

# Processing Deserts and the Missing Middle

## Mapping Meat-Processing Infrastructure Gaps Across Wisconsin's Pasture Landscape

**Dr. Success Okafor, Policy Economist (Fellow)**

Michael Fields Agricultural Institute



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## Abstract

The integration and maintenance of livestock into diversified farming systems requires access to inspected meat-processing infrastructure as a legal precondition for market participation. Commercial market sale requires the use of an inspected facility, making practical geographic access to such infrastructure a necessary condition for participation. This study examines the spatial distribution of inspected red-meat slaughter infrastructure relative to pastureland across Wisconsin's 72 counties and introduces two analytical constructs, the processing desert and the processing thinness index, for measuring infrastructure adequacy at the state scale.

Using licensing data from the Wisconsin Department of Agriculture, Trade and Consumer Protection, we filter 286 licensed meat establishments to 69 state- and federally inspected red-meat slaughter establishments by removing 67 custom-exempt facilities and 150 official facilities that lack slaughter capacity. Spatial analysis of this filtered layer against the Agricultural Conservation Planning Framework 2024 pasture dataset reveals that 26 of 72 counties, 36 percent of the state, contain no inspected red-meat slaughter facility within their borders, constituting absolute processing deserts that collectively hold approximately 718,939 acres of pasture land with no in-county inspected slaughter option. Among the 46 served counties, we define the processing thinness index as total county pasture acreage divided by facility count; values range from 1,074 acres per processor (Milwaukee) to 108,319 acres per processor (Lafayette), with a statewide median of 27,825 used to separate functional deserts from moderately served counties. Distance analysis shows county centroids up to 77.3 miles from the nearest inspected facility, and drive-time service-area analysis shows that large portions of northern Wisconsin fall outside a study-defined 60-minute service area of any inspected processor.

A weak negative association between population density and thinness ( $R^2 = 0.073$ ,  $b = -10.207$ ) suggests that thinner infrastructure is more common in rural counties, while the absence of facilities in several southeastern urban counties may reflect a distinct peri-urban pattern. These findings identify a structural infrastructure vulnerability relevant to diversified livestock-system adoption and maintenance and provide a replicable spatial methodology for targeting further capacity assessment and investment.

## In Brief

**More than a third of Wisconsin's counties have no inspected facility where livestock can be legally slaughtered for sale, leaving roughly 719,000 acres of pasture with no in-county path to market. This analysis maps where those gaps are, distinguishes counties that lack any processor from those whose single plant is stretched too thin, and shows how investment can be targeted to where it would most help farmers, rural economies, and local food systems.**

**Keywords:** *processing deserts; processing thinness; diversified farming systems; meat-processing infrastructure; geographic information systems; rural equity; Wisconsin*

Despite sustained policy attention to local and regional food systems, and the dramatic exposure of processing bottlenecks during the COVID-19 pandemic, the geographic distribution of small and mid-scale inspected processing infrastructure has received limited systematic spatial analysis. A substantial literature documents the long-run consolidation of slaughter capacity into a small number of very large plants (Saitone et al. 2024), the resulting fragility of meat supply chains (Lusk et al. 2021), and the specific difficulties that diversified and pasture-based operations face in securing slaughter and processing services (Johnson et al. 2012; Gwin et al. 2013; Ge et al. 2025). What this literature has not produced is a standardized, replicable spatial framework for identifying and measuring processing access at the county or regional scale, a tool comparable to the food-access atlases that now routinely inform retail-side policy.

Processing access also sits within a broader literature on rural logistics and food supply-chain resilience. Moving food through sparsely populated regions poses distinct logistical and cost challenges, and logistics itself is increasingly understood as a matter of policy rather than private operation alone (Savy 2016; Evangelista et al. 2021). The COVID-19 pandemic sharpened attention to the resilience and sustainability of food supply chains under disruption (Golan et al. 2020; Trotter et al. 2023), and regional food-flow analyses in the U.S. Upper Midwest have begun to identify the thresholds at which distribution networks remain resilient (Miller 2021). Inspected slaughter is one node in this larger chain, upstream of the aggregation, distribution, and retail functions through which meat ultimately reaches consumers. Although those downstream functions lie beyond the scope of this study, situating processing access within the supply chain clarifies why its absence forecloses participation in local meat markets.

This paper addresses that gap using Wisconsin as a case study. Wisconsin is an instructive setting: it maintains one of the largest pastureland bases in the Upper Midwest, a deep heritage of dairy and livestock farming, growing farmer interest in diversified and grass-based systems, and documented consumer demand for locally produced meat. The paper makes three contributions. First, it offers a spatial definition and operationalization of meat-processing deserts grounded in regulatory licensing data, yielding a methodology transferable to other states. Second, it introduces the processing thinness index, a county-level measure of infrastructure adequacy relative to the agricultural land base that captures constraints a binary desert/non-desert classification would miss. Third, it documents the spatial and demographic distribution of processing gaps across Wisconsin, identifying where infrastructure constraints are most severe and where targeted investment would most effectively enable diversified livestock-system adoption. The empirical analysis here is the spatial companion to a broader economic argument for diversified farming systems. This paper provides spatially explicit evidence that a specific infrastructure constraint binds the livestock component of those systems.

## Introduction



**Diversified farming systems (DFS) integrate multiple crop and animal enterprises and ecological processes to deliver productivity, environmental, and resilience benefits that simplified row-crop systems cannot** (Kremen and Miles 2012; Tamburini et al. 2020; Rasmussen et al. 2024). Among the components most central to ecologically functional diversified systems is livestock integration, which supports nutrient cycling, the productive use of permanent pasture and cover crops, and farm economic diversification (Russelle et al. 2007; Bowman and Zilberman 2013).

**A growing body of evidence indicates that diversified systems are at least as profitable as simplified systems once the full accounting of costs and benefits is considered** (Sanchez et al. 2022), and that diversification can advance environmental and social outcomes jointly (Rasmussen et al. 2024). Yet the ability of farmers to realize the economic potential of livestock integration depends not only on land, knowledge, and market demand, but on access to a critical and frequently overlooked piece of infrastructure: the inspected meat-processing facility.

In the United States, the Federal Meat Inspection Act and its state equivalents require that livestock destined for commercial market sale be slaughtered and processed in an inspected facility (Federal Meat Inspection Act, 21 U.S.C. §601 et seq.). This requirement creates a fundamental dependency: commercial sale depends on access to an inspected processor. For this study, a county without an inspected red-meat slaughter facility is classified as an absolute processing desert, while drive-time analysis separately evaluates practical access across county boundaries.

The construct is deliberately analogous to the food desert, the low-income, low-access framework developed by the U.S. Department of Agriculture to measure spatial deprivation of grocery access (Ver Ploeg et al. 2009), but it is applied to the supply side of the food system, where the binding access barrier is not the consumer's distance to a store but the producer's distance to a federally or state-inspected slaughter facility. Processing is one node in a longer supply chain that also includes aggregators, distributors, and retail and food-service buyers. Although these downstream functions are beyond the scope of this study, access to inspected slaughter is a necessary precondition for participation in them, and a fuller account of local meat-system development would situate processing access within that broader chain.



## Background and conceptual framework

### **Livestock integration and the infrastructure precondition**

Livestock play a distinctive functional role in diversified systems. Ruminants convert perennial forage and crop residues into marketable products, return nutrients to soils through managed grazing, and provide an economic enterprise whose returns are weakly correlated with grain markets, dampening whole-farm income variance (Russelle et al. 2007; Bowman and Zilberman 2013). Integrating livestock with cropping has been associated with reduced synthetic-input dependence and improved economic stability under commodity-price volatility, and pasture-based systems underpin the conservation value of perennial cover (Schulte et al. 2017; Tamburini et al. 2020). Despite these benefits, adoption of livestock integration among diversified operations remains below its theoretical potential, constrained by knowledge gaps, capital requirements, market-access challenges, and regulatory complexity.

We do not claim that livestock integration is uniformly stalled in Wisconsin.

Dairy consolidation and declining herd numbers have coincided with growing interest in grass-based and direct-market beef. Our argument is narrower: where producers do pursue livestock integration, access to inspected processing can become a binding constraint on reaching commercial markets.

