The Impact of the Taylor Grazing Act: Heterogeneous Investment Responses and Land Use Change

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Abstract

The Taylor Grazing Act of 1934 converted the open range of the American West into grazing rights bundled with private "base" property. I model how this structure directs complementary investment toward the deeded base and test its predictions with a continuous-treatment difference-in-differences design covering 302 western counties from 1910 to 1974. Secure rights capitalized durably into farmland values, by 21 percent at low intensity and 48 percent at high, even as grazing pressure fell. Investment reallocated as the model predicts, tilting from land toward capital as exposure rose. The Act appears to have stabilized cattle production, with the adjustment falling on sheep, most sharply at high exposure, where their methods, historically less dependent on private land, ran up against a qualification built on holding it. The effects persist four decades after the Act, evidence that how rights are structured, not merely whether they exist, shapes production for generations.

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1 Introduction

It is well established that more secure property rights raise the expected return to investment (Besley, 1995; Field, 2007; Galiani and Schargrodsky, 2010). When producers can better protect what their asset yields, they improve it, reorganize production around it, and capitalize the gains into its value (Hornbeck, 2010). But security is rarely allocated uniformly. Where rights are contested or administratively assigned, the producers best positioned within the relevant political and institutional hierarchy can expect more secure claims, invest more heavily, and earn higher returns (Goldstein and Udry, 2008). Thus, the structure of the rules governing who holds a secure claim can matter as much as the security itself, shaping what gets invested in and who is in a position to invest at all.

This paper studies a setting in which the asset that determined access to a newly secured right was itself a productive private input. The Taylor Grazing Act of 1934 converted use of the remaining western public domain from open and unregulated grazing to leased, regulated, and exclusive permits. Access originally turned on two qualifications: demonstrated prior use of the range and ownership of base property, private land able to support livestock outside the grazing season. Where an applicant held one and not the other, the first rules ranked use above property. Within a year of passage that ordering was reversed at the request of range ranchers. The Act thus made access to a public resource more secure while making ownership of a complementary private asset the gateway to that security. I exploit variation across counties in the share of land brought into the permit system, largely fixed more than a decade before the Act, to show how this design capitalized rents into private ranch assets, redirected investment between land expansion and intensification, and altered the distribution of gains between cattle and sheep operations.

To organize the analysis, I develop a model of ranch investment in which secure access to public forage raises the value of the operation, with the form of the response dependent on the price of the complementary private land needed to qualify. Where private land is abundant and cheap relative to the range, the model predicts land-extensive investment where ranchers acquire the base property that secures their claim and expand. Where private land is scarce and costly, it predicts intensification on the holdings already in place. Because the county-level share of land entering the permit system, which I denote α_c, governs both the value of access and the scarcity of qualifying land, the model predicts that the level of investment should rise with α_c while its composition shifts from land toward capital as α_c increases.

The estimates bear this out. Using county-level data from the Census of Agriculture for 302 western counties from 1910 to 1974 and a dose-response difference-in-differences framework that accommodates continuous treatment (Callaway et al., 2025), I find that total farm value rose by 21, 36, and 48 percent in low-, medium-, and high-intensity counties relative to counties with essentially no exposure, and stayed there through 1974. The increase was not consolidation. The change in the number of farms is statistically indistinguishable from 0 across treatment bins such that the value of the average operation similarly rose by 27, 38, and 64 percent, respectively. The composition of the response varied as predicted. Land in farms rose most at moderate exposure, peaking at 10 percentage points of county area near an α_c of 25 percent and fading above 65 percent, with nearly all the new acreage in pasture. At high exposure, where additional private land was relatively scarce, operators reworked the crop ground they held, nearly doubling the share in hay, and raised operating expenditure

by 39 percent, with the increase arriving as labor in the medium run and equipment in the long run.

The distributional consequences appear as a break from the relatively uniform substitution patterns that preceded the Act. Cattle and sheep are close substitutes on the range and their relative returns are set in national markets, such that counties across the exposure distribution adjusted their composition in much the same way. After the Act the two diverge with α_c. Cattle production is flat across the distribution while sheep contract through the medium and long runs, by roughly 30 percent at an α_c of 75 percent and 45 percent at 85 percent. Sheep operations typically required little deeded ground, so a rule built on base property was likely to bear hardest on them.

Identification rests on the predetermination of α_c. Property rights reforms are typically endogenous political outcomes, and studies of their effects often lean on historical accidents of assignment or regime transitions for exogenous variation (Libecap and Lueck, 2011; Lueck and Pastrana, 2024; Yoo and Steckle, 2016). Here the reform itself was a political outcome, but a county's exposure to it was not. Which land remained federal in 1934 was decided by where homesteading had succeeded and where it had failed, a process that had largely run its course more than a decade before the Act, with county boundaries being drawn earlier still. When the grazing districts then took in essentially all of what remained, a county's exposure was the residual of settlement history rather than of any choice made under the new regime. The empirical work conditions on the geographic and New Deal-era differences that accompany public land shares. Section 5.2 states the assumptions the cross-exposure comparisons require.

This paper makes three contributions. First, I show how the reform's effects varied with the extent of a county's exposure to it. Recent work shows that property rights uncertainty deterred investment in the West (Alston and Smith, 2022), and that different land acquisition methods generated different investment strategies (Hauck, 2023). Closest to this paper, Bühler (2023) finds vegetation at least ten percent more productive inside grazing district boundaries than outside and, in county census data, more cattle and higher farm values where any district land fell within a county's borders. He attributes this to secure tenure resolving uncertainty over future use and aligning the incentives of ranchers and regulators. Less is known about what that response consisted of, or who bore its costs. Measuring exposure instead as the share of county land in the system, I find the farm value response rising from 21 to 48 percent across the intensity distribution. Second, I show that the composition of the response, and not only its size, was governed by the eligibility condition. Where prior work finds unequal security arising from standing within the institutions that govern access (Goldstein and Udry, 2008), here it was generated by a formal rule which selected among producers by their production technology rather than by their use of the resource. Conditioning access on base property made the local land market the binding constraint, producing land expansion where that market was deep and intensification where it was not. Third, I document the political economy of the condition itself. The preference ordering that favored base property was not the Act's. Administrators initially set prior use above it. However, the order was reversed within a year at the request of the operators it favored, whose long-lived investments made secure tenure most valuable and concentrated the gains from pressing for it (Kantor, 1998), and whose cooperation the agency could not do without (Calef, 1960; Libecap, 1981).

The setting also bears on the foundational literatures on the commons and the initial assignment of rights. The Act closed one of the largest commons in American history. The dissipation it was meant to arrest, along with the informal institutions that had governed the range before it, are the classic subjects of the common-pool literature (Wiggins and Libecap, 1985; Ostrom, 1990; Anderson and Hill, 2004). That literature takes up who is included when a commons closes, but largely as a question of who captures the rents. Less studied is what the condition of inclusion does to the private assets of those it admits. The Act adopted the design the first-possession literature predicts for a commons run under a rule of capture, with access limited and its transfer restricted (Lueck, 1995), but not the criterion that literature takes as dominant. Where bargaining is costless, the choice of criterion would settle the distribution of rents and not the use of the resource (Coase, 1960), since the rights would trade toward their highest-valued use. Here the permits did trade, but the eligibility condition traveled with them. A permit was valuable only through the base property that qualified it, so the condition shaped what producers acquired and how they produced no matter how freely the rights changed hands. The structure of the right, and not only its security, was allocative.

A government that rations access to a public resource must adopt some rule for who qualifies, and the rule may be a choice even where the rationing is not. On the evidence of the western range, the choice allocates more than access.

2 Historical Background

Appendix A gives the fuller history, along with the underlying series and their sources.

2.1 Land Distribution and Early Development of the Public Range

Throughout westward expansion, the federal government distributed vast swaths of land through homesteading acts and other programs, with around 285 million acres given out or sold off (Coggins and Lindeberg-Johnson, 1982). In the plains and Midwestern states where most land was arable, this process worked well – homesteaders selected the highest quality allotments, and the next wave claimed the best of what remained until most land had been distributed. In the West, however, this pattern broke down. Much of Western land proved unable to support the small-scale farming typical of plains homesteads, and while the rangeland grasses could support large-scale ranching, even enlarged homesteading allotments remained too small to individually support viable cattle operations.[1] These circumstances resulted in large expanses of lower quality, unclaimed lands remaining under federal ownership and open to public use (Coggins and Lindeberg-Johnson, 1982).

The suitability of Western rangelands to free-grazing cattle operations led to rapid expansion of livestock on public lands. Estimates suggest that cattle in Arizona increased from

[1]Congress recognized the mismatch and enlarged the allotments. The Enlarged Homestead Act of 1909 doubled the standard entry from 160 to 320 acres on non-irrigable land, and the Stock-Raising Homestead Act of 1916 raised it to 640 acres on land designated chiefly valuable for grazing. Even a full section was too small for a cattle operation in country where forage requirements ran to tens of acres per animal, and restrictions on claiming multiple allotments kept most operators from assembling enough land through homesteading alone.

around 50,000 to over a million within the second half of the 1800s (Coggins and Lindeberg-Johnson, 1982). Initially, the vast unsettled lands could accommodate this growth, and informal property rights emerged in which possession was recognized as a right to use and notification in local papers established claims. As ranges became more saturated, cattlemen's associations developed to enforce prior rights and manage collective costs. These associations provided leverage to exclude non-members through control of goods necessary for successful operations. By denying access to round-ups, corrals, and other essential tools, individually operating on these ranges could be made prohibitively costly. Membership in associations and the access rights they granted were often traded or sold, functioning as de facto property rights (Anderson and Hill, 2004).

Sheep operations were run differently. While both kinds of outfit drew on the same three sources of feed: forage from the range, hay and pasture off irrigated ground, and purchased concentrates, a sheep operation met a considerably larger share of its annual requirement from the range itself. It could also graze over range that cattle could only use through additional investments. Cattle had to drink every day and would rarely travel more than four miles from water, so range beyond that distance was unavailable until a well or reservoir had been built at a cost of several hundred to several thousand dollars; sheep could graze for a month or more on dew alone and could sustain themselves on snow in winter (Calef, 1960). Control of herds worked differently as well. A cattle operation could hold its animals by fencing or by riders, typically choosing between them on cost, but sheep were too vulnerable to be left unattended and so were herded regardless. Thus, a sheep operation needed no corrals, no round-ups, and no fences. It therefore needed neither the goods the associations controlled nor, at the extreme, any deeded ground at all.[2] The associations had no hold on it, so that the introduction of sheep weakened their principal exclusion mechanism (Anderson and Hill, 2004). What they did for the operations they covered they went on doing, but the leverage that had kept outsiders off a claimed range did not bear on a user who wanted none of it.

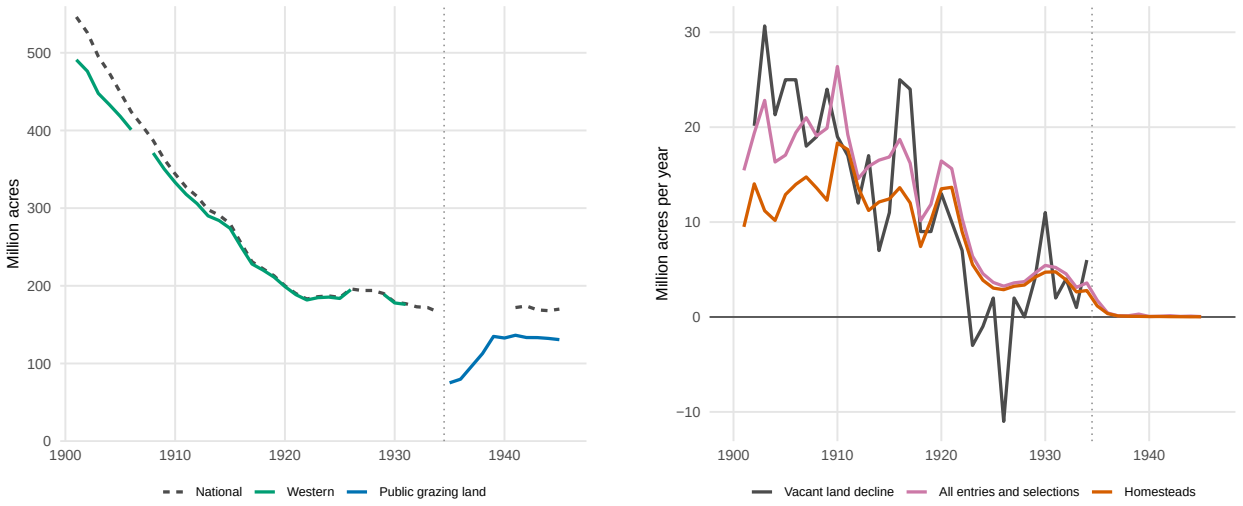
While range operations were coalescing across the public acres, the acreage itself was contracting. Vacant, unappropriated, and unreserved public land in the eleven western states fell from 491 million acres in 1901 to 176 million by 1931. The pace tells more than the extent as disposal ran at roughly 22 million acres a year at the turn of the century, 16 million through 1910, and 10 million over the fifteen years to 1925, before falling to 1.3 million a year between 1925 and 1931. Every state in the sample shows the same shape, and however far its stock had fallen, it was substantially flat from about 1922 onward. Homesteading accounts for most of the decline. Cumulative original entries between 1902 and 1931 total 303 million acres nationally against a fall in the national stock of some 297 million. Figure 1 plots the stock and the annual flows.[3] Executive Order 6910 of November

[2]Most sheep ranches held deeded ground like any other, running their bands off a home place and putting up hay on irrigated land. However, the same features made it possible to run with no home place at all, and while operations of that kind were not the modal case, they were a real part of the industry. Appendix A.2 gives the comparison in full.

[3]The category counts land that was vacant, unappropriated, and unreserved, so it excludes federal land already withdrawn for other purposes. Land taken into the national forest reserves, which grew from 167.9 million acres in 1908 to 194.5 million in 1909, leaves the category without passing into private hands. State-level figures are transcribed from the Annual Reports of the Commissioner of the General Land Office, which

26, 1934 withdrew what remained in the western states from settlement, location, sale, or entry pending classification, with entry falling to negligible levels thereafter.

The two processes came together on the range. Western herds did not shrink as the public domain did. Cattle in the western states rose from roughly 8 million to 10 million head between 1900 and 1930 and sheep held near 25 million, over a period in which the land still open to entry fell by about two thirds (Libecap, 1981). Overcrowding persisted, and climatic conditions compounded it, leading to severe soil erosion and significant degradation of rangelands (Stout, 1970). A survey in 1936 classed only 42 percent of the western range as in fair or better condition.[4] Continued concerns over rangeland conditions and conflicts between the various users of the range culminated in the passage of the TGA, which was signed on June 28, 1934 (Ross, 1984).



(a) Vacant Public Land and Land in Districts

(b) Annual Decline and Original Entries

Figure 1: The Public Domain in the West, 1901–1945

Note: Panel (a) plots vacant, unappropriated, and unreserved public land nationally and for the eleven western states in the sample, with public land within grazing districts overlaid from 1935. Panel (b) plots the annual decline in the national vacant stock against all original entries and selections and against homestead original entries. The national and entry series are F 8, F 11, and F 15 of United States. (1949); the state series is transcribed from the Annual Reports of the Commissioner of the General Land Office. State detail is unavailable for 1907, 1927, and 1928, and those gaps are left open. The Interior reports give no district figure for fiscal 1937; it is the only gap in a short series and is filled by linear interpolation. Negative values in Panel (b) indicate years in which restorations to entry exceeded disposals; the 1926 value reflects the statistical revision described above rather than a return of land. The dotted line marks 1934.

do not give state detail for 1907, 1927, or 1928; national figures are series F 8 and F 15 of United States. (1949). The 1926 report states that a special check of each district land office produced a complete revision of the statistics, so figures from 1926 forward are not strictly comparable with earlier years. Appendix A.3 gives the series in full.

[4]Box (1978), reported in Libecap (1981). The same series gives 67 percent in 1966 and 68 percent in 1972.

2.2 Introduction of Access Rights to the Range

The intent of the Taylor Grazing Act was:

> to stop injury to the public grazing lands by preventing over-grazing and soil deterioration, to provide for their orderly use, improvement, and development, to stabilize the livestock industry dependent upon the public range, and for other purposes.

What it changed were the terms on which the range was held. Use of the unreserved public domain had been free, unregulated, and open to anyone who turned stock onto it; after 1934 it was to be leased, regulated, and exclusive (Calef, 1960). Lands incorporated were evaluated as to their carrying capacity and divided into grazing allotments with the help of local advisory boards. Carrying capacity was estimated in animal-unit months (AUMs), with equivalent numbers of livestock differing by type.[5] Permits specifying the number of AUMs, which grazing allotments, the type of animal, and the grazing season of use were issued to qualifying applicants, with licensed grazing quickly ramping up.[6]

The districts took in most of what vacant land remained. Enrollment reached its final extent within five years. The first district was established in March 1935, and public land within districts rose from 75.1 million acres that year to 112.8 million by 1938 and 134.9 million by 1939, peaking at 136.3 million in 1941.[7] Across the ten states for which the Interior reports give state detail, public land in districts in 1940 correlates with the state's remaining 1931 public domain at 0.90, and at 0.95 conditioning on state area. Three states account for nearly all of the shortfall—California enrolled 20 percent of its 1931 vacant public land, Arizona 63 percent, and Nevada 66 percent — and excluding them, the other seven enrolled 93 percent of what they had remaining in 1931.[8]

The most restrictive rules on the allocation of grazing licenses are those regarding the preference rights requiring property ownership. Preference for allocation was tied to categories of base property adjacent or near grazing allotments. Adjacent base property was assessed on its ability to support livestock and assigned a corresponding number of AUMs.[9]

[5] An animal-unit month is the forage required to support one cow, one horse, or five sheep or goats for one month.

[6] By the end of 1935, 15,081 licenses covering 8,396,351 head of livestock had been authorized within the newly created districts; the figures had risen to 18,752 licenses covering 10,910,558 head by 1937 (U.S. Department of the Interior, 1938).

[7] The Act initially limited incorporation to 80 million acres, and a 1936 amendment raised the figure to 142 million; the limit was removed altogether in 1954 (Ross, 1984). The 142 million acre figure is often reported as the acreage the Act brought under management. However, enrollment never reached it. The acreage is public land within district boundaries, which is smaller than gross district area. The thirty-seven districts of fiscal 1936 held 79.8 million acres of public land inside boundaries enclosing 198 million acres in all ownerships (Calef, 1960).

[8] Washington is absent from the Interior state tables; it had 930,389 acres of vacant public land remaining in 1931. Shares above 100 percent are possible because land was restored to entry between 1931 and 1940, so the 1931 stock is not a ceiling on what could later be enrolled. Appendix A.3 gives the series and the state detail.

[9] In practice, the estimated capacity was heavily tied to previous livestock loads. There were no reliable data on range condition or carrying capacity, and allotments were set largely on what applicants reported having run, with the result that permits in most districts totaled more livestock than the range could support (Calef, 1960).

