The Effect of Land Fragmentation on Green Infrastructure Development in Rural America

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Abstract: Small American farmers face mounting economic pressures that threaten their survival. Green infrastructure development, such as wind power, solar power, or conservation easements, offers a potential source of supplementary income, but land requirements for such developments often exceed the size of the farms most in need of their revenue. We quantify how farm size and land ownership fragmentation affect the location and intensity of green development across the rural United States using a range of measures of land fragmentation at the county, section, and parcel levels. Fragmentation is most clearly a barrier to wind development, for which larger, less fragmented holdings predict greater development at every scale. Evidence is weaker for solar development, and conservation easements display a more complex pattern, with fragmentation raising the incidence of easements at some scales while consistently reducing the area they cover. The results suggest that the small farms most in need of supplementary income are often those least able to attract it, and that policies promoting income diversification through green development may do little to help them unless the barriers against the assembly of fragmented land are addressed.

1 Introduction

Small farms are considered by many to be the backbone of rural America, and an integral part of the national identity and culture (Deller and Boyce, 2025). However, the economic challenges faced by farmers over recent years have only grown, often forcing farmers into taking on large amounts of debt, or going out of business altogether. These pressures are particularly acute for small farms which have fewer assets against which they can borrow, and smaller margins in their cash flows that would otherwise allow them to more easily absorb fluctuations in annual profits.

U.S. farm income dropped from a 2013 high of more than $120 billion to $88 billion in 2019 (AFBF, 2019), while the farm sector's debt-to-asset ratio rose from 11.4% to 13.5% over the same period. The effects of this can be seen in the change in the number of farms in operation—the total number of U.S. farms fell below two million in 2022, with declines in every revenue class below $1 million even as the number of larger operations grew (Lacy, 2024). Small family farms, which comprise 86 percent of American farms (Lim and Lacy, 2025), are especially vulnerable in this environment given their limited capital reserves, and for them income diversification has become an increasingly important strategy for survival.

There are an increasing number of options available for farms to diversify their income streams away from traditional agricultural revenue. One such option is leasing land for green infrastructure development. Wind energy, solar energy, and easements can each offer farmers supplementary income without necessarily requiring them to cease agricultural production. These opportunities have grown rapidly over recent years—wind lease payments to U.S. landowners rose from over $195 million in 2014 to over $700 million in 2019 (AWEA, 2015; 2020), with annual payments per turbine ranging from $7,000 to $14,000 (AWEA, 2018). For context, mean annual net income for moderate sales farms (the highest-sales category of "small farms") was only $51,359 in 2018 (ARMS, 2023), making a single turbine lease a substantial addition to farm income. There is evidence that diversification is one of the primary reasons that farmers choose to allow wind production on their land (Sutherland and Holstead, 2014). Solar has grown even faster—U.S. utility-scale solar capacity surpassed 100 GW in 2024, up from roughly 82 GW a year earlier (U.S. Energy Information Administration, 2024), compared to a mere 6.2 GW of new solar capacity in 2014 (Solar Energy Industries Association, 2015). A 2024 survey of agricultural producers by Purdue University found that a majority of farmers who were approached about solar leasing had been offered more than $1,000 per acre per year (Morgan, 2024; Purdue University/CME Group Ag Economy Barometer, 2024), several times the value of typical cropland rental rates. In contrast to wind and solar projects, conservation easements offer a different form of income opportunity. Easements come in several different forms, each with its own purpose and associated land use restrictions. While an easement aimed at nature conservation may restrict agricultural activity and effectively remove the land from a farm's productive capital stock, a farmer may instead place their land into an agricultural conservation easement. These generally only restrict future non-agricultural development, allowing the owner to continue farming the fields in question. While easements typically do not generate continuous revenue streams for landowners, those who choose to enroll eligible land may receive significant tax savings or even direct monetary payments in exchange for restricting future development (Parker and Thurman, 2019). A landowner who donates a qualifying easement retains ownership of the land and can claim a federal income tax deduction for the value of the development rights they forgo (Parker and Thurman, 2019); several states add transferable income tax credits on top, with Virginia granting a credit worth 40 percent of the value of a donated easement (Virginia Department of Conservation and Recreation, 2026) and Colorado one of up to 90 percent of fair market value, capped at $5 million per donation (Colorado Department of Revenue, 2025). Funding for agricultural easements comes from both government and the nonprofit sector. The most notable example of this is the U.S. Department of Agriculture's

Agricultural Conservation Easement Program, the stated purpose of which is to help farmers and ranchers keep their land in agriculture by contributing up to half of an easement's fair market value, and up to 75 percent for grasslands of special environmental significance (U.S. Department of Agriculture, Natural Resources Conservation Service, 2024), alongside state programs and private land trusts.

While these potential opportunities for income diversification may be available in principle, not all farmers are equally well placed to take advantage of them. Green infrastructure projects typically require a minimum area of contiguous land, often far exceeding the size of an individual farm. A commercially viable wind farm of 50 megawatts has a total project area of nearly 4,500 acres (Denholm et al., 2009). Given that roughly 57 percent of U.S. farms are smaller than 100 acres (USDA, 2019), a wind developer in a region that consists predominantly of small farms might need to contract with over 40 landowners to assemble enough land for a single project. Utility-scale solar plants require roughly 8 to 9 acres per megawatt of capacity (Ong et al., 2013), so the projects that supply the bulk of U.S. solar capacity occupy hundreds to thousands of acres, though most installations by count are far smaller. Meanwhile, conservation easements tend to be larger than most individual farms—agricultural easements acquired through state programs averaged roughly 190 acres in 2023 (American Farmland Trust, Farmland Information Center, 2025).

The need to coordinate with multiple landowners introduces several potential barriers to development. Transaction costs rise with each additional contracting party, as developers must find, negotiate with, and write agreements for each owner individually (Coase, 1960; Demsetz, 1967; Libecap, 1993; Ostrom, 1990). Anticommons effects can emerge when multiple owners each set their participation price independently, driving the aggregate cost of land assembly above the level that would prevail under consolidated ownership (Buchanan and Yoon, 2000; Heller, 2008). Strategic holdups may also arise when a pivotal landowner demands a disproportionate share of the surplus (Brooks and Lutz, 2016; Menezes and

Pitchford, 2004). All three mechanisms predict that the probability of development decreases as the number of landowners increases.

This creates a predicament for small farmers. The farms that would benefit most from supplementary income are precisely those that are least well positioned to attract it, because the fragmentation of land ownership associated with small farms raises the cost and complexity of project assembly. Much of the economic pressure on small farms may simply be the result of market dynamics in a globalized world, where economies of scale among other factors inevitably work against smaller operations; the fragmentation barrier, by contrast, is an additional and distinct disadvantage—one that forecloses the very diversification strategies that might otherwise help small farms absorb those pressures. If this disadvantage is severe enough, it may contribute to the long-term trend of small and mid-sized farm exits and consolidation (Sumner, 2014), as farmers who cannot access alternative revenue streams face greater pressure to sell.

This paper investigates the relationship between land ownership fragmentation and the development of wind projects, solar projects and conservation easements across the rural United States. We employ three spatial scales of analysis, each using a different measure of fragmentation: average farm size at the county level, the inverse Herfindahl-Hirschman Index of ownership concentration at the PLSS section level, and parcel size combined with the number of surrounding landowners at the parcel level.

We find that the effects of land fragmentation vary across the three forms of green development. Wind energy shows the strongest and most consistent relationship: larger, less fragmented landholdings are associated with more installed wind capacity at all three scales. Solar development is more weakly related to fragmentation, with varying degrees of significance attached to the relevant variable coefficients across the three levels of analysis. Conservation easements present a more nuanced picture, with more fragmented areas being found to be more likely to contain an easement, but where easements are present they cover smaller areas of land as fragmentation rises, suggesting that the determinants of conservation differ from those of energy development.

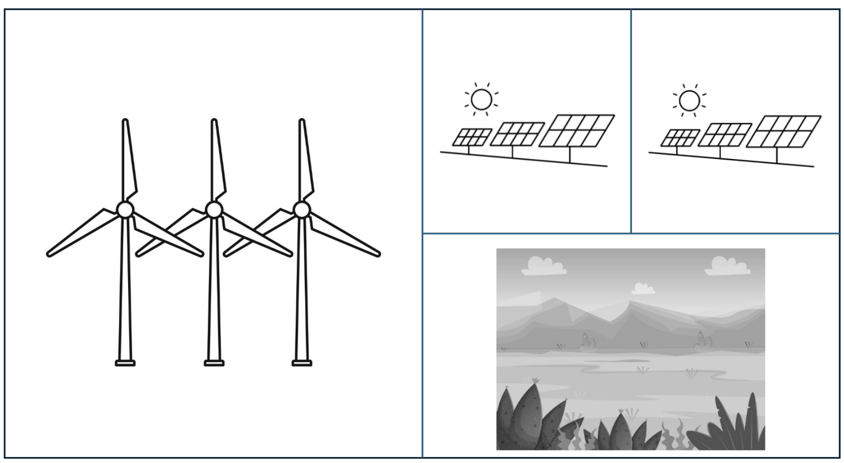
This paper makes two main contributions. First, we bring together the three theoretical mechanisms of transaction costs, anticommons and strategic holdups through which land fragmentation might impede land assembly and test their common empirical prediction across a national sample and three spatial scales. Existing work studies a single resource or a single scale; by examining wind, solar, and easements side by side at the county, section, and parcel levels, we are able to separate the role of a parcel's own size from the fragmentation of the land around it, and to document where the fragmentation barrier binds most tightly. Second, we contribute to a growing literature on fragmented ownership and natural resource use (B. Leonard and Parker, 2021; Winikoff and Parker, 2023) by showing that the barrier extends beyond oil and wind to solar and easements.

2 Theory

There are multiple theoretical pathways through which land fragmentation may affect the likelihood of green infrastructure development taking place. The specific economic factors that create barriers to development depend to some extent on the type of development being considered—while there are certain commonalities between wind projects, solar projects, and conservation easements, there are also distinct differences due to the relative quantities of land required for each investment type, and therefore differences in the degrees of required coordination between landowners.

Figure 1: Comparison of land requirements and parcel size

(a) Land requirements for wind, solar, and easements.



(b) Land with heterogeneous fragmentation.

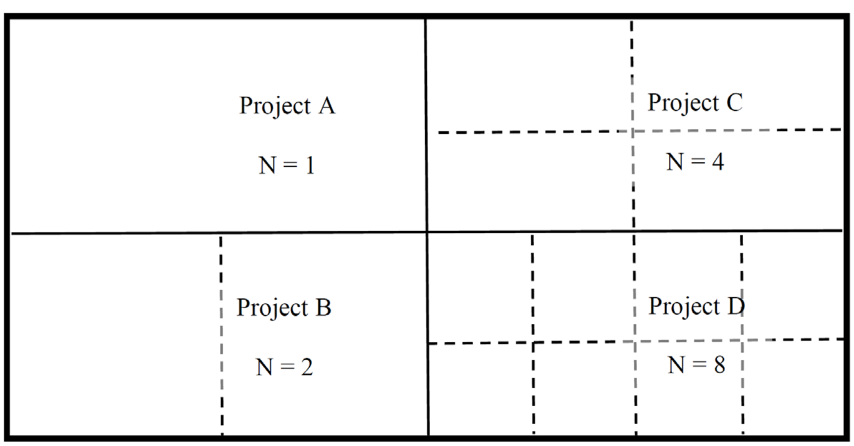


Figure 1 shows a selection of stylized representations of the relative quantities of contiguous land that each form of development would require in order to take place, as well as the range of parcel sizes that may exist within an area with a heterogeneous distribution of land ownership. Wind projects typically span several thousand acres, whereas solar projects and conservation easements generally require far less land—solar installations range from tens of acres for smaller utility-scale projects to several hundred or more for the largest plants, while easements, though highly variable in size, average a couple of hundred acres. The distribution of land requirements for each form of development can be seen in appendix figures 9, 10 and 11.

By comparing figure 1a with figure 1b, we can see how the interaction between the type of development and the degree of land fragmentation will determine the number of landowners, N, that would have to coordinate in order for a given development to go ahead. A developer seeking to build a solar project could do so by contracting with a single landowner if the land in question were in the left hand side of panel 1b, whereas a wind project located on the right hand side of panel 1b would require the consent of 12 different landowners.

We have identified three primary mechanisms through which an increase in N may decrease the likelihood of development taking place: transaction costs, anticommons effects, and strategic holdup incentives. All of these have the potential to be the dominant factor in preventing development from taking place.

2.1 Transaction Costs

The framework of transaction costs has previously been applied across a range of topics in agricultural and natural resource economics (Foster and Rosenzweig, 2022; Schulz et al., 2015). In order to apply such a framework to this paper, we make two assumptions. Firstly, that an increase in contracting costs associated with a given project will reduce the probability of that project going ahead, resulting from a decrease in the expected surplus for a developer. In the case of a wind or solar project, this logic is straightforward to apply. If a potential developer expects to gain a surplus $S(R,T) = R - T$ from a project, where R is the expected revenue from the project and T is the transaction cost associated with coordinating with the necessary landowners, S is decreasing in T and there will exist a $\bar{T}$ above which S will be sufficiently small that the project will no longer be desirable. In the case of conservation easements, the same logic applies in a slightly different way. Rather than a developer seeking to maximize their profit, the easement grantee will seek to maximize the benefit[1] that a given easement would provide. The value of conservation benefits derived from an easement may only be realized to a sufficiently large degree with a minimum area of contiguous land (Graves et al., 2019), and there are fixed costs associated with accepting a new easement (Schuster and Arcese, 2015). While both of these factors will encourage easement holders to prefer larger areas of land, if large areas are associated with a higher T then the surplus S will be too low for the easement to be accepted. Overall, transaction costs can be thought of as a tax on the value of the project. On the developer's or conservation agent's side, gaining permission to launch the project entails transaction costs of finding owners, and negotiating and writing leases. On the landowner's side, transaction costs may entail hiring lawyers, researching liability laws, and monitoring the developer or conservation agent.

The second assumption is that contracting costs rise with the number of contracting parties (Coase, 1960; Demsetz, 1967; Libecap, 1993; Ostrom, 1990). In the simplest case where transaction costs rise linearly at a rate of τ per private owner, the contracting costs of assembling a project is $T(N) = \tau N$, therefore making the total surplus function of a developer/grantee $S(R,N) = R - \tau N$. The larger the value of N, the less likely a project is to go ahead.

If these assumptions hold then the implication is that barriers to the development of green

[1] Examples of benefits that may be valued by an easement grantee could include ecosystem services such as habitat conservation, groundwater management, soil erosion control, or carbon sequestration.

infrastructure may be reduced either by decreasing the number of required landowners, or by reducing the marginal transaction cost of each additional owner. The former solution essentially implies that encouraging larger landholdings and reducing the number of small farms is a potential solution, but this is at odds with the initial motivation of this paper—helping small farms to mitigate unnecessary barriers to development which they may face. In this sense, the latter solution is far more appealing, and there are potential ways in which institutional arrangements may help to reduce the marginal transaction cost τ. These are discussed in greater detail later in the paper.

2.2 Anticommons

In an anticommons framework, allocating too many ownership rights to a resource of fixed size can make it increasingly difficult to utilize the resource, leading to "underuse" and a failure to capture resource rents (Buchanan and Yoon, 2000; Heller, 2008). The anticommons model is often applied to cases in which multiple regulatory agencies have the authority to prevent or tax economic activity. These cases range from cell phone towers (Mitchell and Stratmann, 2015) to water irrigation in the western United States (Bretsen and Hill, 2008). The overlapping jurisdictions lead to high costs of resource use and low levels of utilization. More closely related to our setting of small farms, B. Leonard and Parker (2021) apply the theory to the problem of horizontal drilling for oil (fracking) through multiple private landholdings and find that high levels of land fragmentation reduce oil production. Many other examples of the anticommons phenomenon also involve private owners. For example, Heller (1998; 2008) focuses on the "gridlock" problem of consolidating minor patents owned by multiple entrepreneurs to create major innovations.

In our case, a higher N due to smaller farms can reduce the probability of a resource development or conservation project going ahead because each landowner can request whatever price they choose for participating, and the aggregate price that must be paid by the developer increases with the number of owners. This is because rational owners do not consider their effect on other owners when setting prices, leading to an aggregate price that exceeds the income-maximizing price, and therefore lowering the amount of resource use and rents relative to sole private ownership. For example, consider a wind developer who must negotiate with N farmers. Each sets a price (e.g., an annual lease payment) for turbine placement. An "exclusion" externality problem arises because individual landowners do not consider how their prices affect the expected payments available for other landowners. Whereas a sole owner bears the full cost of charging a wind developer a higher price, in terms of lowering the probability of wind farm development, smaller landowners bear only a fraction of this cost. This causes the aggregate price of development to rise with N relative to what a sole owner would charge, leading to reductions in the probability that a wind farm will be built. A more detailed explication of the theoretical underpinnings of the anticommons framework can be found in Winikoff and Parker (2023).

The anticommons model could be nested within a transaction cost framework because it assumes that resource owners (small farmers) cannot coordinate to fix the overpricing externality. Implicit is the assumption that transaction costs prevent coordination between farmers. As we discuss later in the paper, whether anticommons or transaction cost problems are responsible for why higher N reduces project likelihood has important policy implications.

2.3 Strategic Holdups

The final framework that may be relevant for green infrastructure development is strategic holdups. The essence of this framework is that landowners may try to capture a disproportionate share of the project surplus by demanding a higher payment if they believe that they are a "pivotal" resource owner. In essence, if a landowner has the ability to hold a project to ransom, then they have an incentive to try to do so. While this framework has a degree of similarity to the anticommons model—both are the result of multiple independent actors behaving in an uncoordinated decision making environment—the fundamental difference is that the anticommons phenomenon emerges naturally from each agent pursuing their own self-interest *without* behaving strategically, whereas holdups are the result of an intentional choice made by "pivotal" participants to use their relative market power to extract the maximum possible rent (Brooks and Lutz, 2016; Menezes and Pitchford, 2004). Whether or not one farmer holds a "pivotal" site will depend on a range of factors. For example, farmers are more likely to be pivotal in the case of connecting recreational trails than they are for a wind project. As Isaac et al. (2016) demonstrate, the ability of hold-outs to block projects falls dramatically when unanimity is relaxed because the number of feasible leasing arrangements increases combinatorially.

3 Data

We employ three spatial scales of analysis (county, section, and parcel), each using a different measure of land ownership fragmentation. The outcome variables—wind turbines, solar panels, and conservation easements—along with most covariates are common across all three levels. We first detail the shared outcome variables and controls before describing the fragmentation measures specific to each scale of analysis.

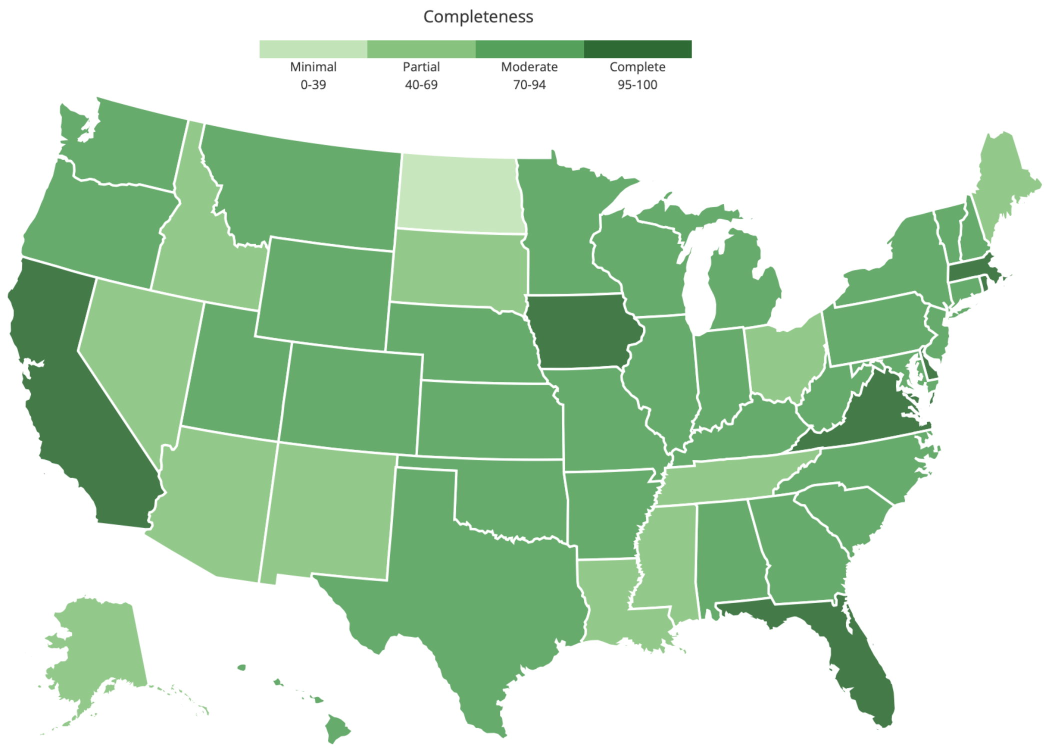
3.1 Wind, Solar, and Easements

We use wind turbine data from the United States Geological Survey (Hoen et al., 2024). These data include every turbine for every utility-scale wind project in the United States up to and including 2024. They include the location, height, and capacity of each turbine, as well as the name of the corresponding wind project. We observe the operating year for each turbine, and our analysis includes all turbines that were operational as of 2024. We drop a small number of wind projects with a total capacity less than 1 MW.

Our data on solar projects also come from the United States Geological Survey (Fujita et al., 2024). These data include the location, capacity, operating year, and spatial footprint of every utility-scale solar project in the United States up to and including 2024. We again drop projects that are less than 1 MW in capacity.

Our easement data are compiled by the National Conservation Easement Database (NCED), which we obtained via the USGS PAD-US database (USGS, 2024c). These data include the geographic boundaries of conservation and open-space easements established up to 2024. They are assembled from records voluntarily submitted by easement holders and state stewards. Coverage is therefore broad but not exhaustive: we do not observe easements that are sensitive in nature or held by an entity that chooses not to report. Coverage by state is shown in figure 2. We use the PAD-US database to determine land ownership (public versus private) and protection status.

Figure 2: Completeness of easement data by state (ProtectedLands.net, 2024)



3.2 Geographic and Economic Controls

We control for several geographical variables that affect the suitability of land for wind projects, solar projects, or conservation easements. We control for endowed resource quality using raster data for wind speed (Maclaurin et al., 2014), solar irradiance (Sengupta et al., 2018), land conservation value (Belote et al., 2017), and county-level natural amenity values (USDA, 1999). We use data on elevation (USGS, 2024a) to construct slope and ruggedness (measured in degrees and TRI respectively) and use soil quality data from NRCS (2024).[2]

We also control for several measures of economic development. We use 2021 national county designations along with population data and the locations of metropolitan areas,

[2]The Terrain Ruggedness Index (TRI) is described in Wilson et al. (2007).

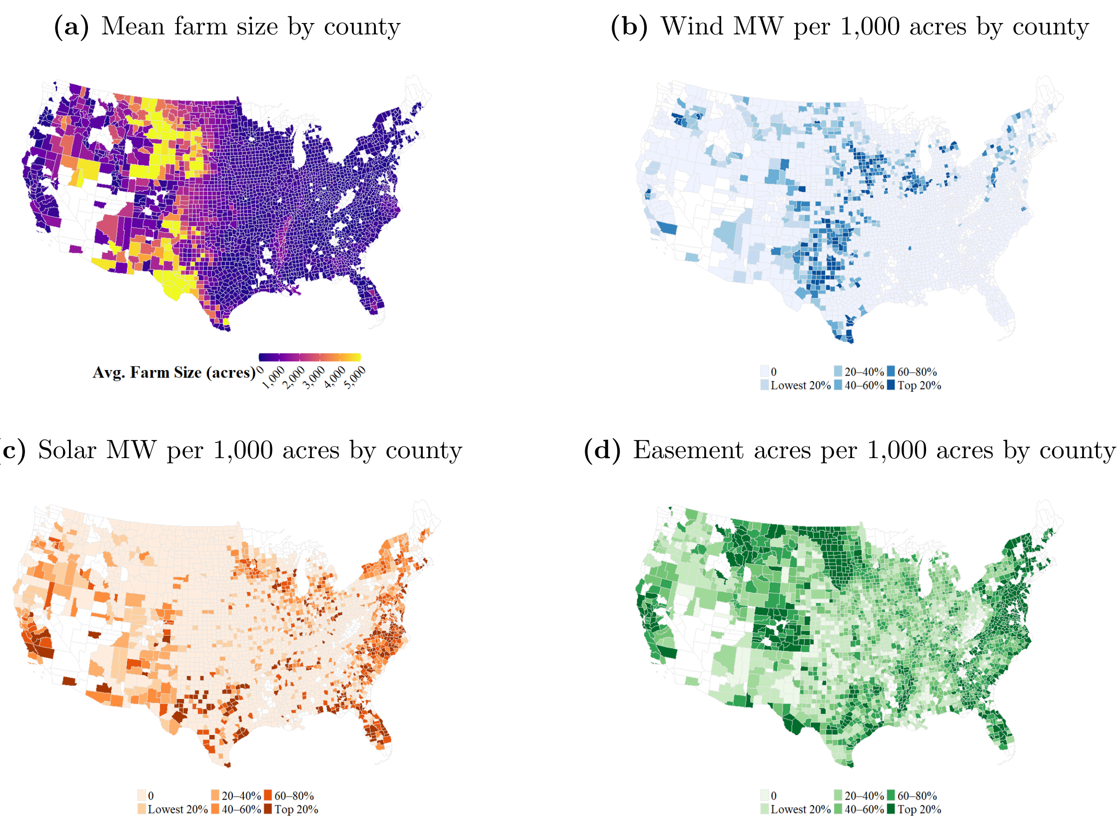
towns, and cities from U.S. Census Bureau (2024a; 2021).[3] We use data on roads (U.S. Census Bureau, 2024b), railroad lines (U.S. Census Bureau, 2024c), airports (USDOT, 2024) and transmission infrastructure (HIFLD, 2024), as well as land use data from the USGS (2024b).

[3]The 2021 dataset was used for county population because it was the final publication to use the same FIPS codes as those found in the 2022 Census of Agriculture.

3.3 Fragmentation Measures

County-Level Analysis Our county-level measures of fragmentation are average and median farm size, drawn from the 2022 USDA Census of Agriculture (NASS, 2024b).[4] The county sample is limited to counties consisting of at least 10% agricultural land, which drops 11% of counties. We also use data from the 2002 through 2022 Censuses of Agriculture to describe changes in farm size over the last two decades. Figure 3a shows that farms tend to be largest in the Western U.S. and smallest in the Northeast and Midwest. For comparison, figures 3b, 3c, and 3d show the spatial distribution of wind, solar, and conservation easements. Table 6 in appendix B shows full county summary statistics.

Figure 3: Overview of agricultural, wind, solar, and conservation metrics by county.