This paper isolates one structural barrier that has received comparatively little spatial attention in the DFS literature: the absence of viable inspected-processing access. Unlike agronomic or knowledge constraints, which farmers can in principle address on their own operations, processing access is a shared infrastructure dependency external to the farm gate, and therefore one that individual effort cannot overcome.

### **The decline and consolidation of small-scale processing**

The contraction of small and mid-scale meat-processing capacity in the United States is well documented and is driven by consolidation pressures, regulatory compliance costs, thin operating margins, and competition from large commodity processors (Saitone et al. 2024). Plant-level analysis of federally inspected facilities shows that slaughter capacity is now concentrated in a small number of very large plants: for cattle, the ten largest plants account for roughly nine-tenths of national capacity (Saitone et al. 2024). The rapid plant-level consolidation of the 1990s and early 2000s disproportionately eliminated the small and very small slaughter establishments that diversified and pasture-based operations depend upon.

The consequence for local food systems is structural rather than incidental: even as consumer demand for local, sustainably produced meat has grown, the infrastructure required to bring that meat to market has thinned (Johnson et al. 2012; Gwin et al. 2013).

The COVID-19 pandemic exposed the fragility of this consolidated system. Temporary closures and capacity reductions at large plants produced a historic divergence between farm-gate livestock prices and wholesale meat prices, with beef and pork packing each losing on the order of 40 percent of capacity at the worst of the disruption (Lusk et al. 2021). In response, the USDA committed substantial funds to expand independent processing capacity. However, the targeting of those investments has not been systematically informed by spatial analysis of where capacity gaps are most severe relative to production potential, precisely the deficiency this paper's method is designed to remedy.

Recent work on the northeastern United States demonstrates that slaughter and processing capacity is a first-order barrier to expanding grass-finished beef production, and that overcoming it requires coordinated, spatially aware investment (Ge et al. 2025); Wisconsin's base of pasture land raises the same question for a major Upper Midwest dairy and livestock state.

### **Food deserts as a methodological precedent**

The food-desert framework provides the closest methodological precedent for this study. As operationalized by the USDA Economic Research Service, a food desert is a census tract that is simultaneously low income and low access, where low access is defined by distance thresholds to the nearest supermarket, commonly more than one mile in urban areas and more than ten miles in rural areas (Ver Ploeg et al. 2009). Two features of this framework are directly transferable. First, it demonstrates that access barriers to food-system participation can be spatially measured, mapped, and used to target interventions. Second, it shows how the combination of a geographic threshold with a complementary measure of need produces a robust and defensible definition of access deprivation. We adopt analogous logic for the supply side, defining processing deserts by the absence of inspected slaughter capacity within county borders and operationalizing processing thinness as a continuous measure of infrastructure adequacy relative to the pasture land base. We use the term "processing desert" by analogy to the food-desert literature, while recognizing the critique that "desert" can imply a natural condition rather than one produced by policy and investment choices. We retain the term deliberately because our analysis attributes these gaps to structural processes, including historical underinvestment and the displacement of processing capacity by development, rather than to any natural or inevitable state. As with the food-desert concept, the framework is designed to be replicable across states and scales.

### **The binding-constraint logic**

The central analytical claim of this paper is that inspected processing infrastructure can function as a binding constraint on diversified livestock-system adoption where practical access is absent or inadequate. The argument borrows the concept of a binding constraint from development economics, which identifies the single factor most limiting to a desired outcome when several conditions are necessary but not all are simultaneously satisfied. The regulatory mechanism is decisive: because the law requires inspected slaughter for commercial market sale, limited practical access to an inspected facility can constrain the farmer-to-consumer transaction even when other conditions are favorable.

In a county with abundant pasture, motivated farmers, and strong consumer demand but no inspected processor, processing access may become the binding factor rather than land, motivation, or demand. This framing matters for policy because it implies that interventions confined to farmer training, market development, or consumer education may be insufficient in counties with limited practical access unless corresponding infrastructure constraints are also addressed.

### **Operational definitions introduced by this study**

Because the constructs below are introduced here rather than inherited from prior literature, we state them explicitly. Each definition is operational, tied to a specific, reproducible calculation on public data, so that the framework can be applied without ambiguity to other states (see Table 1).

Combining the absence/presence of facilities with the thinness index yields a four-category county typology: absolute deserts (zero facilities); functional deserts (facilities present, TI above median); moderately served counties (TI at or below median, fewer than three facilities); and well-served counties (three or more facilities and TI at or below the median). Together these categories form a continuum of processing-access deprivation that is more informative than a binary classification and that supports differentiated policy responses (Table 2).





## Materials and methods



### Study area

Wisconsin comprises 72 counties spanning intensively farmed southern, central, and eastern districts, the rolling unglaciated Driftless Area of the west/southwest, and sparsely settled forested counties in the north. The state's extensive permanent-pasture base and its dairy and livestock heritage make it a representative and policy-relevant setting for examining processing access.

All analysis used the county as the unit of observation, consistent with the scale at which licensing, demographic, and agricultural-land data are reliably available and at which infrastructure policy is typically targeted.

### Data sources

Four primary datasets were used. (i) Wisconsin meat-establishment data were obtained from the Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP) Meat Establishments Inspected and Custom Directory, retrieved in August 2024 (Wisconsin DATCP 2024). The directory lists all 286 licensed meat establishments with facility name, address, inspection status, and license-activity fields. The inspection-status field distinguishes Official establishments operating under state or federal inspection from Custom establishments that serve individual farmers and cannot legally process livestock for commercial sale; the license-activities field records specific authorized activities, including Red Meat Slaughter. (ii) Pasture land data were drawn from the Agricultural Conservation Planning Framework (ACPF) 2024 dataset for Wisconsin (Tomer et al. 2017), whose field-boundary database classifies agricultural fields using a six-year land-cover sequence derived from USDA Farm Service Agency boundaries and the USDA National Agricultural Statistics Service Cropland Data Layer; fields with an isAG value of 2 (pasture, grass, and hay) constitute the pasture layer. (iii) County boundaries were obtained from the Wisconsin DNR County Boundaries (24K) dataset. (iv) Population and demographic data for all 72 counties, population, land area, population density, and change since 2020, were compiled from U.S. Census Bureau Population Estimates Program figures (U.S. Census Bureau 2024). The county-level analytical variables and their sources are summarized in Table 4.



## Establishment filtering

The most consequential methodological step was filtering the establishment directory to retain only facilities relevant to diversified farmers seeking market access. Of the 286 establishments, 67 custom-exempt establishments were excluded from the inspected-commercial layer. Custom-exempt facilities operate under the custom-slaughter exemption to the Federal Meat Inspection Act and process animals for the owner's use rather than for sale by the cut at retail or to commercial buyers. They nonetheless support an active direct-market channel, in which a farmer sells a whole, half, or quarter live animal to a consumer who then receives the custom-processed meat and pays the processing fee directly.

Because this study measures access to inspected slaughterhouses capable of supplying commercial and retail markets, these facilities fall outside the layer of interest; their role in direct sales is discussed in Section 5. Of the remaining 219 Official establishments, 150 were excluded because they do not hold a Red Meat Slaughter license activity; these include facilities such as further-processing operations, sausage makers, and cut-and-wrap-only businesses that, although officially inspected, cannot perform the slaughter function a farmer requires to bring an animal to market. Filtering produced a final analytical layer of 69 inspected red-meat slaughter establishments (24.1 percent of all establishments). Facilities operating under federal USDA inspection and those under Wisconsin state inspection were both retained: Wisconsin operates a state meat-inspection program under standards required by federal law to be at least equal to federal requirements, so both facility types permit legal intrastate market transactions.

To isolate officially inspected red meat slaughter facilities, the *Select by Attributes* tool in ArcGIS Pro was used with the expression ***USER\_Inspe LIKE '%Official%' AND USER\_Lic\_1 LIKE '%Red Meat Slaughter%'***. The query returned 69 matching facilities, which were exported to a new feature layer, **WI\_RedMeat\_Slaughter\_Official** used in subsequent analyses.

