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Double Standards: Regulating Street Connectivity in Public and Private Communities in the United States

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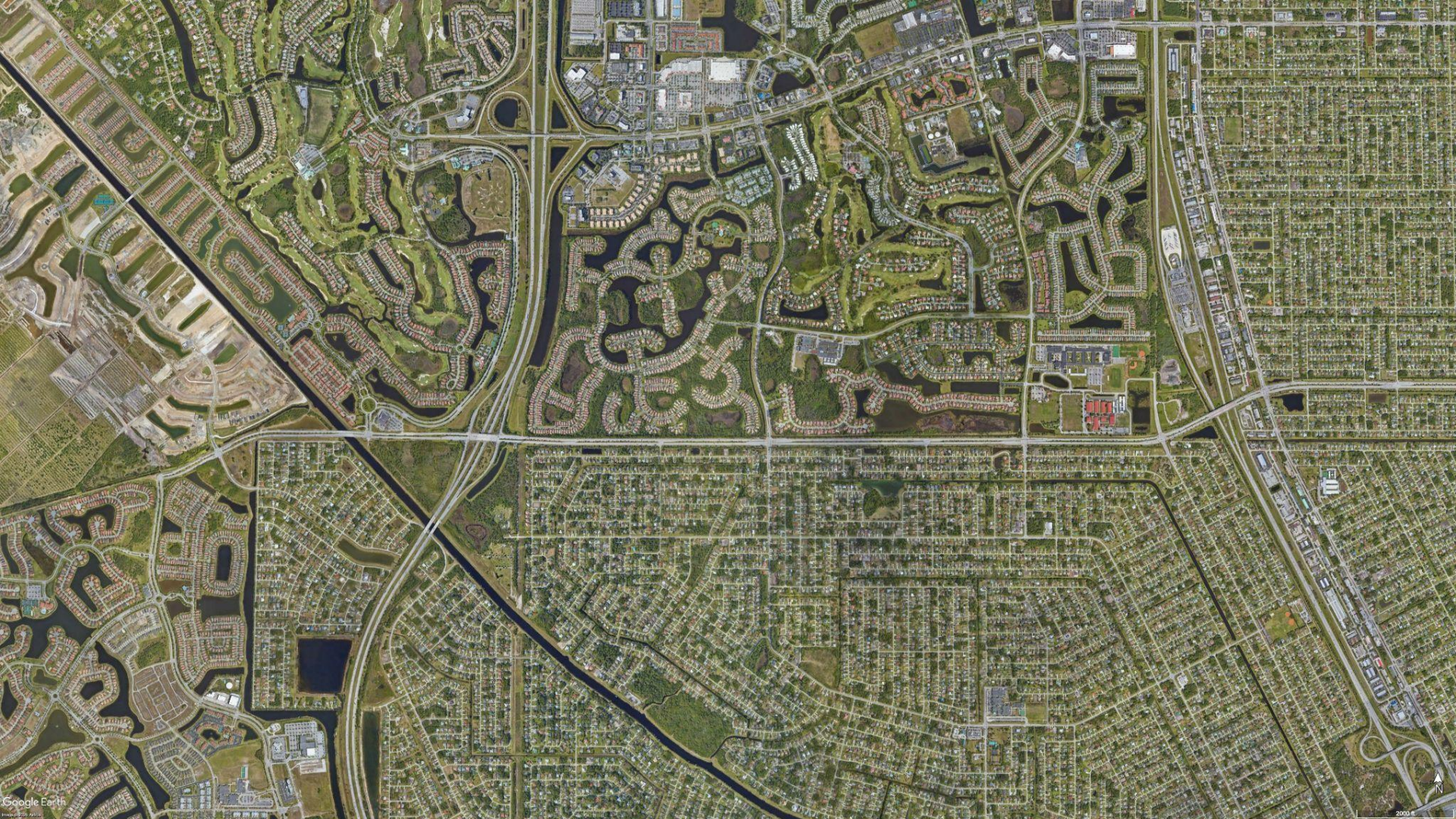
Google Earth
2000 ft
N

Street connectivity as a core planning metric

Street connectivity has long been a key measure in urban planning. Seminal work like A Century of Sprawl defined nodal degree—the number of streets meeting at an intersection—as a central indicator.