(a) Mean farm size by county

(b) Wind MW per 1,000 acres by county

(c) Solar MW per 1,000 acres by county

(d) Easement acres per 1,000 acres by county

Notes: Figures show the distribution of average farm size per county, density of wind generation capacity, density of solar generation capacity, and density of conservation easements across the United States. Counties that contain less than 10% agricultural land were removed from the sample (displayed in white).

[4] This census is conducted every five years, making 2022 the most recent year available.

Section-Level Analysis Our use of the term "section" is taken from the Public Land Survey System (PLSS). A standard PLSS township is a 6 by 6 mile square subdivided into 36 sections, each equal to 1 square mile (640 acres). This makes the section an appropriate unit for our analysis: fine enough to capture local variation in land ownership, but large enough to contain commercially viable development projects in most parts of the country. Where official PLSS section boundaries exist, we use them directly. However, the PLSS does not cover the entire continental United States—most of the South and parts of the East Coast were surveyed under earlier metes-and-bounds systems and lack PLSS coverage. For these areas, we construct synthetic sections by extending the PLSS grid outward from the nearest principal meridian using the same 1-mile spacing, producing a nationally consistent set of approximately 1-square-mile cells. The full methodology used to generate the synthetic sections is described in appendix A.

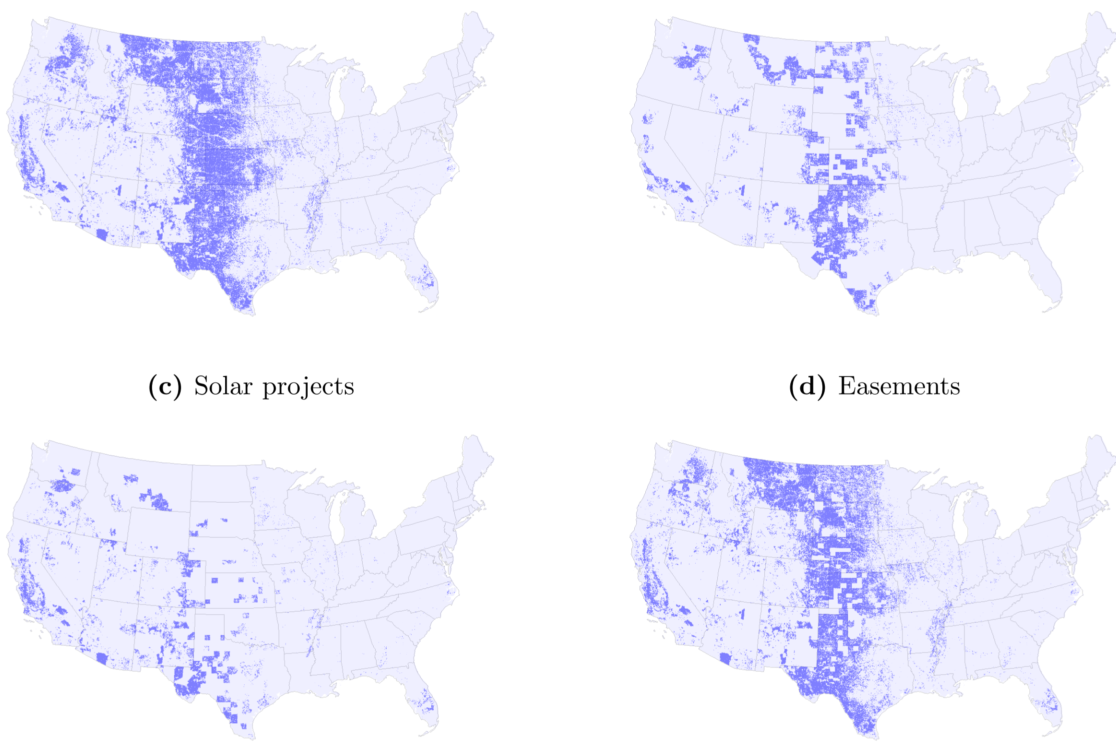
We use proprietary national parcel data from ReportAll USA (2024) to measure section-level ownership fragmentation. These data are cross-sectional, from the final quarter of 2024. For each parcel, we observe the identities of the parcel owners.

We use two different measures of fragmentation. The first is the number of landowners in a given section.[5] This measure does not account for a heterogeneous distribution of land holding size between different landowners (e.g., a section with four landowners, each with 25%, would have the same value as a section where one has 85% and three have 5%). Therefore, we also use a second measure that is the inverse of the Herfindahl-Hirschman index (HHI).[6] According to Adelman (1969) and Libecap and Wiggins (1984), the inverse of the HHI can be interpreted as the "equal share landowner equivalent," i.e., any combination of shares that yields an HHI of 1/4 (an inverse HHI of 4) is equivalent to 4 landowners each owning one quarter of the land in question.

[5]We exclude developed land when making this calculation because we are primarily concerned with evaluating the fragmentation of farmland which may be available for green development. Land that is already developed falls outside of this category and its degree of fragmentation is not relevant.

[6]This measure is defined as $HHI = \sum_i s_i^2$, where s_i is owner i's share of the given area of land.

Figure 4: Section sample



(a) Total sample

(b) Wind projects

(c) Solar projects

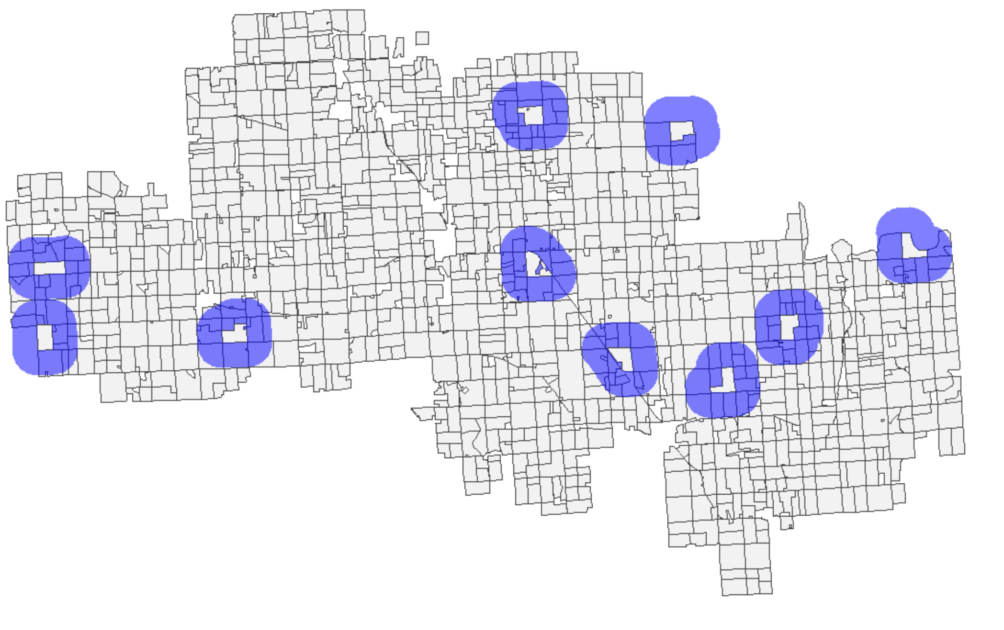
(d) Easements

Notes: Sample maps show square mile sections that are at least 75% privately owned and 75% undeveloped, and are within a county that contains the specified form of green development.

We drop sections within which any parcel ownership data were missing, as well as sections where less than 75% of land is privately owned and undeveloped, while presenting results using alternative filtering thresholds as robustness checks. Figure 4a shows the sections that remain in our sample after filtering. We then create subsamples for each form of green development that only include counties where the given form of development has taken place. These subsamples are displayed in figures 4b, 4c and 4d. Table 7 in appendix B shows full section summary statistics.

Parcel-Level Analysis We use the same ReportAll parcel data as the section-level analysis and measure fragmentation as the number of unique owners within a 1/2 mile radius of each parcel, normalized by the parcel perimeter length. This radius covers at least 700 acres for a 20-acre parcel, sufficient to encompass most commercially viable projects while avoiding land unlikely to be relevant to development decisions. We also explore sensitivity to radii of 1/4 and 1 mile. Table 8 in appendix B shows full parcel summary statistics.

Figure 5: Example 100 acre parcels with 1/2 mile buffer zones



Notes: Figure shows parcels located in Adams County, IL as an example of the number and size of parcels typically encompassed with a 1/2 mile buffer surrounding parcels that are 100 acres in size.

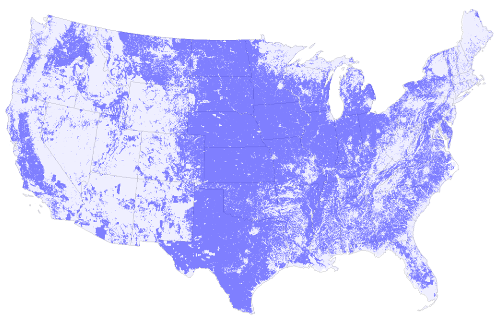
We make several restrictions to limit our sample to parcels with a reasonable chance of green infrastructure development. First, we remove parcels smaller than 20 acres, a restriction that drops 92% of parcels but only 10% of land area. This restriction removes the majority of parcels from built-up residential areas. Second, we limit our sample to parcels that are privately owned, undeveloped, and whose primary land use is farmland.[7] This drops 40% of parcels and 35% of land area, and the resulting parcel sample is shown in figure 6a.

[7]Undeveloped farmland is defined as any combination of cropland, pasture, grassland or shrubland.

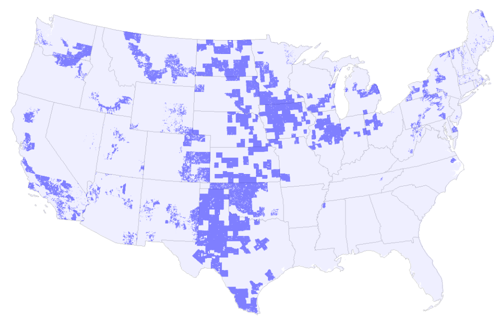
We also present regression results produced from data without the farmland restriction as a robustness check. Finally, we limit the subsamples used in the analysis of each form of green development to parcels that are within counties where there is at least one instance of the respective form of development taking place. Figures 6b, 6c and 6d show the resulting subsamples. Table 1 reports summary statistics for the principal variables across all three levels of analysis.

Figure 6: Parcel sample

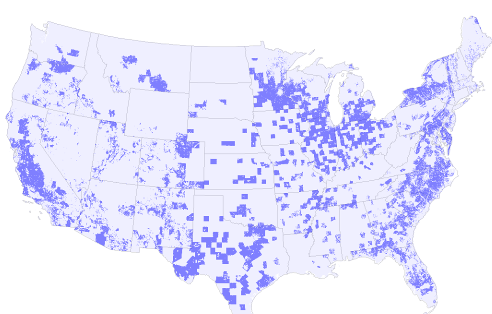
(a) Total sample



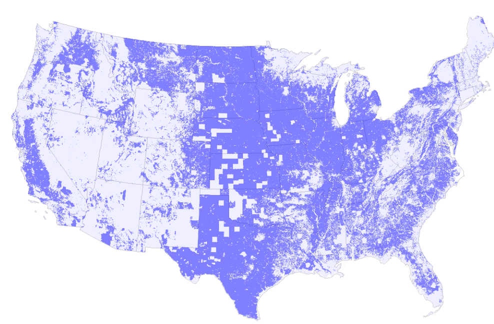
(b) Wind projects



(c) Solar projects



(d) Easements



Notes: Sample maps show parcels that are majority comprised of farmland—or, for the solar panel, parcels that are majority developed-open-space or low-intensity land on which a solar project is located—and are within a county that contains the specified form of green development.

Table 1: County, section, and parcel level summary statistics

	County		Section		Parcel	
Variable	Mean	SD	Mean	SD	Mean	SD
Panel A: Outcomes						
=1 if Wind Project	0.166	0.372	0.017	0.131	0.005	0.069
=1 if Solar Project	0.349	0.477	0.001	0.037	0.001	0.032
=1 if Easement	0.922	0.268	0.048	0.213	0.042	0.200
Wind MW/1,000 Acres	0.098	0.337	0.044	0.385	—	—
Solar MW/1,000 Acres	0.062	0.196	0.099	4.845	—	—
Ease. Acres/1,000 Acres	34.802	77.653	3.260	23.718	—	—
Panel B: Fragmentation						
Avg. Farm Size (Acres)	748	1,651	—	—	—	—
Med. Farm Size (Acres)	202	592	—	—	—	—
Landowners	—	—	3	2	—	—
Inv. HHI	—	—	2	1	—	—
No. of Owners in 1/2-mile Radius	—	—	—	—	8.73	4.93
Panel C: Controls						
Windiness (m/s)	6.71	0.79	7.17	1.05	6.94	0.96
Sunniness (kWh/m^2/day)	4.50	0.45	4.80	0.62	4.46	0.50
Amenity/Conservation Value	3.42	1.00	1.97	0.65	1.32	0.71
Transmission	294	270	0.42	0.49	0.18	0.39
Share Public	—	—	—	—	0.05	0.14
Parcel Area (Acres)	—	—	—	—	106	343
N	2,723		395,819		6,476,476	

County transmission is total km of transmission lines in the county; section and parcel transmission variables are indicators for being within the specified buffer distance. County amenity/conservation uses amenity rank, while section and parcel use conservation-value measures where applicable.

3.4 Identification

Our data are cross-sectional, and therefore our analysis relies on the assumption that the relative pattern of ownership fragmentation across locations has been persistent over the relevant time period. Exactly what qualifies as a relevant time period depends on which specific form of green development we choose to focus on. The first state law creating conservation easements came into effect in 1959 (*Scenic Easement Deed Act* 1959), whereas the first US onshore wind and solar projects were commissioned in 1980 (UMASS, 2024) and 1982 (USDOE, 1984) respectively. While these years mark the very first instances of these forms of green development being found in the US, table 2 shows that wind power did not begin to grow in a meaningful way until after 1997, solar did not take hold until the 2010s, and that the total stock of easements more than doubled from 1997 to 2022, in contrast to the 1980s and 1990s, when easement growth was substantially lower.

Table 2: Farm size and green development over time

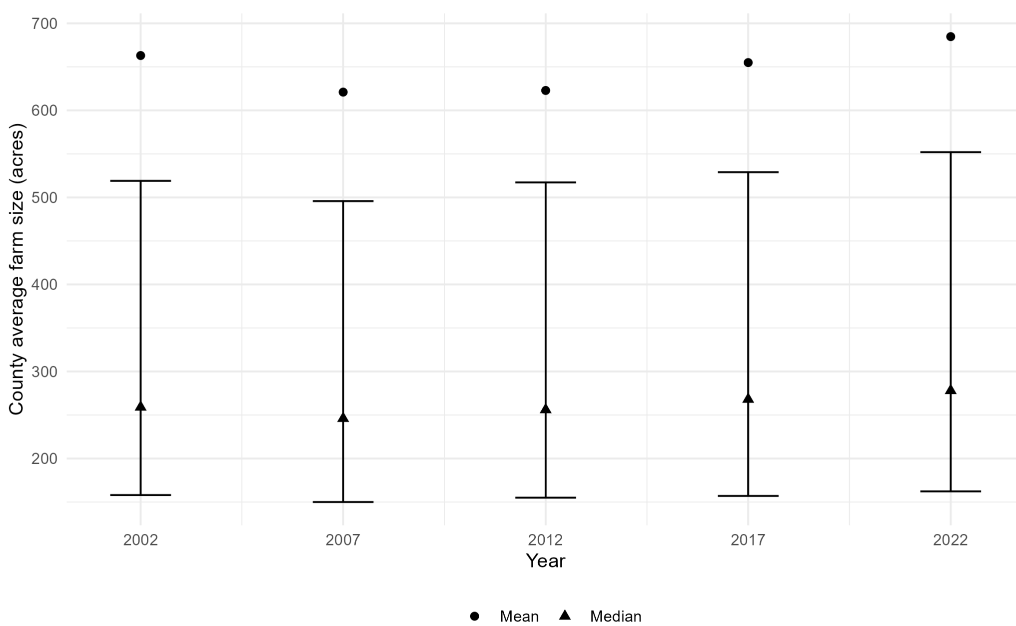
Year	Average Farm Size (Acres)	Median Farm Size (Acres)	Wind Capacity (MW)	Solar Capacity (MW)	Easements (Million Acres)
1982	-	-	0.3	0.0	26.7
1987	-	-	44.8	13.8	27.2
1992	-	-	45.9	105.8	28.4
1997	-	-	68.8	105.8	31.4
2002	441	94	2,540.7	108.8	38.8
2007	418	80	12,450.4	143.4	47.9
2012	434	80	55,606.9	2,676.7	55.6
2017	441	75	87,452.5	26,645.3	60.4
2022	463	72	142,732.0	73,248.5	63.4

Notes: Average Farm Size (Acres) and *Median Farm Size (Acres)* are from the Census of Agriculture (NASS, 2024b) for census years 2002 onward. Values are omitted for years prior to 2002 because previous censuses undercounted small and new farm operations (NASS, 2004). *Wind Capacity (MW)* is cumulative installed nameplate wind capacity as of each census year (Hoen et al., 2024). *Solar Capacity (MW)* is cumulative installed utility-scale solar nameplate capacity as of each census year (Fujita et al., 2024). *Easements (Million Acres)* is cumulative conservation easement acreage (in millions of acres) as of each census year, from the National Conservation Easement Database (NCED) via the USGS Protected Areas Database (USGS, 2024c).

Given that virtually all wind and solar capacity, and roughly two-fifths of the current easement stock, postdate 2000, our chosen window for the cross-sectional design is the

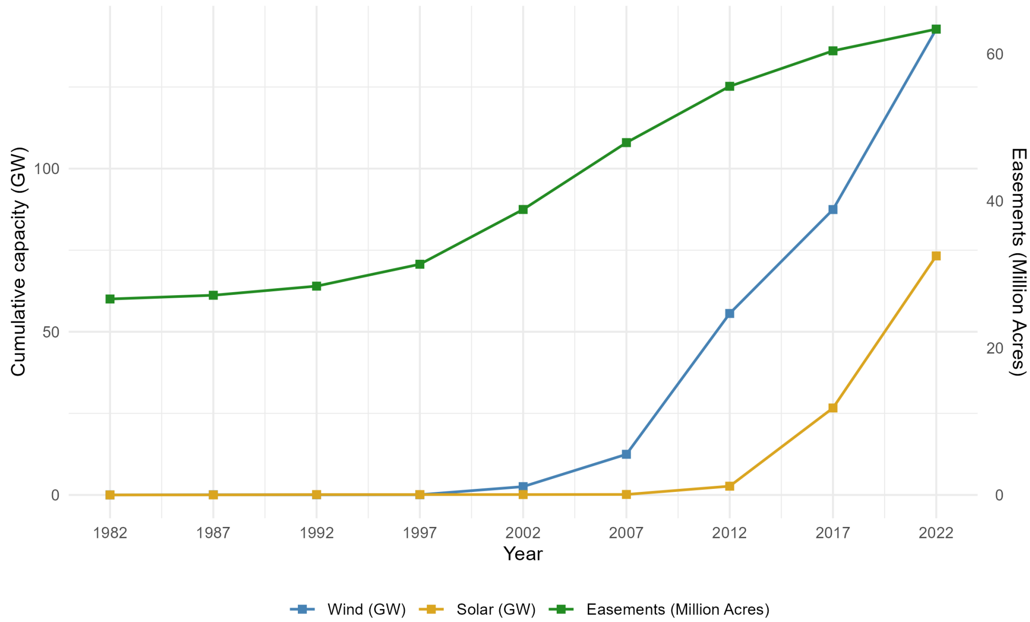
2002–2022 period for which comparable farm-size data are available. The design does not require that farm sizes were entirely static over this period; it requires that the *relative* pattern of ownership fragmentation across locations was persistent, so that fragmentation measured at the end of the window is a valid proxy for fragmentation at the time development decisions were made. Ownership patterns are highly persistent, driven by inheritance, family succession, and infrequent outright sales (Foster and Rosenzweig, 2022), and this persistence is visible in our own data—county mean farm size in 2002 strongly predicts mean farm size in 2022 (table 13). Table 2 and figure 7 also show that the national mean and the cross-county distribution of farm size were broadly stable over the window, though the national median declined as mid-sized farms exited and the number of very small farms grew. Figure 8, by contrast, shows steady growth in all three forms of green development over the same period. For easements, a majority of the current stock predates the window, so the cross-sectional design leans more heavily on persistence than it does for wind and solar; we return to this point in discussing the instrument below.

Figure 7: Evolution of mean county farm size from 2002 to 2022.



Notes: Whiskers denote the upper and lower quartiles of the county-level distribution of mean farm size in each census year.

Figure 8: Development of wind projects, solar projects and conservation easements over time.



Reverse Causality

A central concern for a cross-sectional design such as ours is reverse causality. Rather than ownership fragmentation shaping where green development occurs, development might itself reshape ownership. We address this concern on institutional grounds and, at the county level, with an instrumental-variable specification that utilizes pre-development variation in farm size.

The first and most direct form of reverse causality would arise if developers physically consolidated fragmented land prior to development. This would involve purchasing parcels outright from multiple landowners, thereby endogenously reducing fragmentation in areas chosen for development. There is no consistent evidence of this occurring in the wind or solar industries, where the near-universal practice is for developers to negotiate lease agreements with existing landowners rather than to acquire outright land ownership (AWEA, 2020; Denholm et al., 2009; Shoemaker, 2007). Under a standard wind energy lease, the landowner retains ownership of the land and receives annual royalty payments in exchange for granting the developer the right to construct and operate turbines on the property (AWEA, 2018; Shoemaker, 2007; Winikoff and Parker, 2023). The same lease-based model is prevalent in utility-scale solar development and, by definition, in conservation easements, which are voluntary encumbrances placed on existing ownership rather than transfers of title. Developers therefore do not alter the ownership structure of land as a precondition for development.

A related concern could be that development lease income might enable farm consolidation in areas that benefited from early development by providing capital that allowed landowners to purchase neighboring parcels. This mechanism would make already-developed areas appear more consolidated than they were at the time development decisions were made, inflating the cross-sectional association between consolidated ownership and development.

While the lease-based structure of green development makes it unlikely that development reshapes ownership directly, the income channel cannot be ruled out on institutional grounds alone. We therefore present a county-level instrumental variable specification that instruments mean farm size measured in the 2022 Census of Agriculture with mean farm size from the 2002 Census of Agriculture (NASS, 2004; 2024b). Given the persistence of ownership patterns documented above, the instrument is strongly correlated with current farm sizes. Crucially, 2002 predates the modern period of renewable expansion—cumulative installed wind capacity stood at roughly 2.5 GW in 2002 (table 2), a tiny amount compared to the more than 145 GW installed by 2024 (Hoen et al., 2024), and utility-scale solar deployment was negligible. Farm sizes measured in 2002 therefore cannot have been shaped by the wind and solar development they are used to explain; the exclusion restriction otherwise rests on our controls for the geographic determinants of siting. In the case of easements, a substantial conservation easement stock was already in place by 2002 (table 2), so in this instance the instrument's validity rests instead on the fact that easements act as encumbrances on existing ownership rather than transfers of title, and do not themselves alter farm size. We use the 2002 census year because it is the earliest for which the Census of Agriculture reliably enumerates small and new farm operations (NASS, 2004), with earlier censuses under-counting these farms leading to the potential of introducing measurement error into the instrument.

The 2002 census data contain a small number of mismeasured county values which we exclude from the IV sample. Twelve counties report zero mean farm size, despite having positive farm counts, and a further five reflect a change in census methodology that occurred between the 2002 and 2022 census years. Beginning with the 2007 census, NASS increased the accuracy of its enumeration of agricultural operations on American Indian reservations, collecting individual reports from producers that earlier censuses had bluntly aggregated into a small number of large operations (NASS, 2024a). This resulted in the farm counts of the affected counties increasing by anything from 3 to 15 times their 2002 values, reducing the county average farm sizes by similar factors. We therefore drop every county whose farm count more than tripled between the two censuses. All seven counties meeting this criterion lie on or adjacent to the Navajo Nation, and two of them are also among the twelve zero-coded counties. No other county in the sample comes close to this threshold, with the next largest farm-count ratio being 2.1. These two rules remove 17 counties in total.

Spatial Correlation

A second concern is that the estimated relationship reflects unobserved factors that vary smoothly across space rather than fragmentation itself. We address this at the section and parcel levels with two complementary checks, each suited to the scale at which it is feasible.

At the section level we use spatial first differences (Druckenmiller and Hsiang, 2018), the approach Winikoff and Parker (2023) apply in the same setting. Rather than assume the conditional-independence assumption holds across all sections, we assume it holds only between a section and its immediate neighbor, and we difference the specification across adjacent sections. The differencing removes any omitted factor that neighboring sections share, leaving identification to the within-pair variation in fragmentation. We difference each section against the nearest in-sample section to its west and cluster standard errors by township.

At the parcel level, the sample restrictions leave too few adjacent parcels in the data for spatial first differences to be feasible, as Winikoff and Parker (2023) note for their own parcel regressions. We instead implement a within-township permutation test. For each of 500 iterations, we randomly reassign the number of surrounding owners across parcels within the same township, preserving the marginal distribution of the fragmentation variable while breaking any systematic relationship between fragmentation and the outcome within each township. The primary regression is re-estimated on the permuted data and the coefficient is recorded, with the distribution of 500 placebo coefficients providing a benchmark against which we evaluate the actual estimate.

Taken together, these specifications provide a layered identification strategy in which the most plausible non-causal explanation at each scale is addressed. The county-level analysis establishes the broad pattern, with the lagged farm size instrument providing additional assurance that the estimated correlations are not driven by feedback from development to farm size. The section and parcel-level analyses exploit within-township variation in ownership concentration and are therefore less exposed to confounding geographic factors that affect the county-level analysis.

4 County-Level Analysis

4.1 Empirical Strategy

The county-level analysis serves as a broad, high-level overview of the relationship between land ownership concentration and green infrastructure development across the United States. We use mean farm size as the primary independent variable. For each form of green development, we estimate two specifications that distinguish between the extensive and intensive margins. The extensive margin outcome is a binary indicator equal to one if a county has any wind capacity, solar capacity, or conservation easement acreage respectively. The intensive margin outcome, estimated on the subsample of counties where the respective form of development is present, measures the density of each outcome: MW of wind capacity per 1,000 acres, MW of solar capacity per 1,000 acres, and easement acres per 1,000 acres.

The primary regression specification is shown in equation 1:

$$\text{Development}_i = \alpha + \beta \, \text{Log}(\text{MeanFarmSize}_{\text{i}}) + \delta X_i + \epsilon_i \tag{1}$$

where Development_i is either the extensive or intensive margin measure of the green development in question (wind, solar, or easements), MeanFarmSize_i is the mean farm size of the county, and X_i controls for 14 covariates (shown in appendix B, table 6) including sunniness, windiness, and conservation amenity value. State fixed effects are also included, and standard errors are clustered at state level.

4.2 Results

Table 3 shows the county-level regression results. The probabilities of finding a wind project, solar project, or conservation easement within a county are all positively correlated with average farm size, with the strongest coefficients being observed for wind and solar.