## County-level facility counts and pasture acreage

County processor counts were generated with the Spatial Join tool (county boundaries as target features, filtered processor points as join features, Contains match option, one-to-one join), producing a Join\_Count field; counties with Join\_Count = 0 were identified as absolute deserts.

Total pasture acreage per county was computed in two steps because a single-tool Summarize Within operation returned a field-reference error: a Spatial Join (Within) first assigned county identifiers to each pasture parcel, after which the Dissolve tool aggregated parcel acreage by county (COUNTY\_NAM field, Sum statistic on Acres), yielding SUM\_Acres. A single null-county record arising from parcels intersecting county boundaries was excluded from subsequent analysis. The two-step procedure is reported here in full in the interest of methodological transparency and reproducibility.

## **Processing thinness index and county typology**

The processing thinness index was calculated with the Calculate Field tool as  $\text{SUM\_Acres} \div \text{Join\_Count}$ ; the 26 desert counties correctly received null values because division by zero is undefined. Summary statistics across the 46 served counties yielded a mean of 32,589 and a median of 27,825 acres per processor; the median was adopted as the typology split point because it is robust to the right-skew introduced by a small number of extreme high-thinness counties and is exactly reproducible. County typology was then assigned with a Python expression evaluating facility count and thinness: counties with zero facilities were classified as absolute deserts; counties with facilities and TI above 27,825 as functional deserts; counties with TI at or below 27,825 and fewer than three facilities as moderately served; and counties with three or more facilities and TI at or below 27,825 as well served.

## **Distance and drive-time service-area analysis**

Two complementary access measures were computed. Straight-line distance to the nearest inspected processor was derived by generating county centroids (Feature to Point, centroids constrained inside county polygons) and applying the Near tool against the filtered processor layer (Miles US Survey, planar method), producing NEAR\_DIST. Network drive-time service areas were generated with the ArcGIS Network Analyst extension using all 69 processor locations as facilities and cutoffs of 20, 40, and 60 minutes under a driving-time travel mode. The 60-minute contour is treated as a study-defined planning threshold rather than a universally established maximum hauling time. The two measures are complementary: the county-based classification identifies the presence or absence of in-county facilities, while the travel-time service areas evaluate practical network access across county boundaries. Their comparison shows where the county-based classification aligns with road-network accessibility.

## **Rurality and statistical analysis**

Population density (persons per square mile) was joined to the county analytical layer by standardized county name and adopted as the operational measure of rurality. Population density was chosen as a simple, transparent, and fully reproducible proxy for rurality at the county scale. It is not a formal rural classification; established schemes such as the USDA Economic Research Service Rural-Urban Continuum Codes and the Census Bureau urban and rural delineations capture additional dimensions of rurality. Density was adopted here for its continuity with the county unit of analysis and its ease of replication across states. The relationship between density and processing thinness across the 46 served counties was examined with an ordinary-least-squares linear fit and scatter plot. The correlation is treated as supporting evidence to the primary cartographic results rather than as a test of a causal hypothesis; its interpretation is discussed alongside its limitations in Section 5.

## Results

### Establishment filtering and facility distribution

Filtering reduced the 286-establishment directory to 69 inspected red-meat slaughter establishments, the only facilities legally capable of slaughtering livestock for commercial market sale in Wisconsin. These 69 facilities are unevenly distributed, concentrating in south-central and central Wisconsin and thinning markedly to the north. Overlaying facility locations on the ACPF pasture layer reveals an immediate visual mismatch between the distribution of processing capacity and the distribution of pasture land, with extensive pasture in northern and western Wisconsin served by few or no facilities (Figure 1).

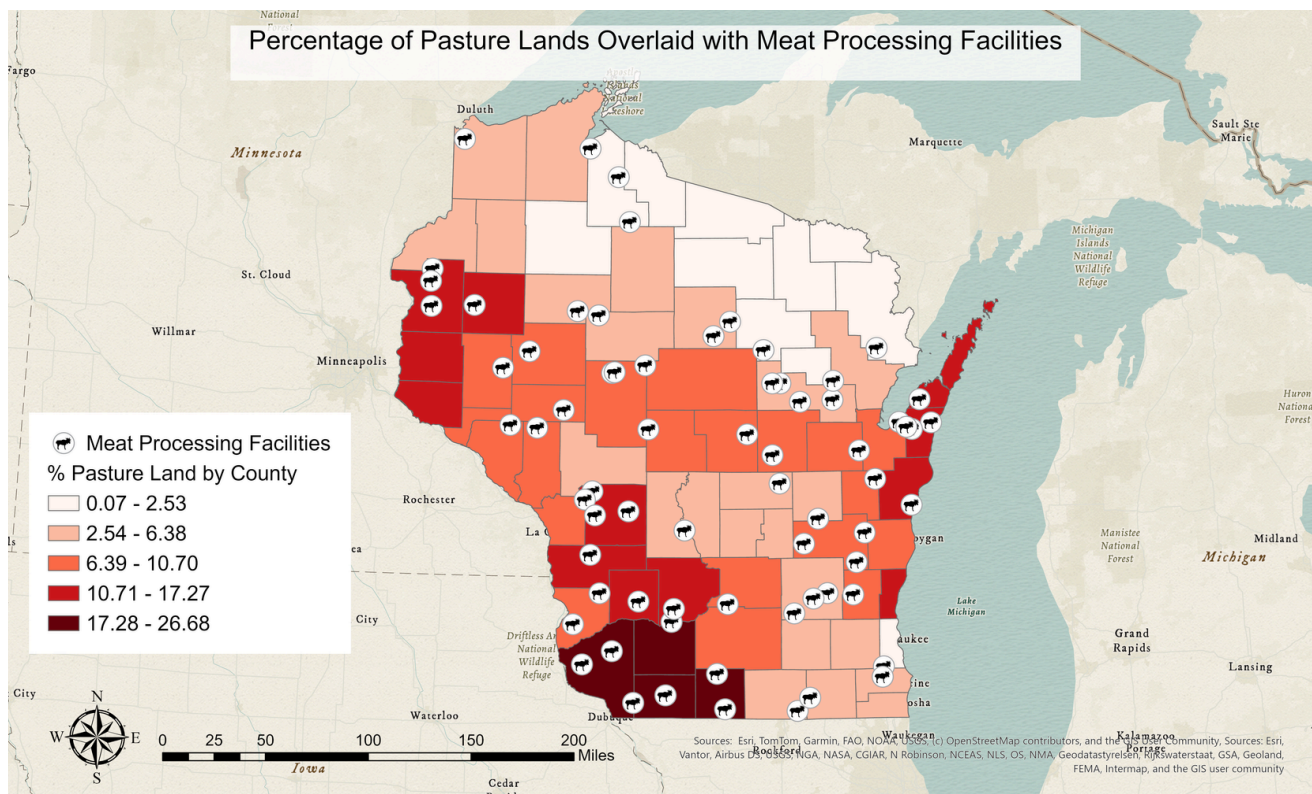


Figure 1. Pasture land and inspected red-meat slaughter facilities in Wisconsin. Symbols show the 69 filtered inspected processors. Large northern and western pasture areas are served by few or no facilities. Sources: Wisconsin DATCP (2024); Tomer et al. (2017).

## Absolute processing deserts

Spatial join of the 69 facilities against county boundaries shows that 26 counties contain zero inspected red-meat slaughter facilities, 36.1 percent of all Wisconsin counties, constituting absolute processing deserts (Figure 2). The remaining 46 counties contain at least one facility, with the majority holding only one. The desert counties cluster in northern Wisconsin, consistent with rural depopulation and land-use change in that region.

Notably, however, deserts are not exclusively northern: several southeastern counties, including Kenosha and Racine, also lack any inspected processor. This pattern may reflect different processes, including limited infrastructure in sparsely populated agricultural regions and possible displacement of agricultural infrastructure by urban or suburban development; however, these mechanisms are not directly tested here.