Connectivity shapes how cities function and grow, affecting accessibility, sustainability, and livability. Yet we know little about whether public and private street networks have followed the same trajectory.

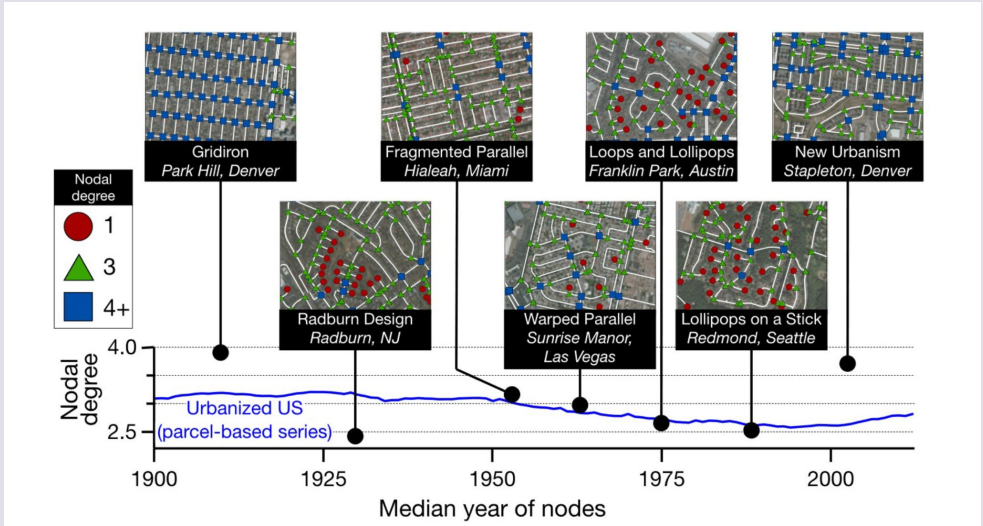

Image Source: Barrington-Leigh, C and Millard-Ball, A (2015), “A century of sprawl in the United States.” PNAS

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Design rules differ, does connectivity?

Private streets often operate under different regulations, such as allowances for narrower widths. These contrasts prompted our question:

Do regulatory double standards also extend to street connectivity? In other words, is there a street connectivity gap between public and private streets?

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A three-part framework to examine the public–private connectivity gap

Connectivity Calculation	Private Identification	Development Timing
Measure	**Classify**	**Compare over Time**

Measuring connectivity with a consistent national dataset

We use OpenStreetMap (2025-01) for its completeness and local accuracy, focusing on residential and living streets relevant to subdivision design.

Parameters follow established best practices (e.g., intersection consolidation radius of 20 meters) ensuring results are comparable with prior studies.

These choices provide a robust and consistent foundation for measuring connectivity nationwide.

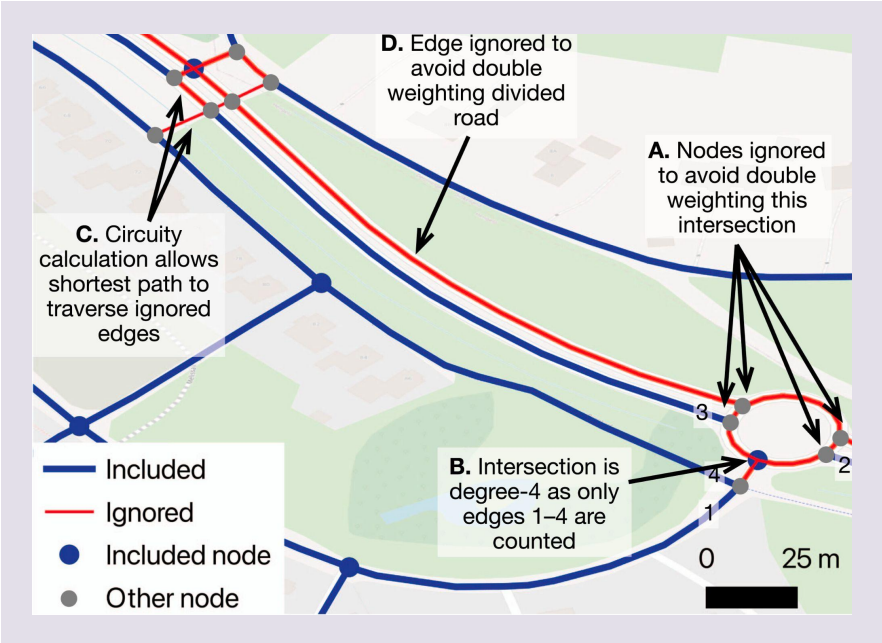

Image Source: Barrington-Leigh, C., & Millard-Ball, A. (2025). A high-resolution global time series of street-network sprawl. EPB