Capacity was allocated in order of category preference for base property up to the assigned AUMs until the estimated capacity was reached or assigned AUMs were exhausted. In the latter case, remaining capacity could be allocated to other applicants not meeting the initial base property requirements.

That the condition took this form was not settled by the Act itself. The statute gave preference to landowners engaged in the livestock business, to bona fide occupants and settlers, and to owners of water or water rights, but the ordering among applicants was administrative. The first circular ranked prior use above property for applicants who had one and not the other; within the year the order was reversed, after ranchers objected at a regional meeting that as written it gave an operator without base property priority over a local landowner who had not previously run stock on the range. The revised order was intended to remove the operator without base property, and largely did.[10]

In theory, licenses tied to base property could be revoked. In practice, a permittee who complied with the rules had little to fear from the renewal process, and licenses were typically issued for ten-year periods.[11] The combined renewal reliability and preferential treatment made base property status valuable. Additionally, this status was transferable, either along with the base property or by outright sale to similarly positioned property, such that it was typical for the status to be capitalized into sales prices of ranch property (Ragsdale, 1969). The necessity of owning or controlling such private base property to secure TGA permits highlights the critical role of private land availability and cost in how ranchers could leverage these new access rights, a core consideration in the theoretical model presented in the following section.

3 Theoretical Framework

This section develops a theoretical model to formalize how farmers' investment responses to the Taylor Grazing Act vary with local conditions. The model generates two key predictions. First, overall investment increases with treatment intensity (α_c) because the TGA reduces output losses from insecure access to public grazing. Second, investment composition shifts systematically with α_c: where complementary private land is abundant (low α_c), farmers pursue land-extensive strategies; where scarce (high α_c), farmers shift toward capital-intensive strategies. This heterogeneity arises because TGA permits required "base property"—private land whose cost increases with α_c—creating a fundamental trade-off in how farmers could capitalize on newly secured grazing access.

Consider a farmer in each county c and time period t, with a share of county land in public grazing acres, $\alpha_c \in [0, 1]$, choosing a level of overall investment I_{ct} to maximize profits. The farmer produces output $F(I_{ct}, q_{ct})$, where q_{ct} denotes land quality. $F(\cdot, \cdot)$ is increasing in

[10] The reversal followed a regional meeting of district representatives at Salt Lake City and was given effect by a new circular; the ordering appears in the Rules for Administration of Grazing Districts of June 14, 1937. See Calef (1960), pp. 60–61, and Foss (1960), p. 63. Appendix A.4 gives the sequence and the mechanics of allocation.

[11] Section 3 provides that no permittee complying with the rules shall be denied renewal where the denial would impair the value of the grazing unit when that unit is pledged as security for a bona fide loan. Calef (1960), p. 70, observes that since cancellation would inevitably impair that value, an operator holding even an original one-year license could put the question beyond reach by pledging the unit against a small loan.

both arguments and $F_{12}(\cdot,\cdot) > 0$ (meaning the arguments are complements). Availability of public grazing land augments production by scaling up output on private farms, $\psi(\alpha_c) \geq 1$, where $\psi(\alpha_c)$ is increasing in α_c. In the style of Hornbeck (2010), a fraction of this output, $\tau(\alpha_c) \in [0,1]$, is lost in each period due to lower security of output from public lands prior to the TGA; this lost fraction is assumed to be increasing in the share of county land in public grazing acres, $\tau'(\alpha_c) > 0$. Investment is produced at some cost, $C_{ct}(I_{ct})$. Thus, farmers choose their level of investment to maximize:

$$\max_{I_{ct}} \quad (1-\tau(\alpha_c))\psi(\alpha_c)F(I_{ct}, q_{ct}) - C_{ct}(I_{ct}) \tag{1}$$

An optimal interior solution satisfies the first-order constraint:

$$C'_{ct}(I_{ct}) = (1-\tau(\alpha_c))\psi(\alpha_c)F_1(I_{ct}, q_{ct}) \tag{2}$$

Or, rearranging:

$$\frac{C'_{ct}(I_{ct})}{F_1(I_{ct}, q_{ct})} = (1-\tau(\alpha_c))\psi(\alpha_c) \tag{3}$$

In equation 2, the marginal cost of investment is set equal to the marginal return in output the farmer expects to retain. The optimal choice of investment, $I^*(\alpha_c, q_{ct})$, depends on land quality and the share of county land in public grazing acres. Higher land quality directly increases investment by raising the marginal return to investment. However, the pre-TGA effect of public grazing land is ambiguous. Equation 3 shows that the relationship between α_c and the farmer's investment level is unclear without further assumptions on $\tau(\alpha_c)$ and $\psi(\alpha_c)$. At $\alpha_c = 0$, I assume $\tau(\alpha_c) = 0$ and $\psi(\alpha_c) = 1$, so the ratio of marginal cost to marginal benefit of investment is 1, representing the optimality condition under a standard property rights regime. At higher α_c, this ratio may vary. I assume that the passage of the TGA, by establishing more secure access rights and reducing competition as detailed in Section 2, reduces the lost portion, $\tau(\alpha_c)$, by some factor. Consequently, the resulting change in optimal investment due to the TGA, $\Delta I^*(\alpha_c, q_{ct})$, will be increasing in α_c.

To further model the nature of this investment, I assume that the overall investment I_{ct} can be achieved through two broad forms: investment in land, I^L_{ct}, and investment in capital, I^K_{ct}. Thus, $I_{ct} = \text{Inv}(I^L_{ct}, I^K_{ct})$, where $\text{Inv}(\cdot,\cdot)$ is the investment production function. The price of capital, p^K, is assumed to be constant across counties. The price of complementary private land (a key component of I^L_{ct} or necessary for it), p^L, is assumed to be increasing in the share of land in public grazing acres (α_c). This reflects that as α_c increases, the remaining private land suitable for agricultural operations (and potentially required as base property for TGA permits) becomes scarcer, driving up its relative price. Farmers choose the combination of I^L_{ct} and I^K_{ct} to minimize their cost while achieving their optimal level of new investment, ΔI^*. That is:

$$\min_{I^L_{ct}, I^K_{ct}} \quad p^L I^L_{ct} + p^K I^K_{ct} \quad \text{subject to: } \text{Inv}(I^L_{ct}, I^K_{ct}) \geq \Delta I^*(\alpha_c, q_{ct}) \tag{4}$$

An optimal interior solution satisfies the condition that the ratio of input prices equals the ratio of their marginal products in achieving the investment target. Let $\text{Inv}_1(I^L_{ct}, I^K_{ct})$ denote the marginal product of land investment (the partial derivative of the investment

production function Inv with respect to I_{ct}^L) and $\text{Inv}_2(I_{ct}^L, I_{ct}^K)$ denote the marginal product of capital investment (the partial derivative with respect to I_{ct}^K). Then, the condition is:

$$\frac{p^L}{p^K} = \frac{\text{Inv}_1(I_{ct}^L, I_{ct}^K)}{\text{Inv}_2(I_{ct}^L, I_{ct}^K)} \tag{5}$$

Given the assumption that p^L is increasing in α_c, equation 5 implies that the optimal ratio of land investment to capital investment shifts away from land and towards capital as α_c increases. To see this more formally, consider the elasticity of substitution between capital and land investment, defined as:

$$\sigma = \frac{d\ln(I_{ct}^K/I_{ct}^L)}{d\ln(\text{Inv}_1/\text{Inv}_2)} = \frac{d\ln(I_{ct}^K/I_{ct}^L)}{d\ln(p^L/p^K)} \tag{6}$$

where the second equality follows from equation 5. This elasticity measures how the ratio of capital to land investment responds to changes in the ratio of their marginal products or, equivalently at the optimum, to changes in the price ratio.

Taking the total derivative with respect to α_c and applying the chain rule:

$$\frac{d\ln(I_{ct}^K/I_{ct}^L)}{d\alpha_c} = \frac{d\ln(I_{ct}^K/I_{ct}^L)}{d\ln(p^L/p^K)} \cdot \frac{d\ln(p^L/p^K)}{d\alpha_c} = \sigma \cdot \frac{d\ln(p^L/p^K)}{d\alpha_c} = \sigma \cdot \frac{1}{p^L}\frac{dp^L}{d\alpha_c} \tag{7}$$

Since land and capital are substitutes in the investment optimization problem ($\sigma > 0$) and $\frac{dp^L}{d\alpha_c} > 0$, it follows that $\frac{d\ln(I_{ct}^K/I_{ct}^L)}{d\alpha_c} > 0$. This implies that the ratio $\frac{I_{ct}^K}{I_{ct}^L}$ increases with α_c.

Therefore, if land investment is utilized when $\alpha_c = 0$, the relationships between the TGA-induced change in total investment (ΔI^*), land investment (ΔI_{ct}^L), and capital investment (ΔI_{ct}^K) with α_c take a general form such that while ΔI^* increases with α_c, the share of this increase coming from ΔI_{ct}^L is expected to decrease with α_c, while the share from ΔI_{ct}^K is expected to increase.

This theoretical framework leads to the following primary testable hypotheses for the empirical analysis:

H1: The Taylor Grazing Act led to an increase in overall agricultural investment, and this positive effect is larger for counties with a higher pre-existing share of public grazing land (α_c).

H2: The TGA's impact on the *composition* of agricultural investment varies systematically with α_c:

(a) Counties with a lower α_c are expected to exhibit greater increases in land-intensive investments (e.g., farm acres).

(b) Counties with a higher α_c are expected to exhibit greater increases in capital-intensive investments (e.g., share of farm value in equipment, improvements to existing farmland).

4 Data and Summary Statistics

4.1 Data Sources and Variable Construction

To estimate how the TGA influenced a variety of agricultural outcomes, I draw data from multiple sources. My primary outcome variables come from the U.S. Census of Agriculture for the years 1910 to 1974 (Haines et al., 2018). These county-level variables include measures of overall agricultural investment such as total farm value and the value of farm equipment. To test for heterogeneity in investment composition, I utilize proxies for land-intensive investment like the share of county area in farms and acres in pasture, and proxies for capital-intensive investment such as total operating expenses and its labor and equipment components. I also use acreage in hay, separated into grain cut for hay and timothy and clover, to measure on-ranch forage production.

My key continuous treatment intensity variable, α_c (the share of a county's total acreage contained in grazing allotments established by the TGA), is constructed using historical spatial data for TGA grazing allotments from the Bureau of Land Management (BLM) and historical county boundaries. I employ these maps to calculate α_c for each county.[12] While land settlement patterns historically involved sorting into higher quality land, settlement was largely complete by the time TGA allotments were determined. Figure 2 illustrates the spatial distribution of treatment intensity across sample counties, with α_c ranging from 0% (no TGA land) to 99% of county area in grazing allotments, providing substantial variation for identification. To control for other time-varying factors, several additional sources were employed. Measures of the Palmer Drought Severity Index (PDSI) were collected from the Center for Disease Control and Prevention's National Environmental Public Health Tracking Network (Centers for Disease Control and Prevention, 2022), from which I construct a five-year moving average for each county. Data on per capita New Deal spending on relief, public works, and expenditures from the Agricultural Adjustment Act (AAA) and other agencies are drawn from Fishback and Kantor (2018), covering total funds distributed by county across 31 programs from 1933 to 1935.

The empirical analysis focuses on a balanced panel of 302 counties from the 11 Western states, spanning the period 1910 to 1974. Following Bailey and Duquette (2014), data are aggregated to time-consistent 1910 county or supercounty boundaries to ensure consistent units of observation over time.[13]

4.2 Pre-treatment Balance and Parallel Trends Assumption

Treatment intensity reflects a settlement process that was substantially complete before the Act. As Section 2.1 documents, disposal of the western public domain had effectively ended by the early 1920s, and the land that remained federal was organized into grazing districts in

[12] Grazing allotments are administrative management units whose boundaries enclose intermingled state, railroad, and private land alongside federal acreage. α_c therefore measures the share of county area falling within allotment boundaries available for grazing rather than the share in federal ownership.

[13] Supercounties are aggregated from counties which either shift boundaries or split into multiple counties during the period of analysis such that each unit represents the smallest consistent boundary across all years in the sample period. By aggregating counties in this way, unit consistency is maintained with minimal assumptions on the distribution of land and resources within supercounties.

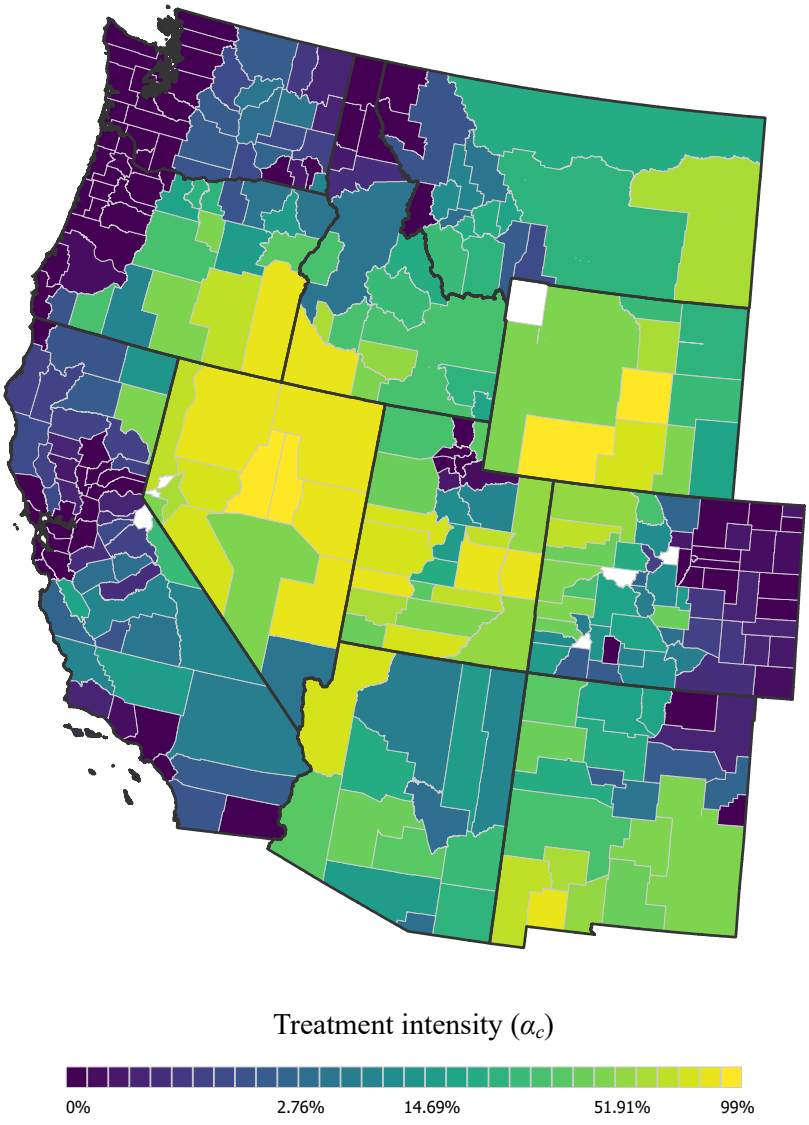


Figure 2: Distribution of Treatment Intensity Across Western Counties

Note: Counties are shaded by treatment intensity (α_c), the share of county area in Taylor Grazing Act allotments, ranging from 0% (dark purple) to 99% (yellow). White areas were excluded from the analysis sample. County boundaries are aggregated to time-consistent 1910 definitions.

close proportion to what each state had left. County exposure is therefore fixed by nineteenth and early twentieth-century settlement patterns and land quality rather than by anything contemporaneous with the Act.

To compare pre-treatment outcomes across the range of treatment intensity, I first split the sample into treatment and control using the median value of α_c (2.76% of county area), where the control group comprises counties below the median. Within the treatment set, I create three intensity groups based on quartiles of α_c among treated counties: Low-intensity comprised of the first quartile, Medium comprised of the second and third quartiles, and High comprised of the fourth quartile, with cutpoints at 14.69% and 51.91% of county area, respectively.

A critical assumption for the difference-in-differences strategy is that, in the absence of the TGA, counties in each treatment intensity bin would have evolved along parallel trends to the control group. While I cannot directly test this counterfactual, I can examine whether pre-TGA trends differed systematically across treatment bins. If counties with different future treatment intensities were already on divergent trajectories before 1934, this would violate the parallel trends assumption and confound estimates of the TGA's causal effects.

Table 1 reports results from separate comparisons of each treatment bin against the control group, using the same specification as the main results described in Section 5. All regressions are weighted by county area to reflect results for an average acre in the sample. For each treatment group g and each pre-treatment window spanning years t_0 to t_1, I estimate:

$$\frac{Y_{c,t_1} - Y_{c,t_0}}{t_1 - t_0} \;=\; \gamma_g \cdot \mathbf{1}(c \in g) \;+\; X_c'\theta \;+\; \delta \frac{\Delta \text{PDSI}_c}{t_1 - t_0} \;+\; \epsilon_c \tag{8}$$

where the outcome is the annual differential change in Y across the window, $\mathbf{1}(c \in g)$ indicates that county c belongs to group g, X_c contains elevation range, latitude and longitude with their squares and interaction, and per capita New Deal spending on relief, public works, and AAA programs, and ΔPDSI_c is the change in the five-year drought average across the same window.[14] The coefficient γ_g is the differential annual change for group g relative to control counties: the differential growth rate for log outcomes in Panel A and the differential change in percentage points per year for the ratio outcomes in Panels B and C. Standard errors are heteroskedasticity-robust.[15]

I report two windows, 1910 to 1925 and 1925 to 1930, chosen to bracket the end of homesteading documented in Section 2.1 rather than by reference to any outcome.[16] Both

[14] Treatment intensity is essentially uncorrelated with drought severity during the Dust Bowl years: the correlation between α_c and the five-year PDSI average in 1935 is -0.06. Adding the 1930 level as an additional control leaves the livestock estimates slightly larger rather than smaller.

[15] Differencing the outcome across the window rather than fitting a trend to levels allows the control set to absorb differential change rather than differential levels, matching the main specification. No state-specific trends are included. In the binned comparisons Arizona, Nevada, and Wyoming contain no control counties, so within those states there is no treated-versus-control contrast to make and they drop out.

[16] The census was taken in 1910, 1920, 1925, and 1930, so the four pre-treatment observations permit windows of fifteen, ten, and five years. The intermediate window straddles the end of homesteading and gives the same answer: over 1920 to 1930, total farm value, farm counts, and the sheep-cattle ratio remain indistinguishable from control counties, while animal units continue to decline differentially at medium and high intensity.

Panel C outcomes are first observed in 1925 and so can only be evaluated over the second window.

The results fall into three groups. First, several outcomes show no differential movement in either window. Total farm value, the number of farms, and the ratio of sheep to cattle are indistinguishable from control counties in both for most bins. These are the outcomes on which the paper's central claims rest.