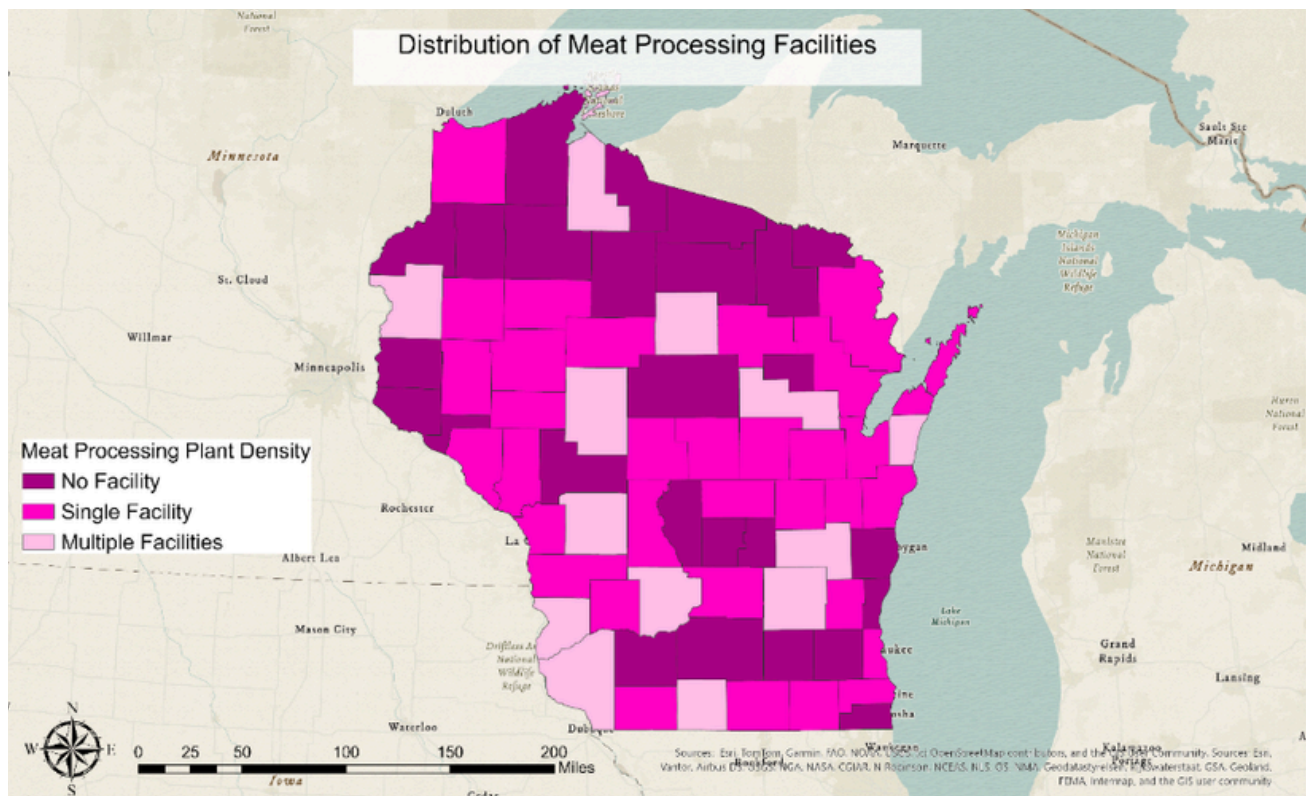


Figure 2. Distribution of inspected meat-processing facilities. Counties shown by facility count: processing desert (0), single facility (1), and multiple facilities (2+). Twenty-six counties contain no inspected red-meat slaughter facility. Source: Wisconsin DATCP (2024).

## Pasture acreage within deserts

The 26 absolute desert counties collectively contain approximately 718,939 acres of pasture land, with a mean of 27,651 acres per desert county (Table 3). This is a substantial agricultural land base located in counties with no in-county inspected slaughter facility. The acreage figure indicates the scale of pasture located in counties without an in-county facility; it does not establish current livestock demand or whether producers use facilities in neighboring counties.



## Processing thinness among served counties

Among the 46 served counties, the processing thinness index ranges from 1,074 acres per processor in Milwaukee County to 108,319 acres per processor in Lafayette County, with a mean of 32,589 and a median of 27,825 (Figure 3). The extreme range indicates substantial variation in pasture acreage per facility, although the index does not measure facility capacity or current utilization. Lafayette County is the most striking case: with one of the largest pasture bases in the state served by a single inspected processor, its thinness of 108,319 represents a large potential pasture land base relative to one facility. Comparable extremes appear in Vernon (90,233), Barron (66,614), and Grant (61,513) counties. Several of these lies in the Driftless Area of southwestern Wisconsin, among the state's most productive grass-based landscapes, where potential infrastructure vulnerability may be substantial.

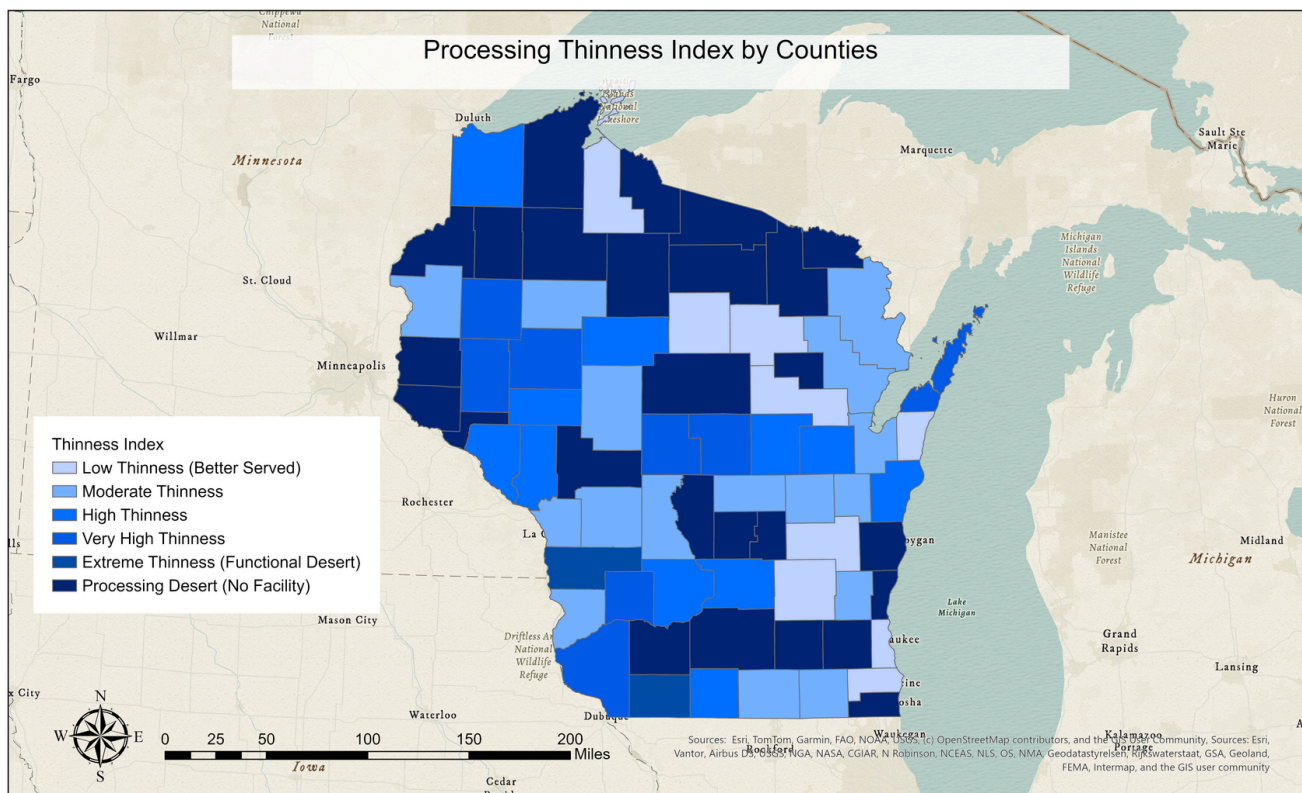


Figure 3. Processing thinness index by county. Thinness (pasture acres per inspected processor) classified by natural breaks; desert counties (null thinness) shown separately. The highest-thinness counties concentrate in the southwestern Driftless Area. Sources: Wisconsin DATCP (2024); Tomer et al. (2017).