A doubling of mean farm size is associated with a 3.8 percentage point increase in the probability of a county containing a wind project, a 4.0 percentage point increase in the probability of containing a solar project, and a 2.3 percentage point increase in the probability of containing an easement, although the easement coefficient is not statistically significant. We find the densities of wind, solar, and easements within counties that contain them all increase by varying degrees as the mean county farm size increases. A doubling of mean farm size is associated with an additional 0.1 MW of wind capacity per 1,000 acres, with the same increase being associated with an additional 0.1 MW of solar per 1,000 acres, and an additional 13.7 acres of easements per 1,000 acres. The relative magnitudes of the standard errors associated with these coefficients imply that mean farm size is more significant at the extensive margin than the intensive margin for wind, while for solar and easements it is the intensive margin at which the coefficient is more significant.

We present alternative specifications in appendix D. Table 9 shows results for the combined intensive and extensive margins, which are similar across all three outcome variables. Median farm size regression results in appendix table 10 are less conclusive.

As a further check on the county-level estimates, and to address the reverse-causality and unobserved-heterogeneity concerns set out in the identification section, we re-estimate the specifications using the lagged farm size instrument. Tables 11 and 12 in appendix D report OLS and IV estimates side by side for the extensive and intensive margins respectively, and table 13 reports the corresponding first stage. Reported first-stage F-statistics are cluster-robust. In the full sample, which underlies the extensive-margin estimates, the instrument is strong, with a first-stage F of 948.6, and the F exceeds 850 in every subsample. The extensive-margin IV estimates are close to their OLS counterparts. The coefficient on mean farm size moves from 0.038 to 0.052 for the presence of solar and remains statistically significant, while the wind IV estimate of 0.035 is similar in magnitude to the OLS estimate of 0.042 but is less precisely estimated and loses statistical significance. As in the OLS specification, mean farm size does not significantly predict easement presence. The intensive-margin IV estimates are similarly stable, with the solar and easement coefficients close to their OLS counterparts and remaining significant. The stability of the point estimates suggests that the positive association between farm size and wind and solar development is not driven by contemporaneous feedback from development to farm size. Finally, average partial effects from a logit specification of the extensive margins are reported in appendix table 14, and are broadly consistent with the linear probability estimates.

It is worth noting the significance of a number of the control variables. For example, mean wind speed (windiness) is highly correlated with wind generation capacity as one would expect, while the same relationship can be seen between insolation (sunniness) and solar generation. A positive correlation can be seen between amenity rank and easement acres, but this effect is less pronounced and not statistically significant. The amount of transmission infrastructure within a county is highly correlated with both wind and solar, which is consistent with expectations. Other notable results include the positive correlation between wind power and the percentage of farm owners who live off (away from) their land, and the positive relationship between land value per acre and the prominence of easements. The former is intuitive if it is believed that wind turbines have a visual disamenity for those located close by, while the latter is likely to be a result of the potential financial incentives offered to landowners. The amount of financial benefit that a landowner receives from placing their land into easement is often related to the market value of the land in question.

Table 3: County-Level Regression Estimates

	Wind = 1	Wind MW/1,000 Acres | MW > 0	Solar = 1	Solar MW/1,000 Acres | MW > 0	Easement = 1	Ease. Acres/1,000 Acres | Ease Acres > 0
	(1)	(2)	(3)	(4)	(5)	(6)
Log(Avg. Farm Size)	0.0379**	0.1217	0.0393**	0.0903***	0.0228	13.74**
	(0.0180)	(0.1010)	(0.0185)	(0.0264)	(0.0205)	(5.183)
Windiness	0.2454***	0.4181***	0.0209	-0.0322*	0.0170	-4.520
	(0.0323)	(0.1433)	(0.0205)	(0.0188)	(0.0168)	(2.756)
Sunniness	0.0756	0.0408	0.2988***	0.1468*	-0.1396*	-13.35
	(0.0775)	(0.3573)	(0.0838)	(0.0796)	(0.0758)	(29.59)
Amenity Rank	-0.0050	-0.0218	-0.0314*	-0.0278	0.0114	0.2864
	(0.0144)	(0.0372)	(0.0162)	(0.0183)	(0.0105)	(3.297)
Log(Transmission)	0.0549***	0.1947***	0.0500***	0.1060***	-0.0058	-2.428
	(0.0139)	(0.0480)	(0.0158)	(0.0338)	(0.0120)	(2.469)
Log(Pop. Density)	-0.1681***	-1.014***	0.2257***	-0.1785***	-0.0441	16.19
	(0.0512)	(0.3458)	(0.0583)	(0.0575)	(0.0309)	(19.22)
Share Public	-0.1181	-0.2172	-0.0153	-0.0225	-0.0150	6.624
	(0.0884)	(0.3147)	(0.1016)	(0.1024)	(0.0642)	(25.30)
Share Protected	-0.0013	0.0068	-0.0251	-0.0446	0.0514**	22.10*
	(0.0657)	(0.0931)	(0.0396)	(0.0370)	(0.0220)	(13.04)
Log(Dist. Metro Area)	-0.0005	0.0094	-0.0139**	-0.0025	-0.0126***	0.9259
	(0.0067)	(0.0138)	(0.0058)	(0.0076)	(0.0045)	(1.552)
Log(Acres Irrigated)	-0.0086**	0.0129	0.0091***	0.0084*	0.0066*	-0.5870
	(0.0040)	(0.0140)	(0.0030)	(0.0046)	(0.0038)	(0.9553)
Log(Ag. Products Sold)	0.0073	-0.0693**	0.0104	-0.0013	0.0048	1.734
	(0.0061)	(0.0316)	(0.0098)	(0.0068)	(0.0080)	(1.953)
Log(Value/Acre)	0.0521	0.1831	0.0837*	0.0321	0.0991***	27.23**
	(0.0464)	(0.1761)	(0.0434)	(0.0388)	(0.0322)	(11.87)
Perc. Live Off-Farm	0.1210**	0.1533	-0.1485***	-0.0217	-0.0384	11.84
	(0.0539)	(0.1356)	(0.0453)	(0.0411)	(0.0575)	(13.61)
Log(Elevation)	0.0430***	-0.2141**	-0.0551**	-0.0410***	-0.0148*	-6.543**
	(0.0158)	(0.0801)	(0.0206)	(0.0108)	(0.0077)	(2.691)
Log(Land Area)	0.0173	-0.4623***	0.0771**	-0.1587***	0.0577***	-0.3419
	(0.0259)	(0.0802)	(0.0337)	(0.0459)	(0.0180)	(3.759)
Dependent variable mean	0.16599	0.59108	0.34925	0.17711	0.92214	37.741
Observations	2,723	447	2,723	951	2,723	2,511
R^2	0.30615	0.35508	0.36071	0.27932	0.16724	0.45454

Notes: OLS estimates. The unit of observation is a county. Columns (1), (3), and (5) use the full county sample; columns (2), (4), and (6) restrict the sample to counties where the respective dependent variable is positive. Observation counts in the intensive-margin columns fall below the number of positive counties implied by the extensive-margin dependent-variable means because fixed-effect singletons (counties that are the only developed observation in their state) are dropped from estimation. *Wind = 1*, *Solar = 1*, and *Easement = 1* are binary indicators equal to one if the county has any installed wind capacity, solar capacity, or conservation easement acreage as of 2024, respectively. *Wind MW/1,000 Acres*, *Solar MW/1,000 Acres*, and *Ease/1,000 Acres* measure megawatts of installed wind capacity, megawatts of installed solar capacity, and conservation easement acres per 1,000 acres of county land area as of 2024, respectively. *Log(Avg. Farm Size)* is the natural log of mean farm size (acres) from the 2022 Census of Agriculture. *Windiness* is mean wind speed (m/s). *Sunniness* is mean solar irradiance (kWh/m^2/day). *Amenity Rank* is the USDA Natural Amenity Rank, a composite index of climate, topography, and water features. *Log(Transmission)* is the log of total electricity transmission line length (km) within the county. *Log(Pop. Density)* is the log of population per acre. *Share Public* is the share of county land area that is publicly owned. *Share Protected* is the share of county land area under protected status, from the USGS Protected Areas Database (PAD-US) (USGS, 2024c). *Log(Dist. Metro Area)* is the log of distance to the nearest metropolitan area (km). *Log(Acres Irrigated)* is the log of irrigated cropland (acres) from the 2022 Census of Agriculture. *Log(Ag. Products Sold)* is the log of total agricultural products sold (thousands of USD) from the 2022 Census of Agriculture. *Log(Value/Acre)* is the natural log of the average value of farmland and buildings per acre (USD) from the 2022 Census of Agriculture. *Perc. Live Off-Farm* is the share of principal farm operators whose primary residence is not on the farm. *Log(Elevation)* is the log of mean county elevation (m). *Log(Land Area)* is the log of county land area (acres). All regressions include state fixed effects. Standard errors clustered by state in parentheses. $^*p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.

5 Section-Level Analysis

5.1 Empirical Strategy

The section-level analysis offers a higher degree of spatial resolution than the county-level analysis through the use of the ReportAll parcel data. While using mean farm size as the independent variable allows for high-level correlations to be observed, most counties are likely to have a substantial degree of heterogeneity in their land ownership distribution. By using a smaller scale of analysis such as a section, this heterogeneity can be accounted for.

Equations 2 and 3 show the regression specifications used in the case when the number of landowners and the inverse HHI respectively were used as independent variables:

$$\text{Development}_i = \alpha + \beta \, \text{Landowners}_i + \delta X_i + \epsilon_i \tag{2}$$

$$\text{Development}_i = \alpha + \beta \, \text{Inv.HHI}_i + \delta X_i + \epsilon_i \tag{3}$$

where Development_i is the same measures of green development as for the county-level regressions, Landowners_i is the number of unique private owners of parcels greater than 20 acres within a given section, and Inv.HHI_i is the inverse Herfindahl-Hirschman Index calculated using parcels greater than 20 acres. As there is a degree of variability in the exact size of each section, the log of section area is included among the controls.[8] X_i controls for 14 covariates (shown in appendix B table 7). Fixed effects for township, GAP protection status[9], and a multi-subcounty indicator are also included, and Conley standard errors are used (Conley, 1999). The multi-subcounty indicator equals one for sections that straddle a

[8]Sections are nominally 640 acres, but some are smaller due to the nature of the PLSS survey methodology and clipping at state lines.

[9]Gap Analysis Project (GAP) codes are the categorizations of protection from the PAD-US database, with values ranging from 1 to 4.

county-subdivision (subcounty) boundary and zero for sections lying entirely within a single subcounty.

Counties where no instance of the relevant form of green development is observed are dropped. The absence of green development within an entire county is likely to signify a particular characteristic, such as the existence of local laws, especially setback regulations in the cases of wind and solar, which would prevent such development from taking place, thus making these observations unhelpful for identifying the effect of ownership fragmentation on green development.

We chose townships for our spatial fixed effects as they reflect the spatial consistency of the Public Land Survey System (PLSS) grid. PLSS townships are a predominantly uniform 36 square miles across those parts of the continental United States where they exist, in contrast to counties which range from a few to tens of thousands of square miles, and census tracts which are defined by population density and are therefore far coarser in the rural areas where wind, solar, and easement development is concentrated. Using a geographically inconsistent spatial unit as a fixed effect may cause them to absorb different amounts of local variation in different parts of the country, which would risk creating bias in the coefficients of spatially correlated variables. In states where local government is administered at the township level—primarily in the Midwest and Great Lakes—PLSS townships also align with actual administrative boundaries, providing both spatial consistency and policy relevance simultaneously. For the remaining areas of the country not covered by the PLSS, we generate synthetic townships anchored to the nearest PLSS principal meridian, providing a consistent spatial scale even where administrative townships do not exist. A detailed explanation of this methodology can be found in appendix A.

Two limitations of this approach should be acknowledged. First, in much of the Plains, Mountain West, and South, land use regulations such as wind turbine setback requirements are determined at the county level rather than the township level. Township fixed effects will therefore absorb within-county spatial variation that is unrelated to local policy, which may reduce residual variance but means the fixed effects serve a different conceptual role depending on the region. Second, synthetic townships constructed for non-PLSS areas of the South have no relationship to any administrative, cultural, or ecological boundary; they function purely as a spatial regularization device. As a robustness check, we also present results using subcounty fixed effects and find that the coefficients of interest are broadly stable across both specifications.

5.2 Inclusion Criteria

For both the section and parcel level analyses, the question of exactly which categories of landowners should be included in the fragmentation variable calculations had to be considered. For example, should the number of landowners of all categories of land be included in the "number of unique landowners" variable, or only landowners of parcels which would actually be available to host the form of green development in question? The following lays out the rationale for each outcome variable.

Wind In the case of wind, the parcels of interest are those that have the potential to host a wind project, if they are not already doing so. This means that they must currently be undeveloped, and they must be privately held and not in an easement that restricts land use. We therefore determine fragmentation by measuring the number of owners of land which is private, not in easement, and is undeveloped. We established ownership and development status at the parcel level in the following manner. While each parcel contains information on the name of the specific owner, there are too many public entities to easily determine which parcels are publicly owned by owner name alone. We therefore use the PAD-US data and overlay the "Fee" layer onto the parcel data, counting a parcel that has any overlap as being publicly owned.

With regards to development, each parcel contains data on the type of land cover of which it consists. There are several different categories of land use that could plausibly be included in this analysis; however, given that the overarching motivation is to determine the availability of alternative revenue streams specifically for farmers, the rule that we settled on was to include any parcel that was more than 50% undeveloped farmland as previously defined. In many cases the number of buildings on a parcel is available within the data—in theory one could assert that land is no longer undeveloped if the number of buildings is greater than zero, but farms will generally require at least a farm house, barns, and a grain or milk silo, so it would be unreasonably restrictive to limit our sample in this way.

Solar In the case of solar, the landowner category selection becomes slightly more nuanced. The way in which we categorize landowners by their type of land cover must be modified due to the nature of solar power. Unlike a wind project or a conservation easement, installing a solar project on a plot of land typically involves covering the majority of the land area in impermeable manmade objects, potentially changing the visible land use from undeveloped to some category of developed land. Hernandez et al. (2015) found that, in addition to the four categories of undeveloped land used to define farmland in the case of wind, the combined categories of *developed* land[10] accounted for around 12% of installed solar capacity as of 2015. 8% of this solar capacity fell within the categories of "Developed, Open Space" or "Developed, Low Intensity", both of which are plausible land cover types that former farmland may transition to after the construction of a solar project (Levin et al., 2023).

Therefore, when selecting the parcel sample for solar project analysis, we included parcels that are either majority farmland, or majority "Developed, Open Space" or "Developed, Low Intensity" *and* have a solar project located on the land. This means that we are not including developed land that does not have a solar project and was therefore not developed for that purpose, but does allow us to include land that may formerly have been farmland before the

[10]Developed land can be categorized as open space, low intensity, medium intensity or high intensity.

installation of solar panels.

Easements In the case of easements, we do not have the same concerns as for solar, and the majority land cover type is limited to the same four categories previously defined as those which constitute farmland.

The proportion of land surrounding a given parcel that is publicly owned is important to take into account for easement analysis, as it is highly likely that proximity to public lands will increase the likelihood of a given parcel being placed into an easement. It is also likely that proximity to other easements will increase the likelihood of a parcel being placed into easement itself due to the potential for complementarity of the benefits brought by such an easement (Baldwin and P. B. Leonard, 2015; Graves et al., 2019).

The measure of fragmentation used for easements is therefore the number of surrounding owners of privately held farmland which may or may not be in easement. In this sense, the measure is different from that used for wind and solar, as the fragmentation measure for both of those would not count land that was privately held but in easement, as the easement would likely preclude the land's use being changed to hosting a wind or solar project.

5.3 Results

Table 4 shows results for the section-level regressions. The inverse HHI is the primary independent variable, and the outcome variables are the same measures of wind, solar, and easement density as those used in the county-level analysis. The results include fixed effects for township and GAP status code, and use Conley standard errors. Also included is the multi-subcounty fixed effect for sections that straddle sub-county administrative boundaries, which controls for discontinuous local incentives and planning regulations that may obscure the effects of other covariates.

Each additional equal-share landowner is associated with a 0.07 percentage point increase in the probability of a section containing a wind project, a negligible change in the probability of containing a solar project, and a 0.34 percentage point increase in the probability of containing an easement. Only the coefficient for the presence of easements is significant at the $P < 0.01$ level; the coefficients for wind and solar presence are not significantly different from zero. Among sections that do contain each form of green development, we find that the density of wind capacity and easement acreage decreases significantly with the number of equal-share landowners, while the association with solar density is not statistically significant. Each additional equal-share landowner is associated with a decrease of 0.1 MW of wind capacity per 1,000 acres and 2.5 fewer easement acres per 1,000 acres. For wind projects and easements, the results imply that the number of landowners within a section is a notable factor in determining the density of development in sections where it does take place, but only in the case of easements do we find evidence that the number of landowners (positively) affects the probability of any green development taking place with any statistical significance.

Table 4: Section-Level Regression Estimates

	Wind = 1	Wind MW/1,000 Acres | MW > 0	Solar = 1	Solar MW/1,000 Acres | MW > 0	Easement = 1	Ease. Acres/1,000 Acres | Acres > 0
	(1)	(2)	(3)	(4)	(5)	(6)
Inv. HHI	0.0007	-0.0993***	7.84×10^{-6}	-0.7916	0.0034***	-2.454***
	(0.0005)	(0.0229)	(0.0002)	(2.233)	(0.0005)	(0.7643)
Windiness	0.0605***	0.6166***	0.0014	14.50	0.0055	-1.715
	(0.0065)	(0.2222)	(0.0014)	(18.92)	(0.0034)	(7.452)
Sunniness	0.0715	-2.920	-0.0090	-111.7	-0.1819***	-223.0**
	(0.0697)	(3.393)	(0.0206)	(342.1)	(0.0395)	(103.5)
Conservation Value	-0.0174***	0.0057	-0.0004	-10.10	0.0082***	38.85***
	(0.0040)	(0.0796)	(0.0017)	(6.405)	(0.0020)	(4.811)
Airport <5km	-0.0208***	-0.1416	-0.0025		-0.0041	0.3518
	(0.0050)	(0.3048)	(0.0040)		(0.0047)	(7.853)
Transmission <5km	0.0196***	0.1051	0.0054***	-0.7680	0.0015	-1.266
	(0.0035)	(0.0794)	(0.0013)	(5.044)	(0.0016)	(2.628)
Dist. to Rail	-0.0003	-0.0058	0.0001	1.821	0.0004**	0.2982
	(0.0003)	(0.0108)	(0.0001)	(2.029)	(0.0002)	(0.3666)
Dist. to Road	0.0010**	0.0090	-7.17×10^{-5}	0.5374	-0.0002	-0.7093
	(0.0005)	(0.0129)	(0.0002)	(1.362)	(0.0002)	(0.4574)
Log(Elevation)	0.0893***	5.533***	0.0032	385.6	-0.0015	60.22**
	(0.0239)	(1.011)	(0.0029)	(476.4)	(0.0169)	(27.21)
Slope	0.0167*	0.7403	-0.0031	280.0	-0.0195***	-66.39***
	(0.0088)	(0.7858)	(0.0021)	(271.8)	(0.0045)	(16.05)
Ruggedness	-0.0474**	-2.166	0.0073	-809.9	0.0512***	175.8***
	(0.0235)	(2.201)	(0.0056)	(777.7)	(0.0121)	(43.81)
Soil	5.69×10^{-9}	1.11×10^{-7}	-1.05×10^{-9}	-8.25×10^{-7}	1.8×10^{-9}	-2.46×10^{-7}
	(1×10^{-6})	(1×10^{-6})	(1×10^{-6})	(1.05×10^{-5})	(1×10^{-6})	(3.85×10^{-6})
Log(Area)	0.0035***	-2.327***	0.0018***	-513.9***	0.0091***	-6.937
	(0.0013)	(0.7621)	(0.0007)	(18.74)	(0.0018)	(10.88)
Share Public	-0.0244	-1.336	0.0097	-2.503	0.1221***	-55.56**
	(0.0153)	(1.060)	(0.0097)	(47.03)	(0.0230)	(26.88)
Share Developed	0.2442***	6.148***	0.0960***	-58.72	-0.0428**	-191.0***
	(0.0416)	(1.896)	(0.0295)	(54.61)	(0.0214)	(43.50)
Dependent variable mean	0.04197	2.5016	0.00472	81.496	0.05428	70.804
Observations	163,695	6,561	107,858	393	340,592	17,042
R^2	0.46776	0.46409	0.29894	0.94058	0.55761	0.29229

Notes: OLS estimates. The unit of observation is a PLSS First Division section. The sample is restricted to sections where at least 75% of land area is undeveloped and at least 75% is privately owned. The sample further excludes sections within counties with no wind, solar, or easement development respectively. Columns (1), (3), and (5) use the full section sample; columns (2), (4), and (6) restrict the sample to sections where the respective dependent variable is positive. Observation counts in the intensive-margin columns fall below the number of positive sections implied by the extensive-margin dependent-variable means because fixed-effect singletons (sections that are the only developed observation in their fixed-effect group) are dropped from estimation. A blank coefficient cell indicates that an indicator control was dropped from that regression because it had no within-fixed-effect variation in the subsample. *Wind = 1*, *Solar = 1*, and *Easement = 1* are binary indicators equal to one if the section has any installed wind capacity, solar capacity, or conservation easement acreage as of 2024, respectively. *Wind MW/1,000 Acres*, *Solar MW/1,000 Acres*, and *Ease/1,000 Acres* measure megawatts of installed wind capacity, megawatts of installed solar capacity, and conservation easement acres per 1,000 section acres as of 2024, respectively. *Inv. HHI* is the inverse of the Herfindahl-Hirschman Index (HHI) of land ownership concentration derived from parcels greater than 20 acres within the section; higher values indicate greater fragmentation and can be interpreted as the number of equal-share landowner equivalents. *Windiness* is mean wind speed (m/s). *Sunniness* is mean solar irradiance (kWh/m^2/day). *Conservation Value* is a land conservation priority score. *Airport <5km* is an indicator equal to one if an airport lies within 5 km of the section centroid. *Transmission <5km* is an indicator equal to one if an electricity transmission line passes within 5 km of the section centroid. *Dist. to Rail* is distance to the nearest railroad (km). *Dist. to Road* is distance to the nearest road (km). *Log(Elevation)* is the log of mean section elevation (m). *Slope* is mean terrain slope (degrees). *Ruggedness* is the Terrain Ruggedness Index (TRI). *Soil* is a composite soil quality index. *Log(Area)* is the natural log of section area (acres), included to control for the mechanical tendency of larger sections to contain development. *Share Public* is the share of section land area that is publicly owned. *Share Developed* is the share of section land area classified as developed. All regressions include township, multi-subcounty, and GAP fixed effects. Conley standard errors (20 km cutoff) in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Similarly to our findings from the county-level analysis, wind speed is a significant determinant of the presence of a wind project, while sunniness is a less powerful predictor of solar power than was the case at the county level. Other variables of note include the indicator for transmission lines within 5km, which is positive and significant at the extensive margin for both wind and solar, consistent with transmission infrastructure being necessary for utility-scale electricity generation; at the intensive margin, and for easements at either margin, the transmission coefficients are not statistically significant. Ruggedness of the land is negatively correlated with wind as one would expect due to the increased difficulty and cost of building on and accessing large areas of rugged land. The log of section area enters positively and significantly at the extensive margin, confirming that larger sections are mechanically more likely to contain development.

We carried out a range of robustness checks to verify our results which are presented in appendix E. Results for the same specification with standard errors clustered at the township level can be seen in table 15, while table 16 shows results using subcounty instead of township fixed effects. Results using alternative section filtering conditions can be found in tables 17 and 18. In all cases, the magnitudes of the key coefficients were broadly consistent, although we saw larger standard errors in the 90% results due to the smaller sample size.

We also present results using a combined density measure that pools the extensive and intensive margins over the full sample of sections in table 19. In this pooled specification the coefficient on the inverse HHI is small and not statistically significant for any of the three outcomes, reflecting the offsetting extensive and intensive effects documented above. For example, in the case of easements, fragmentation raises the probability of any easement while reducing easement density where one is present, and the two effects roughly cancel when the margins are combined.

Table 20 substitutes the raw number of landowners per section for the inverse HHI. The landowner results are qualitatively consistent—wherever the coefficients are significant, they carry the same signs as those on the inverse HHI (positive for the presence of easements and negative for wind). The landowner coefficient on wind density is roughly half the corresponding inverse-HHI coefficient, while the coefficients on easement presence are of comparable magnitude. The main difference arises at the easement intensive margin, where the landowner count, unlike the inverse HHI, does not significantly predict easement density, consistent with the inverse HHI being a richer measure of fragmentation that also captures heterogeneity in holding sizes.

In order to check against omitted spatial factors, we apply the spatial first differences estimator described in our discussion of identification, differencing the section specification against each section's immediate western neighbor. Results are reported in appendix tables 21 and 22. The key coefficients survive the differencing. At the extensive margin, the inverse-HHI coefficient on easement presence remains positive and significant, confirming that the easement result is not an artifact of smoothly-varying spatial confounders. The intensive-margin results, estimated among adjacent sections that both host development, are stronger still: an additional equal-share landowner is associated with a reduction of 0.1 MW of wind capacity per 1,000 acres and a reduction of 3.3 easement acres per 1,000 acres, both significant at the 1% level. The wind coefficient is almost identical to its cross-sectional counterpart and the easement coefficient is larger, the same pattern Winikoff and Parker (2023) document when they subject their estimates to this test. The solar columns rest on too few adjacent solar-hosting sections to interpret. We take the persistence of the wind and easement results under spatial first differences as evidence that the section-level relationships reflect ownership fragmentation rather than unobserved geography. Finally, average partial effects from logit specifications of the extensive margins are reported in appendix table 23, and are broadly consistent with the linear probability results.

6 Parcel-Level Analysis

6.1 Empirical Strategy

The parcel-level analysis is the final and most granular level of the analysis. While the section-level analysis offers insight into the effects of land fragmentation at a small spatial scale, the parcel-level analysis allows for further differentiation between the effects of own-parcel size and the degree of fragmentation of the land surrounding a given parcel. The specification for the parcel level regressions is shown in equation 4:

$$\text{Development}_i = \alpha + \beta \, \text{Owners}_i + \delta \, \text{Log}(\text{Size}_i) + \gamma \, X_i + \epsilon_i \tag{4}$$

where Development_i is an indicator for the presence of the type of green development in question (wind turbines, solar panels, or easements), Owners_i is the number of unique private owners of undeveloped farmland parcels greater than 20 acres within a 1/2 mile radius of a given parcel, normalized by the parcel perimeter, Size_i is parcel size, and X_i controls for 12 covariates (shown in appendix B, table 8). Township and GAP status code fixed effects are also included, and Conley standard errors are used.

As with the section-level analysis, the regression sample is restricted to counties that contain at least one parcel with the development outcome and at least one without. The rationale for this restriction, as well as the justification for the choice of township as the fixed effects unit, is discussed in section 5.1.