Second, a set of outcomes moves during the homestead era and settles afterward. The share of county area in farms, average farm size, and the per-acre values of land, buildings, and equipment all differ from control counties over 1910 to 1925 and none is distinguishable from zero over 1925 to 1930.[17] These are the outcomes most directly tied to land moving out of the public domain, and the differential movement ends when that process does. The signs are also those of settlement rather than anticipation with farmland expanding while per-acre values fall.

Third, stocking moves in both windows. County animal units decline differentially in medium- and high-intensity counties over 1910 to 1925 and continue to do so, at a faster rate, over 1925 to 1930. This is a genuine pre-treatment trend, and I do not treat the post-1934 movement in stocking as an effect of the Act. Animal unit counts are used descriptively throughout. The livestock outcome I do interpret is the sheep-to-cattle ratio, which is clean in both windows and which is the margin most directly governed by relative prices.

4.3 Relative Prices and Livestock Composition

The livestock outcome I interpret is the sheep-to-cattle ratio rather than the level of either species. The mix between species reflects the structure of the operation, while the number of animals reflects its scale. It also raises the alternative explanation this subsection addresses. If counties differed in how strongly they responded to relative prices, a national price movement could generate a gradient in treatment intensity that resembles a treatment effect. Figure 3 reports the series that would drive such a response.

Panel (a) shows real prices for cattle, lamb, and wool in 1930 dollars.[18] Panel (b) shows lamb and wool prices relative to cattle, each normalized to its own 1925–1930 average so the movements before and after the Act can be compared directly.

Relative prices moved substantially in both directions over the pre-treatment period. The price of lamb relative to cattle rose 40 percent between 1910 and 1925 and fell 47 percent between 1925 and 1930; wool relative to cattle rose 30 percent and then fell 53 percent over the same windows. Across the full pre-treatment period the relative price of lamb varied by a factor of two and that of wool by a factor of nearly three.

[17] Equipment value per 100 acres at medium intensity is the one exception, remaining marginally significant over 1925 to 1930 at 2.3% per year. Medium-intensity counties are not where the post-treatment equipment response is concentrated, and the corresponding high-intensity estimate is +0.0016 with a standard error of 0.0148.

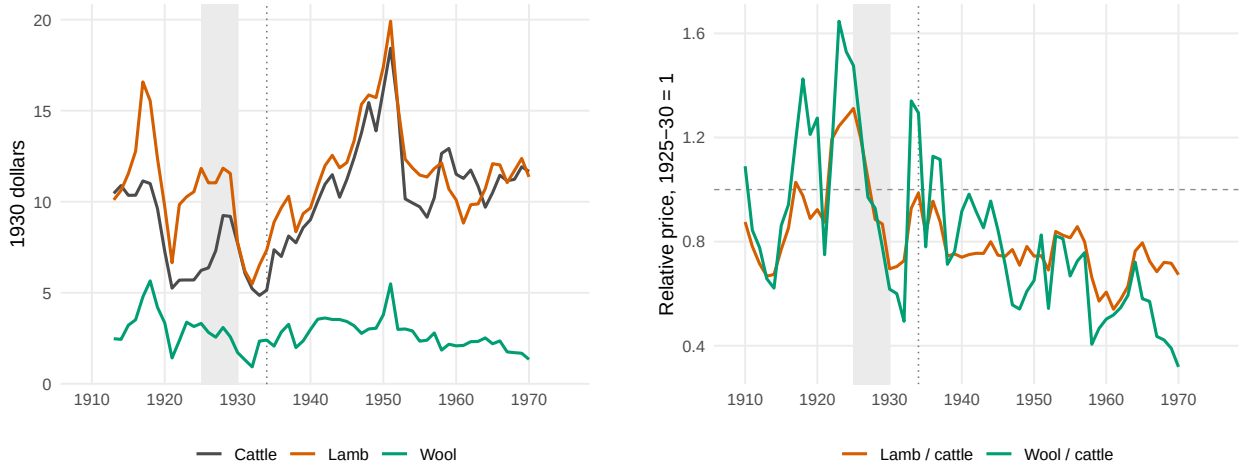
[18] Wool is reported in cents per pound and is converted to dollars per head at 8.8 pounds per fleece, the 1937 Washington average (USDA NASS, Washington historic data). Fleece weights vary across the region and over time: in 1999, weight per fleece in the eleven western states ranged from 6.1 pounds in Arizona to 9.5 in Montana, with a sheep-weighted mean of 8.2. Prices are deflated using the annual CPI, which begins in 1913; the ratios in Panel (b) require no deflator and are shown from 1910.

Table 1: Pre-Treatment Trends in County Outcomes

	Low vs Control		Medium vs Control		High vs Control	
	Annual change 1910–25 (1)	Annual change 1925–30 (2)	Annual change 1910–25 (3)	Annual change 1925–30 (4)	Annual change 1910–25 (5)	Annual change 1925–30 (6)
Panel A: Intensive Margin (1910-1930)						
Farm value	-0.001	-0.007	0.009*	0.006	0.007	0.012
	(0.003)	(0.010)	(0.004)	(0.006)	(0.005)	(0.008)
Number of farms	-0.004	0.005	-0.001	0.002	0.005	-0.011
	(0.005)	(0.013)	(0.004)	(0.006)	(0.004)	(0.008)
Animal units	-0.007	-0.016	-0.020**	-0.025*	-0.031**	-0.052**
	(0.005)	(0.009)	(0.004)	(0.011)	(0.004)	(0.012)
Average farm size	0.009	-0.028	0.029**	-0.000	0.021*	0.015
	(0.007)	(0.017)	(0.005)	(0.011)	(0.008)	(0.015)
Land value per acre	-0.007	0.014	-0.019**	0.005	-0.018*	0.011
	(0.005)	(0.015)	(0.004)	(0.009)	(0.007)	(0.013)
Building value per acre	0.000	0.029	-0.022**	0.007	-0.017*	0.000
	(0.007)	(0.016)	(0.005)	(0.010)	(0.008)	(0.014)
Equipment value per acre	-0.005	0.025	-0.018**	0.024*	-0.025**	0.002
	(0.006)	(0.013)	(0.005)	(0.011)	(0.008)	(0.015)
Panel B: Structural (1910-1930)						
Equipment intensity	0.000	0.001	0.000*	0.002**	-0.000	0.000
	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)
Ownership concentration	-0.002	-0.004	-0.001	-0.000	0.001	-0.003
	(0.001)	(0.004)	(0.001)	(0.002)	(0.001)	(0.002)
Farmland share of county	-0.000	-0.005	0.005**	0.002	0.002	0.001
	(0.001)	(0.003)	(0.001)	(0.002)	(0.001)	(0.003)
Sheep-cattle ratio	0.020	0.011	-0.026	-0.023	-0.035	0.004
	(0.026)	(0.039)	(0.015)	(0.023)	(0.022)	(0.038)
Panel C: Land Use (1925-1930)						
Cropland share	—	0.003	—	0.003	—	0.003
		(0.004)		(0.003)		(0.003)
Pasture share	—	-0.005	—	-0.005	—	0.013
		(0.005)		(0.003)		(0.008)

Notes:
Tests for pre-treatment differences. Each column differences each outcome across a window and regress the change on treatment against control, reporting the annual differential change. Columns (1), (3), and (5) cover 1910–1925, which spans the close of the homestead era; columns (2), (4), and (6) cover 1925–1930, the only stretch of settled western land tenure before the Act. Reporting both as annual rates makes the two windows directly comparable. Panel C variables are first observed in 1925, so columns (1), (3), and (5) are empty. Consistent with the main specification, models condition on the same control set as the estimation (elevation, quadratic geography, New Deal program flows, and drought) and include no state trend controls. Standard errors are heteroskedasticity-robust. Panel A uses logs; Panels B–C use levels.
** p<0.01, * p<0.05

Because these prices are national, a common shock would generate a gradient in treatment intensity only if counties differed in how strongly they responded to it. Across both of these movements the sheep-to-cattle ratio remains indistinguishable from control counties, which suggests that ranchers were not differentially sensitive to relative prices along the exposure distribution before the Act.



(a) Real Prices

(b) Prices Relative to Cattle

Figure 3: Livestock Prices, 1913–1974

Note: Prices are from Historical Statistics of the United States, Colonial Times to 1970 (United States., 1975), Chapter K (series K576 cattle, K581 sheep, K582 lamb, K560 wool); the series ends in 1970. Panel (a) reports prices in 1930 dollars, with wool converted to dollars per head. Panel (b) reports each series relative to cattle, normalized to its 1925–1930 average. The shaded band marks the 1925–1930 baseline period and the dotted line marks 1934. The wool price is reported on a calendar-year basis through 1942, an April–March marketing year from 1943 to 1962, a nine-month period in 1963, and a calendar-year basis from 1964; incentive payments under the National Wool Act, which begin in 1955, are recorded as government payments rather than as price.

5 Empirical Strategy

5.1 Estimation

My empirical strategy aims to estimate the heterogeneous causal effects of the Taylor Grazing Act (TGA) on agricultural investment and outcomes, as a function of the county-level intensity of treatment, α_c (the share of county land in TGA grazing allotments). Traditional two-way fixed effects (TWFE) models with continuous treatment variables can face challenges when treatment effects are heterogeneous.[19] I therefore estimate the underlying

[19] Callaway et al. (2025) show that the TWFE estimand places non-transparent and possibly negative weights on the underlying causal parameters, and that these weights depend on the entire distribution of the dose rather than on the dose distribution among treated units.

two-by-two comparisons directly, following the forward-engineering approach of Baker et al. (2026).

1. Dose-Aware Event Studies. I estimate dynamic treatment effects for counties grouped by treatment intensity (dose). I use the same treatment bins defined in Section 4.2: control counties (below the median α_c of 2.76%), and treated counties divided into Low, Medium, and High-intensity groups based on quartiles of α_c among treated counties. For each dose group I estimate a difference against the 1930 base year, conditional on controls, tracing out:

$$ATT_g(e) = E[Y_{c,1934+e} - Y_{c,1930} \mid c \in g] - E[Y_{c,1934+e} - Y_{c,1930} \mid c \in \text{Control}] \tag{9}$$

This dose-aware approach allows treatment effects to vary by both treatment intensity and time since treatment, avoiding the negative weighting issues that can arise in TWFE models with heterogeneous effects.[20,21] Aggregating across the doses within each bin follows Callaway et al. (2024), who set out event-study and dose-response aggregations as complementary summaries of the same underlying parameters, and is an explicit choice of the kind Callaway et al. (2025) recommend in preference to allowing a regression specification to determine the weights implicitly.

2. Dose-Response Functions with Continuous Treatment. To examine how effects vary continuously with α_c, I estimate dose-response functions for different post-treatment windows. For each time period (short run: 1935–1940, medium run: 1945–1950, long run: 1954–1974), I calculate the change from pre-treatment baseline (averaging available years from 1925–1930) and estimate:

$$\Delta Y_{c,period} = \beta_1 \alpha_c + \beta_2 \alpha_c^2 + \beta_3 \alpha_c^3 + X_c' \gamma + \epsilon_c \tag{10}$$

where $\Delta Y_{c,period}$ is the change in outcome from baseline to the period average, the cubic polynomial in α_c allows for flexible dose-response relationships, and X_c includes geographic and climate controls. This specification estimates how the treatment effect varies with treatment intensity, with the polynomial allowing for non-linear relationships as predicted by the theoretical model. The curves are plotted across the full range of α_c, but above $\alpha_c = 0.85$ only seven counties support the fit and the cubic and spline specifications diverge sharply. I therefore shade that region, suppress the confidence bands within it, which are wide enough to be uninformative, and do not interpret estimates drawn from it.

All regressions are weighted by county area so results represent effects for an average acre of land. Confidence intervals are percentile intervals from a county pairs bootstrap. I control for potential confounders including: (i) geographic characteristics (elevation range, quadratic polynomials in latitude and longitude with interactions); (ii) climate controls (the change

[20] Because every treated county is exposed at the same date, there is no variation in treatment timing and the group-time parameters of Callaway and Sant'Anna (2021) reduce to this single set of comparisons. With a single treated cohort there are no forbidden comparisons for a staggered-adoption estimator to repair, so the estimator is a covariate-adjusted difference rather than the `att_gt` procedure, which is designed for staggered adoption.

[21] Grazing districts were organized between 1935 and 1939, with public land in districts rising from 75 million acres in 1935 to 133 million by 1940. Because α_c measures eventual exposure, the 1935 estimate is scored at full dose while roughly half of the eventual enrollment had occurred, and is attenuated accordingly. Enrollment is largely complete by the 1940 census.

in the five-year moving average PDSI); and (iii) New Deal program spending per capita (AAA, relief, and public works programs from 1933–1935). Because the estimating equation is specified in differences, these time-invariant controls absorb county-specific trends rather than differences in levels. State-specific trends are not included.[22]

5.2 Identifying Assumptions

The key identifying assumption for both approaches is parallel trends: in the absence of the TGA, time-dosage group averages of counties with different treatment intensities would have evolved along parallel paths conditional on controls. While this counterfactual cannot be directly tested, I provide two pieces of supporting evidence. First, the pre-treatment analysis in Section 4.2 examines differential trends by treatment intensity over 1910–1930 and reports which outcomes satisfy the assumption. Second, the distribution of federal lands across counties was largely determined by 19th- and early 20th-century settlement patterns and land quality, as described in Section 2.1 — factors at the county level are plausibly exogenous to anticipated agricultural policy changes in the 1930s.

Comparisons across levels of exposure require more. Callaway et al. (2025) show that the difference between two dose groups is not identified by parallel trends alone, because it contains a selection term as well as a causal response. Eliminating that term requires strong parallel trends, and its conditional form identifies $ATT_x(d)$, which can be compared across doses.[23] I therefore assume strong parallel trends conditional on the control set described above. This is necessary for comparison both across the treatment bins and along the dose-response curve.

Two features of this setting support it. Counties did not choose their exposure, so the selection interpretation of the bias term has little purchase. And the dimensions along which high- and low-exposure counties most plausibly differ in their response — aridity, terrain, and position — are the covariates in X_c. The assumption is nonetheless stronger than parallel trends. Claims about the level of an effect at a given exposure require only the latter; claims about how effects vary with exposure require the former.

6 Main Results

6.1 Investment Responses on Private Land

Figure 4 presents event study estimates of the Taylor Grazing Act's impact on total farm value across treatment intensity groups. Several key patterns emerge that are consistent with

[22] As noted in Section 4.2, Arizona, Nevada, and Wyoming contain no control counties, so in the binned comparisons there is no treated-versus-control contrast to make within those states and they drop out. The continuous specification does not have that problem, but state accounts for 46 percent of the variance in α_c, so state-specific trends would discard nearly half the identifying variation.

[23] $ATT_x(d)$ is not local to a dose group and so can be compared across doses without the selection term, at the cost of being local to the covariate values conditioned on. Callaway et al. (2025) also note that comparisons among units at similar doses are more defensible than comparisons among units at very different ones, which is how I read the dose-response curves.

the theoretical prediction that investment responses increase with the county-level share of public grazing land.

First, point estimates suggest a monotonic ordering of treatment effects by intensity group, though the confidence intervals overlap. Effects grow through the 1940s and stabilize by 1950. Averaging the 1950 and 1954 estimates, high-intensity counties ($\alpha_c > 51.91\%$) stand approximately 48 percent above control counties and medium-intensity counties ($14.69\% < \alpha_c < 51.91\%$) approximately 36 percent. Both groups remain at that level through 1974. Low-intensity counties ($2.76\% < \alpha_c < 14.69\%$) stand approximately 21 percent above control counties over the same two years, but these estimates are never statistically distinguishable from zero at any point in the series and return to near zero in the 1960s.

Second, the timing of these effects is economically meaningful. The groups begin to separate soon after 1934, but the effects are modest at first and build over fifteen years. High-intensity counties stand roughly 2 percent above control counties in 1935, 13 percent in 1940, and 19 percent in 1945 before reaching their full level around 1950. Estimates become distinguishable from zero in 1940 at medium intensity and in 1945 at high intensity.

This gradual emergence tracks the pace at which the Act was implemented. As Figure 1 shows, public land was brought into grazing districts between 1935 and 1939, with enrollment essentially complete by 1940. The adjudication that fixed carrying capacities and issued ten-year term permits against qualifying base property continued into the following decade. Even then the formal allocation was only part of what had to be worked out. Actual grazing patterns were settled through informal agreements among the permittees, the advisory board, and the district grazier, which did not change anyone's formal claim and which a single change in ranch ownership could unsettle for several years (Calef, 1960). The effects grow as the allocation of rights was settled rather than appearing at the moment of passage. That the effects persist through 1974, four decades after the Act, suggests these represent permanent shifts in land use patterns rather than transitional adjustments.

Third, the increase cannot be explained by consolidation into fewer but more efficient operations. Total farm value is a county aggregate, so combining two farms into one leaves the county total unchanged unless the underlying assets became more valuable. Figure 5 shows that the number of farms is not detectably changed at any intensity; averaging 1950 and 1954, the estimates are small and negative and none is distinguishable from zero. Average value per operation rises by approximately 27, 38, and 64 percent across the three intensity groups over the same years. The Act did not draw new operators into these counties, and it did not induce consolidation to a detectable degree. It raised the value of the operations already present, consistent with securing an existing claim on rents. Further, these magnitudes are economically substantial. Average farm value in high-intensity counties was \$10,026 in 1930. The estimated effect implies an additional \$6,400 per farm by the early 1950s, in 1930 dollars.

A natural interpretation of higher operation values is that the underlying assets became more productive, supporting more livestock or supporting the same livestock at lower cost. Figure 6 suggests that the first of these channels is not a significant contributor. Grazing does not increase in any intensity group at any point after 1934. Animal units in the two higher intensity groups fall below control counties over the 1940s and remain there, while low-intensity counties show no change. Treated counties were already reducing herds between 1925 and 1930, so I do not read the decline itself as an effect of the Act. It does, however, run against value creation through increased herd sizes. Although flat animal unit counts do

not rule out a higher net present value from more secure long-term access for existing stock.