## Processing-desert typology

The four-category typology synthesizes the absolute-desert and thinness findings into a single representation (Figure 4). Absolute deserts dominate the north and recur in scattered southeastern counties; functional deserts concentrate in central and southwestern Wisconsin, corresponding to high-pasture Driftless Area counties with limited slaughter capacity; moderately served counties form a central corridor; and well-served counties are distributed with modest clustering in the central and eastern regions. The typology identifies several counties with large pasture bases and livestock traditions that also fall into absolute- or functional-desert categories, marking priority areas for closer capacity assessment.

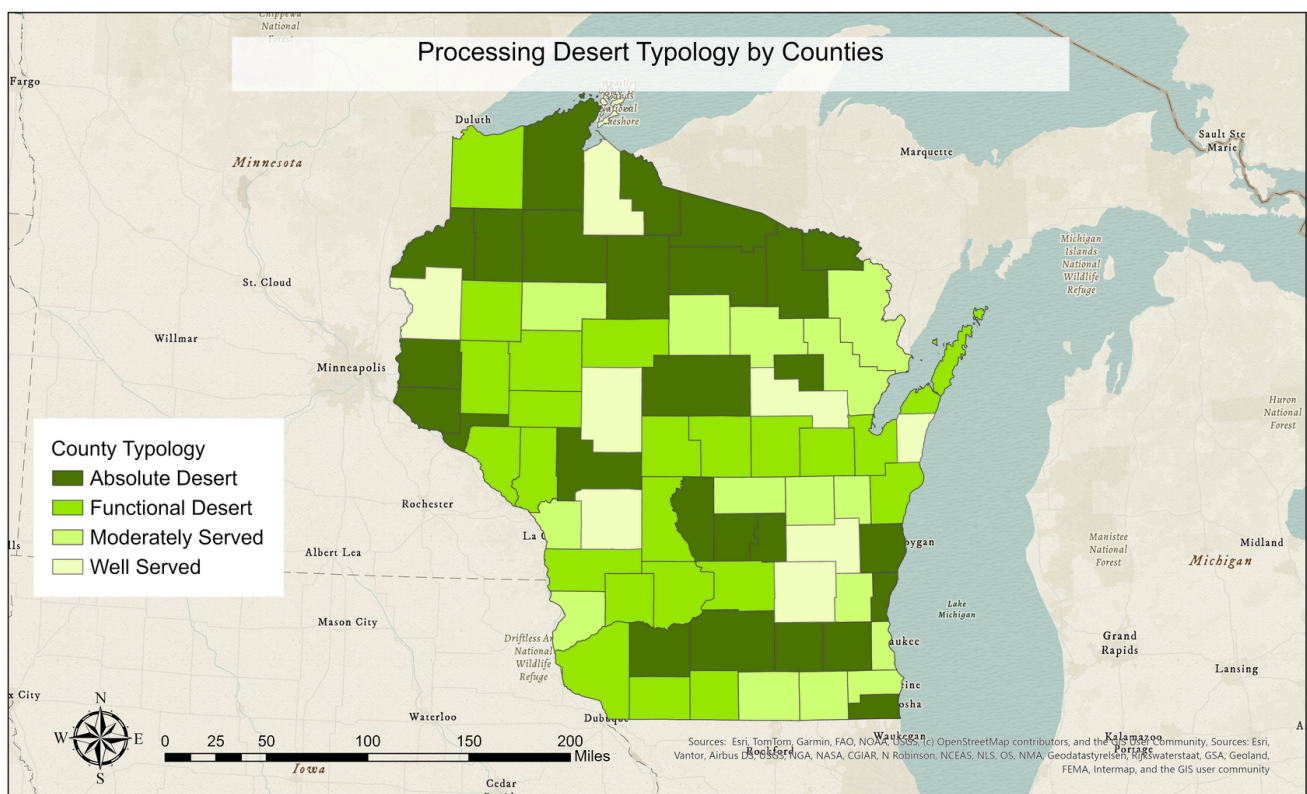


Figure 4. Processing-desert typology by county. Counties classified as absolute desert, functional desert, moderately served, or well served, using the statewide median thinness (27,825 acres per processor) as the split point. Sources: Wisconsin DATCP (2024); Tomer et al. (2017).



## Distance to the nearest processor

Straight-line distance from county centroids to the nearest inspected processor ranges from 0.815 miles in Lafayette County to 77.3 miles in far northeastern Wisconsin (Figure 5). A clear geographic gradient emerges, with southern and eastern counties predominantly in the lowest distance classes and northern counties in the highest. The pattern mirrors the facility distribution of Section 4.1, with physical distance to processing rising sharply as one moves north into less densely settled territory.

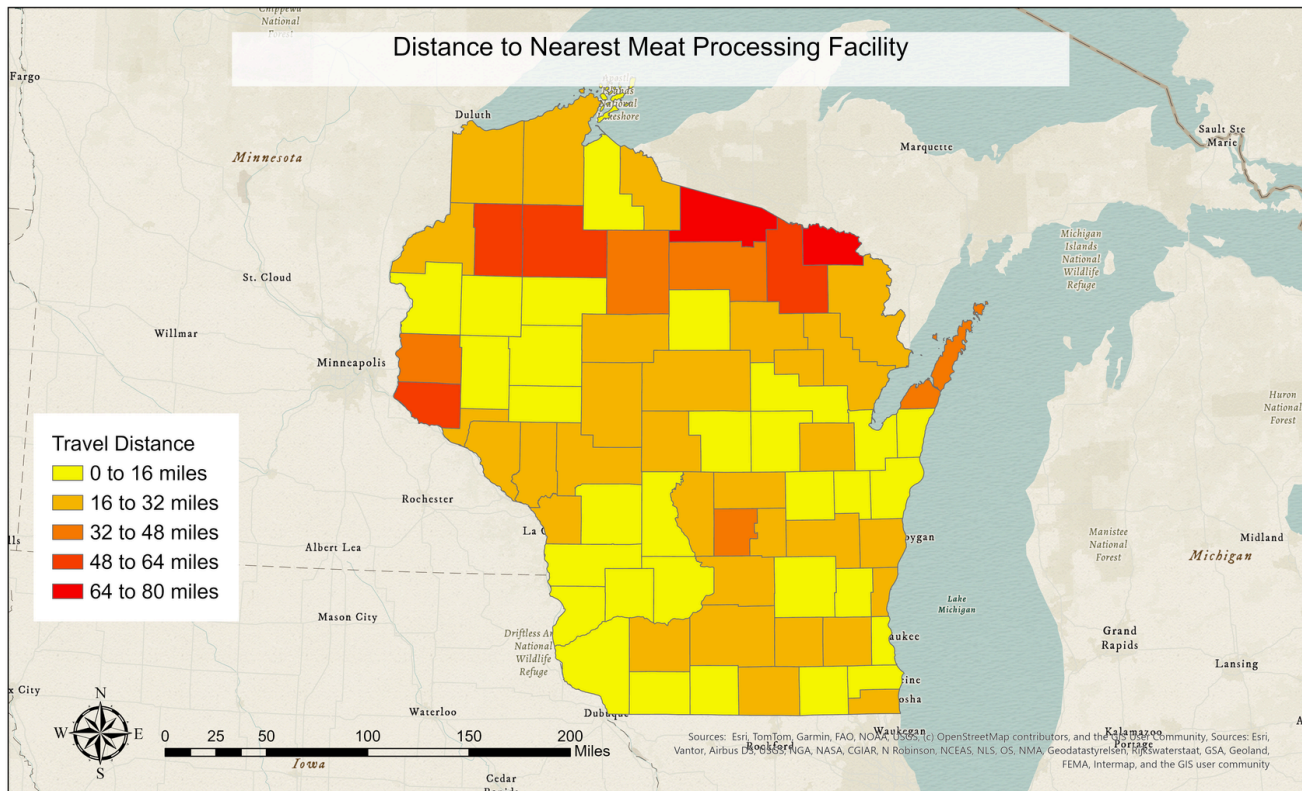


Figure 5. Distance to nearest meat processing facility. Straight-line distance from county centroid to nearest inspected red-meat slaughter facility, classified at approximately 16-mile intervals (range 0.815–77.3 miles). Source: Wisconsin DATCP (2024).