Refining connectivity for residential networks

We further enhance accuracy by removing artifacts that distort nodal degree:

- Roundabouts at cul-de-sac ends ()
- Knuckle or court streets
- Short parallel segments
- Short dangling segments

This tailored refinement yields more realistic connectivity measures for residential neighborhoods.

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A three-part framework to examine the public–private connectivity gap

Connectivity Calculation	**Private Identification**	Development Timing
Measure	**Classify**	Compare over Time

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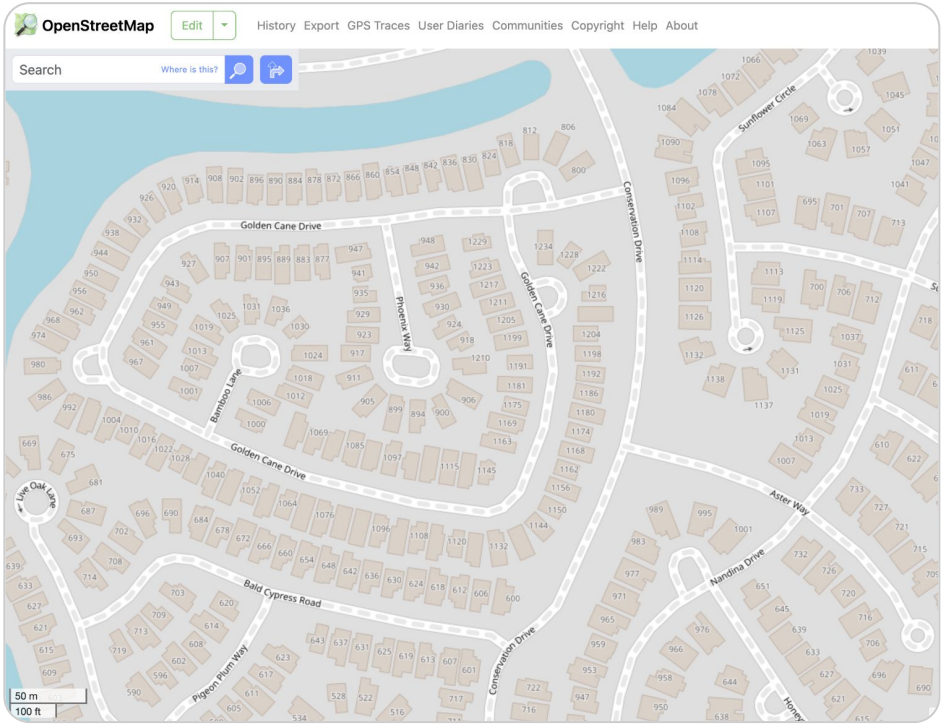
Identifying private streets from OSM tags

We extract ownership and access information directly from OpenStreetMap.

Tags such as ownership=private and access=private serve as key indicators.

All classifications follow standard OSM contributor definitions to ensure consistent interpretation and national comparability.



Using Street View absence to infer private streets

Private streets are often missing from Google Street View coverage.