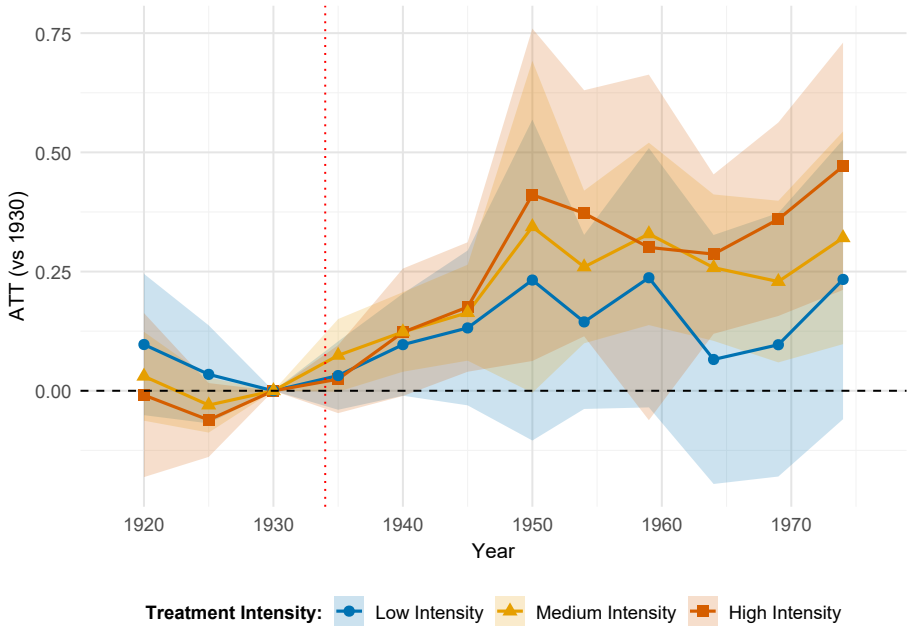


Figure 4: Total Farm Value by Treatment Intensity

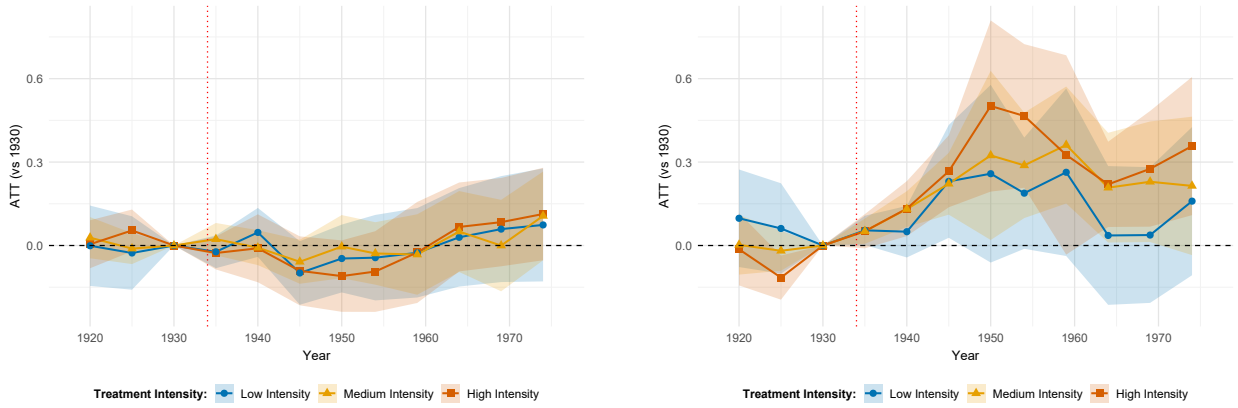
Note: The outcome is log total farm value, the census valuation of land, buildings, implements, and machinery on all farms in the county. Treatment intensity bins are defined as Low ($2.76\% < \alpha_c \leq 14.69\%$), Medium ($14.69\% < \alpha_c \leq 51.91\%$), and High ($\alpha_c > 51.91\%$); control counties have $\alpha_c \leq 2.76\%$. Estimates are differences against the 1930 base year, weighted by county area, with shaded areas showing 95% confidence intervals from standard errors clustered at the county level. $N = 151$ control, 38 Low, 75 Medium, and 38 High-intensity counties.

6.2 Testing Investment Composition

The theoretical model predicts that farmers' investment strategies should vary systematically with the pre-existing share of public grazing land in their county (α_c). Specifically, counties with lower α_c should pursue land-extensive strategies while those with higher α_c should shift toward capital intensification. To test this hypothesis, I examine how investment composition changes continuously with treatment intensity. Figure 7 places the two margins side by side. Panel (a) reports the share of county area in farms. Panel (b) reports total operating expenses.[24] Set against each other, the two strategies peak at opposing regions of the distribution.

The land-extensive investment pathway is evident in Panel (a), which shows changes in farmland per county acre. Aggregate land expansion was most pronounced for counties with moderate public land shares, peaking at an α_c of approximately 25 percent and declining to zero above 65 percent. These counties had both sufficient incentive from access rights and

[24]Operating expenses are a sum of labor and equipment expenses.



(a) Number of Farms

(b) Average Farm Value

Figure 5: Decomposing the Change in County Farm Value

Note: Panels decompose the county aggregate in Figure 4 into the number of operations and the value of each. Both are in logs. Treatment intensity bins are defined as Low ($2.76\% < \alpha_c \leq 14.69\%$), Medium ($14.69\% < \alpha_c \leq 51.91\%$), and High ($\alpha_c > 51.91\%$); control counties have $\alpha_c \leq 2.76\%$. Estimates are differences against the 1930 base year, weighted by county area, with shaded areas showing 95% confidence intervals from standard errors clustered at the county level. $N = 151$ control, 38 Low, 75 Medium, and 38 High-intensity counties.

available private land to expand operations. In contrast, counties with minimal public land gained little from the TGA, while those dominated by public land faced binding constraints on private land availability. Also of note is that this shaped response develops early, with the short-run estimates already tracing the same profile and peaking at the same point.

Panel (b) shows total operating expenses, which peak much higher in the distribution. Operating expenses rise with α_c from 7 percent at the low end to 39 percent at an α_c of 55 percent and remain at roughly that level across the upper range. Where the land response has faded, between 50 and 65 percent of county area, expenditure is still climbing. Where private land was available, ranchers expanded their holdings to support herds. Where it was not, they spent on improving the operation of lands they already held.

The timing separates the two margins as clearly as the dose gradient does. Land in farms is already rising between 1935 and 1940, peaking at 3.8 percentage points at an α_c of 25 percent. Operating expenses are slightly negative across the entire dose range over the same years, appearing only in the medium run and reaching their full level in the long run. Ranchers acquired land first, which is the direct response to an eligibility requirement written in terms of deeded property, and increased what they spent on their operations afterward.

Together, these results provide strong evidence for Hypothesis 2. Investment strategies diverged systematically based on local land market conditions: counties with abundant private land pursued extensification while those with scarce private land shifted toward intensification. The effects strengthen over time, suggesting these represent fundamental restructuring rather than temporary adjustments.

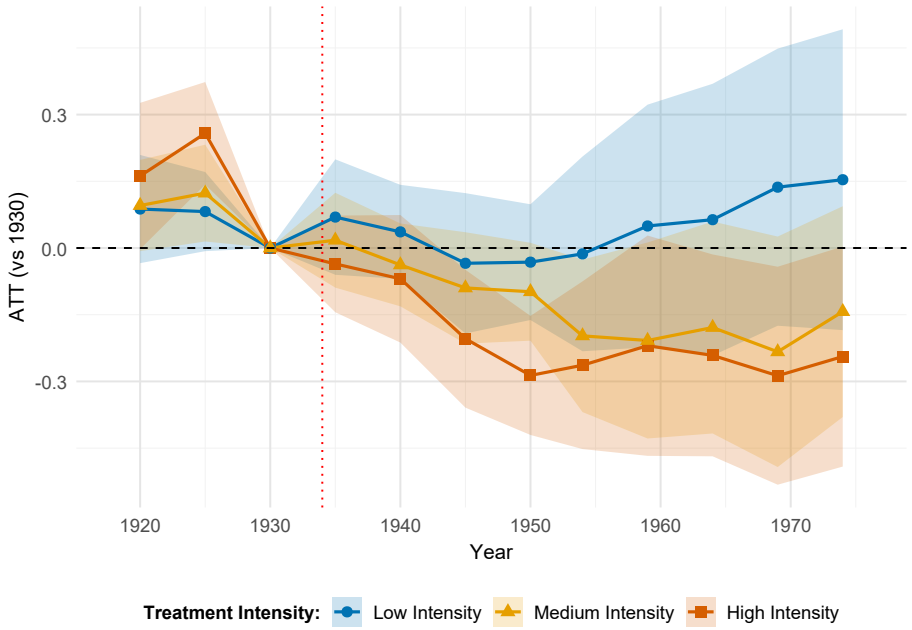


Figure 6: Animal Unit Months by Treatment Intensity

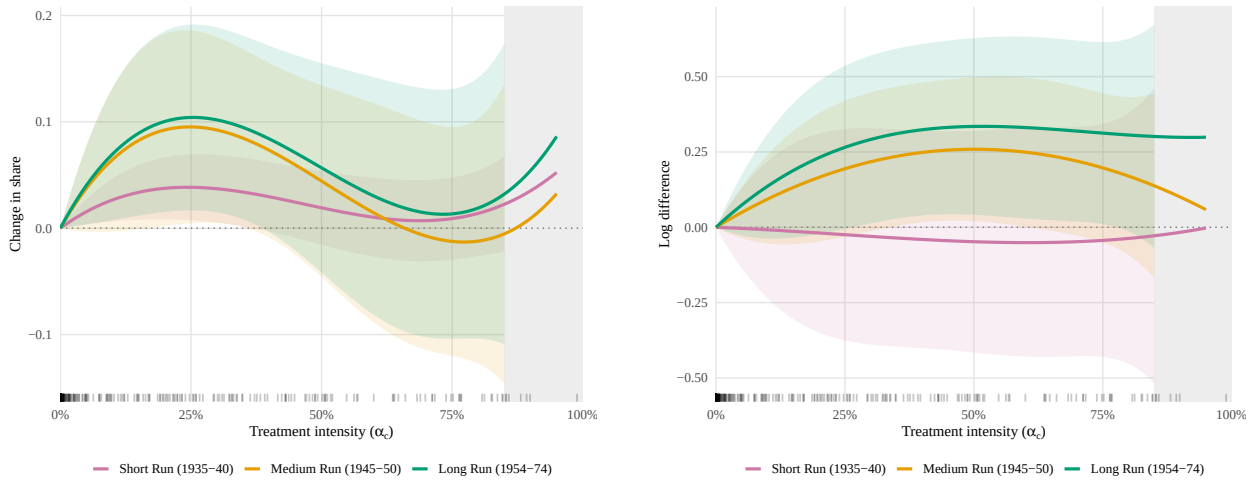
Note: Animal unit months are constructed following the standard federal convention of one cow or five sheep. The 1925 estimate for high-intensity counties is positive and distinguishable from zero, reflecting herd reductions in treated counties over the five years preceding the Act. Treatment intensity bins are defined as Low ($2.76\% < \alpha_c \leq 14.69\%$), Medium ($14.69\% < \alpha_c \leq 51.91\%$), and High ($\alpha_c > 51.91\%$); control counties have $\alpha_c \leq 2.76\%$. Estimates are differences against the 1930 base year, weighted by county area, with shaded areas showing 95% confidence intervals from standard errors clustered at the county level. $N =$ 151 control, 38 Low, 75 Medium, and 38 High-intensity counties.

6.3 Mechanisms and Supporting Evidence

To understand the mechanisms underlying the investment patterns documented above, I examine both land use and input choices. These provide insight into how ranchers operationalized their divergent investment strategies.

Figure 8 separates the land brought into farms by use, with both panels reported as shares of county area so they can be read against the aggregate in Figure 7. Panel (a) shows pasture, which accounts for almost the entire response. It rises to 8.1 percentage points of county area at an α_c of 25 percent and remains between 4 and 6 points across the upper range. Panel (b) shows cropland, which is flat, adding at most 0.7 percentage points at low exposure and turning slightly negative above an α_c of 55 percent. The extensive margin was expansion of the private grazing complement to public range, not a general increase in cultivated acreage.

The corresponding adjustment occurs within the crop acreage operations already held. Figure 9 reports hay as a share of cropland, which rises with exposure and plateaus at roughly 4.6 percentage points above an α_c of 45 percent. Against a baseline of 5.6 percent of cropland in high-intensity counties and 5.8 percent at medium intensity, this is close to



(a) Land in Farms

(b) Operating Expenses

Figure 7: Investment Composition Response to Treatment Intensity

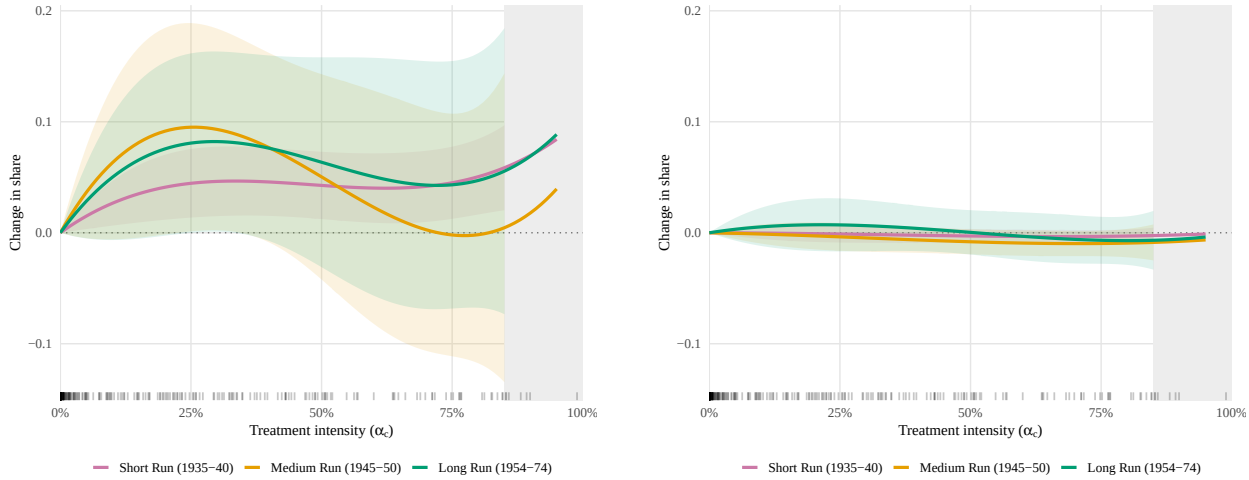
Note: Panel (a) reports land in farms as a share of county area; Panel (b) reports log total operating expenses, the sum of labor expenditure and the value of implements and machinery. Lines are cubic polynomials in α_c estimated with geographic and climate controls and three New Deal per-capita program flows, weighted by county area; shaded areas are 95% sup-t simultaneous confidence bands. Bands are suppressed above $\alpha_c = 0.85$, where seven counties support the fit. Tick marks on the horizontal axis show the distribution of α_c. Estimates are changes from the 1925–1930 baseline to the short run (1935–1940), medium run (1945–1950), and long run (1954–1974).

a doubling of the share of crop ground devoted to feed.[25] Cropland acreage itself is flat, so the increase in hay acreage came out of whatever other crops these counties had been growing. The shift appears immediately, reaching 2.4 percentage points in the short run, and continues to build through the long run.

Forage is one route to greater capacity on a fixed land base. Operating inputs are the other. Figure 10 decomposes the aggregate expenditure response from Figure 7 into its two components. Panel (a) shows labor expenditure, which peaks in the medium run at 21 percent around an α_c of 45 percent and moderates thereafter. Panel (b) shows equipment, which reaches a similar level to labor in the medium run though less precisely estimated, and continues rising into the long run to 48 percent at 65 percent of county area, holding across the upper range. Both margins are largest where the private land base could not be extended, though at moderate exposure they also accompany the pasture expansion documented above.

[25]Because cropland is a small share of these counties, the shift amounts to roughly 0.16 percentage points of county area at high exposure, against the 8.1 points of pasture added at moderate exposure. Bement (1969), using data from the 1940s through the early 1960s, puts the sustainable stocking rate on western shortgrass range at 0.18 AUM per acre, against roughly 2.6 AUM for an acre of irrigated hay meadow yielding 1.2 tons (Jacobs et al., 1993). Per thousand acres of county area, the pasture expansion therefore adds about 15 AUMs of forage while the hay adds about 4, on two percent of the acreage. Though the two are typically drawn in different seasons, the relative magnitudes make clear that increases in hay production, though substantial, were insufficient on their own to match the stocking capacity added by land-extensive investment.

This temporal sequencing, in conjunction with the land results above, suggests a rational progression of intensification strategies. In the short run, ranchers expanded the private grazing base where land remained available. Medium-run adjustments emphasized labor intensification, hiring additional workers and increasing management intensity. Finally, long-run adaptations shifted toward mechanization and equipment investment as the most sustainable form of intensification. The progression from land to labor to capital reflects binding constraints that emerged sequentially as the easier margins of adjustment were exhausted.



(a) Pasture

(b) Cropland

Figure 8: Land Use Composition of the Extensive Margin

Note: Both panels report acreage as a share of total county area, so they are additive against land in farms in Figure 7. Lines are cubic polynomials in α_c estimated with geographic and climate controls and three New Deal per-capita program flows, weighted by county area; shaded areas are 95% sup-t simultaneous confidence bands. Bands are suppressed above $\alpha_c = 0.85$, where seven counties support the fit. Tick marks on the horizontal axis show the distribution of α_c. Estimates are changes from the 1925–1930 baseline to the short run (1935–1940), medium run (1945–1950), and long run (1954–1974).

6.4 Livestock Composition and Incidence

These mechanisms collectively reveal how the Taylor Grazing Act induced fundamentally different development paths based on local resource endowments. Counties with abundant private land could expand operations extensively, adding pasture and maintaining traditional production methods. Those facing land constraints were forced to innovate, intensifying both their use of existing land and their investment in productivity-enhancing capital. Those responses describe how ranches adapted to the permit regime. They do not establish whether its benefits fell evenly across the livestock systems competing for the same range.