## Drive-time service areas

Network drive-time analysis at 20, 40, and 60-minute cutoffs shows that substantial portions of northern Wisconsin fall outside a study-defined 60-minute service area of any inspected facility (Figure 6). The uncovered areas in the far north and northwest are particularly notable. Because this measure relies on the road network rather than straight-line distance, it provides a practical comparison with the county-based desert classification.

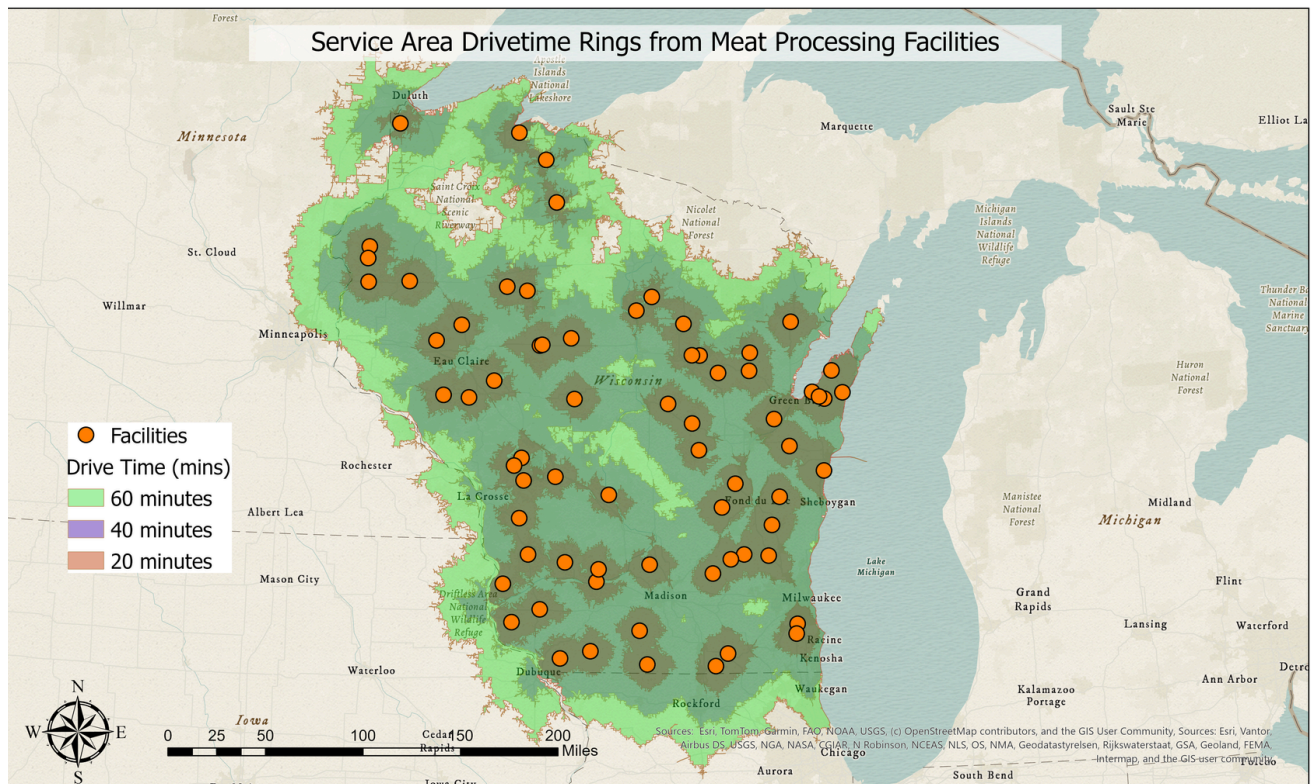


Figure 6. Drive-time service areas from inspected processors. Service-area contours at 20, 40, and 60 minutes of network drive time from the 69 inspected facilities. Northern and northwestern districts lie beyond the study-defined 60-minute service threshold. Source: Wisconsin DATCP (2024); ArcGIS Network Analyst.



## Rurality and processing access

Population density shows a limited spatial correspondence with desert and high-thinness classifications (Figure 7). Northern counties, predominantly absolute deserts, are also among the least densely populated, most falling below 80 persons per square mile. Across the 46 served counties, the linear fit between density and thinness is negative ( $R^2 = 0.073$ ;  $b = -10.207$ ; intercept = 34,560), suggesting that lower-density counties tend toward higher thinness. The relationship is modest in magnitude, reflecting substantial within-group variation and the influence of urban outliers such as Milwaukee, which combines very high density with minimal pasture and therefore low thinness, but the negative slope is only directionally consistent with greater infrastructure thinness in some rural counties.

Six of the 26 desert counties also lost population since 2020, suggesting that processing gaps may compound broader rural vulnerabilities in a subset of counties; the majority, however, are demographically stable or growing, indicating that the observed processing gaps cannot be explained solely by depopulation.

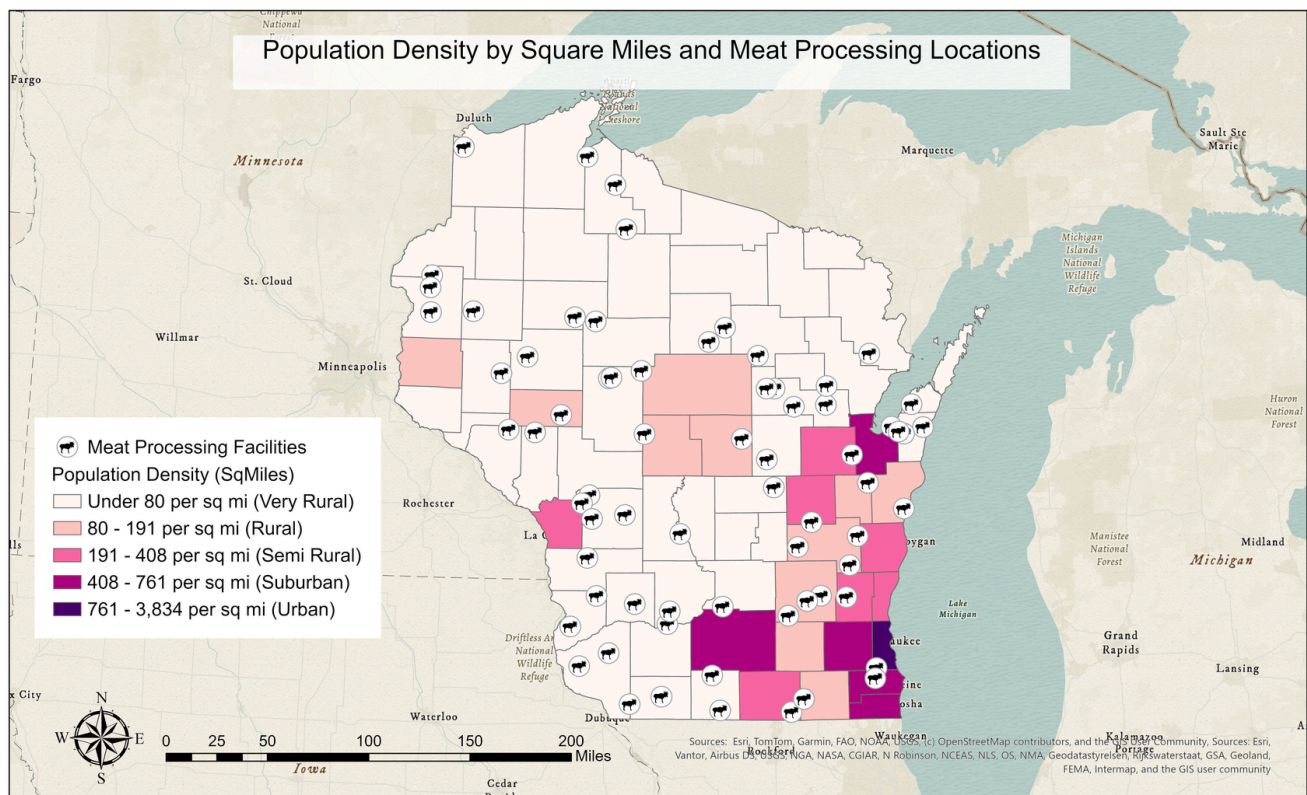


Figure 7. Population density and inspected processing locations. County population density (persons per square mile) with inspected processors overlaid. The least dense northern counties coincide with absolute deserts; selected southeastern counties may represent a distinct peri-urban pattern. Sources: U.S. Census Bureau (2024); Wisconsin DATCP (2024).