6.2 Results

Table 5 shows the results for the parcel level regressions. The coefficients for parcel size are positive and highly significant for all three outcome variables, with wind having the highest correlation, followed by easements and then finally by solar. A doubling of parcel size increases the probability of the parcel hosting a wind turbine by 1.2 percentage points, a solar panel by 0.33 percentage points, and an easement by 1.1 percentage points. These results are consistent in sign with the county-level and section-level results, although the relative magnitudes of the coefficients are slightly different, with wind projects now being found to be the most significantly affected by parcel size.

The coefficients for the normalized number of owners within a 1/2 mile radius—the measure of fragmentation of the land surrounding a given parcel—are less in line with expectations. The coefficient for wind is positive but not significant, while the coefficient for solar is positive and highly significant, indicating that an additional owner within radius per mile of perimeter actually increases the likelihood of the parcel hosting a solar panel by 0.04 percentage points. This suggests that the fragmentation of land surrounding a given parcel is unrelated to the likelihood of finding a wind project in that location, and that fragmentation is positively correlated with the presence of a solar project. It is only in the case of easements where we find a significant and negative coefficient for fragmentation, where an additional owner within radius of a parcel per mile of perimeter decreases the likelihood of the parcel hosting an easement by 0.08 percentage points.

We carried out a range of robustness checks, all presented in appendix F. Table 24 reports the primary specification with standard errors clustered at the township level, while table 25 uses subcounty instead of township fixed effects; both are comparable to our primary specification. Tables 26 and 27 vary the radius from 1/2 mile to 1/4 mile and 1 mile respectively, and table 28 uses the raw number of owners within radius while separately controlling for parcel perimeter. The coefficients on the key variables show some minor variation across these specifications, but overall the results are broadly unchanged.

We also show results produced from alternative parcel samples. The results in table 29 were generated using data that were not filtered to remove parcels not classified as farmland. The coefficients of interest are broadly unchanged for solar and easements, but

Table 5: Parcel-Level 1/2 Mile Regression Estimates

	Turbine = 1 (1)	Solar = 1 (2)	Easement = 1 (3)
Log(Parcel Size)	0.0120***	0.0033***	0.0106***
	(0.0008)	(0.0002)	(0.0004)
Normalized Owners in Radius	5.11×10^{-5}	0.0004***	-0.0008***
	(6.36×10^{-5})	(4.45×10^{-5})	(7.49×10^{-5})
Windiness	0.0364***	-0.0006	-0.0018
	(0.0026)	(0.0009)	(0.0019)
Sunniness	0.0350*	-0.0014	-0.1226***
	(0.0208)	(0.0074)	(0.0206)
Conservation Value	-0.0053***	0.0001	0.0091***
	(0.0008)	(0.0003)	(0.0008)
Airport in Radius	-0.0041***	0.0007	-0.0065***
	(0.0009)	(0.0011)	(0.0019)
Transmission in Radius	0.0039***	0.0036***	-0.0013***
	(0.0007)	(0.0003)	(0.0005)
Rail in Radius	-0.0027***	0.0007**	0.0005
	(0.0006)	(0.0003)	(0.0007)
Road in Radius	-0.0037***	0.0002	-0.0001
	(0.0005)	(0.0002)	(0.0004)
Slope	0.0062***	-0.0011***	-0.0184***
	(0.0017)	(0.0004)	(0.0027)
Ruggedness	-0.0175***	0.0023**	0.0480***
	(0.0048)	(0.0011)	(0.0076)
Soil	6.55×10^{-10}	-1.25×10^{-10}	-5.26×10^{-10}
	(1×10^{-6})	(1×10^{-6})	(1×10^{-6})
Share Surrounding Public	-0.0036***	0.0022***	0.0230***
	(0.0014)	(0.0007)	(0.0021)
Share Surrounding Developed	0.0040*	0.0182***	-0.0748***
	(0.0021)	(0.0017)	(0.0047)
Dependent variable mean	0.01519	0.00283	0.04474
Observations	2,061,624	2,282,524	6,048,690
R^2	0.17228	0.08922	0.41853

Notes: OLS estimates (linear probability model). The unit of observation is a parcel of at least 20 acres classified primarily as farmland. The sample excludes parcels within counties with no wind, solar, or easement development respectively. *Turbine = 1*, *Solar = 1*, and *Easement = 1* are binary indicators equal to one if a wind turbine, solar project, or conservation easement, respectively, is located on the parcel as of 2024. *Log(Parcel Size)* is the log of parcel area (acres). *Normalized Owners in Radius* is the number of distinct landowners within 1/2 mile divided by the length of the parcel perimeter in miles. *Windiness* is mean wind speed (m/s). *Sunniness* is mean solar irradiance (kWh/m^2/day). *Conservation Value* is a land conservation priority score. *Airport in Radius* is an indicator equal to one if an airport lies within 1/2 mile. *Transmission in Radius* is an indicator equal to one if an electricity transmission line passes within 1/2 mile. *Rail in Radius* is an indicator equal to one if a railroad is located within 1/2 mile. *Road in Radius* is an indicator equal to one if a road is located within 1/2 mile. *Slope* is mean terrain slope (degrees). *Ruggedness* is the Terrain Ruggedness Index (TRI). *Soil* is a composite soil quality index. *Share Surrounding Public* is the share of land within 1/2 mile of the parcel that is publicly owned. *Share Surrounding Developed* is the share of land within 1/2 mile classified as developed. All regressions include township and GAP fixed effects. Conley standard errors (20 km cutoff) in parentheses. *p<0.1; **p<0.05; ***p<0.01.

the surrounding-ownership coefficient for wind, which is small and statistically insignificant in the primary specification, becomes negative and significant at the 1% level in this larger sample. Table 30 shows results where we additionally include Log(Dist. To Mailing Address), the natural log of the distance between a parcel and the parcel owner's registered address, as an additional control variable.[11] The coefficients for Log(Dist. To Mailing Address) are positive across all three outcome variables, consistent with the interpretation that absentee landowners are more amenable to hosting green infrastructure on their land. The coefficients of interest on parcel size and surrounding ownership fragmentation remain stable relative to the primary specification.

We also apply the within-township permutation test to the parcel-level estimates, with results reported in table 31. The coefficient on the normalized number of surrounding owners lies in the extreme tail of the placebo distribution for all three outcomes. No placebo draw was as large in absolute value for solar or easement ($p \approx 0.002$), and only about one percent of draws were as extreme for wind ($p = 0.012$), indicating that the estimated relationships are not generated by the spatial arrangement of parcels within townships. Notably, the wind coefficient remains in the tail of the placebo distribution even though it is not distinguishable from zero under the Conley standard errors of our primary specification, suggesting that the surrounding-ownership relationship for wind is more systematic than the conventional standard errors alone would imply. Finally, average partial effects from logit specifications of the extensive margins are reported in appendix table 32, and are again broadly consistent with the linear probability results.

[11] This was not included in our main specification due to the lack of completeness of the variable within our dataset.

7 Discussion

Across all three spatial scales, the evidence points in a consistent direction for wind: areas with larger, less fragmented landholdings host more wind development. At the county level, larger mean farm size significantly raises the probability of hosting a wind project (the wind density coefficient is also positive, although with a large standard error); at the section level, the density of wind capacity falls with each additional equal-share landowner; and at the parcel level, the probability of hosting a turbine rises steeply with own-parcel size. The wind result is also the most robust in the paper. It holds when we difference sections with their neighbors to remove shared spatial confounders, and instrumenting farm size with its pre-development value leaves the point estimate similar in magnitude, though less precisely estimated. The mutual reinforcement of our range of identification strategies, each addressing a different threat, makes a strong case that ownership fragmentation is a key determinant of wind development. The only result that goes against the trend is the fragmentation measure (as opposed to the parcel size measure) at the parcel level, which bears no significant relationship to wind siting in our primary farmland sample, though it does turn negative and significant when we use the broader sample of farm and non-farm parcels in our estimation. For wind, the evidence therefore suggests that the primary barrier appears to be the size of a given individual holding which may or may not be considered for a wind project, rather than the fragmentation or otherwise of a larger area comprised of several smaller parcels.

Solar development is only weakly tied to fragmentation, and not always in the predicted direction. Farm size predicts solar presence at the county level, and own-parcel size predicts siting at the parcel level, but the section-level relationship is negligible, and the association between surrounding ownership and solar siting is positive and statistically significant. The likely explanation is that solar rarely faces a land-assembly problem at all—most solar projects in our sample occupy well under a hundred acres (figure 10), so a single willing landowner typically suffices, and siting is governed more by insolation, proximity to transmission, and local permitting than by the structure of surrounding ownership. The positive association with surrounding ownership may reflect solar's tendency to locate on the fringes of settled areas, where parcels are smaller and local demand for electricity generation is high.

Conservation easements present the most complex pattern, and the one least consistent with renewable energy generation. More fragmented sections are modestly more likely to contain an easement, yet where easements are present they cover less land as fragmentation rises. The extensive-margin result is intuitive given the context that easements are not assembled by a single developer seeking a contiguous block of land for physical infrastructure. Each owner in a section represents an independent chance that someone chooses to conserve, so sections with more owners are more likely to contain at least one easement, even as fragmentation limits the size of any single one. With that being said, evidence from the parcel-level results suggests that parcels surrounded by more owners are significantly less likely to be placed into easement themselves. This is consistent with the complementarities emphasized in the conservation literature—protecting a parcel is worth more when it adjoins other protected or intact land (Baldwin and P. B. Leonard, 2015; Graves et al., 2019)—and it suggests that fragmentation does indeed impose a cost on conservation, although not in the same way as it does for wind project assembly. Easement enrollment is not blocked outright, but the value of what any single owner can provide by placing their land into easement is eroded by the lack of complementarity. The determinants of conservation clearly differ from those of energy development, with conservation value and proximity to public land playing a larger role.

The parcel-level analysis lets us separate two distinct channels: the size of a parcel itself, and the fragmentation of the land around it. Own-parcel size is the more powerful predictor for all three outcomes, consistent with the minimum-contiguous-area requirement operating at the level of the individual landholding. For wind and solar projects, the fragmentation of surrounding ownership is either indistinguishable from zero in the case of wind, or opposite in sign to the land-assembly prediction in the case of solar. These results suggest that, at least at the half-mile scale we examine, the binding constraint is whether a single landowner controls enough land themselves, rather than how many neighbors a developer would need to coordinate with. By contrast, in the case of easements the surroundings matter in the direction that the theory predicts, though more plausibly through the complementarity channel described above than through the costs of assembly.

The three theoretical mechanisms that we consider—transaction costs, anticommons, and strategic holdups—all predict a negative relationship between the number of owners and the probability of development. While we have no clear way of distinguishing them in the empirical setting of this paper, the identification of the dominant mechanism will be important for those wishing to implement policies that would increase access to these development opportunities for small farms. If transaction costs are the most substantial barrier, then better information for landowners and standardized contracting could lower the cost of assembling land. If anticommons pricing dominates, then mechanisms that coordinate landowners, such as uniform compensation offers, or majority-based participation rules such as forced pooling, may be needed to overcome the collective-action problem. If strategic holdups by pivotal owners are the issue, then take-it-or-leave-it offers and reduced dependence on any single parcel may help.

8 Conclusion

In this paper we set out to evaluate the evidence for whether or not the fragmentation of land ownership associated with small farms limits their ability to capitalize on three categories of green infrastructure development. We conclude that the answer depends on the form of development under consideration. In the case of wind projects, the evidence strongly suggests that the answer is yes. At every scale of analysis, wind development was found to be concentrated where landholdings are large and consolidated. For solar projects, the relationship is weak and inconsistent in direction. Finally, in the case of conservation easements, the picture is more complex. Fragmentation was found to raise the prevalence of easements across sections while simultaneously limiting the area covered by them, and parcels with more highly fragmented surroundings were less likely to be conserved at all.

These findings have implications for the policies often promoted as a means of helping small farms diversify their income. To the extent that wind and, to a lesser degree, solar development are concentrated in areas of consolidated ownership, the small farms that stand to benefit most from lease income are precisely those least able to attract it. Programs that simply publicize the availability of green development opportunities may therefore do little for the most fragmented areas. Policies that directly lower the cost of assembling land, such as standardized contracts and shared negotiation platforms to reduce transaction costs, or coordination mechanisms such as uniform compensation offers and majority-based participation rules to address anticommons pricing, are more likely to be beneficial to small farmers. However, such interventions carry distributional and efficiency trade-offs that we do not attempt to resolve here.

The determinants of conservation easements remain more ambiguous and merit further investigation. The opposing extensive- and intensive-margin relationships we document, together with the apparent importance of conservation value and proximity to public land, suggest that easement siting is driven by considerations quite different from the land-assembly logic that governs energy infrastructure development.

More broadly, our results are suggestive for the long-run prospects of small farms in the United States. If the inability to access supplementary income streams adds to the financial pressures that are driving small and mid-sized farms out of business, then the fragmentation barrier that we document may be one of the channels through which the disadvantages of operating at a small scale compound over time. In this sense, understanding the barriers against the assembly of fragmented land, and lowering them where it is appropriate to do so, is relevant not only to the pace of green infrastructure development, but also to the survival of the small farms that are considered by many to be integral to the social and cultural fabric of the nation.

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Appendix A: Construction of Synthetic PLSS Sections

Where official BLM cadastral data exist, we use real PLSS section boundaries drawn directly from the BLM Ground Control Database (GCDB) First Division layer, retaining only standard sections (FRSTDIVTYP = "SN") with valid 15-character PLSSID codes. Ohio is treated as fully synthetic because BLM coverage there is only around 19% of the state area, a legacy of pre-PLSS metes-and-bounds surveying; including the sparse real coverage would produce a patchwork grid inconsistent with the rest of the state.

For all other areas without BLM coverage—including the original 13 colonies, Vermont, Maine, Kentucky, Tennessee, West Virginia, Texas, and Ohio, as well as Spanish and French land grants, tribal reservations, national parks, and miscellaneous digitization gaps—we construct synthetic sections to ensure every CONUS location receives a section identifier. The gap area to be filled is defined as the CONUS boundary minus the buffered union of all real sections (a $\pm$100m open/close buffer is applied to close hairline gaps between adjacent real sections before the difference is taken). Fragments smaller than 1 km^2 are discarded as slivers.

Each gap polygon is assigned to a principal meridian (PM) using a Voronoi tessellation seeded from the 31 CONUS PM origins. This ensures that synthetic townships in a given area inherit the coordinate frame of the historically closest PM, producing IDs that are consistent with the real PLSS identifiers used in the same region. A synthetic township grid is then generated for each PM zone using the same geometric logic as the real survey: townships are 6 miles square, with longitude widths computed at the latitude of the correction-band baseline to account for meridian convergence. Correction bands reset the reference meridian every four townships, replicating the standard PLSS surveying convention. The 36 sections within each synthetic township are laid out on a 6×6 one-mile grid using the PLSS standard serpentine numbering scheme (beginning at the northeast corner, alternating direction by row).

Synthetic townships and sections are clipped at state lines, matching the practice of the original PLSS surveyors who stopped lines at jurisdictional boundaries rather than extending them across. A synthetic grid cell that straddles a state line produces two separate polygons with distinct identifiers—for example, a cell along the Kentucky–Tennessee border yields one "`KY-5PM-T`n`N-R`r`W`" township and one "`TN-5PM-T`n`N-R`r`W`" township, each carrying only the sections that fall within its respective state. No synthetic section therefore crosses a state line, and every township identifier unambiguously maps to a single state.

Output identifiers take the form `{state}-{PM}-T{n}{dir}-R{r}{dir}` for townships (e.g. `IA-5PM-T3N-R7W`) and append `-S{section_no}` for sections (e.g. `IA-5PM-T3N-R7W-S14`). A `source` flag distinguishes real from synthetic units, and an `is_partial` flag marks any section whose clipped area falls below 95% of the expected full-section area for its parent township. Sections below 10,000 m^2 after clipping are discarded as degenerate. All area calculations use the CONUS Albers Equal Area projection (EPSG:5070); geometries are stored in WGS84 (EPSG:4326).

Appendix B: Summary Statistics

Table 6: County-Level Summary Statistics

Variable	Mean	SD
=1 if Wind Project	0.17	0.37
Turbine Count	25	89
Turbine Capacity (MW)	55	187
Wind MW/1,000 Acres	0.10	0.34
=1 if Solar Project	0.35	0.48
Solar Count	2	5
Solar Capacity (MW)	31	131
Solar MW/1,000 Acres	0.06	0.20
=1 if Easement	0.92	0.27
Easement Count	101	413
Easement Acres	19,028	52,110
Easement Acres/1,000 Acres	34.80	77.65
Avg. Farm Size (Acres)	748	1,651
Med. Farm Size (Acres)	202	592
Windiness (m/s)	6.71	0.79
Sunniness (kWh/m^2/day)	4.50	0.45
Amenity Rank	3.42	1.00
km Transmission Lines	294	270
Pop. Density (per Acre)	0.19	0.39
Share Public	0.10	0.15
Share Protected	0.23	0.36
Dist. to Metro Area (km)	27	39
Acres Irrigated	19,400	54,551
Ag. Products Sold (1,000s)	192,832	351,003
Land Value/Acre	5,124	3,657
Perc. Live Off-Farm	0.57	0.25
Elevation (m)	427	475
Land Area (Acres)	583,406	725,347

N = 2,723.

Notes: All variables are measured at the county level. *=1 if Wind Project* is an indicator equal to one if any wind turbine is present on or associated with the observation unit. *=1 if Solar Project* is an indicator equal to one if a utility-scale solar project is present on or associated with the observation unit. *=1 if Easement* is an indicator equal to one if a conservation easement is present on or associated with the observation unit. *Turbine Count* is the total number of wind turbines within the observation unit. *Turbine Capacity (MW)* is the total nameplate capacity (MW) of all wind turbines within the observation unit. *Wind MW/1,000 Acres* is total wind nameplate capacity (MW) per 1,000 acres of the observation unit. *Solar Count* is the total number of utility-scale solar installations within the observation unit. *Solar Capacity (MW)* is the total nameplate capacity (MW) of all solar installations within the observation unit. *Solar MW/1,000 Acres* is total solar nameplate capacity (MW) per 1,000 acres of the observation unit. *Easement Count* is the number of conservation easements within the observation unit. *Easement Acres* is the total area (acres) under conservation easement within the observation unit. *Ease. Acres/1,000 Acres* is total area under conservation easement (acres) per 1,000 acres of the observation unit. *Avg. Farm Size (Acres)* is the average size of farms in the county (acres), from the 2022 Census of Agriculture. *Med. Farm Size (Acres)* is the median size of farms in the county (acres), from the 2022 Census of Agriculture. *Windiness* is mean wind speed (m/s). *Sunniness* is mean solar irradiance (kWh/m^2/day). *Amenity Rank* is the USDA Natural Amenity Rank, a composite index of climate, topography, and water features. *km Transmission Lines* is the total length of electricity transmission lines (km) within the county. *Pop. Density (per Acre)* is county population per acre. *Share Public* is the share of county land area that is publicly owned. *Share Protected* is the share of county land area under protected status, from the USGS Protected Areas Database (PAD-US) (USGS, 2024c). *Dist. to Metro Area (km)* is the distance from the county centroid to the nearest metropolitan area (km). *Acres Irrigated* is irrigated cropland area (acres) from the 2022 Census of Agriculture. *Ag. Products Sold (1,000s)* is total agricultural products sold (USD, thousands) from the 2022 Census of Agriculture. *Land Value/Acre* is the average value of farmland and buildings per acre (USD) from the 2022 Census of Agriculture. *Perc. Live Off-Farm* is the share of principal farm operators whose primary residence is not on the farm. *Elevation (m)* is mean county elevation in meters. *Land Area (Acres)* is total county land area in acres.

Table 7: Section-Level Summary Statistics

Variable	Mean	SD
=1 if Wind Project	0.017	0.131
Turbine Count	0.058	0.540
Turbine Capacity (MW)	0.124	1.086
Wind MW/1,000 Acres	0.044	0.385
=1 if Solar Project	0.001	0.037
Solar Count	0.001	0.043
Solar Capacity (MW)	0.258	8.540
Solar MW/1,000 Acres	0.099	4.845
=1 if Easement	0.048	0.213
Easement Count	0.097	0.534
Easement Acres	9	68
Easement Acres/1,000 Acres	3.260	23.718
No. of Landowners	3	2
Inv. HHI	2	1
Windiness (m/s)	7.17	1.05
Sunniness (kWh/m^2/day)	4.80	0.62
Conservation Value	1.97	0.65
Airport <5km	0.016	0.125
Transmission <5km	0.423	0.494
Dist. to Rail	24	22
Dist. to Road	9	8
Elevation (m)	873	470
Slope	3	4
Ruggedness	1	1
Soil	1,023,372	944,248
Share Developed	0.02	0.03
Share Public	0.00	0.03

N = 395,819.

Notes: All variables are measured at the section level (approximately 1 square mile, ≈640 acres). *=1 if Wind Project* is an indicator equal to one if any wind turbine is present on or associated with the observation unit. *=1 if Solar Project* is an indicator equal to one if a utility-scale solar project is present on or associated with the observation unit. *=1 if Easement* is an indicator equal to one if a conservation easement is present on or associated with the observation unit. *Turbine Count* is the total number of wind turbines within the observation unit. *Turbine Capacity (MW)* is the total nameplate capacity (MW) of all wind turbines within the observation unit. *Wind MW/1,000 Acres* is total wind nameplate capacity (MW) per 1,000 acres of the observation unit. *Solar Count* is the total number of utility-scale solar installations within the observation unit. *Solar Capacity (MW)* is the total nameplate capacity (MW) of all solar installations within the observation unit. *Solar MW/1,000 Acres* is total solar nameplate capacity (MW) per 1,000 acres of the observation unit. *Easement Count* is the number of conservation easements within the observation unit. *Easement Acres* is the total area (acres) under conservation easement within the observation unit. *Ease. Acres/1,000 Acres* is total area under conservation easement (acres) per 1,000 acres of the observation unit. *Landowners* (or *No. of Landowners*) is the number of distinct private landowners of undeveloped farmland parcels (≥20 acres) within the section. *Inv. HHI* is the inverse of the Herfindahl-Hirschman Index computed from private farmland ownership shares within the section, interpreted as the equivalent number of equal-share landowners. *Windiness* is mean wind speed (m/s). *Sunniness* is mean solar irradiance (kWh/m^2/day). *Conservation Value* is a land conservation priority score. *Airport <5km* is an indicator equal to one if an airport lies within 5 km of the section centroid. *Transmission <5km* is an indicator equal to one if an electricity transmission line passes within 5 km of the section centroid. *Dist. to Rail* is distance to the nearest railroad (km). *Dist. to Road* is distance to the nearest road (km). *Elevation (m)* is mean section elevation in meters. *Slope* is mean terrain slope (degrees). *Ruggedness* is the Terrain Ruggedness Index (TRI). *Soil* is a composite soil quality index. *Share Developed* is the share of section land area classified as developed. *Share Public* is the share of section land area that is publicly owned.

Table 8: Parcel-Level Summary Statistics

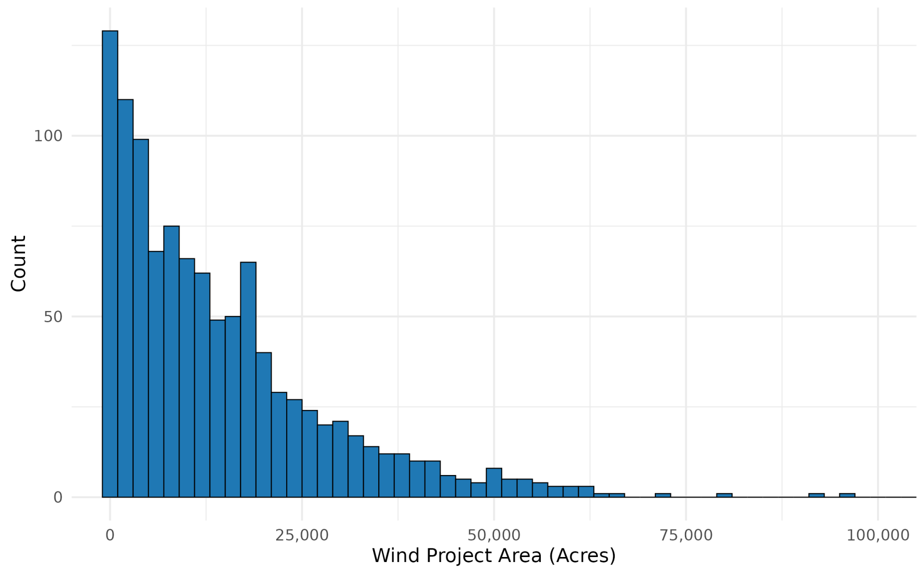
Variable	Mean	SD
=1 if Wind Project	0.005	0.069
=1 if Solar Project	0.001	0.032
=1 if Easement	0.042	0.200
Area (Acres)	106	343
Perimeter (Miles)	2	1
Windiness (m/s)	6.94	0.96
Sunniness (kWh/m^2/day)	4.46	0.50
Conservation Value	1.32	0.71
No. of Owners in 1/2-mile Radius	8.73	4.93
=1 if Airport in Radius	0.003	0.056
=1 if Transmission in Radius	0.183	0.386
=1 if Rail in Radius	0.088	0.283
=1 if Road in Radius	0.272	0.445
Slope	2	3
Ruggedness	1	1
Soil	1,004,470	906,906
Share Surrounding Public	0.05	0.14
Share Surrounding Developed	0.07	0.08

N = 6,476,476.

Notes: The unit of observation is a parcel of at least 20 acres classified primarily as farmland. *=1 if Wind Project* is an indicator equal to one if any wind turbine is present on or associated with the observation unit. *=1 if Solar Project* is an indicator equal to one if a utility-scale solar project is present on or associated with the observation unit. *=1 if Easement* is an indicator equal to one if a conservation easement is present on or associated with the observation unit. *Area (Acres)* or *Parcel Area (Acres)* is the area of the parcel in acres. *Perimeter (Miles)* is the perimeter of the parcel in miles. *Windiness* is mean wind speed (m/s). *Sunniness* is mean solar irradiance (kWh/m^2/day). *Conservation Value* is a land conservation priority score. *No. of Owners in 1/2-mile Radius* is the number of distinct private landowners of undeveloped farmland parcels within a 1/2-mile radius of the parcel centroid. *Airport in Radius* is an indicator equal to one if an airport lies within 1/2 mile. *Transmission in Radius* is an indicator equal to one if an electricity transmission line passes within 1/2 mile. *Rail in Radius* is an indicator equal to one if a railroad is located within 1/2 mile. *Road in Radius* is an indicator equal to one if a road is located within 1/2 mile. *Slope* is mean terrain slope (degrees). *Ruggedness* is the Terrain Ruggedness Index (TRI). *Soil* is a composite soil quality index. *Share Surrounding Public* is the share of land within 1/2 mile of the parcel that is publicly owned. *Share Surrounding Developed* is the share of land within 1/2 mile classified as developed.