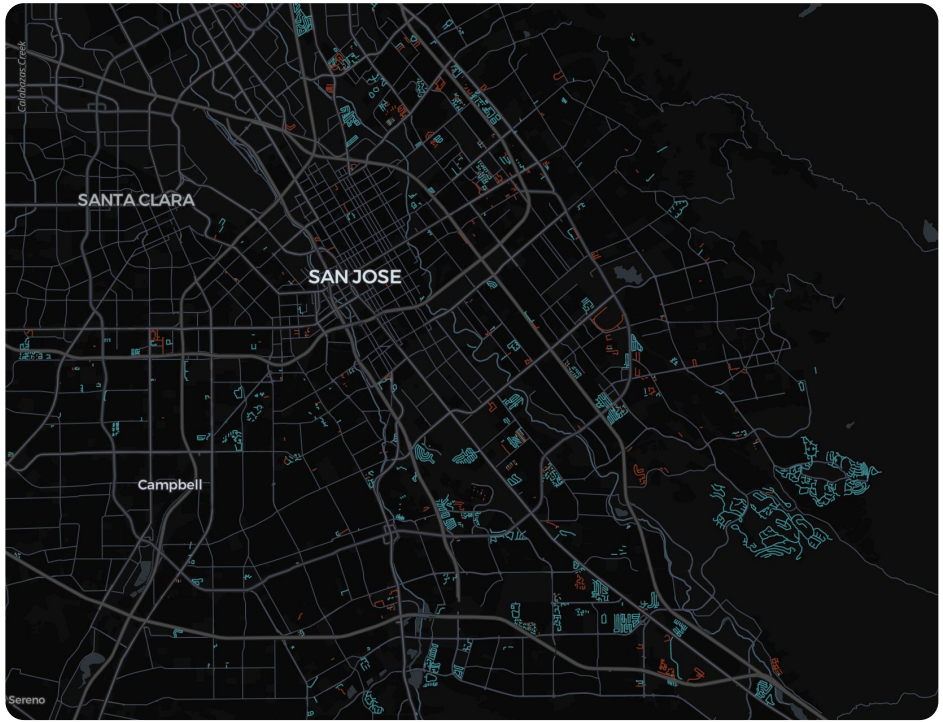
We use this absence as a complementary signal of private streets, especially where OSM tags are incomplete.

This hybrid approach enables broad and scalable detection across diverse urban areas.

Hybrid method improves accuracy across cities

Validation against municipal datasets shows strong precision and recall.

The hybrid method, combining OSM and No Street View, outperforms either source alone, confirming consistent accuracy across diverse urban contexts.



High precision and recall across validation cities

Precision and recall exceed 80% in most cases, confirming high accuracy of the combined method.

Results are consistent across different urban contexts, demonstrating both scalability and robustness of the approach.

A three-part framework to examine the public–private connectivity gap

Connectivity Calculation	Private Identification	Development Timing
Measure	Classify	Compare over Time

Dating street development time with HISDAC-US

We assign build years to residential intersections using HISDAC-US, which reconstructs the built environment of the U.S. from 1810–2020 at 5-year intervals.

Our analysis focuses on the post-1950 period, when private residential subdivisions started to expand more rapidly, to create a more consistent historical baseline to compare public and private networks.

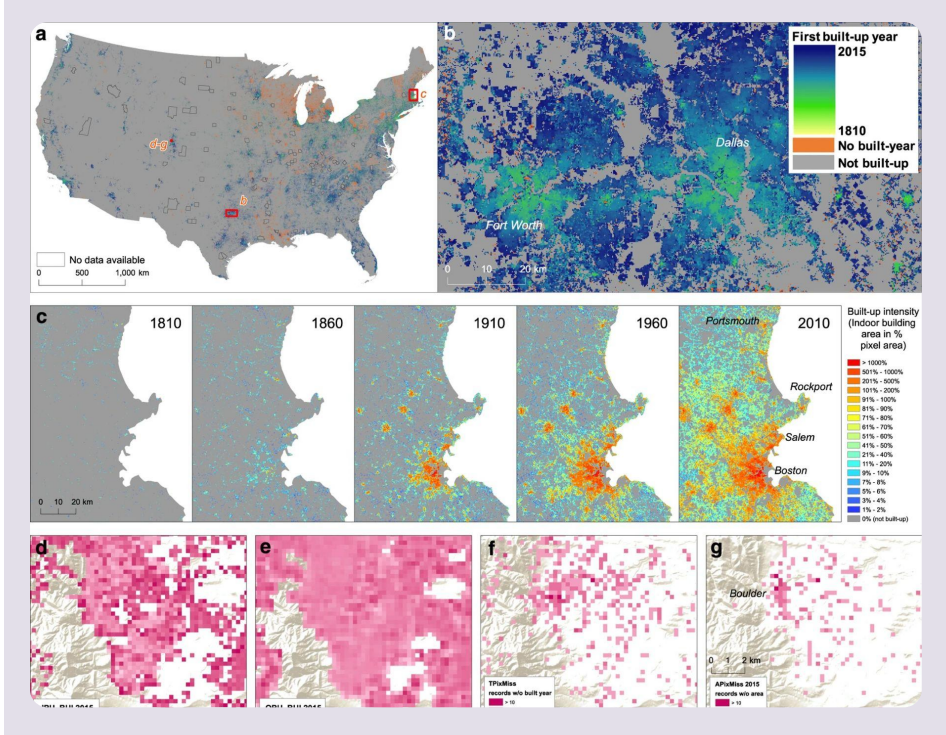


Image Source: Leyk, S., & Uhl, J. H. (2018). HISDAC-US, historical settlement data compilation for the conterminous United States over 200 years. Scientific Data