## Discussion



### Processing access as a binding constraint

That 36 percent of Wisconsin counties contain no inspected red-meat slaughter facility documents a substantial geographic gap in in-county processing infrastructure. This does not mean that commercial transactions are legally impossible in those counties, because producers may use inspected facilities elsewhere; rather, it identifies counties where access depends on crossing county boundaries and, in some cases, traveling beyond the study-defined 60-minute service area. The policy implication is that training and market development alone may not resolve access problems where nearby inspected capacity is absent or inadequate. The 718,939 acres of pasture in these counties indicates the scale of the agricultural land base potentially affected, but it should not be interpreted as current processing demand.

### Functional deserts and the Driftless Area

The thinness analysis shows that the 26-county absolute-desert finding does not capture variation among counties that contain facilities. Counties counted as served by virtue of a single facility may face greater infrastructure vulnerability when a single facility is associated with tens of thousands of acres of pasture. Lafayette County's thinness of 108,319 acres per processor does not measure the facility's actual throughput; rather, it indexes the potential pasture land base associated with a single processor if the county's pasture were more fully engaged in livestock production. The thinness index is therefore best read as a measure of vulnerability to constraint as adoption grows, not as a snapshot of current utilization. The geographic clustering of extreme thinness in the Driftless Area is especially consequential: this region of rolling, erosion-prone terrain is poorly suited to row crops but well suited to grass-based livestock, making it among the highest-potential landscapes for diversified transitions (Schulte et al. 2017). The convergence there of agricultural potential and infrastructure thinness identifies processing capacity as a candidate leverage point for the regional agricultural transition that conservation and food-system actors have long sought (Ge et al. 2025).



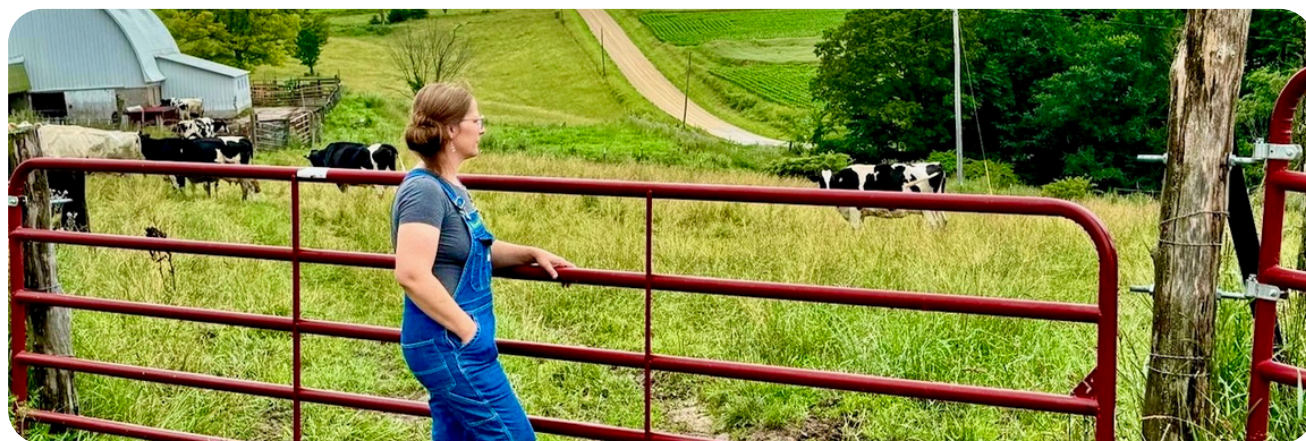
## Rural-equity dimensions

The negative density–thinness relationship is weak ( $R^2 = 0.073$ ) but directionally consistent with greater infrastructure thinness in some rural counties. The map also shows substantial variation, so rurality should be interpreted as one contextual factor rather than a strong predictor. The subset of desert counties also losing population suggests that processing gaps may compound broader agricultural and economic vulnerabilities in some communities. The implication extends beyond agriculture: where diversified farming offers a realistic pathway to farm viability and community food-system development, the absence of processing infrastructure is simultaneously a constraint on rural economic development. Policy frameworks that treat processing-infrastructure investment as rural-development investment, not solely as agricultural policy, may better match the full scope of the problem.



## Two types of processing desert

An important nuance is that deserts are not exclusively rural. Several southeastern urban and suburban counties also lack facilities. One possible explanation is peri-urban displacement of processing infrastructure, but facility-closure histories and land-use changes were not analyzed. Accordingly, this study identifies a distinct spatial pattern rather than confirming a separate causal mechanism. The pattern nevertheless suggests that policy responses may need to differ between remote rural and peri-urban settings.





## Policy recommendations

The findings support five concrete recommendations, each keyed to the county typology so that interventions match the specific form of constraint.

1. **Target federal processing investment spatially.** The USDA Meat and Poultry Processing Expansion Program and the companion Local Meat Capacity grants administered by USDA Rural Development and the Agricultural Marketing Service were created after the pandemic-era disruptions to expand independent capacity (Lusk et al. 2021; USDA Rural Development 2024), but award decisions are not currently conditioned on a spatial measure of where capacity gaps are most severe relative to agricultural potential. The typology map produced here could serve as an initial screening tool: absolute desert counties with substantial pasture bases could be considered for scoring priority, subject to evidence of livestock demand, existing cross-county access, and facility capacity.



2. **Deploy capacity expansion and mobile slaughter options in functional deserts.** In the Driftless Area counties like Lafayette, Vernon, Grant, and Richland, and high-thinness counties like Barron County, a single facility nominally serves pasture bases of 57,000 to 108,000 acres. Expanding existing facilities and licensing mobile or modular inspected slaughter units, which can rotate across high-thinness counties, are lower-cost responses than new fixed plants and match the dispersed character of demand in these landscapes.
3. **Leverage Wisconsin's Equal To state inspection program.** Because state-inspected facilities permit legal intrastate sale, DATCP can expand effective access without waiting for federal grant-in-aid: state-level cost-share for plant upgrades, licensing assistance for new small operators, and investment in the skilled-butcher workforce pipeline all lower the entry barrier for the small plants that serve diversified farms. State action is especially decisive in the 26 absolute desert counties, where any new qualifying facility would provide an in-county inspected slaughter option.

4. **Treat processing infrastructure as rural development policy, not only agricultural policy.** The concentration of deserts and extreme thinness in the state's least dense counties means that processing investment functions simultaneously as farm-viability policy and rural economic development, retaining livestock value-added activity, and the associated employment, within the communities that produce the animals. Framing processing under rural development authorities broadens the funding base beyond agricultural appropriations.
5. **Investigate and preserve capacity in potential peri-urban processing gaps.** In southeastern counties such as Kenosha and Racine, additional analysis of facility closures, land-use pressures, livestock demand, and nearby cross-county access is needed before selecting an intervention. Where existing capacity is threatened, land-use protections and succession assistance may be appropriate. Finally, the analysis should be maintained as a living monitoring tool, updated as licenses change, in the manner of the USDA Food Access Research Atlas, so that moderately served counties approaching the thinness threshold are identified before they become functional deserts.



These recommendations connect the supply-side infrastructure question to the broader economic case for diversified systems: supporting diversified system maintenance and adoption may require both appropriate incentives and sufficient physical infrastructure through which livestock products can reach the market.



## Limitations

Several limitations bound these conclusions. First, the thinness index measures a structural relationship between land base and facility count, not actual processing demand or facility capacity; a high-thinness county with little current livestock production may experience no present constraint, while a low-thinness county whose single facility operates at capacity may. The index is best understood as a vulnerability measure as adoption grows, not a direct measure of current access. The analysis counts inspected facilities but does not account for their throughput, which varies widely, from operations processing a few dozen animals per week to those processing hundreds per day. A county served by one high-capacity plant may face less constraint than its facility count suggests, while a county with a single small plant may face more; the thinness index should therefore be interpreted as a structural measure of access relative to the land base rather than a measure of realized processing capacity.