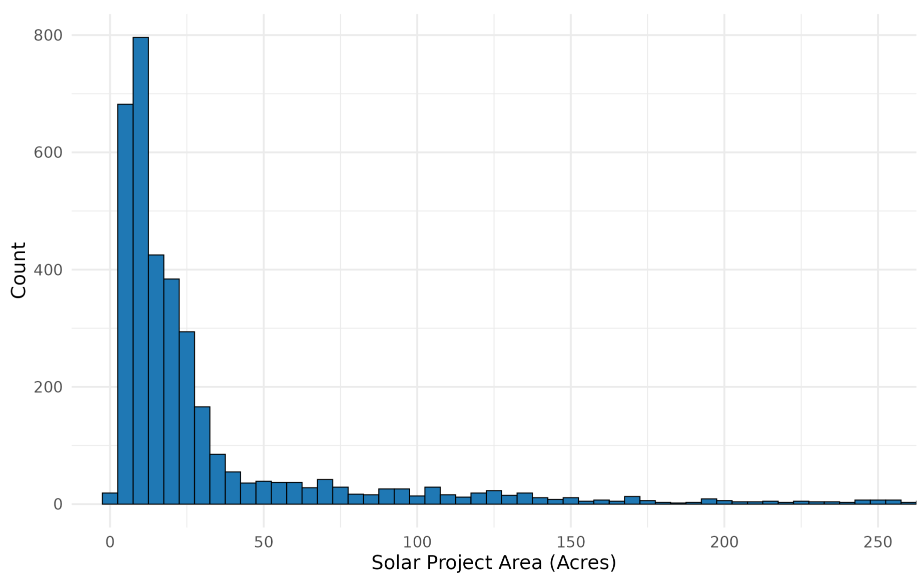
Appendix C: Green Development Land Requirements

Figure 9: Wind project land requirements



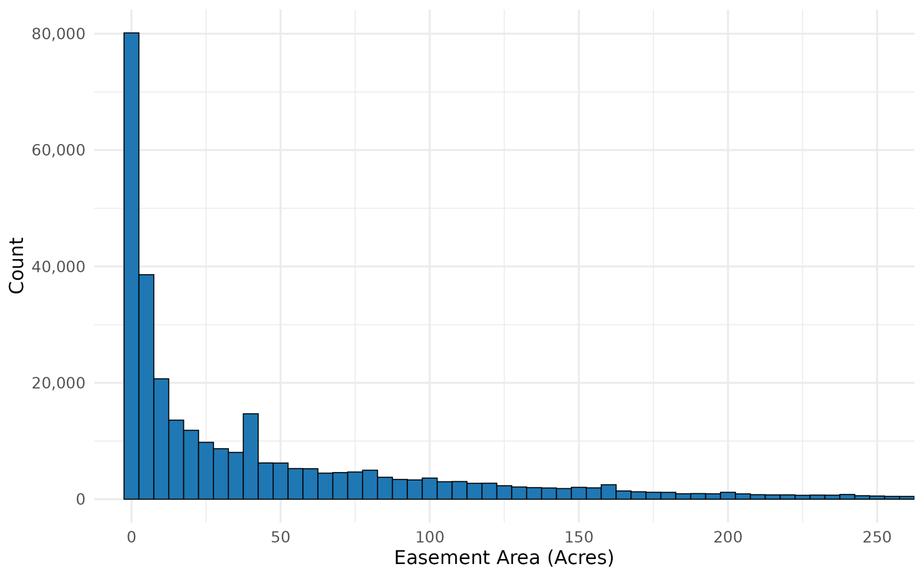
Notes: Histogram showing the distribution of wind project size in our sample. Size is calculated from the turbine locations within the source shapefile by drawing a convex hull around the turbines that compose a project. Each distinct project counts as one observation, and project size is measured in acres. The x-axis is truncated at 100,000 acres.

Figure 10: Solar project land requirements



Notes: Histogram showing the distribution of solar project size in our sample. Size is taken directly from the object outline in the source shapefile. Each distinct project counts as one observation, and project size is measured in acres. The x-axis is truncated at 250 acres.

Figure 11: Easement land requirements



Notes: Histogram showing the distribution of easement size in our sample. Each distinct easement counts as one observation, and easement size is measured in acres. The x-axis is truncated at 250 acres.

Appendix D: County Results

Table 9: County-Level Regression Estimates: Combined intensive and extensive margins

	Wind MW/1,000 Acres (1)	Solar MW/1,000 Acres (2)	Ease. Acres/1,000 Acres (3)
Log(Avg. Farm Size)	0.0528***	0.0360***	11.56**
	(0.0186)	(0.0111)	(4.592)
Windiness	0.1713***	-0.0083	-4.245
	(0.0396)	(0.0094)	(2.763)
Sunniness	0.0340	0.1032***	-13.07
	(0.0662)	(0.0350)	(27.85)
Amenity Rank	-0.0220*	-0.0110	0.3573
	(0.0120)	(0.0072)	(3.041)
Log(Transmission)	0.0660***	0.0306**	-2.016
	(0.0230)	(0.0120)	(2.386)
Log(Pop. Density)	-0.1887***	-0.0264	15.22
	(0.0432)	(0.0239)	(19.04)
Share Public	-0.0326	-0.0447	4.601
	(0.0622)	(0.0318)	(22.65)
Share Protected	0.0255	-0.0079	22.67*
	(0.0546)	(0.0113)	(12.76)
Log(Dist. Metro Area)	0.0052	-0.0019	0.9874
	(0.0060)	(0.0034)	(1.482)
Log(Acres Irrigated)	-0.0071*	0.0024	-0.3945
	(0.0039)	(0.0016)	(0.9414)
Log(Ag. Products Sold)	-0.0020	0.0025	1.589
	(0.0042)	(0.0028)	(1.769)
Log(Value/Acre)	0.0788	0.0134	25.10**
	(0.0474)	(0.0159)	(10.79)
Perc. Live Off-Farm	0.1140**	-0.0359*	13.54
	(0.0466)	(0.0208)	(13.61)
Log(Elevation)	0.0239	-0.0345***	-6.513**
	(0.0173)	(0.0106)	(2.610)
Log(Land Area)	-0.0673**	-0.0288*	0.2014
	(0.0309)	(0.0145)	(3.533)
Dependent variable mean	0.09793	0.06186	34.802
Observations	2,723	2,723	2,723
R^2	0.19711	0.20445	0.45533

Notes: OLS estimates. The unit of observation is a county. The sample includes all counties with available data. *Wind MW/1,000 Acres* is megawatts of installed wind generation capacity per 1,000 acres of county land area. *Solar MW/1,000 Acres* is megawatts of installed solar generation capacity per 1,000 acres of county land area. *Ease/1,000 Acres* is conservation easement acres per 1,000 acres of county land area. All dependent variables are measured as of 2024. *Log(Avg. Farm Size)* is the natural log of mean farm size (acres) from the 2022 Census of Agriculture. *Windiness* is mean wind speed (m/s). *Sunniness* is mean solar irradiance (kWh/m^2/day). *Amenity Rank* is the USDA Natural Amenity Rank, a composite index of climate, topography, and water features. *Log(Transmission)* is the log of total electricity transmission line length (km) within the county. *Log(Pop. Density)* is the log of population per acre. *Share Public* is the share of county land area that is publicly owned. *Share Protected* is the share of county land area under protected status, from the USGS Protected Areas Database (PAD-US) (USGS, 2024c). *Log(Dist. Metro Area)* is the log of distance to the nearest metropolitan area (km). *Log(Acres Irrigated)* is the log of irrigated cropland (acres) from the 2022 Census of Agriculture. *Log(Ag. Products Sold)* is the log of total agricultural products sold (thousands of USD) from the 2022 Census of Agriculture. *Log(Value/Acre)* is the natural log of the average value of farmland and buildings per acre (USD) from the 2022 Census of Agriculture. *Perc. Live Off-Farm* is the share of principal farm operators whose primary residence is not on the farm. *Log(Elevation)* is the log of mean county elevation (m). *Log(Land Area)* is the log of county land area (acres). All regressions include state fixed effects. Standard errors clustered by state in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table 10: County-Level Regression Estimates: Median farm size

	Wind = 1	Wind MW/1,000 Acres | MW > 0	Solar = 1	Solar MW/1,000 Acres | MW > 0	Easement = 1	Ease. Acres/1,000 Acres | Ease Acres > 0
	(1)	(2)	(3)	(4)	(5)	(6)
Log(Med. Farm Size)	0.0038	0.0518	-0.0173	0.0245	-0.0196	0.3296
	(0.0177)	(0.0355)	(0.0184)	(0.0181)	(0.0169)	(2.400)
Windiness	0.2516***	0.4164***	0.0292	-0.0175	0.0227	-2.284
	(0.0332)	(0.1434)	(0.0204)	(0.0184)	(0.0171)	(2.415)
Sunniness	0.1097	0.1095	0.3419***	0.2166***	-0.1111	-0.6013
	(0.0781)	(0.3059)	(0.0910)	(0.0634)	(0.0732)	(29.80)
Amenity Rank	-0.0057	-0.0198	-0.0330**	-0.0269	0.0102	-0.0722
	(0.0146)	(0.0358)	(0.0162)	(0.0190)	(0.0105)	(3.351)
Log(Transmission)	0.0504***	0.1861***	0.0426**	0.0939***	-0.0114	-4.078*
	(0.0128)	(0.0520)	(0.0159)	(0.0310)	(0.0111)	(2.421)
Log(Pop. Density)	-0.1676***	-0.9984***	0.2145***	-0.1628***	-0.0559*	15.91
	(0.0526)	(0.3404)	(0.0561)	(0.0538)	(0.0309)	(19.66)
Share Public	-0.1208	-0.1763	-0.0315	-0.0182	-0.0305	5.234
	(0.0822)	(0.3254)	(0.1044)	(0.1040)	(0.0659)	(24.63)
Share Protected	-0.0006	0.0014	-0.0260	-0.0412	0.0502**	22.30*
	(0.0662)	(0.0959)	(0.0388)	(0.0354)	(0.0212)	(12.71)
Log(Dist. Metro Area)	-0.0005	0.0113	-0.0126**	-0.0040	-0.0113**	1.014
	(0.0069)	(0.0151)	(0.0055)	(0.0080)	(0.0047)	(1.604)
Log(Acres Irrigated)	-0.0085**	0.0110	0.0089***	0.0088*	0.0063	-0.5213
	(0.0041)	(0.0133)	(0.0030)	(0.0047)	(0.0039)	(0.9562)
Log(Ag. Products Sold)	0.0084	-0.0702**	0.0120	0.0015	0.0059	2.163
	(0.0057)	(0.0330)	(0.0108)	(0.0064)	(0.0082)	(1.989)
Log(Value/Acre)	0.0250	0.1043	0.0436	-0.0324	0.0704***	16.68*
	(0.0424)	(0.1239)	(0.0411)	(0.0334)	(0.0249)	(9.131)
Perc. Live Off-Farm	0.1534***	0.1509	-0.0933*	0.0468	0.0034	25.15*
	(0.0560)	(0.1539)	(0.0511)	(0.0515)	(0.0595)	(13.86)
Log(Elevation)	0.0400***	-0.2258***	-0.0564***	-0.0463***	-0.0148	-7.518***
	(0.0144)	(0.0767)	(0.0204)	(0.0115)	(0.0094)	(2.728)
Log(Land Area)	0.0265	-0.4345***	0.0911**	-0.1439***	0.0678***	3.103
	(0.0255)	(0.0892)	(0.0355)	(0.0428)	(0.0178)	(3.786)
Dependent variable mean	0.16599	0.59108	0.34925	0.17711	0.92214	37.741
Observations	2,723	447	2,723	951	2,723	2,511
R^2	0.30460	0.35129	0.35998	0.26878	0.16739	0.45028

Notes: OLS estimates. The unit of observation is a county. Columns (1), (3), and (5) use the full county sample; columns (2), (4), and (6) restrict the sample to counties where the respective dependent variable is positive. Observation counts in the intensive-margin columns fall below the number of positive counties implied by the extensive-margin dependent-variable means because fixed-effect singletons (counties that are the only developed observation in their state) are dropped from estimation. *Wind = 1*, *Solar = 1*, and *Easement = 1* are binary indicators equal to one if the county has any installed wind capacity, solar capacity, or conservation easement acreage as of 2024, respectively. *Wind MW/1,000 Acres*, *Solar MW/1,000 Acres*, and *Ease/1,000 Acres* measure megawatts of installed wind capacity, megawatts of installed solar capacity, and conservation easement acres per 1,000 acres of county land area as of 2024, respectively. *Log(Med. Farm Size)* is the natural log of median farm size (acres) from the 2022 Census of Agriculture. *Windiness* is mean wind speed (m/s). *Sunniness* is mean solar irradiance (kWh/m^2/day). *Amenity Rank* is the USDA Natural Amenity Rank, a composite index of climate, topography, and water features. *Log(Transmission)* is the log of total electricity transmission line length (km) within the county. *Log(Pop. Density)* is the log of population per acre. *Share Public* is the share of county land area that is publicly owned. *Share Protected* is the share of county land area under protected status, from the USGS Protected Areas Database (PAD-US) (USGS, 2024c). *Log(Dist. Metro Area)* is the log of distance to the nearest metropolitan area (km). *Log(Acres Irrigated)* is the log of irrigated cropland (acres) from the 2022 Census of Agriculture. *Log(Ag. Products Sold)* is the log of total agricultural products sold (thousands of USD) from the 2022 Census of Agriculture. *Log(Value/Acre)* is the natural log of the average value of farmland and buildings per acre (USD) from the 2022 Census of Agriculture. *Perc. Live Off-Farm* is the share of principal farm operators whose primary residence is not on the farm. *Log(Elevation)* is the log of mean county elevation (m). *Log(Land Area)* is the log of county land area (acres). All regressions include state fixed effects. Standard errors clustered by state in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table 11: County-Level Regression Estimates: Instrumental variable, extensive margin

	Wind = 1 (OLS)	Wind = 1 (IV)	Solar = 1 (OLS)	Solar = 1 (IV)	Ease. = 1 (OLS)	Ease. = 1 (IV)
	(1)	(2)	(3)	(4)	(5)	(6)
Log(Avg. Farm Size)	0.0423**	0.0348	0.0378**	0.0523**	0.0202	0.0154
	(0.0179)	(0.0257)	(0.0181)	(0.0219)	(0.0204)	(0.0215)
Windiness	0.2443***	0.2456***	0.0190	0.0165	0.0194	0.0202
	(0.0323)	(0.0327)	(0.0211)	(0.0212)	(0.0163)	(0.0164)
Sunniness	0.0749	0.0817	0.2794***	0.2663***	-0.1498*	-0.1454*
	(0.0788)	(0.0808)	(0.0833)	(0.0822)	(0.0762)	(0.0769)
Amenity Rank	-0.0037	-0.0038	-0.0274*	-0.0271*	0.0116	0.0115
	(0.0147)	(0.0146)	(0.0160)	(0.0160)	(0.0107)	(0.0107)
Log(Transmission)	0.0560***	0.0551***	0.0499***	0.0517***	-0.0063	-0.0069
	(0.0141)	(0.0137)	(0.0156)	(0.0157)	(0.0120)	(0.0119)
Log(Pop. Density)	-0.1737***	-0.1739***	0.2288***	0.2292***	-0.0359	-0.0361
	(0.0508)	(0.0509)	(0.0577)	(0.0580)	(0.0301)	(0.0301)
Share Public	-0.1138	-0.1151	-0.0158	-0.0132	-0.0253	-0.0261
	(0.0914)	(0.0900)	(0.1044)	(0.1034)	(0.0592)	(0.0589)
Share Protected	-0.0062	-0.0060	-0.0238	-0.0241	0.0543***	0.0544***
	(0.0667)	(0.0668)	(0.0405)	(0.0407)	(0.0194)	(0.0194)
Log(Dist. Metro Area)	-0.0002	-0.0002	-0.0151**	-0.0152**	-0.0118**	-0.0118**
	(0.0068)	(0.0068)	(0.0059)	(0.0058)	(0.0044)	(0.0044)
Log(Acres Irrigated)	-0.0086**	-0.0085**	0.0094***	0.0094***	0.0068*	0.0068*
	(0.0041)	(0.0041)	(0.0030)	(0.0030)	(0.0039)	(0.0039)
Log(Ag. Products Sold)	0.0060	0.0062	0.0139	0.0134	0.0065	0.0067
	(0.0061)	(0.0060)	(0.0100)	(0.0097)	(0.0079)	(0.0079)
Log(Value/Acre)	0.0629	0.0571	0.0743*	0.0856**	0.0907***	0.0870***
	(0.0473)	(0.0521)	(0.0433)	(0.0422)	(0.0314)	(0.0319)
Perc. Live Off-Farm	0.1237**	0.1308**	-0.1410***	-0.1547***	-0.0423	-0.0378
	(0.0528)	(0.0562)	(0.0444)	(0.0456)	(0.0575)	(0.0575)
Log(Elevation)	0.0437**	0.0431**	-0.0548**	-0.0537**	-0.0141*	-0.0144*
	(0.0164)	(0.0168)	(0.0208)	(0.0205)	(0.0079)	(0.0079)
Log(Land Area)	0.0126	0.0146	0.0736**	0.0697**	0.0563***	0.0576***
	(0.0263)	(0.0249)	(0.0348)	(0.0343)	(0.0173)	(0.0172)
Dependent variable mean	0.16556	0.16556	0.34775	0.34775	0.92276	0.92276
Observations	2,706	2,706	2,706	2,706	2,706	2,706
R^2	0.30783	0.30690	0.36160	0.36204	0.16771	0.16724
First-stage F		948.6		948.6		948.6

Notes: OLS and instrumental-variable (2SLS) estimates. The unit of observation is a county, using the full county sample. Columns (1)–(2) report estimates for the presence of wind, columns (3)–(4) for the presence of solar, and columns (5)–(6) for the presence of an easement; odd-numbered columns are OLS and even-numbered columns are IV. *Wind = 1*, *Solar = 1*, and *Easement = 1* are binary indicators equal to one if the county has any installed wind capacity, solar capacity, or conservation easement acreage as of 2024, respectively. *Log(Avg. Farm Size)* is the natural log of mean farm size (acres) from the 2022 Census of Agriculture; in the IV columns it is instrumented with the natural log of mean farm size from the 2002 Census of Agriculture. The estimation sample excludes 17 counties with mismeasured 2002 farm-size values (12 zero-coded, five affected by the census's expanded enumeration of American Indian reservations from 2007); see section 3.4. *First-stage F* is the cluster-robust first-stage F-statistic on the excluded instrument. *Windiness* is mean wind speed (m/s). *Sunniness* is mean solar irradiance (kWh/m^2/day). *Amenity Rank* is the USDA Natural Amenity Rank, a composite index of climate, topography, and water features. *Log(Transmission)* is the log of total electricity transmission line length (km) within the county. *Log(Pop. Density)* is the log of population per acre. *Share Public* is the share of county land area that is publicly owned. *Share Protected* is the share of county land area under protected status, from the USGS Protected Areas Database (PAD-US) (USGS, 2024c). *Log(Dist. Metro Area)* is the log of distance to the nearest metropolitan area (km). *Log(Acres Irrigated)* is the log of irrigated cropland (acres) from the 2022 Census of Agriculture. *Log(Ag. Products Sold)* is the log of total agricultural products sold (thousands of USD) from the 2022 Census of Agriculture. *Log(Value/Acre)* is the natural log of the average value of farmland and buildings per acre (USD) from the 2022 Census of Agriculture. *Perc. Live Off-Farm* is the share of principal farm operators whose primary residence is not on the farm. *Log(Elevation)* is the log of mean county elevation (m). *Log(Land Area)* is the log of county land area (acres). All regressions include state fixed effects. Standard errors clustered by state in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table 12: County-Level Regression Estimates: Instrumental variable, intensive margin

	Wind MW/1,000 Acres OLS (1)	Wind MW/1,000 Acres IV (2)	Solar MW/1,000 Acres OLS (3)	Solar MW/1,000 Acres IV (4)	Ease. Acres/1,000 OLS (5)	Ease. Acres/1,000 IV (6)
Log(Avg. Farm Size)	0.1279	0.1947	0.0920***	0.1061***	13.79**	13.76**
	(0.1071)	(0.1191)	(0.0274)	(0.0347)	(5.259)	(6.510)
Windiness	0.4254***	0.4198***	-0.0329*	-0.0356*	-4.529	-4.524
	(0.1411)	(0.1385)	(0.0188)	(0.0200)	(2.764)	(2.720)
Sunniness	0.0660	0.0120	0.1502*	0.1387	-12.91	-12.88
	(0.3509)	(0.3495)	(0.0814)	(0.0836)	(29.95)	(29.03)
Amenity Rank	-0.0197	-0.0181	-0.0286	-0.0287	0.3274	0.3265
	(0.0391)	(0.0394)	(0.0179)	(0.0180)	(3.291)	(3.315)
Log(Transmission)	0.1930***	0.1994***	0.1057***	0.1081***	-2.385	-2.389
	(0.0490)	(0.0496)	(0.0341)	(0.0351)	(2.468)	(2.369)
Log(Pop. Density)	-1.016***	-0.9799***	-0.1788***	-0.1794***	16.23	16.22
	(0.3512)	(0.3368)	(0.0587)	(0.0590)	(19.29)	(19.30)
Share Public	-0.1951	-0.1845	-0.0040	-0.0010	7.659	7.655
	(0.3397)	(0.3358)	(0.1008)	(0.1023)	(25.93)	(26.11)
Share Protected	-0.0074	-0.0020	-0.0479	-0.0481	21.85	21.86
	(0.0981)	(0.1010)	(0.0378)	(0.0381)	(13.11)	(13.15)
Log(Dist. Metro Area)	0.0095	0.0067	-0.0034	-0.0034	0.9623	0.9625
	(0.0140)	(0.0138)	(0.0076)	(0.0076)	(1.561)	(1.569)
Log(Acres Irrigated)	0.0135	0.0149	0.0079*	0.0079*	-0.6178	-0.6177
	(0.0140)	(0.0140)	(0.0047)	(0.0047)	(0.9549)	(0.9479)
Log(Ag. Products Sold)	-0.0676**	-0.0666**	0.0007	0.0002	1.782	1.783
	(0.0322)	(0.0311)	(0.0067)	(0.0070)	(2.070)	(2.070)
Log(Value/Acre)	0.2124	0.2741	0.0318	0.0441	27.52**	27.49**
	(0.2037)	(0.2069)	(0.0418)	(0.0426)	(12.19)	(12.68)
Perc. Live Off-Farm	0.1526	0.1314	-0.0241	-0.0398	12.04	12.07
	(0.1401)	(0.1314)	(0.0418)	(0.0497)	(13.79)	(16.19)
Log(Elevation)	-0.2163**	-0.2102**	-0.0412***	-0.0408***	-6.595**	-6.597**
	(0.0804)	(0.0798)	(0.0108)	(0.0108)	(2.705)	(2.706)
Log(Land Area)	-0.4688***	-0.4908***	-0.1623***	-0.1654***	-0.5480	-0.5398
	(0.0785)	(0.0812)	(0.0457)	(0.0468)	(3.793)	(3.796)
Dependent variable mean	0.59613	0.59613	0.17775	0.17775	37.891	37.891
Observations	443	443	941	941	2,497	2,497
R^2	0.35199	0.35723	0.27845	0.27838	0.45433	0.45330
First-stage F		1322.2		858.0		943.4

Notes: OLS and instrumental-variable (2SLS) estimates. The unit of observation is a county, restricted in each pair of columns to counties with positive wind, solar, or easement development respectively. Columns (1)–(2) report estimates for wind capacity density, columns (3)–(4) for solar capacity density, and columns (5)–(6) for easement density; odd-numbered columns are OLS and even-numbered columns are IV. *Wind MW/1,000 Acres*, *Solar MW/1,000 Acres*, and *Ease. Acres/1,000 Acres* measure megawatts of installed wind capacity, megawatts of installed solar capacity, and conservation easement acres per 1,000 acres of county land area as of 2024, respectively. *Log(Avg. Farm Size)* is the natural log of mean farm size (acres) from the 2022 Census of Agriculture; in the IV columns it is instrumented with the natural log of mean farm size from the 2002 Census of Agriculture. The estimation sample excludes 17 counties with mismeasured 2002 farm-size values (12 zero-coded, five affected by the census's expanded enumeration of American Indian reservations from 2007); see section 3.4. *First-stage F* is the cluster-robust first-stage F-statistic on the excluded instrument. *Windiness* is mean wind speed (m/s). *Sunniness* is mean solar irradiance (kWh/m^2/day). *Amenity Rank* is the USDA Natural Amenity Rank, a composite index of climate, topography, and water features. *Log(Transmission)* is the log of total electricity transmission line length (km) within the county. *Log(Pop. Density)* is the log of population per acre. *Share Public* is the share of county land area that is publicly owned. *Share Protected* is the share of county land area under protected status, from the USGS Protected Areas Database (PAD-US) (USGS, 2024c). *Log(Dist. Metro Area)* is the log of distance to the nearest metropolitan area (km). *Log(Acres Irrigated)* is the log of irrigated cropland (acres) from the 2022 Census of Agriculture. *Log(Ag. Products Sold)* is the log of total agricultural products sold (thousands of USD) from the 2022 Census of Agriculture. *Log(Value/Acre)* is the natural log of the average value of farmland and buildings per acre (USD) from the 2022 Census of Agriculture. *Perc. Live Off-Farm* is the share of principal farm operators whose primary residence is not on the farm. *Log(Elevation)* is the log of mean county elevation (m). *Log(Land Area)* is the log of county land area (acres). All regressions include state fixed effects. Standard errors clustered by state in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table 13: County-Level Instrumental Variable: First stage

	All Counties (1)	Wind Counties (2)	Solar Counties (3)	Ease. Counties (4)
Log(Avg. Farm Size, 2002)	0.9022***	0.9863***	0.8858***	0.8953***
	(0.0293)	(0.0271)	(0.0302)	(0.0291)
Dependent variable mean	5.9212	6.6317	5.7150	5.8942
Observations	2,706	443	941	2,497
R^2	0.96607	0.96882	0.96168	0.96450
First-stage F	948.6	1322.2	858.0	943.4

Notes: First-stage estimates from the instrumental-variable specification. The unit of observation is a county. The dependent variable is *Log(Avg. Farm Size)* from the 2022 Census of Agriculture. *Log(Avg. Farm Size, 2002)*, the excluded instrument, is the natural log of mean farm size from the 2002 Census of Agriculture. Column (1) uses the full county sample; columns (2), (3), and (4) restrict the sample to counties with positive wind, solar, and easement development respectively, matching the samples used in the corresponding second-stage regressions. The estimation sample excludes 17 counties with mismeasured 2002 farm-size values (12 zero-coded, five affected by the census's expanded enumeration of American Indian reservations from 2007); see section 3.4. All regressions include state fixed effects and the full vector of controls reported in Table 3, with standard errors clustered by state in parentheses. *First-stage F* is the cluster-robust first-stage F-statistic on the excluded instrument. *p<0.1; **p<0.05; ***p<0.01.