Figure 11 reports the ratio of sheep to cattle. The ratio declines across the exposure distribution, though not evenly. It falls to 0.27 log points by an α_c of 25 percent, recovers to 0.17 through the middle of the range, and then drops sharply to 0.29 at 75 percent and

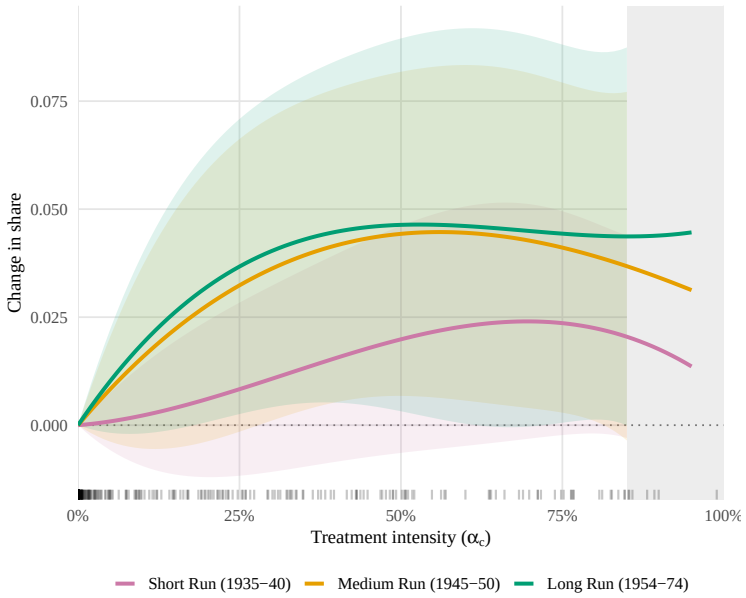


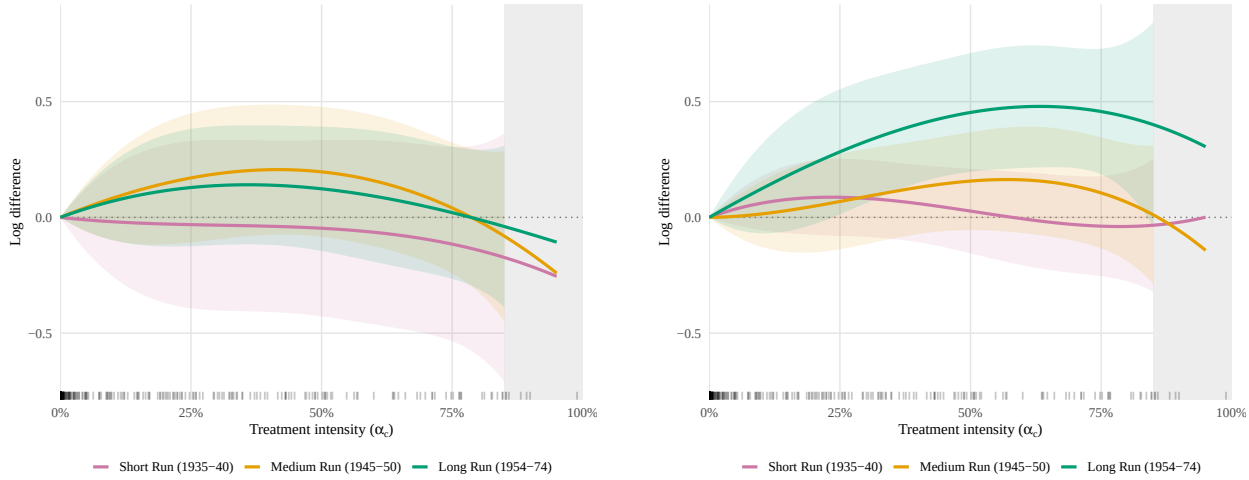
Figure 9: Hay Share of Cropland

Note: Hay acreage as a share of total cropland. Cropland is largely unchanged, so the outcome measures reallocation of crop ground rather than land brought into the operation. Baseline shares over 1925–1930 are 15.1 percent in control counties, 11.1 percent at low intensity, 5.8 percent at medium intensity, and 5.6 percent at high intensity. Lines are cubic polynomials in α_c estimated with geographic and climate controls and three New Deal per-capita program flows, weighted by county area; shaded areas are 95% sup-t simultaneous confidence bands. Bands are suppressed above $\alpha_c = 0.85$, where seven counties support the fit. Tick marks on the horizontal axis show the distribution of α_c. Estimates are changes from the 1925–1930 baseline to the short run (1935–1940), medium run (1945–1950), and long run (1954–1974).

0.51 at 85 percent in the long run, the latter a decline of roughly 40 percent in the ratio. The pattern is present in the medium run at roughly half the magnitude and is absent in the short run.

Figure 12 decomposes the ratio into its components. The decomposition is arithmetic rather than a separate causal claim. The ratio is the difference of two logs, so its movement is fully accounted for by what happens to each species. Panel (a) shows cattle, which is flat. Its long-run estimate never exceeds 0.10 log points in absolute value at any point in the distribution. Panel (b) shows sheep, which falls by 30 percent at an α_c of 75 percent and 45 percent at an α_c of 85 percent. The compositional shift is therefore a contraction of sheep production rather than an expansion of cattle herds. Taken together, the two panels rule out a reallocation between species since had operators been substituting cattle for sheep, cattle would have risen where sheep fell.

A natural alternative explanation is differential responsiveness to relative livestock re-



(a) Labor Expenditure

(b) Equipment Value

Figure 10: Components of Operating Expenditure

Note: Panels decompose total operating expenses in Figure 7 into labor and equipment. Both are in logs. Because the aggregate is the log of the sum, the two panels do not decompose it additively; equipment carries roughly sixty percent of the baseline dollar total in treated counties. Lines are cubic polynomials in α_c estimated with geographic and climate controls and three New Deal per-capita program flows, weighted by county area; shaded areas are 95% sup-t simultaneous confidence bands. Bands are suppressed above $\alpha_c = 0.85$, where seven counties support the fit. Tick marks on the horizontal axis show the distribution of α_c. Estimates are changes from the 1925–1930 baseline to the short run (1935–1940), medium run (1945–1950), and long run (1954–1974).

turns. Section 4.3 provides the relevant comparison. Relative prices moved substantially in both directions before the Act, and neither movement produced a differential compositional response across the exposure distribution. Lamb prices rose 40 percent relative to cattle between 1910 and 1925 while the sheep-to-cattle ratio in high-exposure counties moved in the opposite direction; they then fell 47 percent between 1925 and 1930, nearly twice the entire movement of the following four decades, and the ratio did not respond. The compositional shift documented here occurs after 1934, during a period of comparatively small relative-price movement, and it is concentrated in the counties where the permit system bound hardest. Differential exposure to relative-price incentives appears insufficient to account for it.

The pattern is consistent with a permit system that stabilized the use claims of established operations. Access required deeded base property, with the preference order placing it above even recognized prior use. Where nearly all the accessible forage was federal, an operator without qualifying property had no private alternative. The operations least likely to hold such property were those that had historically run sheep over range with little or no private base. Notably, in the middle of the distribution there was plausibly enough private land in the market that competition for it did not price land focused operations out, and enough of them could acquire what they needed to qualify. The shallowest contraction sits in that range, the same one in which labor expenditure peaked in Figure 10, which favors the herding requirements of sheep. At the top there was nothing to buy at acceptable prices, and at the

bottom, there was little public range worth qualifying for.

The two panels may also describe how adjustment was distributed once the system was in place, though this is more speculative than what precedes it. Carrying capacity within a district was administratively fixed, so the total was not free to move with conditions or prices. Cattle operations were likely to hold the majority of base property the preference order rewarded, so their claims were the ones most likely to be secured. Cattle production is flat across the whole exposure distribution. Operations facing mostly federal forage adjusted their herds much the same as operations facing very little. If the larger claim was held steady against a fixed total, whatever adjustment the range required would have fallen on lower preference operators.

As noted in Section 2.2, the rule that produced this was not the one the Act set out. The first circular ranked prior use above base property among applicants holding one and not the other; within the year that order was reversed at the request of range ranchers, for the stated purpose of removing operators who held no qualifying property (Calef, 1960). What the cattlemen's associations had attempted for decades through control of roundups, corrals, and membership—but could not strictly enforce against operators without the need for those things—the revised preference order seems to have accomplished indirectly through eligibility.

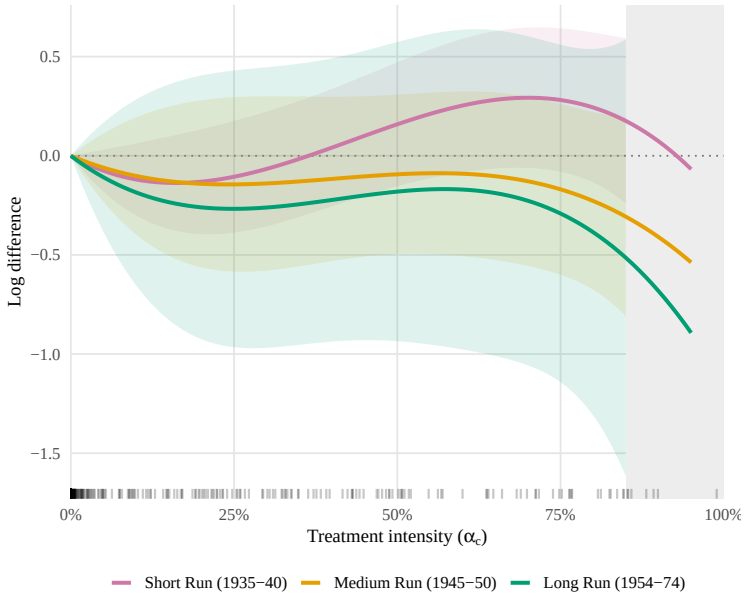
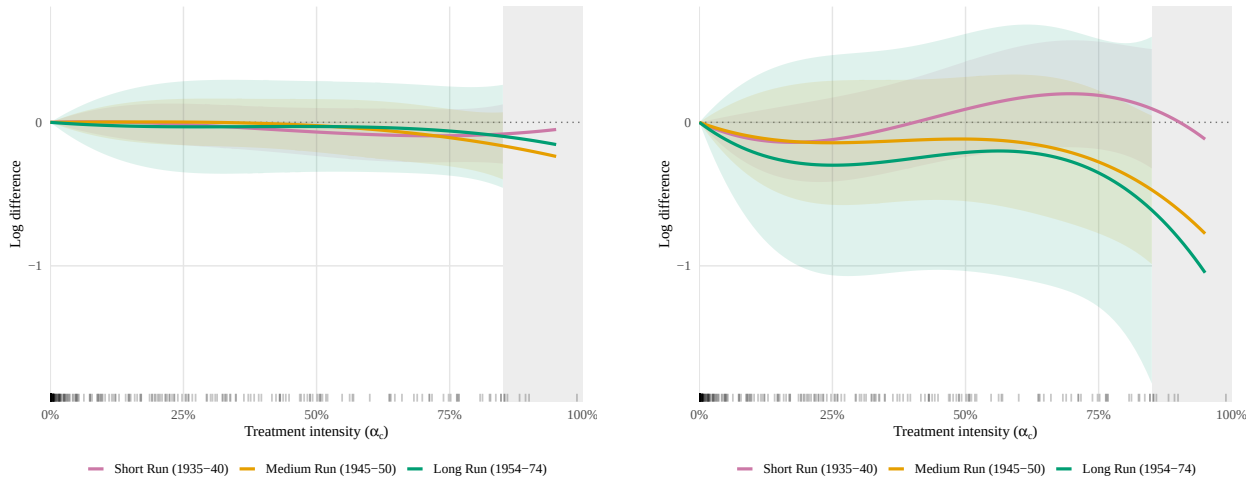


Figure 11: Sheep-to-Cattle Ratio

Note: The outcome is the log ratio of county sheep to county cattle. Lines are cubic polynomials in α_c estimated with geographic and climate controls and three New Deal per-capita program flows, weighted by county area; shaded areas are 95% supt simultaneous confidence bands. Bands are suppressed above $\alpha_c = 0.85$, where seven counties support the fit. Tick marks on the horizontal axis show the distribution of α_c. Estimates are changes from the 1925–1930 baseline to the short run (1935–1940), medium run (1945–1950), and long run (1954–1974).



(a) Cattle

(b) Sheep

Figure 12: Components of the Livestock Composition Shift

Note: Panels decompose the ratio in Figure 11 into its two components. Both are in logs. Lines are cubic polynomials in α_c estimated with geographic and climate controls and three New Deal per-capita program flows, weighted by county area; shaded areas are 95% sup-t simultaneous confidence bands. Bands are suppressed above $\alpha_c = 0.85$, where seven counties support the fit. Tick marks on the horizontal axis show the distribution of α_c. Estimates are changes from the 1925–1930 baseline to the short run (1935–1940), medium run (1945–1950), and long run (1954–1974).

7 Robustness Analysis

I conduct several tests to validate the main results and address potential threats to identification. I first verify that results are not driven by individual states, then address three primary concerns: (1) that unobserved trends in agricultural development correlated with public land shares drive results, (2) that differential technology adoption rather than property rights security explains these findings, and (3) that uncontrolled climatic conditions rather than property rights security explain the observed patterns.

7.1 Geographic Robustness

Figure 13 presents leave-one-out estimates where I sequentially drop each state and re-estimate the dose-response functions for land in farms and total operating expenses, the two outcomes underlying the composition result. Across all specifications and time periods, the leave-one-out estimates (semi-transparent lines) cluster tightly around the baseline estimates (solid lines with confidence intervals). The consistency of results across state exclusions demonstrates that my findings are not driven by any single state's experience, addressing concerns about geographic concentration or state-specific policies not absorbed by the geographic controls.

7.2 Placebo Tests: Non-Grazing Livestock

A key concern is that results reflect unobserved trends in agricultural development or farming practices that happen to correlate with public land shares, rather than the causal effect of the Taylor Grazing Act. Counties with different values of α_c might have been on different agricultural trajectories for reasons unrelated to grazing access—perhaps due to differential exposure to agricultural extension services, modernization trends, credit availability, or New Deal programs. To test whether general agricultural trends drive the results, I examine effects on non-grazing livestock.

Figure 14 presents event study estimates for chicken and pig production per farm. These species underwent their own technological and management transformations during the study period and were eligible for the same agricultural support programs as cattle and sheep—notably, the emergency pig reduction program of 1933–34 was one of the AAA's most visible interventions. If counties with higher public land shares were simply on different agricultural development trajectories, we would observe similar patterns for all livestock types. Instead, both species are indistinguishable from zero in all three intensity groups through the short and medium run, the period over which farm values and animal units separate. Chicken production declines at higher intensities in the long run, two decades after the main effects emerge and on a timeline unrelated to the allocation of grazing rights.[26] The direction is itself informative: a general increase in agricultural productivity correlated with α_c would raise chicken production in more exposed counties rather than lower it. These results confirm that my findings are specific to grazing-dependent production rather than reflecting broader trends in agricultural development correlated with α_c.

7.3 Technology Adoption and Investment Patterns

An alternative explanation is that these results reflect differential adoption of capital-intensive livestock technologies, particularly feedlots, rather than property rights security. While technology adoption could be viewed as one type of agricultural development trend, I test it separately because it represents a specific, observable transformation in production methods during the study period. I present two pieces of evidence against this interpretation.

First, Figure 15 shows dose-response estimates for pig production per farm. Pig operations underwent a parallel technological transformation toward capital-intensive confinement systems during the study period, similar to the feedlot revolution in beef production. If these results reflected inherent differences in technology adoption propensity correlated with public land shares, we would observe similar patterns for pig operations. Instead, I find flat zeros across all time periods, ruling out differential technology adoption as a mechanism.

Second, Figure 16 examines hay production patterns by type. Panel (a) shows that grain hay, an annual crop, increased monotonically with treatment intensity, consistent with the operational needs of expanding cattle operations. Panel (b) shows that timothy and

[26] The widening confidence intervals for chicken production in later periods likely reflect the geographic concentration of poultry operations as the industry specialized, with some counties developing large-scale operations while others exited production entirely. Commercial poultry also relocated substantially over this period, consolidating in the Southeast and away from the arid West, so a decline in western chicken production in the postwar decades likely reflects a national industry pattern rather than a local one.

clover, perennial crops requiring multi-year establishment investments, fall sharply in the short run and turn positive only at the highest exposures by the long run. This pattern for a non-technological agricultural investment bolsters the property rights security mechanism. Annual feed responds immediately to operational needs, while perennial establishment appears only where secure access made a multi-year commitment worthwhile. It also contradicts the feedlot hypothesis, since feedlot adoption reduces rather than increases on-ranch forage requirements, and perennial establishment in particular is what an operation buying its feed would not undertake.

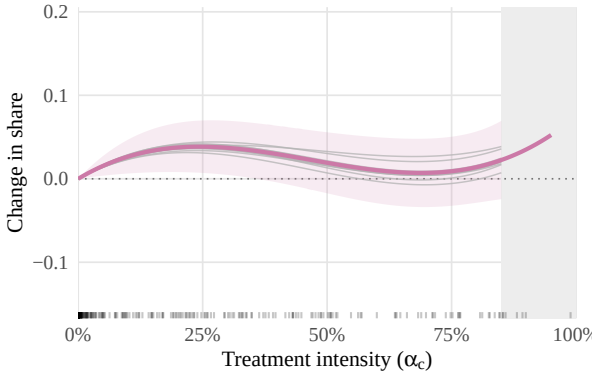
The divergent functional forms between annual and perennial hay crops also provide suggestive evidence against uncontrolled climatic factors driving the results. If climate conditions correlated with public land shares explained the patterns, we would expect both hay types to respond similarly or inversely based on moisture requirements. Instead, I observe fundamentally different responses—monotonic for annual crops versus an early decline and late recovery for perennial investments—consistent with different investment horizons rather than climatic suitability.

8 Conclusion

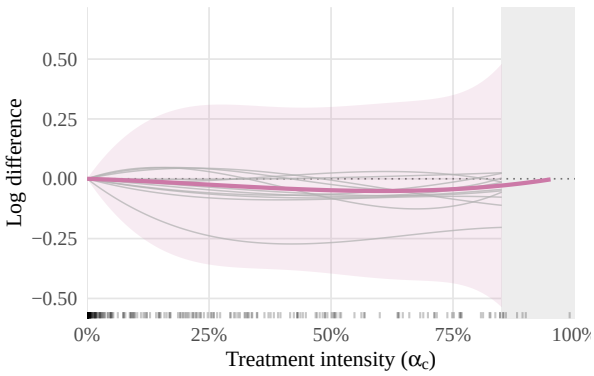
The Taylor Grazing Act of 1934 represents one of the largest property rights reforms in American history. Within five years, the grazing districts it established had taken in essentially all of the western public domain that homesteading had left behind, and converted its use from open and unregulated to leased, regulated, and exclusive. In this paper I exploit variation in the share of county land brought into that system to identify how the reform induced and structured private investment, as well as how it distributed the gains among operations competing for the same range.

The model predicts that the value of secure access rises with the share of a county's grazing land brought into the system, and that the structure of farmers' investment responses to that access depends on the pre-existing share of public land in their county. Where complementary private land is relatively abundant and affordable, theory predicts land-extensive investment strategies. Where it is scarce and costly, capital intensification should dominate. Further, historical context suggests which constituency an investment structure built on base property is likely to favor. Cattle operations already carried higher private land and investment requirements than sheep operations, relative to the forage each drew from the range.

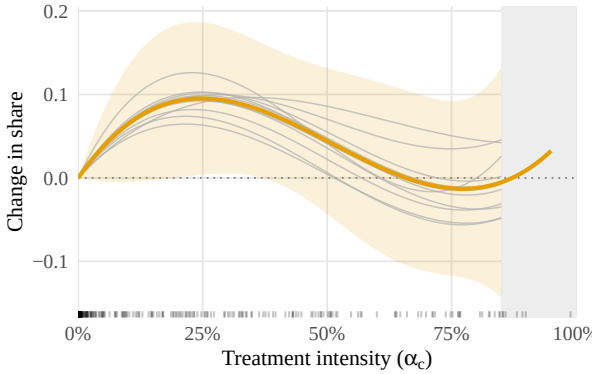
The empirical evidence supports these predictions. The Act raised the value of private ranch assets substantially, as reflected in aggregate farm value. Averaging the 1950 and 1954 estimates, total farm value in high-intensity counties rose 48 percent above control counties and 36 percent in medium-intensity counties, with both remaining at roughly that level through 1974. This is not explained by a detectable consolidation into fewer more, efficient operations. The change in the number of farms is not distinguishable from zero for any intensity, with the value of the average operation rising by 27, 38, and 64 percent across the three groups, roughly \$6,400 per farm in 1930 dollars at high intensity. Nor is the increase in value accompanied by a post-Act expansion in animal units. Instead, the value of secure access was capitalized into the private operations already in place.