Capacity-adjusted thinness, where such data become available, is a priority for future work. Second, the county unit of analysis can obscure sub-county variation in processor proximity and pasture distribution; parcel-level proximity measures would provide a more granular picture. Third, the analysis omits processor capacity (head or tons per week), which is not systematically available from public sources; capacity-adjusted thinness would materially strengthen the metric. Fourth, The ACPF pasture layer is a land-cover classification and does not distinguish actively grazed pasture from idle or unmanaged grassland. USDA-derived classifications are known to have difficulty separating used from idle pasture, so county pasture totals should be read as an upper-bound estimate of the grazable land base rather than a measure of land in active livestock use. Ground-truthing against Wisconsin sources would refine these estimates. Establishing such causality would require longitudinal farm-level data linking changes in processing access to adoption decisions. The county-based absolute-desert classification does not imply that producers lack lawful access to facilities in adjacent counties; the network analysis provides a more direct measure of practical cross-boundary access. Fifth, the use of population density as a rurality proxy is a simplification; future work could substitute a multidimensional classification such as the Rural-Urban Continuum Codes to test the sensitivity of the rural-equity findings. Sixth, A limitation of the inspected-only definition is that it does not capture the custom-exempt direct-market channel. Many smaller-scale Wisconsin producers reach consumers by selling whole, half, or quarter animals that are slaughtered under the custom-exempt exemption, with the processing fee paid directly by the buyer. This channel offers a legal route to consumers in some counties we classify as processing deserts, although it is limited to whole-animal direct sales and cannot supply by-the-cut retail, food service, or wholesale buyers. The desert and thinness measures should therefore be read as indices of access to inspected, commercial-market processing, not as evidence that no legal route from farm to consumer exists.

A complementary analysis that incorporates custom-exempt capacity would refine the picture of direct-market access and is a useful direction for future work. Finally, the drive-time model reflects a single network state and may understate access degradation under adverse seasonal conditions in northern Wisconsin.



## Conclusion

This study documents that 26 of Wisconsin's 72 counties, 36 percent of the state, contain no inspected red-meat slaughter facility capable of serving diversified livestock farmers for commercial market transactions, and that these absolute processing deserts hold approximately 718,939 acres of pasture with no in-county inspected slaughter option. An additional set of counties exhibits extreme processing thinness, with single facilities nominally responsible for pasture bases that in some cases exceed 100,000 acres per processor. Together these findings identify a spatial infrastructure vulnerability that is most visible in rural and high-pasture areas, while also appearing in selected southeastern counties.



The processing-desert framework introduced here, comprising the absolute-desert classification, the processing thinness index, and the four-category typology, provides a replicable, policy-relevant methodology for identifying and measuring processing-infrastructure gaps at the state scale, with definitions explicit enough to transfer to other states. The two-tier distinction between absolute and functional deserts captures dimensions of the access problem that a binary classification would miss and supports differentiated responses: new capacity where facilities are absent, expansion or mobile options where thinness is extreme, and monitoring where access is moderate. Future work should incorporate USDA Census of Agriculture livestock inventory to replace pasture acreage as the demand-side variable, develop parcel-level proximity measures, integrate processor-capacity data where available, and extend the methodology across the Upper Midwest to enable regional comparison and strengthen the evidence base for federal processing-infrastructure policy.

## About The Author

Dr. Success Okafor is the Policy Fellow at MFAI. Dr. Okafor is an agricultural economist specializing in sustainable food systems, spatial analysis, and data-driven agricultural policy. He holds a PhD in Agribusiness and Applied Economics, as well as a post-Baccalaureate Certificate in Data Analytics, from North Carolina A&T State University. Okafor also earned a master's degree in Agribusiness Economics from Southern Illinois University and a Bachelor's degree in Agricultural Economics from the Federal University of Technology Owerri (FUTO), Nigeria.

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## Data availability statement

The meat-establishment directory is publicly available from the Wisconsin DATCP; the ACPF field-boundary and pasture data are available from the Agricultural Conservation Planning Framework; population data are available from the U.S. Census Bureau Population Estimates Program. Derived analytical layers supporting the findings are available from the corresponding authors on reasonable request.

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Tables

Table 1. Operational definitions introduced in this study.

| Term                                  | Definition                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|---------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Processing desert (absolute)          | A county containing no state- or federally inspected red-meat slaughter establishment licensed under the Wisconsin DATCP Meat Establishments program. The term indicates the absence of an in-county inspected slaughter option; producers may still access facilities in neighboring counties.                                                                                                                                                                                        |
| Processing thinness index (TI)        | For a county with at least one qualifying facility, $TI = \text{total county pasture acreage} \div \text{number of inspected red-meat slaughter facilities}$ . TI expresses pasture acreage per facility as a relative vulnerability indicator; higher values indicate a larger land base per facility but do not measure demand, capacity, or utilization. TI is undefined (null) where the facility count is zero, because such counties are already classified as absolute deserts. |
| Functional processing desert          | A county with one or more qualifying facilities but a processing thinness index above the statewide median of served counties (27,825 acres per processor). Functional deserts have a relatively large pasture land base per facility and are treated as higher-priority areas for further capacity assessment.                                                                                                                                                                        |
| Viable hauling threshold (drive time) | A study-defined planning threshold of 60 minutes of network drive time, used to compare practical access across the state. The threshold is not presented as a universal maximum hauling time; 20- and 40-minute contours are reported as higher-service tiers. Areas beyond the 60-minute contour of every inspected facility are treated as outside the study-defined service area.                                                                                                  |

**Table 2. Four-category county typology combining facility presence and the processing thinness index.**

| Category          | Definition                                                | Policy implication                 |
|-------------------|-----------------------------------------------------------|------------------------------------|
| Absolute desert   | No inspected red-meat slaughter facility (Join_Count = 0) | Assess need for new capacity       |
| Functional desert | $\geq 1$ facility; thinness $> 27,825$ (statewide median) | Assess expansion or mobile options |
| Moderately served | Thinness $\leq 27,825$ ; fewer than three facilities      | Monitor as adoption grows          |
| Well served       | Three or more facilities; thinness $\leq 27,825$          | Reference / monitoring category    |



**Table 3. Summary statistics for county-level processing-access variables.**

| Statistic                                                     | Value               |
|---------------------------------------------------------------|---------------------|
| Total counties                                                | 72                  |
| Absolute desert counties                                      | 26 (36%)            |
| Served counties                                               | 46 (64%)            |
| Pasture in desert counties (acres)                            | 718,939             |
| Mean pasture per desert county (acres)                        | 27,651              |
| Processing thinness, served counties — mean (acres/processor) | 32,589              |
| Processing thinness, served counties — median                 | 27,825              |
| Processing thinness, served counties — maximum                | 108,319 (Lafayette) |
| Processing thinness, served counties — minimum                | 1,074 (Milwaukee)   |
| Distance to nearest processor — minimum (mi)                  | 0.815 (Lafayette)   |
| Distance to nearest processor — maximum (mi)                  | 77.3                |
| Population density vs. thinness (served counties), $R^2$      | 0.073               |

*Note: Processing thinness is defined only for served counties ( $\geq 1$  facility); it is undefined for absolute deserts (division by zero).*



**Table 4. County-level analytical variables and their sources.**

| Variable       | Source/Tool                    | Description                                        |
|----------------|--------------------------------|----------------------------------------------------|
| Join_Count     | DATCP 2024 / Spatial Join      | Inspected red-meat slaughter facilities per county |
| SUM_Acres      | ACPF 2024 / Dissolve           | Total pasture acreage per county                   |
| Thinness_Index | Calculated (Calculate Field)   | SUM_Acres ÷ Join_Count; null for desert counties   |
| NEAR_DIST      | Near tool                      | Miles from county centroid to nearest processor    |
| densityMi      | Census PEP 2024                | Population density per square mile (rurality)      |
| County_Type    | Calculated (Python expression) | Four-category typology classification              |