Table 14: County-Level Logit Estimates: Average partial effects

	Wind = 1 (1)	Solar = 1 (2)	Easement = 1 (3)
Log(Avg. Farm Size)	0.0507***	0.0351*	0.0107
	(0.0137)	(0.0180)	(0.0110)
Windiness	0.2654***	0.0299	0.0080
	(0.0172)	(0.0188)	(0.0137)
Sunniness	0.0069	0.3111***	-0.1047***
	(0.0479)	(0.0611)	(0.0396)
Amenity Rank	-0.0029	-0.0305**	0.0124
	(0.0100)	(0.0129)	(0.0089)
Log(Transmission)	0.0366***	0.0622***	-0.0101
	(0.0098)	(0.0142)	(0.0070)
Log(Pop. Density)	-0.2422***	0.1495***	0.0068
	(0.0858)	(0.0545)	(0.0429)
Share Public	-0.1315*	0.0263	-0.0175
	(0.0673)	(0.0820)	(0.0594)
Share Protected	-0.0148	-0.0327	0.0486**
	(0.0198)	(0.0310)	(0.0240)
Log(Dist. Metro Area)	-0.0058	-0.0127**	-0.0090**
	(0.0042)	(0.0053)	(0.0038)
Log(Acres Irrigated)	-0.0028	0.0096***	0.0049**
	(0.0024)	(0.0033)	(0.0019)
Log(Ag. Products Sold)	0.0096	0.0093	0.0050
	(0.0085)	(0.0073)	(0.0044)
Log(Value/Acre)	0.0594***	0.0904***	0.0995***
	(0.0225)	(0.0277)	(0.0191)
Perc. Live Off-Farm	0.0644**	-0.1551***	-0.0004
	(0.0306)	(0.0455)	(0.0255)
Log(Elevation)	-0.0266**	-0.0522***	-0.0239**
	(0.0123)	(0.0104)	(0.0102)
Log(Land Area)	0.0462**	0.0652***	0.0739***
	(0.0198)	(0.0237)	(0.0148)
Dependent variable mean	0.21710	0.33476	0.89167
Observations	2,082	2,578	1,957
Pseudo R^2	0.33626	0.27851	0.23427

Notes: Logit models are estimated by maximum likelihood with fixed effects absorbed following Stammann (2018). Columns report average partial effects, with analytic standard errors following Fernández-Val and Weidner (2016) in parentheses. The unit of observation is a county. The sample includes all counties with available data; states in which the outcome does not vary carry no information in a fixed-effects logit and drop from estimation, which accounts for the smaller observation counts. *Wind = 1* is an indicator equal to one if the county has any installed wind generation capacity as of 2024. *Solar = 1* is an indicator equal to one if the county has any installed solar generation capacity as of 2024. *Easement = 1* is an indicator equal to one if the county has any conservation easement acreage as of 2024. *Log(Avg. Farm Size)* is the natural log of mean farm size (acres) from the 2022 Census of Agriculture. *Windiness* is mean wind speed (m/s). *Sunniness* is mean solar irradiance (kWh/m^2/day). *Amenity Rank* is the USDA Natural Amenity Rank, a composite index of climate, topography, and water features. *Log(Transmission)* is the log of total electricity transmission line length (km) within the county. *Log(Pop. Density)* is the log of population per acre. *Share Public* is the share of county land area that is publicly owned. *Share Protected* is the share of county land area under protected status, from the USGS Protected Areas Database (PAD-US) (USGS, 2024c). *Log(Dist. Metro Area)* is the log of distance to the nearest metropolitan area (km). *Log(Acres Irrigated)* is the log of irrigated cropland (acres) from the 2022 Census of Agriculture. *Log(Ag. Products Sold)* is the log of total agricultural products sold (thousands of USD) from the 2022 Census of Agriculture. *Log(Value/Acre)* is the natural log of the average value of farmland and buildings per acre (USD) from the 2022 Census of Agriculture. *Perc. Live Off-Farm* is the share of principal farm operators whose primary residence is not on the farm. *Log(Elevation)* is the log of mean county elevation (m). *Log(Land Area)* is the log of county land area (acres). All models absorb state fixed effects. *p<0.1; **p<0.05; ***p<0.01.

Appendix E: Section Results

Table 15: Section-Level Regression Estimates: Standard errors clustered at the township level

	Wind = 1	Wind MW/1,000 Acres | MW > 0	Solar = 1	Solar MW/1,000 Acres | MW > 0	Easement = 1	Ease/1,000 Acres | Acres > 0
	(1)	(2)	(3)	(4)	(5)	(6)
Inv. HHI	0.0007	-0.0993***	7.84×10^{-6}	-0.7916	0.0034***	-2.454***
	(0.0005)	(0.0186)	(0.0002)	(1.729)	(0.0004)	(0.6738)
Windiness	0.0605***	0.6166***	0.0014	14.50	0.0055**	-1.715
	(0.0043)	(0.2090)	(0.0012)	(18.26)	(0.0025)	(6.467)
Sunniness	0.0715	-2.920	-0.0090	-111.7	-0.1819***	-223.0**
	(0.0661)	(2.851)	(0.0173)	(272.0)	(0.0352)	(95.90)
Conservation Value	-0.0174***	0.0057	-0.0004	-10.10*	0.0082***	38.85***
	(0.0031)	(0.0740)	(0.0015)	(5.658)	(0.0016)	(3.587)
Airport <5km	-0.0208***	-0.1416	-0.0025		-0.0041	0.3518
	(0.0046)	(0.3016)	(0.0038)		(0.0042)	(6.979)
Transmission <5km	0.0196***	0.1051	0.0054***	-0.7680	0.0015	-1.266
	(0.0024)	(0.0682)	(0.0010)	(4.015)	(0.0014)	(2.531)
Dist. to Rail	-0.0003	-0.0058	0.0001	1.821	0.0004**	0.2982
	(0.0003)	(0.0091)	(0.0001)	(1.743)	(0.0002)	(0.3355)
Dist. to Road	0.0010***	0.0090	-7.17×10^{-5}	0.5374	-0.0002	-0.7093*
	(0.0004)	(0.0105)	(0.0002)	(1.157)	(0.0002)	(0.3961)
Log(Elevation)	0.0893***	5.533***	0.0032	385.6	-0.0015	60.22***
	(0.0162)	(0.8581)	(0.0032)	(339.4)	(0.0124)	(22.45)
Slope	0.0167**	0.7403	-0.0031*	280.0	-0.0195***	-66.39***
	(0.0065)	(0.5540)	(0.0018)	(236.1)	(0.0036)	(13.21)
Ruggedness	-0.0474***	-2.166	0.0073	-809.9	0.0512***	175.8***
	(0.0175)	(1.546)	(0.0049)	(676.8)	(0.0096)	(35.79)
Soil	5.69×10^{-9}	1.11×10^{-7}	-1.05×10^{-9}	-8.25×10^{-7}	1.8×10^{-9}	-2.46×10^{-7}
	(1×10^{-6})	(1×10^{-6})	(1×10^{-6})	(1.06×10^{-5})	(1×10^{-6})	(3.74×10^{-6})
Log(Area)	0.0035***	-2.327***	0.0018**	-513.9***	0.0091***	-6.937
	(0.0013)	(0.7819)	(0.0008)	(65.37)	(0.0015)	(9.647)
Share Public	-0.0244	-1.336	0.0097	-2.503	0.1221***	-55.56**
	(0.0155)	(0.9540)	(0.0094)	(40.29)	(0.0185)	(21.73)
Share Developed	0.2442***	6.148***	0.0960***	-58.72	-0.0428***	-191.0***
	(0.0254)	(1.567)	(0.0279)	(51.67)	(0.0161)	(38.30)
Dependent variable mean	0.04197	2.5016	0.00472	81.496	0.05428	70.804
Observations	163,695	6,561	107,858	393	340,592	17,042
R^2	0.46776	0.46409	0.29894	0.94058	0.55761	0.29229

Notes: OLS estimates. The unit of observation is a PLSS First Division section. The sample is restricted to sections where at least 75% of land area is undeveloped and at least 75% is privately owned. The sample further excludes sections within counties with no wind, solar, or easement development respectively. Columns (1), (3), and (5) use the full section sample; columns (2), (4), and (6) restrict the sample to sections where the respective dependent variable is positive. Observation counts in the intensive-margin columns fall below the number of positive sections implied by the extensive-margin dependent-variable means because fixed-effect singletons (sections that are the only developed observation in their fixed-effect group) are dropped from estimation. A blank coefficient cell indicates that an indicator control was dropped from that regression because it had no within-fixed-effect variation in the subsample. *Wind = 1*, *Solar = 1*, and *Easement = 1* are binary indicators equal to one if the section has any installed wind capacity, solar capacity, or conservation easement acreage as of 2024, respectively. *Wind MW/1,000 Acres*, *Solar MW/1,000 Acres*, and *Ease/1,000 Acres* measure megawatts of installed wind capacity, megawatts of installed solar capacity, and conservation easement acres per 1,000 section acres as of 2024, respectively. *Inv. HHI* is the inverse of the Herfindahl-Hirschman Index (HHI) of land ownership concentration derived from parcels greater than 20 acres within the section; higher values indicate greater fragmentation and can be interpreted as the number of equal-share landowner equivalents. *Windiness* is mean wind speed (m/s). *Sunniness* is mean solar irradiance (kWh/m^2/day). *Conservation Value* is a land conservation priority score. *Airport <5km* is an indicator equal to one if an airport lies within 5 km of the section centroid. *Transmission <5km* is an indicator equal to one if an electricity transmission line passes within 5 km of the section centroid. *Dist. to Rail* is distance to the nearest railroad (km). *Dist. to Road* is distance to the nearest road (km). *Log(Elevation)* is the log of mean section elevation (m). *Slope* is mean terrain slope (degrees). *Ruggedness* is the Terrain Ruggedness Index (TRI). *Soil* is a composite soil quality index. *Log(Area)* is the natural log of section area (acres), included to control for the mechanical tendency of larger sections to contain development. *Share Public* is the share of section land area that is publicly owned. *Share Developed* is the share of section land area classified as developed. All regressions include township, multi-subcounty, and GAP fixed effects. Standard errors clustered by township in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table 16: Section-Level Regression Estimates: Subcounty fixed effects and errors clustered at the subcounty level

	Wind = 1	Wind MW/1,000 Acres | MW > 0	Solar = 1	Solar MW/1,000 Acres | MW > 0	Easement = 1	Ease. Acres/1,000 Acres | Acres > 0
	(1)	(2)	(3)	(4)	(5)	(6)
Inv. HHI	0.0002	-0.1149***	-9.91×10^{-5}	2.580	0.0036***	-2.425***
	(0.0007)	(0.0186)	(0.0002)	(1.943)	(0.0005)	(0.5828)
Windiness	0.0582***	0.8751***	-0.0005	10.35	0.0021	4.112
	(0.0055)	(0.1659)	(0.0007)	(12.39)	(0.0021)	(2.571)
Sunniness	0.0760	0.1847	0.0061	-350.9*	-0.1122***	-102.6***
	(0.0586)	(1.707)	(0.0080)	(201.4)	(0.0241)	(30.01)
Conservation Value	-0.0184***	0.1185	-0.0009	-15.88*	0.0094***	31.79***
	(0.0055)	(0.0942)	(0.0017)	(9.261)	(0.0025)	(3.312)
Airport <5km	-0.0289***	-0.2587*	-0.0012	-33.83**	-0.0021	1.831
	(0.0059)	(0.1490)	(0.0028)	(14.79)	(0.0040)	(5.852)
Transmission <5km	0.0346***	0.0941	0.0076***	-1.348	-0.0018	-1.330
	(0.0041)	(0.0620)	(0.0010)	(10.45)	(0.0016)	(2.136)
Dist. to Rail	-0.0003	-0.0097*	-2.9×10^{-5}	-0.3550	4.1×10^{-5}	-0.1125
	(0.0002)	(0.0055)	(5.23×10^{-5})	(0.5999)	(7.61×10^{-5})	(0.1602)
Dist. to Road	0.0006*	0.0006	4.3×10^{-5}	2.419*	1×10^{-5}	-0.0133
	(0.0003)	(0.0087)	(6.67×10^{-5})	(1.269)	(0.0001)	(0.2548)
Log(Elevation)	0.0375*	0.5981	0.0037	87.33	-0.0046	9.783
	(0.0196)	(0.6624)	(0.0025)	(88.28)	(0.0078)	(11.18)
Slope	-0.0032	0.4313	-0.0031***	134.0	-0.0170***	-39.58***
	(0.0108)	(0.5697)	(0.0011)	(123.1)	(0.0041)	(11.44)
Ruggedness	0.0056	-1.365	0.0074**	-382.2	0.0451***	104.2***
	(0.0290)	(1.633)	(0.0030)	(338.0)	(0.0109)	(31.51)
Soil	2.58×10^{-9}	1.39×10^{-7}	-3.27×10^{-10}	1.5×10^{-5}	3.77×10^{-9}	3.32×10^{-7}
	(1×10^{-6})	(1×10^{-6})	(1×10^{-6})	(1.11×10^{-5})	(1×10^{-6})	(2.31×10^{-6})
Log(Area)	0.0094***	-2.353***	0.0017***	-417.1***	0.0129***	-3.184
	(0.0021)	(0.4487)	(0.0006)	(26.86)	(0.0015)	(5.600)
Share Public	-0.0362**	-1.892	0.0177**	-17.35	0.1248***	-64.27***
	(0.0175)	(1.553)	(0.0084)	(42.17)	(0.0246)	(18.59)
Share Developed	0.2174***	8.174***	0.0748***	-114.1	-0.0092	-184.4***
	(0.0449)	(1.541)	(0.0284)	(81.42)	(0.0168)	(35.87)
Dependent variable mean	0.04181	2.4998	0.00479	79.246	0.05450	69.731
Observations	164,726	6,777	109,775	455	344,122	18,007
R^2	0.21147	0.34710	0.07897	0.83916	0.45567	0.19989

Notes: OLS estimates. The unit of observation is a PLSS First Division section. The sample is restricted to sections where at least 75% of land area is undeveloped and at least 75% is privately owned. The sample further excludes sections within counties with no wind, solar, or easement development respectively. Columns (1), (3), and (5) use the full section sample; columns (2), (4), and (6) restrict the sample to sections where the respective dependent variable is positive. Observation counts in the intensive-margin columns fall below the number of positive sections implied by the extensive-margin dependent-variable means because fixed-effect singletons (sections that are the only developed observation in their fixed-effect group) are dropped from estimation. A blank coefficient cell indicates that an indicator control was dropped from that regression because it had no within-fixed-effect variation in the subsample. *Wind = 1*, *Solar = 1*, and *Easement = 1* are binary indicators equal to one if the section has any installed wind capacity, solar capacity, or conservation easement acreage as of 2024, respectively. *Wind MW/1,000 Acres*, *Solar MW/1,000 Acres*, and *Ease/1,000 Acres* measure megawatts of installed wind capacity, megawatts of installed solar capacity, and conservation easement acres per 1,000 section acres as of 2024, respectively. *Inv. HHI* is the inverse of the Herfindahl-Hirschman Index (HHI) of land ownership concentration derived from parcels greater than 20 acres within the section; higher values indicate greater fragmentation and can be interpreted as the number of equal-share landowner equivalents. *Windiness* is mean wind speed (m/s). *Sunniness* is mean solar irradiance (kWh/m^2/day). *Conservation Value* is a land conservation priority score. *Airport <5km* is an indicator equal to one if an airport lies within 5 km of the section centroid. *Transmission <5km* is an indicator equal to one if an electricity transmission line passes within 5 km of the section centroid. *Dist. to Rail* is distance to the nearest railroad (km). *Dist. to Road* is distance to the nearest road (km). *Log(Elevation)* is the log of mean section elevation (m). *Slope* is mean terrain slope (degrees). *Ruggedness* is the Terrain Ruggedness Index (TRI). *Soil* is a composite soil quality index. *Log(Area)* is the natural log of section area (acres), included to control for the mechanical tendency of larger sections to contain development. *Share Public* is the share of section land area that is publicly owned. *Share Developed* is the share of section land area classified as developed. All regressions include subcounty, multi-subcounty, and GAP fixed effects. Standard errors clustered by subcounty in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table 17: Section-Level Regression Estimates: >50% Private and Undeveloped

	Wind = 1	Wind MW/1,000 Acres | MW > 0	Solar = 1	Solar MW/1,000 Acres | MW > 0	Easement = 1	Ease. Acres/1,000 Acres | Acres > 0
	(1)	(2)	(3)	(4)	(5)	(6)
Inv. HHI	0.0008	-0.1042***	3.87×10^{-5}	-1.689	0.0031***	-2.943***
	(0.0005)	(0.0232)	(0.0002)	(2.732)	(0.0005)	(0.7353)
Windiness	0.0567***	0.6281***	0.0011	19.69	0.0038	-2.198
	(0.0061)	(0.2089)	(0.0012)	(18.80)	(0.0032)	(6.220)
Sunniness	0.0679	-2.672	-0.0023	-69.43	-0.1838***	-168.0**
	(0.0643)	(3.591)	(0.0173)	(292.0)	(0.0382)	(82.93)
Conservation Value	-0.0179***	0.0205	-0.0004	-13.96*	0.0090***	36.23***
	(0.0040)	(0.0815)	(0.0016)	(8.190)	(0.0020)	(4.488)
Airport <5km	-0.0197***	-0.1278	-0.0020	-47.88***	-0.0014	3.274
	(0.0048)	(0.3031)	(0.0036)	(13.27)	(0.0047)	(7.360)
Transmission <5km	0.0198***	0.1323*	0.0055***	-0.6396	0.0012	-0.7078
	(0.0033)	(0.0803)	(0.0012)	(4.296)	(0.0015)	(2.429)
Dist. to Rail	-0.0002	-0.0028	9.87×10^{-5}	2.118	0.0004**	0.3232
	(0.0003)	(0.0106)	(0.0001)	(1.885)	(0.0002)	(0.3476)
Dist. to Road	0.0010**	0.0067	-2.36×10^{-5}	0.5674	-0.0001	-0.6168
	(0.0005)	(0.0125)	(0.0002)	(1.173)	(0.0002)	(0.4265)
Log(Elevation)	0.0838***	5.447***	0.0039	290.2	-0.0075	46.76**
	(0.0217)	(1.072)	(0.0027)	(422.6)	(0.0147)	(22.73)
Slope	0.0144*	0.6457	-0.0032*	262.4	-0.0223***	-51.27***
	(0.0079)	(0.7640)	(0.0017)	(263.2)	(0.0044)	(13.25)
Ruggedness	-0.0412**	-1.927	0.0077*	-757.6	0.0590***	135.3***
	(0.0209)	(2.134)	(0.0046)	(752.7)	(0.0120)	(35.95)
Soil	5.25×10^{-9}	9.16×10^{-8}	-1.14×10^{-9}	-4.53×10^{-7}	6.25×10^{-10}	5.72×10^{-7}
	(1×10^{-6})	(1×10^{-6})	(1×10^{-6})	(1.03×10^{-5})	(1×10^{-6})	(3.52×10^{-6})
Log(Area)	0.0031**	-2.369***	0.0017***	-512.7***	0.0114***	-1.670
	(0.0014)	(0.7364)	(0.0006)	(19.10)	(0.0017)	(8.055)
Share Public	-0.0098	-1.943***	0.0034	-19.53	0.0396***	-47.68***
	(0.0065)	(0.4766)	(0.0037)	(21.74)	(0.0092)	(11.87)
Share Developed	0.2165***	6.650***	0.0852***	-34.65	-0.0376**	-170.2***
	(0.0374)	(1.939)	(0.0269)	(55.40)	(0.0188)	(40.19)
Dependent variable mean	0.04074	2.5011	0.00474	80.206	0.05775	70.925
Observations	173,597	6,755	119,486	432	372,567	19,816
R^2	0.46323	0.45517	0.30417	0.93731	0.55060	0.28276

Notes: OLS estimates. The unit of observation is a PLSS First Division section. The sample is restricted to sections where at least 50% of land area is undeveloped and at least 50% is privately owned. The sample further excludes sections within counties with no wind, solar, or easement development respectively. Columns (1), (3), and (5) use the full section sample; columns (2), (4), and (6) restrict the sample to sections where the respective dependent variable is positive. Observation counts in the intensive-margin columns fall below the number of positive sections implied by the extensive-margin dependent-variable means because fixed-effect singletons (sections that are the only developed observation in their fixed-effect group) are dropped from estimation. A blank coefficient cell indicates that an indicator control was dropped from that regression because it had no within-fixed-effect variation in the subsample. *Wind = 1*, *Solar = 1*, and *Easement = 1* are binary indicators equal to one if the section has any installed wind capacity, solar capacity, or conservation easement acreage as of 2024, respectively. *Wind MW/1,000 Acres*, *Solar MW/1,000 Acres*, and *Ease/1,000 Acres* measure megawatts of installed wind capacity, megawatts of installed solar capacity, and conservation easement acres per 1,000 section acres as of 2024, respectively. *Inv. HHI* is the inverse of the Herfindahl-Hirschman Index (HHI) of land ownership concentration derived from parcels greater than 20 acres within the section; higher values indicate greater fragmentation and can be interpreted as the number of equal-share landowner equivalents. *Windiness* is mean wind speed (m/s). *Sunniness* is mean solar irradiance (kWh/m^2/day). *Conservation Value* is a land conservation priority score. *Airport <5km* is an indicator equal to one if an airport lies within 5 km of the section centroid. *Transmission <5km* is an indicator equal to one if an electricity transmission line passes within 5 km of the section centroid. *Dist. to Rail* is distance to the nearest railroad (km). *Dist. to Road* is distance to the nearest road (km). *Log(Elevation)* is the log of mean section elevation (m). *Slope* is mean terrain slope (degrees). *Ruggedness* is the Terrain Ruggedness Index (TRI). *Soil* is a composite soil quality index. *Log(Area)* is the natural log of section area (acres), included to control for the mechanical tendency of larger sections to contain development. *Share Public* is the share of section land area that is publicly owned. *Share Developed* is the share of section land area classified as developed. All regressions include township, multi-subcounty, and GAP fixed effects. Conley standard errors (20 km cutoff) in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table 18: Section-Level Regression Estimates: >90% Private and Undeveloped

	Wind = 1	Wind MW/1,000 Acres | MW > 0	Solar = 1	Solar MW/1,000 Acres | MW > 0	Easement = 1	Ease. Acres/1,000 Acres | Acres > 0
	(1)	(2)	(3)	(4)	(5)	(6)
Inv. HHI	0.0008	-0.1061***	0.0001	-0.8001	0.0029***	-2.369**
	(0.0006)	(0.0237)	(0.0002)	(2.990)	(0.0005)	(0.9319)
Windiness	0.0668***	0.4625**	0.0015	4.801	0.0077**	4.521
	(0.0072)	(0.2250)	(0.0016)	(17.47)	(0.0035)	(8.669)
Sunniness	0.0702	-2.501	0.0098	192.3	-0.1810***	-214.8*
	(0.0777)	(3.490)	(0.0229)	(350.7)	(0.0399)	(127.1)
Conservation Value	-0.0169***	0.0196	-0.0002	-4.705	0.0069***	41.48***
	(0.0042)	(0.0817)	(0.0018)	(7.125)	(0.0019)	(5.652)
Airport <5km	-0.0214***	-0.1446	-0.0027		-0.0026	2.742
	(0.0049)	(0.3106)	(0.0045)		(0.0046)	(8.752)
Transmission <5km	0.0206***	0.1316	0.0056***	-2.902	0.0018	-0.3037
	(0.0037)	(0.0828)	(0.0014)	(5.842)	(0.0015)	(3.248)
Dist. to Rail	-0.0004	-0.0051	0.0001	1.813	0.0004**	0.1589
	(0.0004)	(0.0109)	(0.0001)	(2.193)	(0.0002)	(0.4502)
Dist. to Road	0.0011**	0.0042	-5.7×10^{-5}	0.8140	-0.0001	-1.120**
	(0.0005)	(0.0129)	(0.0002)	(1.364)	(0.0002)	(0.5631)
Log(Elevation)	0.0902***	5.364***	0.0022	537.6	-0.0049	29.22
	(0.0254)	(0.9819)	(0.0034)	(593.3)	(0.0185)	(32.97)
Slope	0.0211**	0.6009	-0.0039	351.5	-0.0153***	-65.60***
	(0.0103)	(0.8226)	(0.0026)	(308.6)	(0.0043)	(18.87)
Ruggedness	-0.0591**	-1.742	0.0094	-1,016.5	0.0400***	174.7***
	(0.0275)	(2.306)	(0.0069)	(881.1)	(0.0116)	(51.24)
Soil	6.65×10^{-9}	1.66×10^{-7}	-9.67×10^{-10}	-7.97×10^{-6}	1.11×10^{-9}	1.21×10^{-6}
	(1×10^{-6})	(1×10^{-6})	(1×10^{-6})	(5.74×10^{-6})	(1×10^{-6})	(3.95×10^{-6})
Log(Area)	0.0035**	-2.415***	0.0019***	-518.5***	0.0072***	-13.59
	(0.0014)	(0.7587)	(0.0007)	(19.33)	(0.0017)	(12.41)
Share Public	-0.0290	-8.179**	0.0455	231.5	0.3867***	-27.28
	(0.0588)	(3.591)	(0.0401)	(161.6)	(0.0939)	(142.8)
Share Developed	0.2698***	7.428***	0.0892***	54.67	-0.0413*	-205.6***
	(0.0489)	(1.604)	(0.0298)	(118.1)	(0.0229)	(55.71)
Dependent variable mean	0.04339	2.5108	0.00458	86.490	0.04433	67.447
Observations	148,598	6,146	96,175	338	301,120	12,074
R^2	0.47237	0.47494	0.27341	0.94407	0.53107	0.32108

Notes: OLS estimates. The unit of observation is a PLSS First Division section. The sample is restricted to sections where at least 90% of land area is undeveloped and at least 90% is privately owned. The sample further excludes sections within counties with no wind, solar, or easement development respectively. Columns (1), (3), and (5) use the full section sample; columns (2), (4), and (6) restrict the sample to sections where the respective dependent variable is positive. Observation counts in the intensive-margin columns fall below the number of positive sections implied by the extensive-margin dependent-variable means because fixed-effect singletons (sections that are the only developed observation in their fixed-effect group) are dropped from estimation. A blank coefficient cell indicates that an indicator control was dropped from that regression because it had no within-fixed-effect variation in the subsample. *Wind = 1*, *Solar = 1*, and *Easement = 1* are binary indicators equal to one if the section has any installed wind capacity, solar capacity, or conservation easement acreage as of 2024, respectively. *Wind MW/1,000 Acres*, *Solar MW/1,000 Acres*, and *Ease/1,000 Acres* measure megawatts of installed wind capacity, megawatts of installed solar capacity, and conservation easement acres per 1,000 section acres as of 2024, respectively. *Inv. HHI* is the inverse of the Herfindahl-Hirschman Index (HHI) of land ownership concentration derived from parcels greater than 20 acres within the section; higher values indicate greater fragmentation and can be interpreted as the number of equal-share landowner equivalents. *Windiness* is mean wind speed (m/s). *Sunniness* is mean solar irradiance (kWh/m^2/day). *Conservation Value* is a land conservation priority score. *Airport <5km* is an indicator equal to one if an airport lies within 5 km of the section centroid. *Transmission <5km* is an indicator equal to one if an electricity transmission line passes within 5 km of the section centroid. *Dist. to Rail* is distance to the nearest railroad (km). *Dist. to Road* is distance to the nearest road (km). *Log(Elevation)* is the log of mean section elevation (m). *Slope* is mean terrain slope (degrees). *Ruggedness* is the Terrain Ruggedness Index (TRI). *Soil* is a composite soil quality index. *Log(Area)* is the natural log of section area (acres), included to control for the mechanical tendency of larger sections to contain development. *Share Public* is the share of section land area that is publicly owned. *Share Developed* is the share of section land area classified as developed. All regressions include township, multi-subcounty, and GAP fixed effects. Conley standard errors (20 km cutoff) in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table 19: Section-Level Regression Estimates: Combined intensive and extensive margins