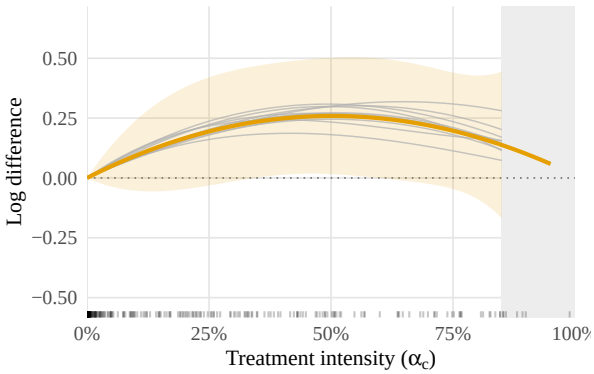
(a) Land in Farms: Short Run



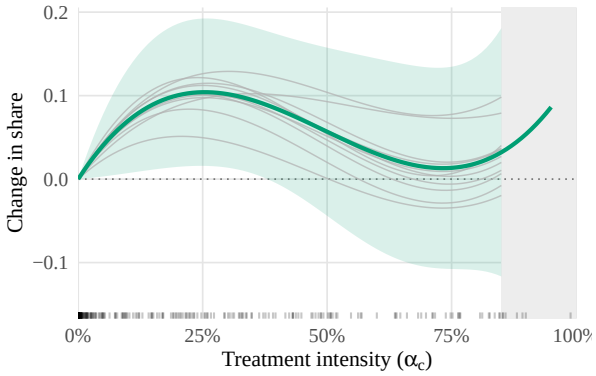
(b) Operating Expenses: Short Run



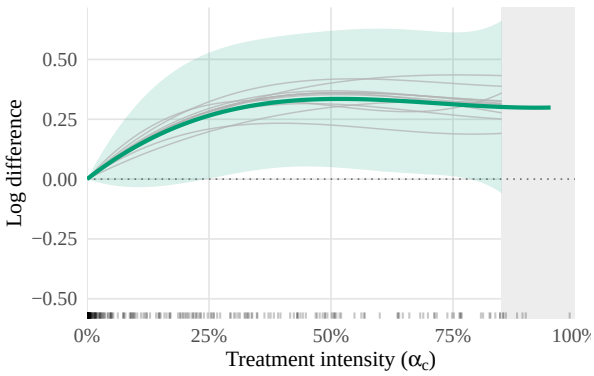
(c) Land in Farms: Medium Run



(d) Operating Expenses: Medium Run



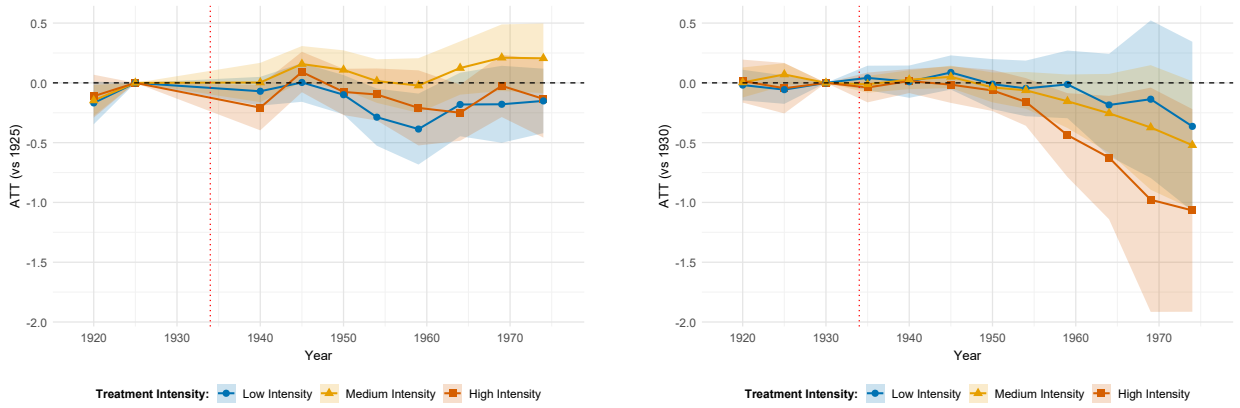
(e) Land in Farms: Long Run



(f) Operating Expenses: Long Run

Figure 13: Leave-One-State-Out Estimates

Note: Each panel re-estimates the dose-response function eleven times, dropping one state at a time. Semi-transparent lines are the drop-one-state estimates; the solid line and shaded band are the full-sample estimate, and shaded areas are 95% sup-t simultaneous confidence bands. All estimates are weighted by county area and use geographic and climate controls and three New Deal per-capita program flows. Rows are the short run (1935–1940), medium run (1945–1950), and long run (1954–1974), each measured against the 1925–1930 baseline.



(a) Pigs per Farm

(b) Chickens per Farm

Figure 14: Placebo Tests: Non-Grazing Livestock

Note: Event study estimates for non-grazing livestock, per farm. Both species underwent significant technological transformation during the study period and were eligible for the same agricultural subsidy programs as cattle and sheep. Treatment intensity bins are defined as Low ($2.76\% < \alpha_c \leq 14.69\%$), Medium ($14.69\% < \alpha_c \leq 51.91\%$), and High ($\alpha_c > 51.91\%$); control counties have $\alpha_c \leq 2.76\%$. Estimates are weighted by county area, with shaded areas showing 95% confidence intervals from standard errors clustered at the county level. The source does not report hog counts for 1930 or 1935, so Panel (a) is referenced to 1925 and those years are absent; Panel (b) is referenced to 1930.

The composition of the response varied with exposure to grazing access in line with the investment patterns predicted by the model. Where private land was available, ranchers expanded operations through the extensive margin. Land in farms rose most in counties with low to moderate public land shares, peaking at a 10 percentage point increase in the share of county area around an α_c of 25 percent and fading to no increase above an α_c of 65 percent, with almost all of the new acres in pasture. Where private land was not available, they pursued a set of increased expenditures and investments at the intensive margin on the operations they already held. At higher exposure, ranches first reallocated existing crop acreage toward hay, with substantial short-run increases and a near doubling by the long run. Operating expenditure then rose through the medium and long runs, reaching 39 percent at an α_c of 55 percent and remaining elevated across the upper range. This increase in operational costs can be further decomposed into labor and equipment in the medium run with additional expansion of equipment in the long run. Equipment reached 48 percent at an α_c of 65 percent in the long run, its peak sitting further toward high intensity than labor's. The adjustment margins also differ in timing: the land response appears first, labor expenditure becomes most pronounced in the medium run, and equipment investment emerges most clearly in the long run. This sequence is consistent with ranches first expanding the private grazing base where land remained available, then increasing labor and eventually durable capital as further extensive adjustment became more costly.

The distributional consequences appear as a break from the relatively uniform substitution patterns across the West prior to the TGA. Cattle and sheep competed for access to the same range forage, and their relative returns were set largely in national markets. Before

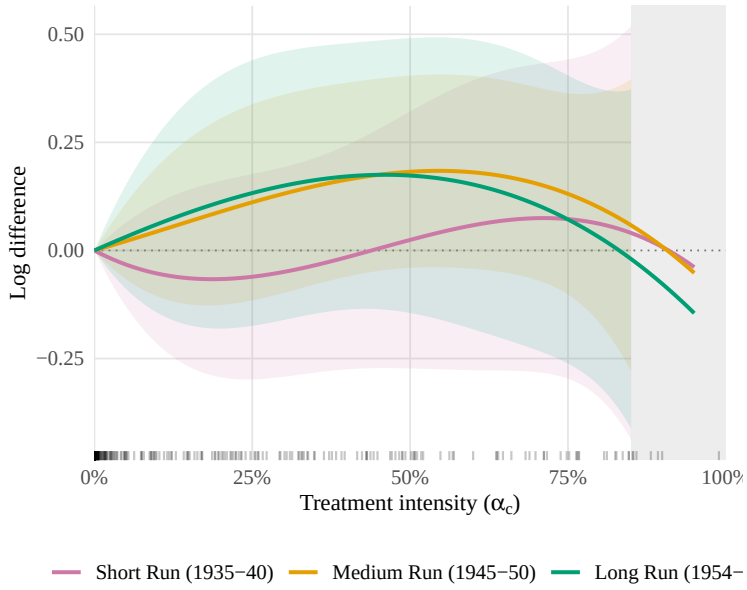
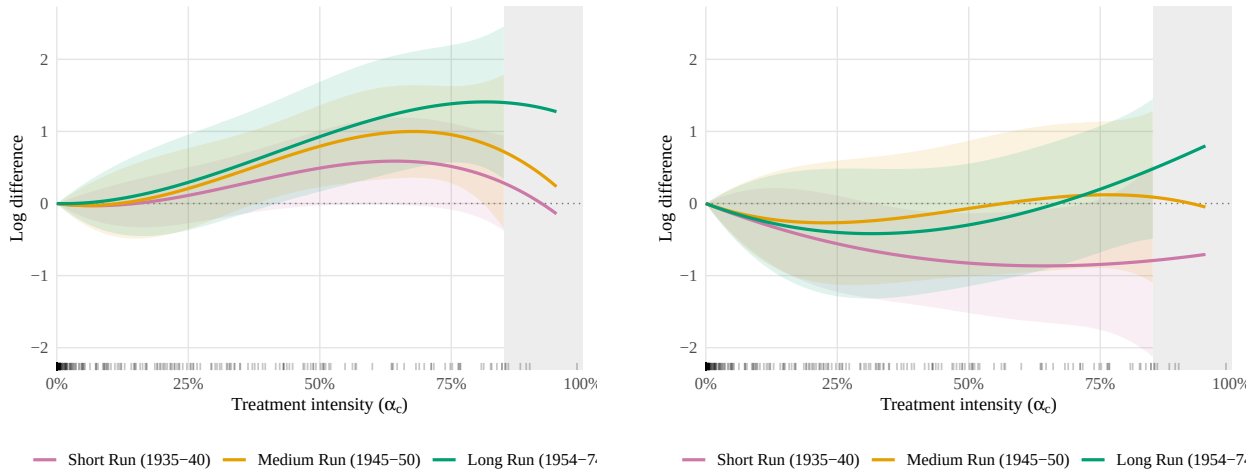


Figure 15: Dose-Response for Pig Production per Farm

Note: Despite undergoing similar capital-intensive confinement technology adoption as beef cattle feedlots during the study period, pig production shows no relationship with public land shares. Lines are cubic polynomials in α_c estimated with geographic and climate controls and three New Deal per-capita program flows, weighted by county area; shaded areas are 95% supt simultaneous confidence bands. Bands are suppressed above $\alpha_c = 0.85$, where seven counties support the fit. Tick marks on the horizontal axis show the distribution of α_c. Estimates are changes to the short run (1935–1940), medium run (1945–1950), and long run (1954–1974). The source does not report hog counts for 1930, so the baseline is 1925 alone.

1934, when those returns moved—and they moved a great deal, in both directions—counties across the exposure distribution adjusted their composition in much the same way. Whatever governed the trade-off between running cattle and running sheep, exposure to the public range appears to have had little bearing on it. After the Act the ratio takes on a differential form across α_c. While cattle production is flat across the whole distribution, sheep move with α_c, rising in the short run and then contracting through the medium and long runs, most sharply at the top.

That divergence points to the rules governing who could hold a permit. The base property preference that mattered most was not originally set out in the Act. In fact, the first circular ranked prior use above base property for applicants holding one and not the other. However, within the year that order was reversed at the request of range ranchers, for the stated purpose of removing operators who held no qualifying property. That is the constituency the historical context pointed to. With cattle claims secured and district capacity administratively fixed, whatever adjustment the range required disproportionately fell on sheep.



(a) Grain Hay (Annual)

(b) Timothy and Clover (Perennial)

Figure 16: Hay Production by Investment Horizon

Note: Differential responses of annual versus perennial hay crops. Grain hay is planted and harvested within a season; timothy and clover require multi-year establishment. Both are in logs. Lines are cubic polynomials in α_c estimated with geographic and climate controls and three New Deal per-capita program flows, weighted by county area; shaded areas are 95% sup-t simultaneous confidence bands. Bands are suppressed above $\alpha_c = 0.85$, where seven counties support the fit. Tick marks on the horizontal axis show the distribution of α_c. Estimates are changes from the 1925–1930 baseline to the short run (1935–1940), medium run (1945–1950), and long run (1954–1974).

That the rule took this form is not surprising given who was in the room. A cattle operation's investments were long-lived—fencing, developed water, a breeding herd carried across seasons—and paid back only if the range was still available across subsequent years. Secure tenure was therefore worth more to cattle operators than to sheep operators, and worth most if eligibility ran through the asset they disproportionately required. The gains from a base-property priority were concentrated among the producers most able to organize for it. This is the political-economy logic emphasized by Kantor (1998): concentrated beneficiaries can bear the organizational costs of overcoming the distributional conflict created by changes in property-rights institutions. Reversing the order was also inexpensive for the agency. It left discretion over carrying capacity, the terms of use, and the administration largely intact, giving administrators little institutional reason to resist. At the same time, the agency had no reliable independent measures of range condition or carrying capacity and minimal staff to develop them. It therefore depended on operators' records of prior use, and its standing depended in part on the goodwill of the ranching associations through which those operators were organized (Calef, 1960; Libecap, 1981). Accommodation was cheap on one side and valuable on the other. The eligibility rule consequently emerged with the participation of the parties it favored.

These findings advance our understanding of property rights in several ways. First, they show that access rights short of ownership can function as quasi-private rights on a region-wide scale. The permits conveyed no title, but they were secure, renewable, and transferable

with the qualifying property. The value of a ranch came to depend not only on what it could produce within its own boundaries but on its ability to secure forage beyond them. Read alongside Bühler (2023), whose boundary comparisons find the range more productive inside the districts than outside, these results suggest that secure, renewable access can generate investment incentives approaching those associated with more complete property rights. Second, and more particularly, they show that conditioning such a right on a private asset does more than transfer rents to the holders of that asset. It redirects what gets invested in, with the direction dependent on the extent to which the required asset can be obtained or improved. The same institutional change produced land extensification where qualifying property was available and capital deepening where it was not. Third, the incidence of a bundled right is decided when the bundle is chosen. Access could have been conditioned on demonstrated use of the range, and briefly was.[27] Conditioning it on ownership of a particular kind of private capital selected among producers by their technology rather than by their use of the resource. That choice is available to any authority allocating a right.

Several limits define the scope of these results. The estimates identify county-level responses to the share of local range brought under the new regime. They do not observe individual permit awards, transactions in base property, or how realized grazing capacity was allocated among operators within a district, so the evidence for the incidence result is a compositional pattern consistent with property-conditioned access rather than a ranch-level account of who displaced whom. The dose-response estimates also require that counties at different levels of exposure would have followed comparable paths conditional on the covariates, an assumption the predetermined distribution of public land makes plausible but does not establish. Nor should the mechanism be expected to operate wherever a public resource is allocated. It requires that the access right be durable and valuable enough to capitalize, that its use depend on a complementary private asset, and that holdings of that asset vary across producers and places.

The mechanism is not particular to rangeland. Modern institutional reforms increasingly allocate access to public resources at national and global scale, often through conditions on private capital: appropriative water rights require diversion works and beneficial use (Leonard and Libecap, 2019), while spectrum licenses may carry build-out obligations that must be met to retain them. Where a right of access is bundled with a private eligibility asset, the resource determines the value of the right, while the eligibility condition shapes the private assets through which that value is realized. By directing investment toward particular land, infrastructure, and production technologies, such rules can also create persistence in subsequent economic choices. The resulting assets can be durable, complementary, and costly to redeploy, so the production structure induced by the eligibility condition may outlast the condition itself. When governments allocate rights to public resources through private eligibility conditions, they allocate more than access. They determine which private assets become valuable, which forms of investment are worth making, and which producers can share in the resulting rents.

[27] Prior use may be considered the dominant method by which the law initially assigns rights in an unowned resource (Lueck, 1995). Assigning the rationed access by demonstrated use would have run the new right to incumbents through their use of the resource itself, as quota systems in fisheries and tradable emissions permits later did; assigning it by base property ran the right through a complementary private asset instead.

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A Historical Appendix

A.1 Land Distribution and Why Western Land Stayed Federal

Throughout westward expansion, the federal government distributed vast swaths of land to public and private parties across the country. State governments, the transcontinental railroads, and other private interests such as mining operations were among the largest beneficiaries. The largest of these programs was homesteading, under which approximately 285 million acres were eventually patented to homesteaders, against roughly 225 million acres granted to the states for various public purposes and 90 million acres patented to railroad corporations to aid in financing construction.[28]

The various homesteading acts and similar laws offered surveyed allotments with modest requirements on activities and improvements to be completed to obtain ownership. These allotments were either offered freely or at a nominal price, such that the quality of land had no bearing on the cost of the homestead, with the result that lands were typically chosen based only on their perceived quality. In the plains and Midwestern states, where most of the land was arable, this did not lead to much of an issue regarding unclaimed land. While the first homesteaders chose the highest quality allotments, the next homesteaders could claim the highest quality allotments remaining. With the large supply of potential homesteaders and few allotments of such low quality as to be unable to support a homestead, this process could repeat until most land had been distributed.

In the West this was often not the case as much of the land proved unable to support the farming homesteads typical of the plains. While some homesteads in the more forgiving climates of river valleys and the like were able to survive, most attempts to claim these lands through farming homesteads failed.

While these lands were ill-suited for the small-scale farming of homesteads, the grasses and scrub brush of the rangeland were capable of supporting large-scale ranching given enough acreage. In fact, Congress recognized the mismatch to some extent and enlarged the allotments with the Enlarged Homestead Act of 1909 doubling the standard entry from 160 to 320 acres on lands classified as non-irrigable, and the Stock-Raising Homestead Act of December 29, 1916 raising it again to 640 acres on lands designated as chiefly valuable for grazing and forage, requiring no cultivation at all.[29] Even a full section, however, remained too small to individually support a viable cattle operation in country where forage requirements ran to tens of acres per animal, and the acts' restrictions on claiming multiple allotments kept most operators from assembling enough land through homesteading to support an operation entirely on private land. These circumstances aided significantly in large expanses of lower quality, unclaimed lands in the West remaining under ownership of the

[28] Historical Statistics of the United States, 1789-1945, Chapter F, source notes to series F 1-219. The railroad figure is patented acreage; grants to railroads are often reported as 129 to 131 million acres, a total that includes grants later forfeited and, in some accounts, the roughly 51 million acres granted by states from land they had themselves received. The most detailed account is Public Aids to Transportation, Volume II (GPO, 1938), Table 13, which records 131,230,358 acres patented to railroads by 1933.

