296243	296243	296243	296243
Adj. R-sq	0.676	0.763	0.816	0.852	0.799	0.879
Dep. Var. Mean	0.219	1919.7	0.00958	0.274	0.129	0.303
Dep. Var. Std.	0.414	35.27	0.0593	0.330	0.260	0.368

Notes: Coefficients from estimating equation (1) for the outcomes indicated in the column headers. Each panel utilizes increasingly finer spatial fixed effects for the main sample. Panel A is state fixed effects. Panel B uses modern county fixed effects. Panel C uses one-third of each township, defined "horizontally" in which the top two rows of sections (#s 1-12), middle two rows (#s 13-24), and the bottom two rows (#s 25-36) in each township are the fixed units. Panel D uses one-fourth (9 sections) of each township based on the four quadrants. Finally, Panel E uses one-ninth (4 sections) of each township based on intersecting horizontal and vertical thirds. To address the railroad land grant, the regressions also include an indicator for whether the section is within the railroad grant, odd numbered, and the interaction term. Additional controls for distance to a railroad, distance to a stream, size of that stream (Strahler order), mean elevation, standard deviation of elevation, average precipitation, average temperature, and soil class are also included. Robust standard errors, clustered by county, in parentheses.
***p<0.01, **p<0.05