	Wind MW/1,000 Acres (1)	Solar MW/1,000 Acres (2)	Ease. Acres/1,000 Acres (3)
Inv. HHI	-0.0022	0.0013	0.0889
	(0.0015)	(0.0214)	(0.0596)
Windiness	0.1538***	-0.1046	0.0845
	(0.0182)	(0.2273)	(0.3833)
Sunniness	0.0709	0.5455	-17.44***
	(0.2728)	(1.457)	(3.965)
Conservation Value	-0.0403***	-0.1166	2.256***
	(0.0115)	(0.1518)	(0.3341)
Airport <5km	-0.0566***	-0.4570	-0.0789
	(0.0140)	(0.3092)	(0.5014)
Transmission <5km	0.0558***	0.5180**	-0.0060
	(0.0094)	(0.2065)	(0.1755)
Dist. to Rail	-0.0011	0.0061	0.0496**
	(0.0009)	(0.0082)	(0.0217)
Dist. to Road	0.0026**	0.0275	-0.0480*
	(0.0012)	(0.0280)	(0.0270)
Log(Elevation)	0.4003***	1.379	2.814
	(0.1058)	(1.130)	(1.810)
Slope	0.0316	-0.6923	-2.690***
	(0.0312)	(0.5911)	(0.4988)
Ruggedness	-0.0986	1.779	7.056***
	(0.0842)	(1.558)	(1.334)
Soil	2.02×10^{-8}	-2.95×10^{-7}	2.03×10^{-7}
	(1×10^{-6})	(1.04×10^{-6})	(1×10^{-6})
Log(Area)	-0.0071	-0.9860	0.3677**
	(0.0109)	(1.101)	(0.1434)
Share Public	-0.1136**	1.341*	1.445
	(0.0472)	(0.7214)	(2.180)
Share Developed	0.8328***	2.453	-6.270***
	(0.1485)	(4.901)	(2.045)
Dependent variable mean	0.10482	0.34763	3.7054
Observations	163,695	107,858	340,592
R^2	0.41887	0.16036	0.35563

Notes: OLS estimates. The unit of observation is a PLSS First Division section. The sample is restricted to sections where at least 75% of land area is undeveloped and at least 75% is privately owned. The sample further excludes sections within counties with no wind, solar, or easement development respectively. *Wind MW/1,000 Acres*, *Solar MW/1,000 Acres*, and *Ease/1,000 Acres* measure megawatts of installed wind capacity, megawatts of installed solar capacity, and conservation easement acres per 1,000 section acres as of 2024, respectively. *Inv. HHI* is the inverse of the Herfindahl-Hirschman Index (HHI) of land ownership concentration derived from parcels greater than 20 acres within the section; higher values indicate greater fragmentation and can be interpreted as the number of equal-share landowner equivalents. *Windiness* is mean wind speed (m/s). *Sunniness* is mean solar irradiance (kWh/m^2/day). *Conservation Value* is a land conservation priority score. *Airport <5km* is an indicator equal to one if an airport lies within 5 km of the section centroid. *Transmission <5km* is an indicator equal to one if an electricity transmission line passes within 5 km of the section centroid. *Dist. to Rail* is distance to the nearest railroad (km). *Dist. to Road* is distance to the nearest road (km). *Log(Elevation)* is the log of mean section elevation (m). *Slope* is mean terrain slope (degrees). *Ruggedness* is the Terrain Ruggedness Index (TRI). *Soil* is a composite soil quality index. *Log(Area)* is the natural log of section area (acres), included to control for the mechanical tendency of larger sections to contain development. *Share Public* is the share of section land area that is publicly owned. *Share Developed* is the share of section land area classified as developed. All regressions include township, multi-subcounty, and GAP fixed effects. Conley standard errors (20 km cutoff) in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table 20: Section-Level Regression Estimates: Number of landowners

	Wind = 1	Wind MW/1,000 Acres	MW > 0	Solar = 1	Solar MW/1,000 Acres	MW > 0	Easement = 1	Ease. Acres/1,000 Acres	Acres > 0
	(1)	(2)	(3)	(4)	(5)	(6)
Landowners	0.0002	-0.0434***	1.99×10^{-7}	0.9605	0.0032***	-0.0877
	(0.0003)	(0.0121)	(0.0002)	(0.9616)	(0.0004)	(0.4202)
Windiness	0.0605***	0.6180***	0.0014	16.14	0.0053	-2.083
	(0.0065)	(0.2242)	(0.0014)	(18.81)	(0.0034)	(7.481)
Sunniness	0.0718	-2.825	-0.0090	-108.7	-0.1811***	-223.5**
	(0.0697)	(3.382)	(0.0206)	(343.3)	(0.0395)	(103.5)
Conservation Value	-0.0175***	0.0159	-0.0004	-9.169	0.0089***	39.33***
	(0.0041)	(0.0797)	(0.0017)	(6.333)	(0.0020)	(4.815)
Airport <5km	-0.0208***	-0.1486	-0.0025		-0.0039	0.1030
	(0.0050)	(0.3064)	(0.0040)		(0.0047)	(7.874)
Transmission <5km	0.0196***	0.1046	0.0054***	-0.8545	0.0015	-1.338
	(0.0035)	(0.0797)	(0.0013)	(5.011)	(0.0016)	(2.645)
Dist. to Rail	-0.0003	-0.0062	0.0001	2.052	0.0004**	0.2952
	(0.0003)	(0.0109)	(0.0001)	(2.076)	(0.0002)	(0.3662)
Dist. to Road	0.0010**	0.0096	-7.17×10^{-5}	0.6256	-0.0002	-0.6986
	(0.0005)	(0.0129)	(0.0002)	(1.350)	(0.0002)	(0.4551)
Log(Elevation)	0.0894***	5.452***	0.0032	374.8	-0.0011	59.98**
	(0.0239)	(1.000)	(0.0029)	(468.4)	(0.0169)	(27.32)
Slope	0.0168*	0.7193	-0.0031	273.9	-0.0193***	-66.62***
	(0.0088)	(0.7839)	(0.0021)	(272.4)	(0.0045)	(16.09)
Ruggedness	-0.0475**	-2.109	0.0073	-792.6	0.0510***	176.7***
	(0.0235)	(2.196)	(0.0056)	(779.1)	(0.0121)	(43.94)
Soil	5.69×10^{-9}	1.09×10^{-7}	-1.05×10^{-9}	-2.1×10^{-6}	1.94×10^{-9}	-1.35×10^{-7}
	(1×10^{-6})	(1×10^{-6})	(1×10^{-6})	(1.08×10^{-5})	(1×10^{-6})	(3.82×10^{-6})
Log(Area)	0.0036***	-2.320***	0.0018***	-513.5***	0.0081***	-8.163
	(0.0013)	(0.7665)	(0.0007)	(18.88)	(0.0018)	(10.85)
Share Public	-0.0244	-1.319	0.0097	-1.326	0.1291***	-49.26*
	(0.0153)	(1.067)	(0.0097)	(47.82)	(0.0230)	(26.79)
Share Developed	0.2446***	6.224***	0.0960***	-64.81	-0.0519**	-194.6***
	(0.0417)	(1.903)	(0.0295)	(54.49)	(0.0213)	(44.02)
Dependent variable mean	0.04197	2.5016	0.00472	81.496	0.05428	70.804
Observations	163,695	6,561	107,858	393	340,592	17,042
R^2	0.46776	0.46301	0.29894	0.94062	0.55791	0.29162

Notes: OLS estimates. The unit of observation is a PLSS First Division section. The sample is restricted to sections where at least 75% of land area is undeveloped and at least 75% is privately owned. The sample further excludes sections within counties with no wind, solar, or easement development respectively. Columns (1), (3), and (5) use the full section sample; columns (2), (4), and (6) restrict the sample to sections where the respective dependent variable is positive. Observation counts in the intensive-margin columns fall below the number of positive sections implied by the extensive-margin dependent-variable means because fixed-effect singletons (sections that are the only developed observation in their fixed-effect group) are dropped from estimation. A blank coefficient cell indicates that an indicator control was dropped from that regression because it had no within-fixed-effect variation in the subsample. *Wind = 1*, *Solar = 1*, and *Easement = 1* are binary indicators equal to one if the section has any installed wind capacity, solar capacity, or conservation easement acreage as of 2024, respectively. *Wind MW/1,000 Acres*, *Solar MW/1,000 Acres*, and *Ease/1,000 Acres* measure megawatts of installed wind capacity, megawatts of installed solar capacity, and conservation easement acres per 1,000 section acres as of 2024, respectively. *Landowners* is the count of distinct owners of private parcels of at least 20 acres within the section. *Windiness* is mean wind speed (m/s). *Sunniness* is mean solar irradiance (kWh/m^2/day). *Conservation Value* is a land conservation priority score. *Airport <5km* is an indicator equal to one if an airport lies within 5 km of the section centroid. *Transmission <5km* is an indicator equal to one if an electricity transmission line passes within 5 km of the section centroid. *Dist. to Rail* is distance to the nearest railroad (km). *Dist. to Road* is distance to the nearest road (km). *Log(Elevation)* is the log of mean section elevation (m). *Slope* is mean terrain slope (degrees). *Ruggedness* is the Terrain Ruggedness Index (TRI). *Soil* is a composite soil quality index. *Log(Area)* is the natural log of section area (acres), included to control for the mechanical tendency of larger sections to contain development. *Share Public* is the share of section land area that is publicly owned. *Share Developed* is the share of section land area classified as developed. All regressions include township, multi-subcounty, and GAP fixed effects. Conley standard errors (20 km cutoff) in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table 21: Section-Level Regression Estimates: Spatial first differences

	Wind =1 (1)	Wind MW/1,000 (2)	Solar =1 (3)	Solar MW/1,000 (4)	Ease =1 (5)	Ease Acres/1,000 (6)
Constant	-2.08×10^{-6}	0.0004	1.22×10^{-5}	0.0111	0.0007**	0.1030***
	(0.0002)	(0.0006)	(6.36×10^{-5})	(0.0103)	(0.0003)	(0.0393)
Δ Inv. HHI	0.0004*	-0.0009	8.3×10^{-5}	0.0034	0.0023***	0.0357
	(0.0002)	(0.0007)	(6.14×10^{-5})	(0.0064)	(0.0004)	(0.0562)
Δ Windiness	0.0146***	0.0267***	0.0012*	0.2443	0.0011	0.4803
	(0.0018)	(0.0064)	(0.0007)	(0.1786)	(0.0038)	(0.4116)
Δ Sunniness	0.0538	0.0749	-0.0016	-0.0384	-0.0891**	-7.002
	(0.0336)	(0.1075)	(0.0097)	(0.6650)	(0.0451)	(5.638)
Δ Conservation Value	-0.0014	-0.0030	0.0001	0.0066	0.0053***	1.427***
	(0.0011)	(0.0033)	(0.0003)	(0.0208)	(0.0014)	(0.2149)
Δ Airport <5km	-0.0031	-0.0080	0.0006	0.0152*	0.0023	-0.7243
	(0.0029)	(0.0110)	(0.0006)	(0.0089)	(0.0041)	(0.5189)
Δ Transmission <5km	0.0022**	0.0045	0.0004	0.0173	-0.0006	-0.1463
	(0.0010)	(0.0029)	(0.0003)	(0.0266)	(0.0014)	(0.1869)
Δ Dist. to Rail	-8.65×10^{-5}	-0.0005	0.0001	0.0302	0.0007**	0.0828**
	(0.0002)	(0.0006)	(9.14×10^{-5})	(0.0185)	(0.0003)	(0.0416)
Δ Dist. to Road	0.0004*	0.0011*	1.11×10^{-6}	-0.0037	0.0001	0.0218
	(0.0002)	(0.0006)	(5.88×10^{-5})	(0.0089)	(0.0003)	(0.0371)
Δ Log(Elevation)	0.0639***	0.3175***	-0.0022	0.0682	0.0026	0.4324
	(0.0076)	(0.0353)	(0.0015)	(0.1684)	(0.0136)	(1.467)
Δ Slope	0.0051***	-0.0003	-0.0010**	-0.4530	-0.0061*	-1.253***
	(0.0016)	(0.0063)	(0.0005)	(0.3287)	(0.0031)	(0.3069)
Δ Ruggedness	-0.0149***	-0.0064	0.0025**	1.186	0.0165*	3.304***
	(0.0042)	(0.0165)	(0.0012)	(0.8685)	(0.0085)	(0.8183)
Δ Soil	3.6×10^{-10}	2.66×10^{-9}	-3.66×10^{-10}	-1.62×10^{-7}	1.22×10^{-9}	4.82×10^{-8}
	(1×10^{-6})	(1×10^{-6})	(1×10^{-6})	(1.01×10^{-6})	(1×10^{-6})	(1×10^{-6})
Δ Log(Area)	0.0016***	-0.0039	0.0005	-0.4176	0.0022**	0.1416
	(0.0005)	(0.0044)	(0.0003)	(0.3045)	(0.0009)	(0.0914)
Δ Share Public	-0.0061	-0.0272*	0.0011	0.0297	0.1028***	1.602
	(0.0045)	(0.0156)	(0.0028)	(0.1181)	(0.0154)	(2.008)
Δ Share Developed	0.0822***	0.3138***	0.0200**	-0.3073	-0.0057	-2.768**
	(0.0104)	(0.0389)	(0.0081)	(0.5088)	(0.0114)	(1.303)
Observations	270,184	270,184	270,184	270,184	270,184	270,184
R^2	0.00162	0.00216	0.00032	0.00072	0.00082	0.00036

Notes: Spatial First Differences (SFD) estimates following Druckenmiller and Hsiang (2018), applied to the section level as in Winikoff and Parker (2023). Every variable is differenced between a section and its immediate western neighbor drawn from the same sample, so that the conditional-independence assumption need only hold between adjacent sections; the differencing removes any unobserved factor common to neighboring sections. All regressors are first differences (Δ) of the variables defined in Table 4; the dependent variables are the correspondingly differenced extensive-margin indicators and per-1,000-acre densities. A constant is included to allow for an average east-west gradient. Neighbors are identified from projected section centroids (CONUS Albers, EPSG:5070): a section's western neighbor is the nearest in-sample section lying immediately to its west. The sample is restricted to sections where at least 75% of land area is undeveloped and at least 75% is privately owned. The sample further excludes sections within counties with no wind, solar, or easement development respectively. *Wind = 1*, *Solar = 1*, and *Easement = 1* are binary indicators equal to one if the section has any installed wind capacity, solar capacity, or conservation easement acreage as of 2024, respectively. *Wind MW/1,000 Acres*, *Solar MW/1,000 Acres*, and *Ease/1,000 Acres* measure megawatts of installed wind capacity, megawatts of installed solar capacity, and conservation easement acres per 1,000 section acres as of 2024, respectively. *Inv. HHI* is the inverse of the Herfindahl-Hirschman Index (HHI) of land ownership concentration derived from parcels greater than 20 acres within the section; higher values indicate greater fragmentation and can be interpreted as the number of equal-share landowner equivalents. *Windiness* is mean wind speed (m/s). *Sunniness* is mean solar irradiance (kWh/m^2/day). *Conservation Value* is a land conservation priority score. *Airport <5km* is an indicator equal to one if an airport lies within 5 km of the section centroid. *Transmission <5km* is an indicator equal to one if an electricity transmission line passes within 5 km of the section centroid. *Dist. to Rail* is distance to the nearest railroad (km). *Dist. to Road* is distance to the nearest road (km). *Log(Elevation)* is the log of mean section elevation (m). *Slope* is mean terrain slope (degrees). *Ruggedness* is the Terrain Ruggedness Index (TRI). *Soil* is a composite soil quality index. *Log(Area)* is the natural log of section area (acres), included to control for the mechanical tendency of larger sections to contain development. *Share Public* is the share of section land area that is publicly owned. *Share Developed* is the share of section land area classified as developed. Standard errors clustered by township in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table 22: Section-Level Regression Estimates: Spatial first differences, developed-only intensive margin

	Wind MW/1,000 | dev. (1)	Solar MW/1,000 | dev. (2)	Ease Acres/1,000 | dev. (3)
Constant	0.0768***	2.685	-1.624
	(0.0278)	(2.029)	(1.345)
Δ Inv. HHI	-0.1006***	1.081	-3.313***
	(0.0261)	(1.316)	(1.249)
Δ Windiness	0.2012	21.43	30.20*
	(0.5835)	(23.03)	(17.41)
Δ Sunniness	5.192	-274.8	-248.5
	(5.767)	(244.8)	(233.1)
Δ Conservation Value	-0.0678	-0.5970	35.59***
	(0.1125)	(6.306)	(6.766)
Δ Airport <5km	-0.5022		-14.09
	(0.7344)		(14.12)
Δ Transmission <5km	-0.0620	-2.122	-2.733
	(0.1205)	(3.549)	(5.781)
Δ Dist. to Rail	-0.0055	0.9931	2.394
	(0.0285)	(1.463)	(1.540)
Δ Dist. to Road	0.0137	-3.579	1.088
	(0.0258)	(2.309)	(1.339)
Δ Log(Elevation)	17.43***	328.4**	-19.46
	(2.276)	(159.0)	(46.54)
Δ Slope	-0.5335	165.1*	-91.12***
	(0.9168)	(95.51)	(25.08)
Δ Ruggedness	1.644	-483.1*	240.9***
	(2.581)	(275.2)	(68.20)
Δ Soil	1.52×10^{-7}	-5.83×10^{-6}	-1.05×10^{-6}
	(1×10^{-6})	(1.19×10^{-5})	(7.34×10^{-6})
Δ Log(Area)	-3.212***	-242.7***	13.97
	(0.6319)	(31.98)	(8.877)
Δ Share Public	-1.488	-79.39	-80.37**
	(1.546)	(53.97)	(36.29)
Δ Share Developed	10.96***	-59.78	-285.6***
	(1.822)	(37.17)	(78.07)
Observations	3,215	184	6,040
R^2	0.13681	0.88667	0.01503

Notes: Spatial First Differences estimates restricted to pairs of adjacent sections that both host the relevant development, the analogue of the developed-only intensive margin; this stress-tests the negative intensive-margin coefficients in Table 4. The dependent variable is the differenced development density. Adjacent developed pairs are uncommon, so the number of observations is small; where there are too few pairs to support the full control vector it is omitted, and the solar column is too sparse to interpret. Neighbors are identified from projected section centroids (CONUS Albers, EPSG:5070): a section's western neighbor is the nearest in-sample section lying immediately to its west. The sample is restricted to sections where at least 75% of land area is undeveloped and at least 75% is privately owned. *Inv. HHI* is the inverse of the Herfindahl-Hirschman Index (HHI) of land ownership concentration derived from parcels greater than 20 acres within the section; higher values indicate greater fragmentation and can be interpreted as the number of equal-share landowner equivalents. *Windiness* is mean wind speed (m/s). *Sunniness* is mean solar irradiance (kWh/m^2/day). *Conservation Value* is a land conservation priority score. *Airport <5km* is an indicator equal to one if an airport lies within 5 km of the section centroid. *Transmission <5km* is an indicator equal to one if an electricity transmission line passes within 5 km of the section centroid. *Dist. to Rail* is distance to the nearest railroad (km). *Dist. to Road* is distance to the nearest road (km). *Log(Elevation)* is the log of mean section elevation (m). *Slope* is mean terrain slope (degrees). *Ruggedness* is the Terrain Ruggedness Index (TRI). *Soil* is a composite soil quality index. *Log(Area)* is the natural log of section area (acres), included to control for the mechanical tendency of larger sections to contain development. *Share Public* is the share of section land area that is publicly owned. *Share Developed* is the share of section land area classified as developed. Standard errors clustered by township in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table 23: Section-Level Logit Estimates: Average partial effects

	Wind = 1 (1)	Solar = 1 (2)	Easement = 1 (3)
Inv. HHI	0.0044	-0.0029	0.0149***
	(0.0030)	(0.0064)	(0.0017)
Windiness	0.6762***	0.0677*	0.0346***
	(0.0279)	(0.0395)	(0.0103)
Sunniness	1.2908***	-0.6223	-1.2820***
	(0.3298)	(0.6135)	(0.1799)
Conservation Value	-0.0611***	-0.0104	0.0556***
	(0.0111)	(0.0284)	(0.0081)
Airport <5km	-0.1591***	-0.0397	-0.0182
	(0.0255)	(0.0404)	(0.0164)
Transmission <5km	0.1003***	0.1431***	0.0099*
	(0.0089)	(0.0123)	(0.0060)
Dist. to Rail	-0.0033***	0.0041	0.0030***
	(0.0012)	(0.0030)	(0.0008)
Dist. to Road	0.0033**	-0.0076**	-0.0014
	(0.0014)	(0.0032)	(0.0009)
Log(Elevation)	1.2812***	0.4046**	0.0127
	(0.1238)	(0.2059)	(0.0395)
Slope	0.4911***	-0.1842	-0.1676***
	(0.0785)	(0.1319)	(0.0247)
Ruggedness	-1.3247***	0.3585	0.4435***
	(0.2217)	(0.3658)	(0.0673)
Soil	0.0000**	-0.0000	0.0000*
	(0.0000)	(0.0000)	(0.0000)
Log(Area)	0.1581***	0.0884***	0.0845***
	(0.0482)	(0.0332)	(0.0136)
Share Public	-0.3208	0.3996	0.4734***
	(0.2061)	(0.3238)	(0.0573)
Share Developed	2.3805***	0.6073***	-0.2546***
	(0.2000)	(0.1575)	(0.0926)
Dependent variable mean	0.31719	0.15597	0.30065
Observations	21,164	3,164	52,503
Pseudo R^2	0.30254	0.21924	0.25885

Notes: Logit models are estimated by maximum likelihood with fixed effects absorbed following Stammann (2018). Columns report average partial effects, with analytic standard errors following Fernández-Val and Weidner (2016) in parentheses. The unit of observation is a PLSS section. The sample is restricted to sections where at least 75% of land area is undeveloped and at least 75% is privately owned. The sample is restricted to sections in townships whose sections vary in the relevant outcome; townships without outcome variation carry no information in a within-township logit. *Wind = 1*, *Solar = 1*, and *Easement = 1* are binary indicators equal to one if the section has any installed wind capacity, solar capacity, or conservation easement acreage as of 2024, respectively. *Inv. HHI* is the inverse of the Herfindahl-Hirschman Index (HHI) of land ownership concentration derived from parcels greater than 20 acres within the section; higher values indicate greater fragmentation and can be interpreted as the number of equal-share landowner equivalents. *Windiness* is mean wind speed (m/s). *Sunniness* is mean solar irradiance (kWh/m^2/day). *Conservation Value* is a land conservation priority score. *Airport <5km* is an indicator equal to one if an airport lies within 5 km of the section centroid. *Transmission <5km* is an indicator equal to one if an electricity transmission line passes within 5 km of the section centroid. *Dist. to Rail* is distance to the nearest railroad (km). *Dist. to Road* is distance to the nearest road (km). *Log(Elevation)* is the log of mean section elevation (m). *Slope* is mean terrain slope (degrees). *Ruggedness* is the Terrain Ruggedness Index (TRI). *Soil* is a composite soil quality index. *Log(Area)* is the natural log of section area (acres), included to control for the mechanical tendency of larger sections to contain development. *Share Public* is the share of section land area that is publicly owned. *Share Developed* is the share of section land area classified as developed. All models absorb township, multi-subcounty, and GAP fixed effects. *p<0.1; **p<0.05; ***p<0.01.