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Using NLCD for finer spatio-temporal resolution

To complement HISDAC-US, we use the National Land Cover Database (NLCD) for higher spatial (30 m) and temporal (annual) resolution.

NLCD's recent coverage captures post-2000 development patterns that historical datasets often miss, allowing us to detect subtle differences in the growth of public and private streets.

Results

PART 01

Growth trajectories of public and private streets

After assigning build years, we trace national development trends for residential intersections.

Private streets have grown steadily in proportion since 1950, with a slowdown around the 2008 financial crisis and a rebound in the past decade.

These trends reveal the growing role of private developments in shaping U.S. residential growth, and highlight the importance of examining potential connectivity double standards.

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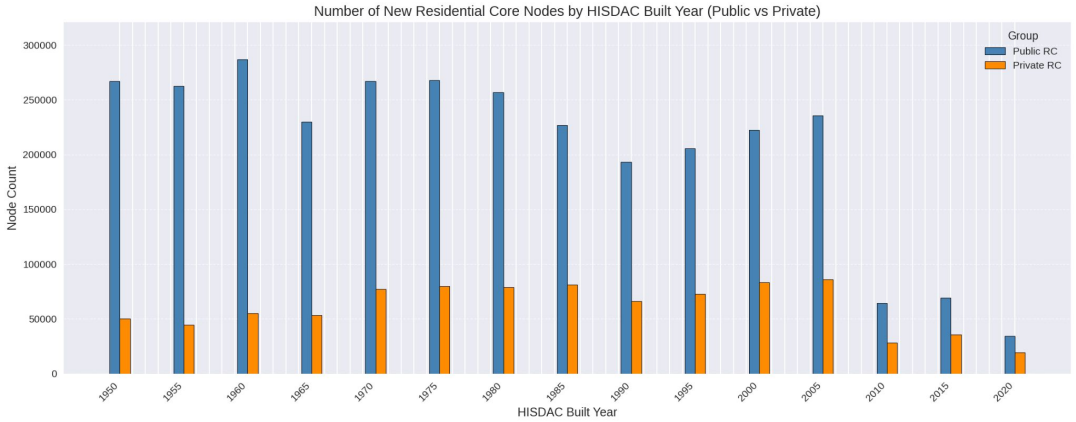
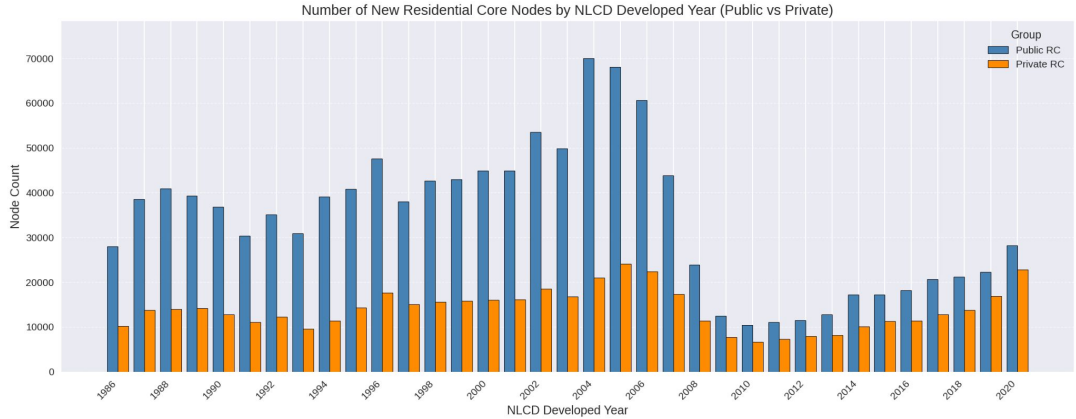