[29] Enlarged Homestead Act of 1909; Stock-Raising Homestead Act, Pub. L. 64-290, 39 Stat. 862 (Dec. 29, 1916). An earlier act, the Kinkaid Act of 1904 (33 Stat. 547), had already allowed 640-acre entries, but only in thirty-seven counties of western Nebraska. Entries under the 1916 act separated surface from subsurface rights, reserving coal and minerals to the United States.

federal government and open to public use.

A.2 Grazing on the Western Ranges

A.2.1 Cattle and Sheep Operations

Cattle and sheep were both run on the western ranges, the dry country where most of the remaining public domain lay.[30] A ranch of either kind ran its stock on dry, unirrigated range for at least part of the year. Throughout a season, both drew on the same three sources of feed: forage from the range, hay and pasture off the ranch's own irrigated ground, and purchased concentrates (Calef, 1960). However, the typical proportions, along with the water each species required, differed substantially between cattle and sheep operations, with those differences largely dictating how much private land and infrastructure each kind of outfit needed.[31]

Broadly speaking, range came in three kinds, distinguished by the season in which each was best used and by where it sat. Summer range was the high mountain country, lush and of high carrying capacity but buried in snow for much of the year; spring-fall range lay at middle elevations, warm enough to graze a month or two before the high country opened and again after it closed; and winter range was the basin floors, the driest ground of all but the only forage available once snow covered the rest. Because range forage cannot be stored, what mattered to a ranch was not its total annual feed but whether it had enough in every month of the year. That seasonal balance set the limits within which a rancher could work, and hay and pasture off irrigated ground filled the gaps.[32]

Water divided the two more sharply. Cattle had to drink every day, so range without water access was worth nothing to them. Stockmen held that a cow would rarely travel more than four miles from water, and range beyond that was unavailable until a well, windmill, or reservoir was built at a cost of several hundred to several thousand dollars. Sheep were not so constrained. Where morning dew was abundant, they could graze for a month or more with no water at all, and in winter they could sustain themselves by eating snow. As a result, sheep could work large sections of range that cattle would struggle to reach until someone had paid to put water there (Calef, 1960, pp. 29–30, 34).[33]

A cattle operation could control its animals by enclosure or by herding with the two buying different things. Once the range was fenced, enclosure cost far less per head of livestock.[34] Alternatively, herding cost more but gave closer control of the range. A herded

[30] The account draws on Calef (1960), whose fieldwork was concentrated in the Middle Rocky Mountain basins.

[31] Some ranches ran both, though larger operations generally specialized in one or the other. Where a range carried grass, weeds, and shrubs, running both returned more than either alone, since cattle take grass while sheep prefer to browse and will also eat the weeds (Calef, 1960).

[32] Calef (1960), pp. 21–25. The ratio of summer to winter feed supply is identified as the most important single factor governing whether a rancher carries young stock through the winter.

[33] Where water sources were widely scattered, cattle grazed the range unevenly, heavily near water and lightly on the ground farthest from it. Careful herding could modify that pattern to some extent, but unless the control was close the uneven pattern prevailed. Herding and the judicious placing of fences were the two means of modifying it (Calef, 1960).

[34] Calef (1960), pp. 28–29, which works the comparison through for a sixteen-section range at late-1950s prices.

band could be worked across the whole of a range rather than concentrating where the animals preferred, and ground in poor condition could be grazed lightly and then left while the band moved on. The two also differed in what they required of the operation. Fencing was capital sunk into ground, and an operation could only legally fence land it held; herding was a wage paid year after year, and it worked as well on land the operation had no claim to at all.[35] A sheep operation had no choice to make. Sheep were too vulnerable to be left unattended, so it employed herders regardless and, thus, needed no fencing.

Selling products worked differently as well. A sheep operation largely had two products, wool in the spring and lambs in the autumn. Wool could be kept for years without deteriorating, so an operation that could afford to wait might hold it for a better market. On the other hand, lambs could not be held. The market was for lambs specifically, so an animal carried past its season fetched mutton prices, which ran far below lamb. For the same reason, an aged ewe wasn't worth much when culled. With its products standardized and its marketing dates fixed, a sheep operation ran on a more regular annual cycle than a cattle operation did, and had fewer options in disposing of its meat animals beyond the annual lambing cycle. Conversely, cattle could be held back through a poor autumn and be expected to gain value over the following year, so a cattle herd could be run up or drawn down as the market moved.[36]

A.2.2 Informal Rights and Their Limits

Operations of both kinds ran largely on public grounds, and had done so long before the homesteaders arrived. Early settlers noticed the ease with which cattle sustained themselves on native vegetation, and the practice of allowing livestock to graze unherded for months, common in Texas and further south, spread quickly through the rangelands. Estimates suggest that cattle in Arizona increased from around 50,000 to over a million within the second half of the 1800s (Coggins and Lindeberg-Johnson, 1982). This rapid settlement of rangelands without private title was common all across the West. Stuart and Phillips (1925) wrote of the changes in Montana, "In 1880, no one ever had heard tell of a cowboy in 'this niche of the woods' and Charlie Russell had made no pictures of them; but in the fall of 1883, there were six hundred thousand head of cattle on the range."

Initially, the vast, unsettled lands of the West were able to support this rapid increase in activity, as cattlemen could avoid conflict by simply moving on to the next unoccupied valley or divide. In this setting, possession was often recognized as a right to use of the land, and notification of claimed land in local papers was sufficient for a reliable right. What made a claim good, though, was using it. Running stock on a piece of range was the evidence that it was held, and an operation that drew down risked seeing the range taken up by someone else. Heavy stocking was therefore in part an investment in the claim rather than only a response to free forage (Libecap, 1981). As the ranges filled with cattle operations, these initial measures proved less reliable, and organizations to improve enforcement of prior rights sprang up. Line camps were put in place where cowboys camped along the edges

[35] Operations did fence public domain they had no title to at some scale. Congress moved against the practice with the Unlawful Enclosures Act of 1885, and enforcement followed. A fence around ground an operation did not hold was possible but not secure (Libecap, 1981).

[36] Calef (1960), pp. 30–32. Mutton is described there as a cheap by-product of lamb and wool.

of ranges and kept the appropriate cattle on or off of the range. Cattlemen's associations were started to aid in resolving conflicts between claimants and lowering collective costs for general management of ranges.[37]

As ranges filled up, associations also needed a way to exclude cattle of nonmembers when those cattle would overcrowd the range. This leverage was provided through association-supplied goods necessary to a successful operation. By excluding nonmembers from round-ups, corrals, and other necessary tools, individually operating on these ranges was too costly to remain viable. This practice was quite successful for a time, and membership in associations and access rights to ranges granted by associations were often considered valuable enough to be traded or sold (Anderson and Hill, 2004). Control of water worked the same way and needed no collective agreement behind it. Since cattle had to drink daily and would not travel far from a source, an operation that held the water held the forage around it, and the cost of developing a new source put much of the surrounding range beyond the reach of anyone who did not (Libecap, 1981).

In the mid to late-19th century, the arrival of sheep to the ranges brought about a significant shift in the bargaining strength of cattlemen's associations. The exclusion worked because a cattle operation could not run without the goods the associations controlled. A sheep operation needed none of them. Its herders held the band together out on the range, so it wanted no corrals and no round-ups, and the animals could work across range with no water on it.

The associations therefore had minimal hold on a sheep operation, landed or not, since the same feature that let herding substitute for fencing let it substitute for membership (Anderson and Hill, 2004). What they did for the operations they covered continued—brands were registered and enforced, round-ups organized, disputes between members settled—but the leverage that had kept outsiders off a claimed range did not bear on a user who wasn't reliant on it.

How far an operation could push its independence from land varied. Most sheep ranches held deeded ground like any other, running their bands off a home place and putting up hay on irrigated land. But the same features made it possible to run with no home place at all, following the range with wagons and moving the band on when the feed gave out.[38] Operations run that way were not the modal case, but they were a real part of the industry, and the distinction would matter when access came to be allocated on the basis of property.

A.3 The Closing of the Public Domain

Whatever claim an operation had to the range, it held it over ground that remained public while how much of that ground there was to hold was still being settled. The General Land Office reported annually on the acreage remaining vacant, unappropriated, and unreserved,

[37] This general management included registration of cattle brands and their enforcement on ranges and at transportation hubs and major points of sale. As they grew larger, they also served as significant lobbying groups in the legislatures of their respective territories.

[38] Shepherds typically lived in wagons on the range and followed the wandering of their herds. This more nomadic approach to livestock herding likely led to increased conflicts between cattle and sheep herders as shepherds drifted across claimed ranges (Herndon, 1984).

recording the closing of the disposal era in the West.[39] In 1901 the eleven western states in the sample held 491 million acres of such land. By 1910 the figure had fallen to 333 million, by 1920 to 199 million, and by 1931 to 176 million. Figure A.1a plots the series. Libecap (1981) reports roughly 500 million acres available in 1900 and 178 million by 1930, which the transcription here matches closely.

The pace of that decline is also informative next to its extent. Vacant land in the eleven states fell by roughly 22 million acres a year between 1901 and 1903, by 16 million a year through 1910, and by 10 million a year over the fifteen years to 1925. Between 1925 and 1931 the rate fell to 1.3 million acres a year. Every state in the sample shows the same pattern. However far its stock had fallen, it was substantially flat from about 1922 onward.

Homesteading accounts for most of the decline. Cumulative original homestead entries between 1902 and 1931 total 303 million acres nationally, against a fall in the national vacant stock of some 297 million acres over the same period.[40] Figure A.1b plots the annual flows. The two series track each other closely through the disposal of the 1910s with both collapsing in the early 1920s. Entry remained minimal until Executive Order 6910 of November 26, 1934 withdrew the remaining public domain in the western states from settlement, location, sale, or entry pending classification, such that original entries reached essentially 0 by 1937.[41]

Two qualifications are worth recording. The decline in the vacant stock reflects withdrawal as well as disposal. The national forest reserves grew from 167.9 million acres in 1908 to 194.5 million in 1909, and land so reserved leaves the vacant category without passing into private hands.[42] And the 1926 report states that a special check of each district land office produced a complete revision of the vacant land statistics, so figures from 1926 forward are not strictly comparable with earlier years.[43]

By the time Congress took up the question of the range, then, the process that had determined which land was federal and which was private was essentially complete. The condition of the range itself was another matter. Western herds did not shrink as the public domain did. Cattle in the western states rose from roughly 8 million to 10 million head between 1900 and 1930 and sheep held near 25 million, over a period in which the land still open to entry fell by about two thirds (Libecap, 1981). Drought and severe winter storms had already cut numbers sharply in the "Great Debacle," after which the advantages of sheep-raising contributed to a further shift toward sheep on the western ranges (Coggins and Lindeberg-Johnson, 1982).[44,45] Overcrowding persisted, and climatic conditions compounded

[39] Annual Report of the Commissioner of the General Land Office, various years. I transcribed the state-level tables for 1901 through 1931; the reports do not give state detail for 1907, 1927, or 1928. Every year for which a national total is also published in Historical Statistics matches the corresponding sum. Alaska is excluded throughout.

[40] Historical Statistics of the United States, 1789-1945, series F 8 and F 15. The comparison is national because homestead entries are not reported by state in this series.

[41] Exec. Order No. 6910 (Nov. 26, 1934). A further order, No. 6964 of February 5, 1935, extended the withdrawal to the remaining public land states.

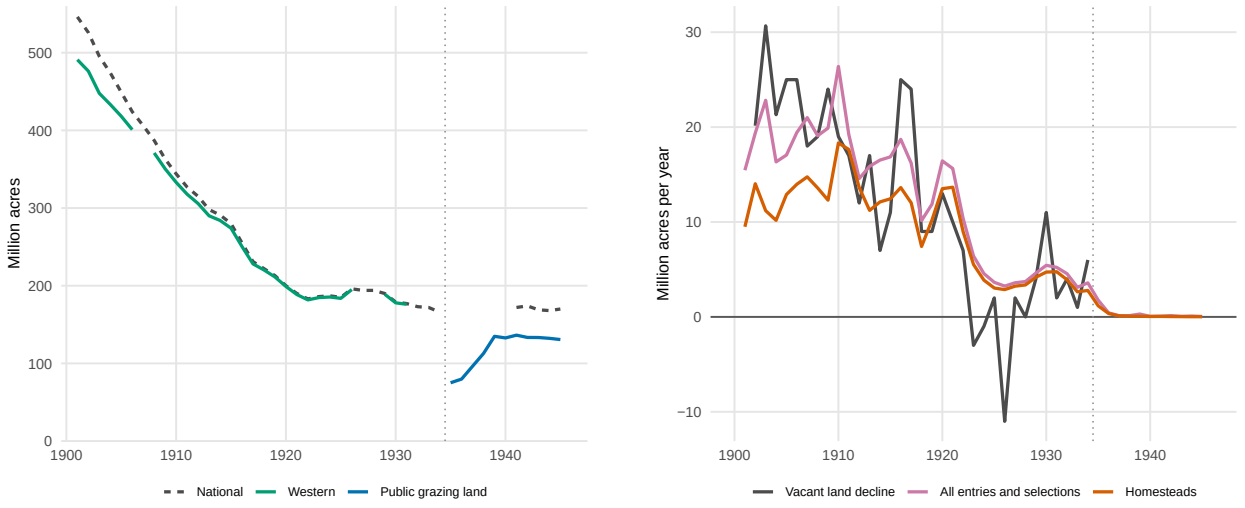
[42] Annual Report of the Commissioner of the General Land Office, 1909.

[43] Annual Report of the Commissioner of the General Land Office, 1926.

[44] Herds were decimated with millions of livestock killed. An operation in Nevada and Idaho went from 38,000 calves reported in 1885 to 68 reported in 1890 (Coggins and Lindeberg-Johnson, 1982).

[45] Much of the conflict between cattlemen and shepherds stemmed from various beliefs about the incompatibility of sheep and cattle, such as sheep carrying oil on their hooves that repelled cattle (Herndon, 1984).

it, leading to severe soil erosion and significant degradation of rangelands (Stout, 1970). A survey in 1936 classed 42 percent of the western range as in fair or better condition.[46] In 1928, degradation of the range led Congress to establish the Mizpah-Pumpkin Creek grazing district in Montana, an experimental cooperative in which the efficacy of leasing public land for grazing was tested. The success of Mizpah-Pumpkin Creek, continued concerns over the state of rangelands, and conflict between various groups on the range culminated in the passage of the TGA in Congress and its signing on June 28, 1934 (Ross, 1984).



(a) Vacant Public Land and Land in Districts

(b) Annual Decline and Original Entries

Figure A.1: The Public Domain in the West, 1901–1945

Note: Panel (a) plots vacant, unappropriated, and unreserved public land nationally and for the eleven western states in the sample, with public land within grazing districts overlaid from 1935. Panel (b) plots the annual decline in the national vacant stock against all original entries and selections and against homestead original entries. The national and entry series are F 8, F 11, and F 15 of United States. (1949); the state series is transcribed from the Annual Reports of the Commissioner of the General Land Office. State detail is unavailable for 1907, 1927, and 1928, and those gaps are left open. The Interior reports give no district figure for fiscal 1937; it is the only gap in a short series and is filled by linear interpolation. Negative values in Panel (b) indicate years in which restorations to entry exceeded disposals; the 1926 value reflects the statistical revision described in the text rather than a return of land. The decline series is not plotted after 1934, when movements in the vacant stock reflect classification and restoration rather than disposal. The dotted line marks 1934.

The Taylor Grazing Act changed the terms on which the western range was held. Use of the unreserved public domain had been free, unregulated, and open to anyone who turned stock onto it; after 1934 it was to be leased, regulated, and exclusive (Calef, 1960). Land brought into grazing districts was evaluated for carrying capacity and divided into allotments,

Despite these commonly shared sentiments, sheep grazing does not exclude cattle grazing on the same land, nor does the reverse hold. In fact, when managed correctly, they can coexist quite successfully (Fulton, 1977).

[46] Box (1978), reported in Libecap (1981). The same series gives 67 percent in 1966 and 68 percent in 1972.

and grazing on it required a permit specifying a number of animal-unit months and the allotments on which they could be taken.[47]

How much land the Act could take in was bounded before anyone was consulted about it. The Act required statewide public hearings before districts could be organized. At those meetings, held in December 1934 and January 1935, attendees elected state committees of stockmen to draw the boundaries. The committees recommended fifty districts covering approximately 142 million acres of vacant, unreserved, and unappropriated public land, which was close to the whole of what remained. Only thirty-two districts were organized, since the Act allowed 80 million acres initially. Though, the 1936 amendment raised the ceiling to the 142 million acre figure the committees had suggested (Calef, 1960, pp. 58–59).[48] The statutory limit, in other words, was the constraint that moved to accommodate the remaining public acreage available to be claimed rather than the inverse.

What land left the public domain over the same years was settled on the land's merits. No land could be alienated from the public domain until it had been classified as suitable for the purpose for which it was being entered, and classification in the early years of the Act was rigorous. Ground was not classed as suitable for agriculture unless it was judged really to be so with public land disposed of according to its potentialities rather than to satisfy the letter of land laws that had never fitted the country (Calef, 1960). The effect was that inclusion of land in classifications subject to the Act's grazing policies was largely not derived through political demands.

Enrollment proceeded quickly reaching its final extent within five years. The first grazing district was established in March 1935, and by the close of that fiscal year thirty-two districts held 75.1 million acres of public land. The figure reached 79.8 million acres in thirty-seven districts by 1936, 112.8 million in forty-nine districts by 1938, and 134.9 million in fifty by 1939. It peaked at 136.3 million acres in 1941 and stood at 130.7 million in 1945, by which time the number of districts had grown to sixty.[49] The enrollment line in Figure A.1a shows the whole of this against the vacant land series it was drawn from.

Notably, the statutory ceiling of 142 million acres was never reached, so the figure commonly reported as the acreage the Act brought under management was a limit rather than a binding constraint. And the districts added after 1939 brought in little additional public land. In fact, the acreage under administration declined slightly over the war years. Instead, enrollment largely tracked what each state had left rather than any other characteristic. Across the ten states for which the Interior reports give state detail, public land in districts in 1940 correlates with the state's remaining 1931 public domain at 0.90, and at 0.95 conditioning on state area.[50] Expressed as a share of what remained, enrollment was near-complete in most of the region. Figure A.2 shows New Mexico at 102 percent, Idaho and

[47] An animal-unit month is the forage required to support one cow, one horse, or five sheep or goats for a month.

[48] The limit was removed altogether in 1954 (Ross, 1984).

[49] Annual Reports of the Secretary of the Interior, Division of Grazing and (from 1939) Grazing Service sections, fiscal years 1935 through 1945. No figure is reported for fiscal 1937. Acreage is public land within district boundaries, which is smaller than gross district area: the thirty-seven districts of fiscal 1936 held 79.8 million acres of public land within boundaries enclosing 198 million acres in all ownerships (Calef, 1960).

[50] Washington is absent from the state tables. It had 930,389 acres of vacant public land remaining in 1931, down from 11.9 million in 1901.