Appendix F: Parcel Results

Table 24: Parcel-Level 1/2 Mile Regression Estimates: Standard errors clustered at the township level

	Turbine = 1 (1)	Solar = 1 (2)	Easement = 1 (3)
Log(Parcel Size)	0.0120***	0.0033***	0.0106***
	(0.0004)	(0.0001)	(0.0002)
Normalized Owners in Radius	5.11×10^{-5}	0.0004***	-0.0008***
	(4.64×10^{-5})	(3.15×10^{-5})	(5.04×10^{-5})
Windiness	0.0364***	-0.0006	-0.0018
	(0.0016)	(0.0007)	(0.0013)
Sunniness	0.0350**	-0.0014	-0.1226***
	(0.0175)	(0.0073)	(0.0179)
Conservation Value	-0.0053***	0.0001	0.0091***
	(0.0006)	(0.0002)	(0.0005)
Airport in Radius	-0.0041***	0.0007	-0.0065***
	(0.0009)	(0.0010)	(0.0019)
Transmission in Radius	0.0039***	0.0036***	-0.0013***
	(0.0005)	(0.0003)	(0.0004)
Rail in Radius	-0.0027***	0.0007***	0.0005
	(0.0005)	(0.0003)	(0.0006)
Road in Radius	-0.0037***	0.0002	-0.0001
	(0.0004)	(0.0002)	(0.0003)
Slope	0.0062***	-0.0011***	-0.0184***
	(0.0013)	(0.0004)	(0.0025)
Ruggedness	-0.0175***	0.0023**	0.0480***
	(0.0034)	(0.0009)	(0.0068)
Soil	6.55×10^{-10}	-1.25×10^{-10}	-5.26×10^{-10}
	(1×10^{-6})	(1×10^{-6})	(1×10^{-6})
Share Surrounding Public	-0.0036***	0.0022***	0.0230***
	(0.0011)	(0.0006)	(0.0017)
Share Surrounding Developed	0.0040**	0.0182***	-0.0748***
	(0.0017)	(0.0014)	(0.0026)
Dependent variable mean	0.01519	0.00283	0.04474
Observations	2,061,624	2,282,524	6,048,690
R^2	0.17228	0.08922	0.41853

Notes: OLS estimates (linear probability model). The unit of observation is a parcel of at least 20 acres classified primarily as farmland. The sample excludes parcels within counties with no wind, solar, or easement development respectively. *Turbine = 1*, *Solar = 1*, and *Easement = 1* are binary indicators equal to one if a wind turbine, solar project, or conservation easement, respectively, is located on the parcel as of 2024. *Log(Parcel Size)* is the log of parcel area (acres). *Normalized Owners in Radius* is the number of distinct landowners within 1/2 mile divided by the length of the parcel perimeter in miles. *Windiness* is mean wind speed (m/s). *Sunniness* is mean solar irradiance (kWh/m^2/day). *Conservation Value* is a land conservation priority score. *Airport in Radius* is an indicator equal to one if an airport lies within 1/2 mile. *Transmission in Radius* is an indicator equal to one if an electricity transmission line passes within 1/2 mile. *Rail in Radius* is an indicator equal to one if a railroad is located within 1/2 mile. *Road in Radius* is an indicator equal to one if a road is located within 1/2 mile. *Slope* is mean terrain slope (degrees). *Ruggedness* is the Terrain Ruggedness Index (TRI). *Soil* is a composite soil quality index. *Share Surrounding Public* is the share of land within 1/2 mile of the parcel that is publicly owned. *Share Surrounding Developed* is the share of land within 1/2 mile classified as developed. All regressions include township and GAP fixed effects. Standard errors clustered by township in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table 25: Parcel-Level 1/2 Mile Regression Estimates: Subcounty fixed effects and standard errors clustered at the subcounty level

	Turbine = 1 (1)	Solar = 1 (2)	Easement = 1 (3)
Log(Parcel Size)	0.0119***	0.0030***	0.0105***
	(0.0006)	(0.0002)	(0.0003)
Normalized Owners in Radius	8.33×10^{-5}	0.0003***	-0.0010***
	(5.89×10^{-5})	(4.88×10^{-5})	(0.0001)
Windiness	0.0298***	0.0004	0.0002
	(0.0021)	(0.0004)	(0.0018)
Sunniness	0.0442**	-0.0036	-0.1370***
	(0.0195)	(0.0051)	(0.0254)
Conservation Value	-0.0067***	-3.48×10^{-5}	0.0094***
	(0.0010)	(0.0003)	(0.0009)
Airport in Radius	-0.0064***	0.0008	-0.0067***
	(0.0010)	(0.0011)	(0.0020)
Transmission in Radius	0.0061***	0.0042***	-0.0019***
	(0.0008)	(0.0003)	(0.0005)
Rail in Radius	-0.0023***	0.0007***	0.0005
	(0.0006)	(0.0002)	(0.0006)
Road in Radius	-0.0046***	0.0002	-2.87×10^{-5}
	(0.0005)	(0.0002)	(0.0004)
Slope	0.0046**	-0.0011***	-0.0185***
	(0.0020)	(0.0004)	(0.0025)
Ruggedness	-0.0141**	0.0022**	0.0484***
	(0.0056)	(0.0010)	(0.0068)
Soil	6.98×10^{-10}	-3.93×10^{-10}	1.45×10^{-10}
	(1×10^{-6})	(1×10^{-6})	(1×10^{-6})
Share Surrounding Public	-0.0035**	0.0018**	0.0257***
	(0.0017)	(0.0009)	(0.0025)
Share Surrounding Developed	-0.0013	0.0156***	-0.0699***
	(0.0025)	(0.0014)	(0.0033)
Dependent variable mean	0.01519	0.00284	0.04475
Observations	2,062,136	2,283,854	6,050,895
R^2	0.10529	0.04715	0.37519

Notes: OLS estimates (linear probability model). The unit of observation is a parcel of at least 20 acres classified primarily as farmland. The sample excludes parcels within counties with no wind, solar, or easement development respectively. *Turbine = 1*, *Solar = 1*, and *Easement = 1* are binary indicators equal to one if a wind turbine, solar project, or conservation easement, respectively, is located on the parcel as of 2024. *Log(Parcel Size)* is the log of parcel area (acres). *Normalized Owners in Radius* is the number of distinct landowners within 1/2 mile divided by the length of the parcel perimeter in miles. *Windiness* is mean wind speed (m/s). *Sunniness* is mean solar irradiance (kWh/m^2/day). *Conservation Value* is a land conservation priority score. *Airport in Radius* is an indicator equal to one if an airport lies within 1/2 mile. *Transmission in Radius* is an indicator equal to one if an electricity transmission line passes within 1/2 mile. *Rail in Radius* is an indicator equal to one if a railroad is located within 1/2 mile. *Road in Radius* is an indicator equal to one if a road is located within 1/2 mile. *Slope* is mean terrain slope (degrees). *Ruggedness* is the Terrain Ruggedness Index (TRI). *Soil* is a composite soil quality index. *Share Surrounding Public* is the share of land within 1/2 mile of the parcel that is publicly owned. *Share Surrounding Developed* is the share of land within 1/2 mile classified as developed. All regressions include subcounty and GAP fixed effects. Standard errors clustered by subcounty in parentheses. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.

Table 26: Parcel-Level 1/4 Mile Regression Estimates

	Turbine = 1 (1)	Solar = 1 (2)	Easement = 1 (3)
Log(Parcel Size)	0.0118***	0.0030***	0.0111***
	(0.0007)	(0.0002)	(0.0004)
Normalized Owners in Radius	-8.53×10^{-5}	0.0005***	-0.0012***
	(8.87×10^{-5})	(6.61×10^{-5})	(0.0001)
Windiness	0.0364***	-0.0006	-0.0017
	(0.0026)	(0.0009)	(0.0019)
Sunniness	0.0356*	-0.0005	-0.1260***
	(0.0208)	(0.0074)	(0.0206)
Conservation Value	-0.0058***	0.0001	0.0089***
	(0.0008)	(0.0003)	(0.0008)
Airport in Radius	-0.0044***	0.0028	-0.0069***
	(0.0011)	(0.0019)	(0.0027)
Transmission in Radius	0.0037***	0.0039***	-0.0011**
	(0.0007)	(0.0003)	(0.0005)
Rail in Radius	-0.0024***	0.0005*	0.0007
	(0.0005)	(0.0003)	(0.0007)
Road in Radius	-0.0044***	0.0001	0.0004
	(0.0005)	(0.0002)	(0.0004)
Slope	0.0062***	-0.0010**	-0.0185***
	(0.0018)	(0.0004)	(0.0027)
Ruggedness	-0.0177***	0.0021*	0.0481***
	(0.0048)	(0.0011)	(0.0076)
Soil	6.58×10^{-10}	-1.27×10^{-10}	-5.21×10^{-10}
	(1×10^{-6})	(1×10^{-6})	(1×10^{-6})
Share Surrounding Public	-0.0034***	0.0014**	0.0231***
	(0.0012)	(0.0006)	(0.0019)
Share Surrounding Developed	-0.0049**	0.0168***	-0.0734***
	(0.0024)	(0.0016)	(0.0042)
Dependent variable mean	0.01519	0.00283	0.04474
Observations	2,061,624	2,282,524	6,048,690
R^2	0.17227	0.08904	0.41857

Notes: OLS estimates (linear probability model). The unit of observation is a parcel of at least 20 acres classified primarily as farmland. The sample excludes parcels within counties with no wind, solar, or easement development respectively. *Turbine = 1*, *Solar = 1*, and *Easement = 1* are binary indicators equal to one if a wind turbine, solar project, or conservation easement, respectively, is located on the parcel as of 2024. *Log(Parcel Size)* is the log of parcel area (acres). *Normalized Owners in Radius* is the number of distinct landowners within 1/4 mile divided by the length of the parcel perimeter in miles. *Windiness* is mean wind speed (m/s). *Sunniness* is mean solar irradiance (kWh/m^2/day). *Conservation Value* is a land conservation priority score. *Airport in Radius* is an indicator equal to one if an airport lies within 1/4 mile. *Transmission in Radius* is an indicator equal to one if an electricity transmission line passes within 1/4 mile. *Rail in Radius* is an indicator equal to one if a railroad is located within 1/4 mile. *Road in Radius* is an indicator equal to one if a road is located within 1/4 mile. *Slope* is mean terrain slope (degrees). *Ruggedness* is the Terrain Ruggedness Index (TRI). *Soil* is a composite soil quality index. *Share Surrounding Public* is the share of land within 1/4 mile of the parcel that is publicly owned. *Share Surrounding Developed* is the share of land within 1/4 mile classified as developed. All regressions include township and GAP fixed effects. Conley standard errors (20 km cutoff) in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table 27: Parcel-Level 1 Mile Regression Estimates

	Turbine = 1 (1)	Solar = 1 (2)	Easement = 1 (3)
Log(Parcel Size)	0.0119***	0.0040***	0.0106***
	(0.0007)	(0.0002)	(0.0004)
Normalized Owners in Radius	9.37×10^{-6}	0.0003***	-0.0004***
	(3.83×10^{-5})	(2.65×10^{-5})	(3.81×10^{-5})
Windiness	0.0363***	-0.0006	-0.0019
	(0.0026)	(0.0009)	(0.0019)
Sunniness	0.0349*	-0.0032	-0.1182***
	(0.0208)	(0.0074)	(0.0205)
Conservation Value	-0.0050***	-4.6×10^{-5}	0.0099***
	(0.0008)	(0.0003)	(0.0008)
Airport in Radius	-0.0035***	0.0014	-0.0047***
	(0.0007)	(0.0009)	(0.0014)
Transmission in Radius	0.0047***	0.0031***	-0.0016***
	(0.0007)	(0.0003)	(0.0005)
Rail in Radius	-0.0024***	0.0006**	-0.0002
	(0.0006)	(0.0003)	(0.0007)
Road in Radius	-0.0031***	0.0001	-0.0003
	(0.0005)	(0.0002)	(0.0004)
Slope	0.0062***	-0.0012***	-0.0184***
	(0.0018)	(0.0004)	(0.0027)
Ruggedness	-0.0178***	0.0025**	0.0480***
	(0.0048)	(0.0011)	(0.0076)
Soil	6.49×10^{-10}	-1.2×10^{-10}	-5.27×10^{-10}
	(1×10^{-6})	(1×10^{-6})	(1×10^{-6})
Share Surrounding Public	-0.0041**	0.0044***	0.0241***
	(0.0017)	(0.0009)	(0.0025)
Share Surrounding Developed	0.0018	0.0200***	-0.0695***
	(0.0027)	(0.0019)	(0.0049)
Dependent variable mean	0.01519	0.00283	0.04474
Observations	2,061,624	2,282,524	6,048,690
R^2	0.17234	0.08956	0.41841

Notes: OLS estimates (linear probability model). The unit of observation is a parcel of at least 20 acres classified primarily as farmland. The sample excludes parcels within counties with no wind, solar, or easement development respectively. *Turbine = 1*, *Solar = 1*, and *Easement = 1* are binary indicators equal to one if a wind turbine, solar project, or conservation easement, respectively, is located on the parcel as of 2024. *Log(Parcel Size)* is the log of parcel area (acres). *Normalized Owners in Radius* is the number of distinct landowners within 1 mile divided by the length of the parcel perimeter in miles. *Windiness* is mean wind speed (m/s). *Sunniness* is mean solar irradiance (kWh/m^2/day). *Conservation Value* is a land conservation priority score. *Airport in Radius* is an indicator equal to one if an airport lies within 1 mile. *Transmission in Radius* is an indicator equal to one if an electricity transmission line passes within 1 mile. *Rail in Radius* is an indicator equal to one if a railroad is located within 1 mile. *Road in Radius* is an indicator equal to one if a road is located within 1 mile. *Slope* is mean terrain slope (degrees). *Ruggedness* is the Terrain Ruggedness Index (TRI). *Soil* is a composite soil quality index. *Share Surrounding Public* is the share of land within 1 mile of the parcel that is publicly owned. *Share Surrounding Developed* is the share of land within 1 mile classified as developed. All regressions include township and GAP fixed effects. Conley standard errors (20 km cutoff) in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table 28: Parcel-Level 1/2 Mile Regression Estimates: Neighbors without normalization

	Turbine = 1 (1)	Solar = 1 (2)	Easement = 1 (3)
Log(Parcel Size)	0.0149***	0.0023***	0.0030***
	(0.0010)	(0.0003)	(0.0005)
Owners in Radius	7.72×10^{-5}	0.0005***	-0.0006***
	(6.35×10^{-5})	(4.86×10^{-5})	(6.87×10^{-5})
Log(Perimeter)	-0.0063***	-0.0007*	0.0198***
	(0.0010)	(0.0004)	(0.0010)
Windiness	0.0363***	-0.0005	-0.0016
	(0.0026)	(0.0009)	(0.0019)
Sunniness	0.0343*	-0.0020	-0.1221***
	(0.0208)	(0.0074)	(0.0205)
Conservation Value	-0.0053***	0.0003	0.0090***
	(0.0008)	(0.0003)	(0.0008)
Airport in Radius	-0.0039***	0.0006	-0.0069***
	(0.0009)	(0.0011)	(0.0019)
Transmission in Radius	0.0039***	0.0035***	-0.0014***
	(0.0007)	(0.0003)	(0.0005)
Rail in Radius	-0.0025***	0.0006**	4.43×10^{-5}
	(0.0006)	(0.0003)	(0.0007)
Road in Radius	-0.0036***	0.0002	-0.0004
	(0.0005)	(0.0002)	(0.0004)
Slope	0.0060***	-0.0010**	-0.0180***
	(0.0017)	(0.0004)	(0.0027)
Ruggedness	-0.0169***	0.0021**	0.0468***
	(0.0048)	(0.0011)	(0.0074)
Soil	6.47×10^{-10}	-1.28×10^{-10}	-5.04×10^{-10}
	(1×10^{-6})	(1×10^{-6})	(1×10^{-6})
Share Surrounding Public	-0.0033**	0.0032***	0.0234***
	(0.0014)	(0.0007)	(0.0021)
Share Surrounding Developed	0.0047**	0.0188***	-0.0751***
	(0.0020)	(0.0017)	(0.0046)
Dependent variable mean	0.01519	0.00283	0.04474
Observations	2,061,624	2,282,524	6,048,690
R^2	0.17233	0.08957	0.41867

Notes: OLS estimates (linear probability model). The unit of observation is a parcel of at least 20 acres classified primarily as farmland. The sample excludes parcels within counties with no wind, solar, or easement development respectively. *Turbine = 1*, *Solar = 1*, and *Easement = 1* are binary indicators equal to one if a wind turbine, solar project, or conservation easement, respectively, is located on the parcel as of 2024. *Log(Parcel Size)* is the log of parcel area (acres). *Owners in Radius* is the number of distinct landowners within 1/2 mile. *Log(Perimeter)* is the log of parcel perimeter (miles). *Windiness* is mean wind speed (m/s). *Sunniness* is mean solar irradiance (kWh/m^2/day). *Conservation Value* is a land conservation priority score. *Airport in Radius* is an indicator equal to one if an airport lies within 1/2 mile. *Transmission in Radius* is an indicator equal to one if an electricity transmission line passes within 1/2 mile. *Rail in Radius* is an indicator equal to one if a railroad is located within 1/2 mile. *Road in Radius* is an indicator equal to one if a road is located within 1/2 mile. *Slope* is mean terrain slope (degrees). *Ruggedness* is the Terrain Ruggedness Index (TRI). *Soil* is a composite soil quality index. *Share Surrounding Public* is the share of land within 1/2 mile of the parcel that is publicly owned. *Share Surrounding Developed* is the share of land within 1/2 mile classified as developed. All regressions include township and GAP fixed effects. Conley standard errors (20 km cutoff) in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table 29: Parcel-Level 1/2 Mile Regression Estimates: Farm and non-farm sample

	Turbine = 1 (1)	Solar = 1 (2)	Easement = 1 (3)
Log(Parcel Size)	0.0080***	0.0022***	0.0159***
	(0.0005)	(0.0001)	(0.0005)
Normalized Owners in Radius	-0.0002***	0.0005***	-0.0008***
	(5.94×10^{-5})	(4.45×10^{-5})	(9.89×10^{-5})
Windiness	0.0181***	-0.0003	-0.0090***
	(0.0013)	(0.0003)	(0.0013)
Sunniness	0.0096	-0.0019	-0.1001***
	(0.0106)	(0.0032)	(0.0173)
Conservation Value	-0.0049***	-0.0002	0.0047***
	(0.0006)	(0.0002)	(0.0007)
Airport in Radius	-0.0038***	0.0012*	-0.0049***
	(0.0006)	(0.0007)	(0.0017)
Transmission in Radius	0.0036***	0.0025***	-0.0006
	(0.0005)	(0.0002)	(0.0004)
Rail in Radius	-0.0024***	0.0007***	0.0013**
	(0.0004)	(0.0002)	(0.0006)
Road in Radius	-0.0031***	0.0002*	0.0001
	(0.0004)	(0.0001)	(0.0004)
Slope	0.0021***	-0.0005***	-0.0091***
	(0.0006)	(0.0001)	(0.0009)
Ruggedness	-0.0064***	0.0011***	0.0212***
	(0.0017)	(0.0003)	(0.0025)
Soil	3.75×10^{-10}	-5.47×10^{-11}	-1.04×10^{-9}
	(1×10^{-6})	(1×10^{-6})	(1×10^{-6})
Share Surrounding Public	-0.0073***	0.0001	0.0494***
	(0.0010)	(0.0003)	(0.0032)
Share Surrounding Developed	0.0020	0.0088***	-0.0789***
	(0.0013)	(0.0008)	(0.0047)
Dependent variable mean	0.01193	0.00205	0.05081
Observations	2,880,870	4,517,379	11,322,040
R^2	0.16655	0.05825	0.33490

Notes: OLS estimates (linear probability model). The unit of observation is a parcel of at least 20 acres. The sample excludes parcels within counties with no wind, solar, or easement development respectively. *Turbine = 1*, *Solar = 1*, and *Easement = 1* are binary indicators equal to one if a wind turbine, solar project, or conservation easement, respectively, is located on the parcel as of 2024. *Log(Parcel Size)* is the log of parcel area (acres). *Normalized Owners in Radius* is the number of distinct landowners within 1/2 mile divided by the length of the parcel perimeter in miles. *Windiness* is mean wind speed (m/s). *Sunniness* is mean solar irradiance (kWh/m^2/day). *Conservation Value* is a land conservation priority score. *Airport in Radius* is an indicator equal to one if an airport lies within 1/2 mile. *Transmission in Radius* is an indicator equal to one if an electricity transmission line passes within 1/2 mile. *Rail in Radius* is an indicator equal to one if a railroad is located within 1/2 mile. *Road in Radius* is an indicator equal to one if a road is located within 1/2 mile. *Slope* is mean terrain slope (degrees). *Ruggedness* is the Terrain Ruggedness Index (TRI). *Soil* is a composite soil quality index. *Share Surrounding Public* is the share of land within 1/2 mile of the parcel that is publicly owned. *Share Surrounding Developed* is the share of land within 1/2 mile classified as developed. All regressions include township and GAP fixed effects. Conley standard errors (20 km cutoff) in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table 30: Parcel-Level 1/2 Mile Regression Estimates: Including distance to mailing address

	Turbine = 1 (1)	Solar = 1 (2)	Easement = 1 (3)
Log(Parcel Size)	0.0134***	0.0034***	0.0112***
	(0.0009)	(0.0002)	(0.0005)
Normalized Owners in Radius	3.22×10^{-5}	0.0005***	-0.0006***
	(8.34×10^{-5})	(4.76×10^{-5})	(6.62×10^{-5})
Windiness	0.0386***	-0.0005	-0.0014
	(0.0031)	(0.0006)	(0.0021)
Sunniness	0.0501*	-0.0011	-0.1107***
	(0.0273)	(0.0080)	(0.0229)
Conservation Value	-0.0048***	0.0001	0.0094***
	(0.0009)	(0.0003)	(0.0009)
Log(Dist. To Mailing Address)	4.16×10^{-5}	0.0008***	0.0002***
	(7.85×10^{-5})	(7.15×10^{-5})	(7.54×10^{-5})
Airport in Radius	-0.0040***	0.0003	-0.0042*
	(0.0012)	(0.0011)	(0.0024)
Transmission in Radius	0.0033***	0.0033***	-0.0013**
	(0.0008)	(0.0004)	(0.0006)
Rail in Radius	-0.0029***	0.0004	-0.0010
	(0.0007)	(0.0003)	(0.0009)
Road in Radius	-0.0036***	0.0003	4.78×10^{-5}
	(0.0006)	(0.0002)	(0.0005)
Slope	0.0061***	-0.0008	-0.0169***
	(0.0021)	(0.0005)	(0.0035)
Ruggedness	-0.0172***	0.0014	0.0435***
	(0.0057)	(0.0013)	(0.0095)
Soil	-1.77×10^{-10}	-1.67×10^{-10}	8.76×10^{-10}
	(1×10^{-6})	(1×10^{-6})	(1×10^{-6})
Share Surrounding Public	-0.0055***	0.0037***	0.0247***
	(0.0019)	(0.0007)	(0.0026)
Share Surrounding Developed	0.0011	0.0174***	-0.0700***
	(0.0026)	(0.0017)	(0.0051)
Dependent variable mean	0.01598	0.00261	0.04491
Observations	1,288,411	1,606,655	4,034,501
R^2	0.17304	0.08516	0.41620

Notes: OLS estimates (linear probability model). The unit of observation is a parcel of at least 20 acres classified primarily as farmland. The sample excludes parcels within counties with no wind, solar, or easement development respectively. *Turbine = 1*, *Solar = 1*, and *Easement = 1* are binary indicators equal to one if a wind turbine, solar project, or conservation easement, respectively, is located on the parcel as of 2024. *Log(Parcel Size)* is the log of parcel area (acres). *Normalized Owners in Radius* is the number of distinct landowners within 1/2 mile divided by the length of the parcel perimeter in miles. *Windiness* is mean wind speed (m/s). *Sunniness* is mean solar irradiance (kWh/m^2/day). *Conservation Value* is a land conservation priority score. *Log(Dist. To Mailing Address)* is the log of distance from the parcel centroid to the owner's mailing address (km), a proxy for owner absenteeism. *Airport in Radius* is an indicator equal to one if an airport lies within 1/2 mile. *Transmission in Radius* is an indicator equal to one if an electricity transmission line passes within 1/2 mile. *Rail in Radius* is an indicator equal to one if a railroad is located within 1/2 mile. *Road in Radius* is an indicator equal to one if a road is located within 1/2 mile. *Slope* is mean terrain slope (degrees). *Ruggedness* is the Terrain Ruggedness Index (TRI). *Soil* is a composite soil quality index. *Share Surrounding Public* is the share of land within 1/2 mile of the parcel that is publicly owned. *Share Surrounding Developed* is the share of land within 1/2 mile classified as developed. All regressions include township and GAP fixed effects. Conley standard errors (20 km cutoff) in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table 31: Parcel-Level 1/2 Mile Regression Estimates: Within-township permutation test

	Wind = 1	Solar = 1	Easement = 1
	(1)	(2)	(3)
Normalized Owners in Radius	5.11×10^{-5}	0.0004^{***}	-0.0008^{***}
	(6.36×10^{-5})	(4.45×10^{-5})	(7.49×10^{-5})
Permutations	500	500	500
Dependent variable mean	0.01519	0.00283	0.04474
Observations	2,061,624	2,282,524	6,048,690
R^2	0.17228	0.08922	0.41853
Perm. p-value	0.012	0.002	0.002

Notes: OLS estimates (linear probability model). The unit of observation is a parcel of at least 20 acres classified primarily as farmland. The sample excludes parcels within counties with no wind, solar, or easement development respectively. *Turbine = 1*, *Solar = 1*, and *Easement = 1* are binary indicators equal to one if a wind turbine, solar project, or conservation easement, respectively, is located on the parcel as of 2024. *Normalized Owners in Radius* is the number of distinct landowners within 1/2 mile divided by the length of the parcel perimeter in miles. Each column reports the estimated coefficient on *Normalized Owners in Radius*; *Log(Parcel Size)*, the full control vector, and the township and GAP fixed effects reported in Table 5 are included but suppressed for brevity. *Permutations* is the number of within-township reassignments of the number of surrounding owners, holding all other variables fixed. *Perm. p-value* is the permutation p-value $(r+1)/(B+1)$, where r is the number of placebo coefficients at least as large in absolute value as the estimated coefficient and B is the number of permutations; the +1 adjustment is a finite-sample correction that prevents a reported value of exactly zero. Conley standard errors (20 km cutoff) in parentheses. *p<0.1; **p<0.05; ***p<0.01.

Table 32: Parcel-Level 1/2 Mile Logit Estimates: Average partial effects

	Turbine = 1 (1)	Solar = 1 (2)	Easement = 1 (3)
Log(Parcel Size)	0.0689***	0.0233***	0.0255***
	(0.0009)	(0.0006)	(0.0003)
Normalized Owners in Radius	-0.0003	0.0036***	-0.0036***
	(0.0002)	(0.0001)	(0.0001)
Windiness	0.2914***	-0.0061***	-0.0082***
	(0.0044)	(0.0019)	(0.0010)
Sunniness	0.5981***	0.0081	-0.2787***
	(0.0549)	(0.0274)	(0.0160)
Conservation Value	-0.0255***	0.0012	0.0252***
	(0.0017)	(0.0010)	(0.0006)
Airport in Radius	-0.0773***	-0.0025	-0.0163***
	(0.0051)	(0.0033)	(0.0032)
Transmission in Radius	0.0129***	0.0215***	-0.0028***
	(0.0012)	(0.0009)	(0.0005)
Rail in Radius	-0.0132***	0.0040***	0.0032***
	(0.0019)	(0.0011)	(0.0008)
Road in Radius	-0.0141***	0.0031***	-0.0004
	(0.0012)	(0.0008)	(0.0005)
Slope	0.1394***	0.0416***	-0.0574***
	(0.0099)	(0.0072)	(0.0019)
Ruggedness	-0.3932***	-0.1386***	0.1504***
	(0.0281)	(0.0207)	(0.0053)
Soil	0.0000***	-0.0000	-0.0000***
	(0.0000)	(0.0000)	(0.0000)
Share Surrounding Public	-0.0425***	0.0152***	0.0269***
	(0.0063)	(0.0028)	(0.0016)
Share Surrounding Developed	-0.2437***	0.0864***	-0.2894***
	(0.0179)	(0.0033)	(0.0049)
Dependent variable mean	0.08278	0.02478	0.12044
Observations	378,294	261,173	2,235,404
Pseudo R^2	0.24355	0.22464	0.38795

Notes: Logit models are estimated by maximum likelihood with fixed effects absorbed following Stammann (2018). Columns report average partial effects, with analytic standard errors following Fernández-Val and Weidner (2016) in parentheses. The unit of observation is a parcel of at least 20 acres classified primarily as farmland. The sample is restricted to parcels in townships whose parcels vary in the relevant outcome; townships without outcome variation carry no information in a within-township logit. *Turbine = 1*, *Solar = 1*, and *Easement = 1* are binary indicators equal to one if a wind turbine, solar project, or conservation easement, respectively, is located on the parcel as of 2024. *Log(Parcel Size)* is the log of parcel area (acres). *Normalized Owners in Radius* is the number of distinct landowners within 1/2 mile divided by the length of the parcel perimeter in miles. *Windiness* is mean wind speed (m/s). *Sunniness* is mean solar irradiance (kWh/m^2/day). *Conservation Value* is a land conservation priority score. *Airport in Radius* is an indicator equal to one if an airport lies within 1/2 mile. *Transmission in Radius* is an indicator equal to one if an electricity transmission line passes within 1/2 mile. *Rail in Radius* is an indicator equal to one if a railroad is located within 1/2 mile. *Road in Radius* is an indicator equal to one if a road is located within 1/2 mile. *Slope* is mean terrain slope (degrees). *Ruggedness* is the Terrain Ruggedness Index (TRI). *Soil* is a composite soil quality index. *Share Surrounding Public* is the share of land within 1/2 mile of the parcel that is publicly owned. *Share Surrounding Developed* is the share of land within 1/2 mile classified as developed. All models absorb township and GAP fixed effects. *p<0.1; **p<0.05; ***p<0.01.