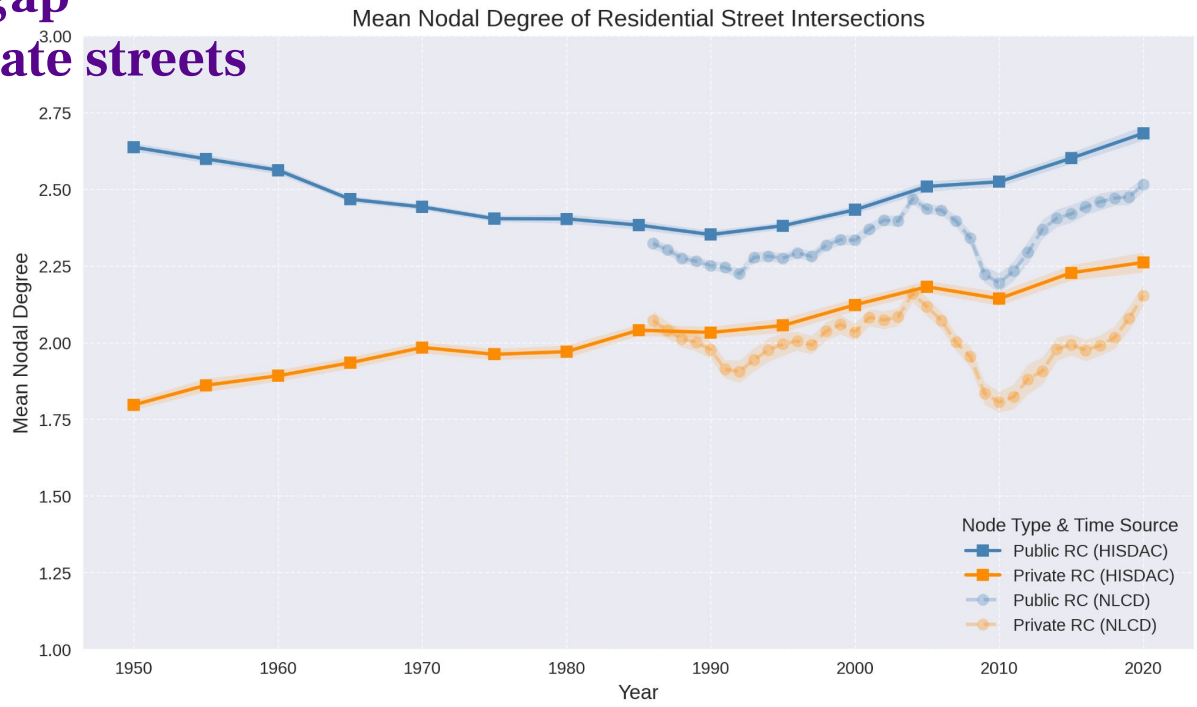


Persistent connectivity gap between public and private streets

Across the national sample, public residential intersections remain consistently more connected than private ones.

In the 1950s, the gap was nearly one full node, narrowing slightly but never closing—and even widening again after 2010.

Both HISDAC and NLCD results confirm this persistent gap, with patterns robust to city-level clustering.