Utah at 98, Oregon at 92, and Colorado and Wyoming in the mid-eighties.[51] The agency had its own reasons for that. A grazing service was worth more, in budget and standing, the more land it administered, and its position depended on the goodwill of the livestock associations whose members used the range (Libecap, 1981). Neither consideration bore on which counties held public land, but both pointed toward taking in as much of it as the statute allowed.

Three states account for nearly all of the remainder. California enrolled 20 percent of its 1931 vacant public land, Arizona 63 percent, and Nevada 66 percent; together they held 35.5 million of the 42.4 million acres left outside districts, or 84 percent of the total. Excluding them, the other seven states enrolled 93 percent of what they had. These shares are close to unchanged across the years for which state detail is available, with seven of the ten states moving by five percentage points or less between 1940 and 1945.

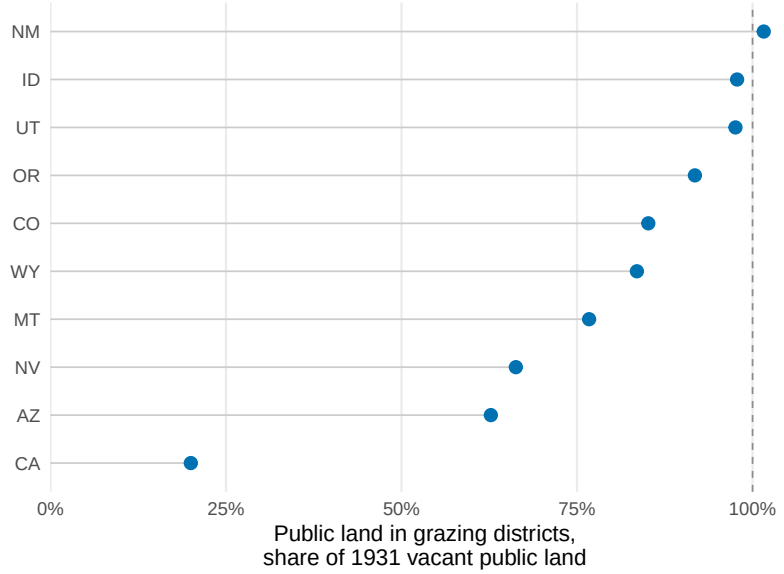


Figure A.2: Enrollment as a Share of Remaining Public Domain, 1940

Note: Public land within grazing districts in fiscal 1940 as a share of the state's vacant, unappropriated, and unreserved public land in 1931. Washington is absent from the Interior state tables. The dashed line marks parity with the 1931 stock; shares above it arise because land was restored to entry between 1931 and 1940, so the 1931 figure is not a ceiling on what could later be enrolled. Shares are close to unchanged through 1945, with seven of the ten states moving by five percentage points or less.

A.4 Access and Allocation

Nothing about the Act determined who among the operators using a district would receive a permit, or how much of the range each would be allotted. Those questions were settled

[51] Shares above 100 percent arise because land was restored to entry between 1931 and 1940, so the 1931 stock is not a ceiling on what could later be enrolled.

administratively, in a process the Division of Grazing had neither the staff nor the information to control.

A model was already to hand. Forest reserves had been withdrawn from the public domain beginning in 1891, and grazing on them was regulated and paid for starting from January 1, 1906 onward.[52] The Forest Service sorted applicants into three preference classes, ranked by proximity and regular use rather than by property: small near-by owners whose stock had regularly grazed the range and who depended upon it, then other regular occupants, then owners of transient stock belonging at a considerable distance. Reductions fell on the lowest class first, which was to be excluded before the others were cut at all. Permits went to the owners of the stock rather than to land, and were forfeited if sold or transferred.[53] The two systems remained distinct in their extent, as Figure A.3 shows, but the Taylor Act's machinery was recognizably a descendant of this one.

Administration within the districts ran through local advisory boards, which coalesced into official district advisory boards with a 1939 amendment but whose role and composition remained mostly the same. The Act required the Secretary to seek their advice before making rules affecting a district. The boards were necessary for a more particular reason. Allocating permits on priorities that turned on previous range use required information about what applicants had actually been running and where, and that information existed largely among the local ranchers (Calef, 1960, p. 60).

The seats generally went to the larger, more aggressive, and more politically conscious operators who could secure election. Many of them were officials of or active in the western livestock associations. Other large operators stayed out, some from a misplaced contempt for a procedure they took to be a formality, some from not seeing what was at stake. Everyone involved understood that whatever the reality, the hearings must not be made to appear dominated by the big ranchers and their associations (Calef, 1960). Operators without a home ranch were poorly represented.[54]

Preference for a permit was tied to base property near or adjacent to the allotments, assessed on its capacity to support livestock and assigned a corresponding number of AUMs. The Act itself gave preference to landowners engaged in the livestock business, to bona fide occupants and settlers, and to owners of water or water rights. Circular No. 2 then set three classes in order of priority: applicants holding dependent commensurate property who had also made prior use of the public range;[55] applicants with prior use but without adequate commensurate property; and applicants with adequate commensurate property but no prior

[52]Forest Reserve Act of 1891; Organic Administration Act of 1897, 16 U.S.C. 551; Transfer Act of 1905, 33 Stat. 628. The fee schedule appears at Regulation 25 of United States. Forest Service. and Pinchot (1905), which provided that on and after January 1, 1906 a reasonable fee would be charged for grazing all classes of live stock on forest reserves, initially from twenty to thirty-five cents per head for cattle and horses and from five to eight cents per head for sheep for the summer season.

[53]United States. Forest Service. and Pinchot (1905), Regulations 11 and 14. Forest Service term permits run for up to ten years, as Taylor Act permits did, and the Forest Service's head-month is nearly identical to the animal-unit month. Grazing fees have been Forest Service policy since 1906 and Interior policy since 1936.

[54]Boards did include separate advisors for both sheep and cattle.

[55]Prior use was defined as grazing the district's federal range in three of the five years between June 28, 1929 and June 28, 1934, a window falling in drought and depression in which some long-established local operators had cut back or stopped altogether (Calef, 1960, p. 61).

use. The two criteria were very differently verifiable. Ownership could be shown from the record, where as a history of range use rested on evidence that was conflicting, debatable, and almost never susceptible of proof.

Further, that initial preference ordering did not survive its first year. At a regional meeting in Salt Lake City, range livestock ranchers objected that the second and third classes were the wrong way round, since as written an operator without base property outranked a local landowner who had not previously run stock on the range. A new circular shortly reversed them. Calef records that the revised order was designed to eliminate the operator without base property and largely did so, and observes that it also tied use of the federal range more closely to the water and irrigated land of the adjoining country.[56] Because each class divided only what remained after those above it had been satisfied, the allocation ran as a cascade, and where preference claims approached the available forage the lowest class received little or nothing.

The consequence was that claims were adjudicated by the claimants' competitors. An applicant asked for the largest permit he thought he could substantiate. A board member familiar with the country, or another rancher wanting forage on the same range, would then contradict him—that he had never run half the stock he claimed, that his animals had grazed only one side of a particular mountain, that they had gone south of a certain draw only in dry years when they were let down to a neighbor's spring. Witnesses were called on both sides. The hearing, as Calef puts it, was in part a test of the applicant's political, forensic, and rhetorical skill (Calef, 1960, pp. 64–66).

How much each permittee received was on no firmer footing. There were no reliable data on range condition or on carrying capacity, and the Division had sixty employees, forty-seven of them outside Washington, or one field employee for every 4.2 million acres it was to administer.(Calef, 1960, pp. 59, 69). Allotments were therefore set largely on what applicants said they had been running. The result was over-allocation on paper: in most districts permits had been issued for many more livestock than the range could properly support, a situation Calef reports all parties recognized as unsatisfactory(Calef, 1960, p. 69).

Adjudication, the process of revising the allocations set under the original temporary permits, began almost at once and was still running decades later, held up by unsurveyed range, by changes in ranch and permit ownership, and by year-to-year variation in range condition, with new cases arising as permits were sold and transferred. Permittees were unwilling to give up AUMs and had several ways of avoiding formal cuts, among them arguing that carrying capacity would rise, or that the neighbors' permits should be cut instead (Calef, 1960, pp. 70–71). Reductions in actual use were easier to obtain than reductions in permits, since a rancher could apply for non-use, grazing fewer AUMs than his permit allowed and paying only for what he took, commonly for up to five consecutive years, without the permit itself being reduced. Permitted AUMs and animals on the range were therefore different quantities.

What made the permit worth holding through all of this was its security. A permittee who complied with the rules had little to fear from the renewal process, and denial in practice required something like misconduct. Section 3 went further, providing that no complying

[56] Calef (1960), pp. 60–61. See also the Rules for Administration of Grazing Districts (June 14, 1937) and Foss (1960), p. 63, which give the revised order.

permittee shall be denied renewal where the denial would impair the value of the grazing unit when that unit is pledged as security for a bona fide loan.[57] Preference status was also transferable, moving with the base property or by outright sale to similarly situated land, and it was typical for the status to be capitalized into the sale price of a ranch (Ragsdale, 1969).

A.5 How the Range Was Run

The boards' reach did not stop at allocation. Half of all grazing receipts were to be turned over to the states in which they were collected, with the legislatures required to spend the money in the counties where it came from. Those funds were invariably handed to the district advisory boards for range improvements instead, at a time when western counties were in stringent need of school and road money—which Calef describes as a startling exemplification of the political power of the range stockmen (Calef, 1960, pp. 75–76) A further quarter of receipts went to the Secretary for range improvement work.

The fees themselves were nominal. The Act set 5 cents per animal unit month, and no fee at all was charged in the first year after a district formed. That was roughly a third of what the national forests charged at the time and a smaller fraction still of private leasing rates. That gap only widened between 1936 and 1950. While the Grazing Service charge rose from 5 to 8 cents per head, the Forest Service charge rose 13 to 42 cents per head.[58] Calef describes the low first fee as designed partly to enlist rancher cooperation and acquiescence in Taylor Act administration. Grazing receipts from the Taylor lands were negligible as federal revenue with under $2.4 million in 1956, a small fraction of a hundredth of one percent of federal income, which is part of why the level attracted so little congressional attention.

What the permits said and what happened on the range were not always the same thing. Grazing patterns were worked out through long-running conversations among the ranchers, the advisory board, and the district grazier, and by exchanges of range use and other give and take. The resulting series of interlocking informal agreements added up to a grazing plan without any change in the ranchers' formal claims and permits. Many were oral, with nothing to enforce them but their mutual acceptability, and the agency recognized them only when they were written down and approved by the range manager. Such arrangements were fragile. A single change in ranch ownership could unsettle a negotiated pattern involving a dozen operators, and it might be several years before the situation stabilized again.[59]

Formal use and actual use diverged for a second reason. While the overstocking of initial permits fixed a ceiling, an operator could work below it at will, applying for non-use or simply paying the full fee while grazing less. Because the original allotments had been set on claimed prior use rather than on any assessment of what the range would carry, the room underneath them was wide. An operator could therefore graze to whatever level the year's prices and range conditions warranted, so long as that level lay below his permit.

[57] Taylor Grazing Act, sec. 3. Calef (1960), p. 70, observes that since cancellation would inevitably impair the value of a grazing unit, an operator holding even an original one-year license could put the question beyond reach by pledging the unit against a small loan.

[58] Calef (1960), pp. 74–75, for the Taylor Act fee and the comparison at the time of the Act; Libecap (1981) for the 1936–1950 series.

[59] Calef (1960), pp. 72–73; Federal Range Code sec. 161.6(g) for the written-agreement requirement.

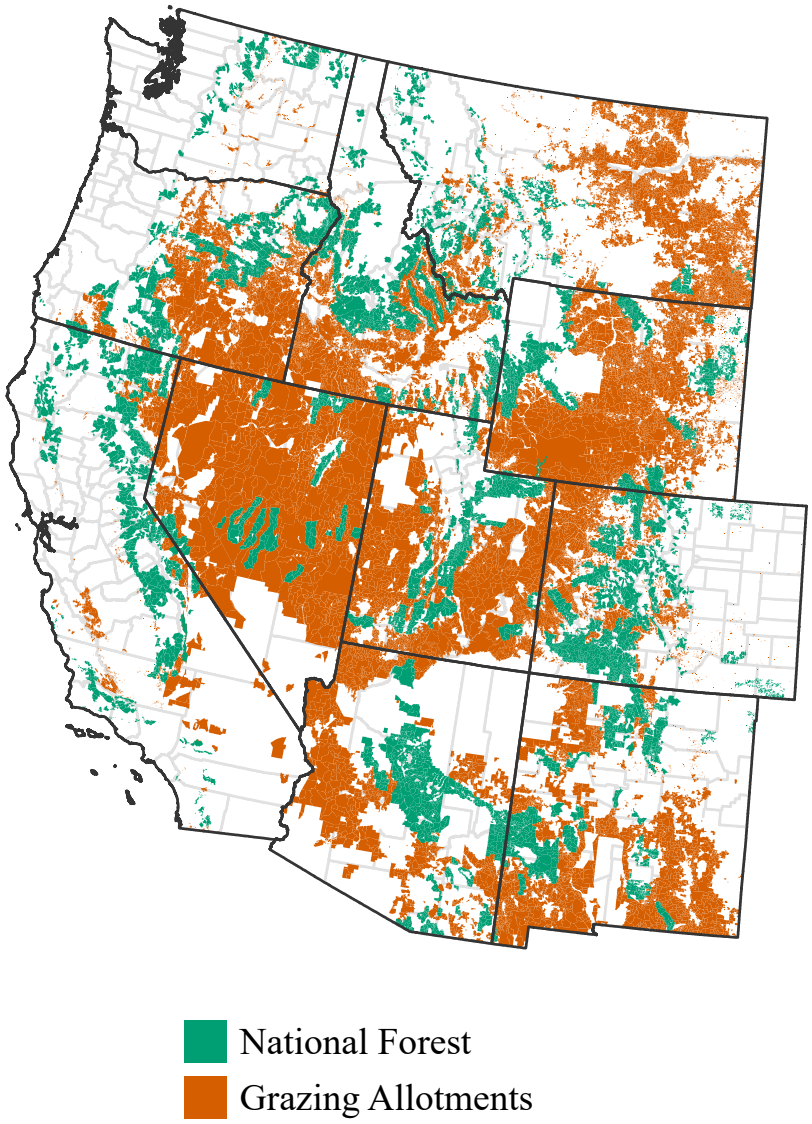


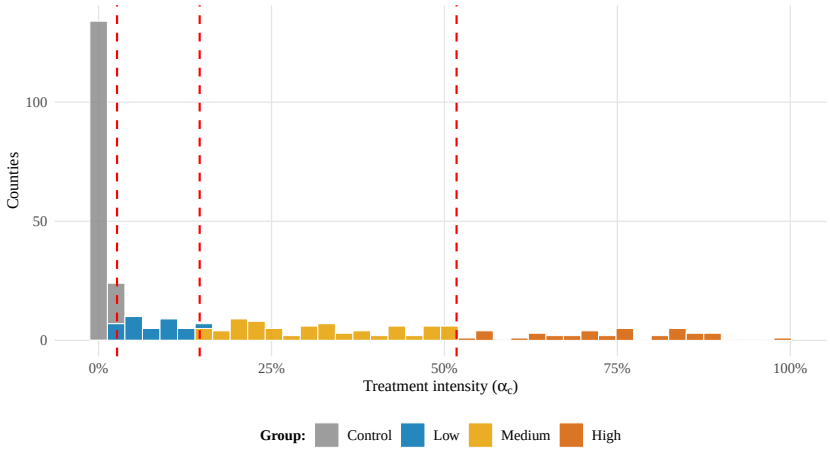
Figure A.3: National Forest and Taylor Grazing Act Allotments

Note: National forest land and Bureau of Land Management grazing allotments in the eleven western states. County boundaries are shown in light grey and state boundaries in darker grey. Allotment polygons are the modern BLM grazing allotment layer used to construct α_c.

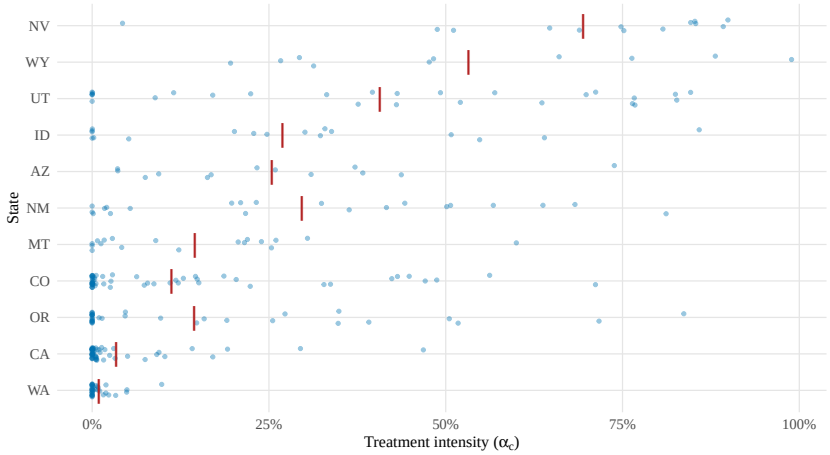
What that level should be was a standing disagreement, and not one between stewardship and myopia. A permittee holding secure and renewable access has reason to keep the forage base intact, but the level at which he keeps it depends on what the stock is worth, and it moves from year to year with prices. The agency worked instead to a fixed standard of vegetation. Both levels may leave the range renewable over time. However, they are not necessarily the same, so what counted as overgrazing was contested rather than measured, and reductions in permitted use were not on their face corrections of rancher behavior (Libecap, 1981). The room below the ceiling narrowed in any case as the agency asserted firmer control through the 1960s and 1970s.

Taken together, this history clarifies both the source and the meaning of county-level exposure to the Taylor Grazing Act. The spatial distribution of the residual public domain was largely the product of pre-1934 land disposal, settlement, and withdrawal, processes that had substantially run their course before the Act. Grazing-district enrollment then incorporated most of the eligible remaining range, with variation across counties arising primarily from the inherited local share of land brought within the permit system. The subsequent allocation of permits and animal-unit months within districts was contested, locally administered, and shaped by incumbent influence; those decisions determined the distribution and terms of access among users, rather than the county-level extent of land exposed to the new regime. Accordingly, α_c measures the share of a county's grazing landscape exposed to a change from open and insecure access to regulated, property-linked grazing rights. Permit allocation is part of the policy's post-treatment mechanism, through which its benefits and constraints were distributed.

B Supplementary Figures and Tables



(a) Distribution of Treatment Intensity



(b) Distribution by State

Figure B.1: Detailed Distribution of Treatment Intensity

Note: Panel (a) shows the distribution of treatment intensity (α_c) across all 302 counties. The distribution is highly right-skewed, with a large mass of counties at or near zero. Dashed lines indicate the cutoffs used for the treated bins: Q1 (Low), Q2–Q3 (Medium), and Q4 (High). Panel (b) shows the distribution of treatment intensity by state.