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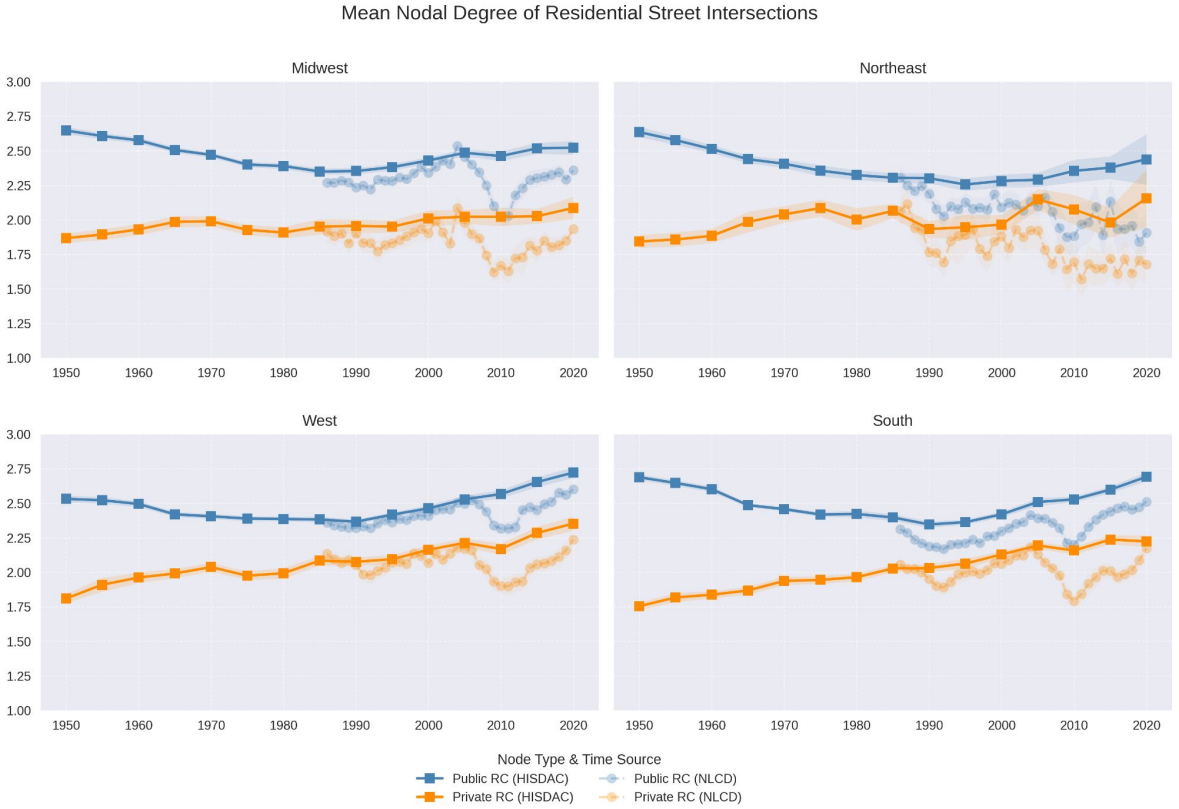
Connectivity gap persists across all U.S. regions

When analyzed by region—Midwest, Northeast, South, and West—the same pattern emerges: a wide gap early on, gradual convergence through 1990, and persistent divergence in recent decades.

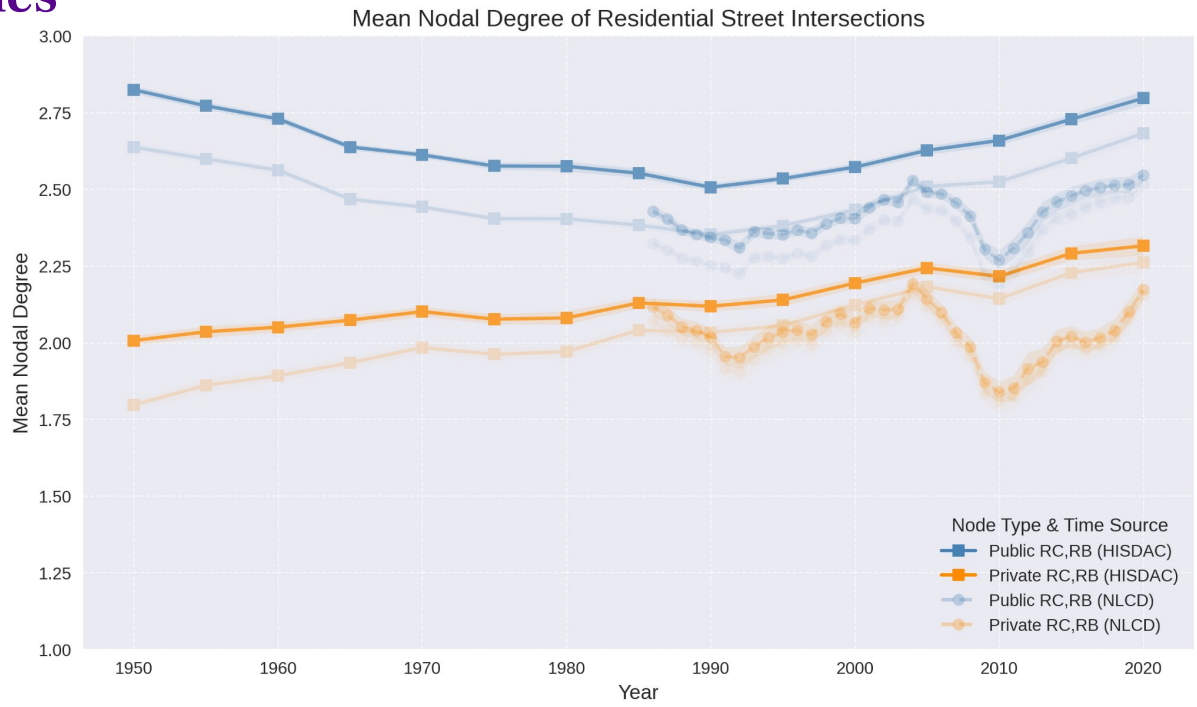
While smaller regional samples widen confidence intervals, the gap remains visible and consistent, indicating a nationwide pattern rather than one driven by local conditions.



Including boundary nodes confirms robustness

Adding intersections that connect residential streets to larger networks slightly raises overall connectivity, as expected, but the public–private gap remains unchanged.

This confirms that the difference is not an artifact of node definitions, but reflects a genuine design divergence in residential connectivity standards.

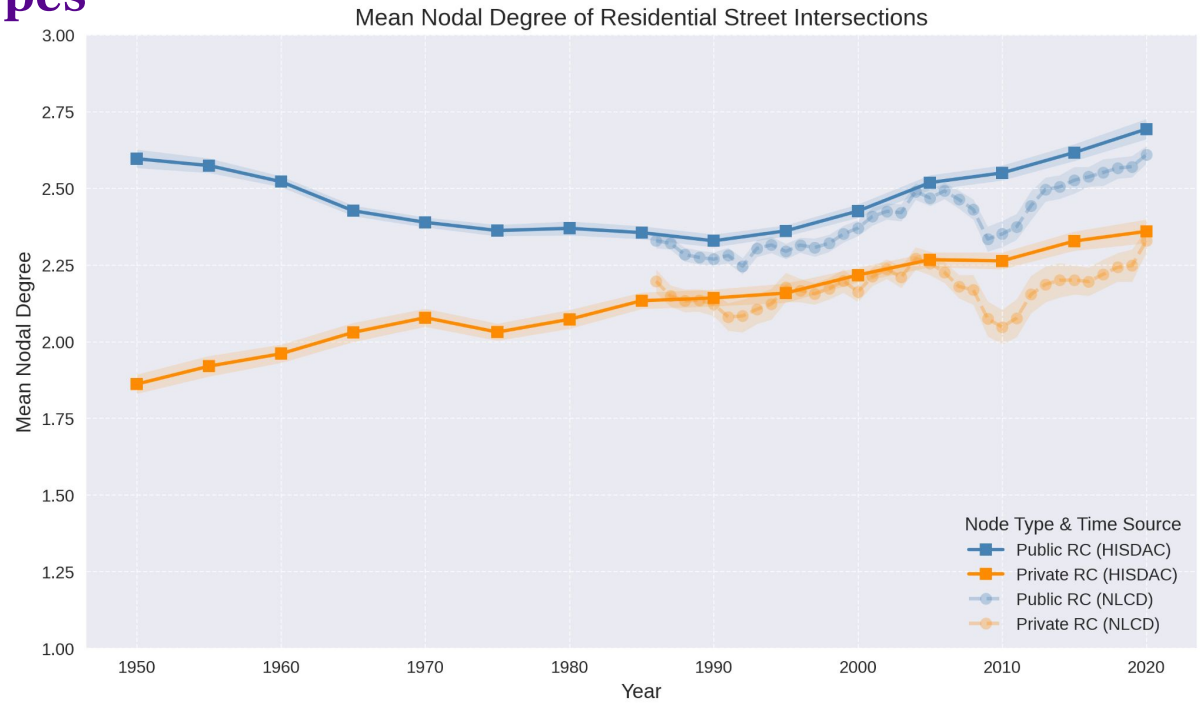


PART 01

Connectivity gap holds in cities containing both types of streets

Restricting analysis to cities with at least 10% of both public and private streets yields trends nearly identical to the national result.

Even in these mixed-network settings, private streets remain systematically less connected, confirming that the gap is not due to city composition or dominance by one street type.



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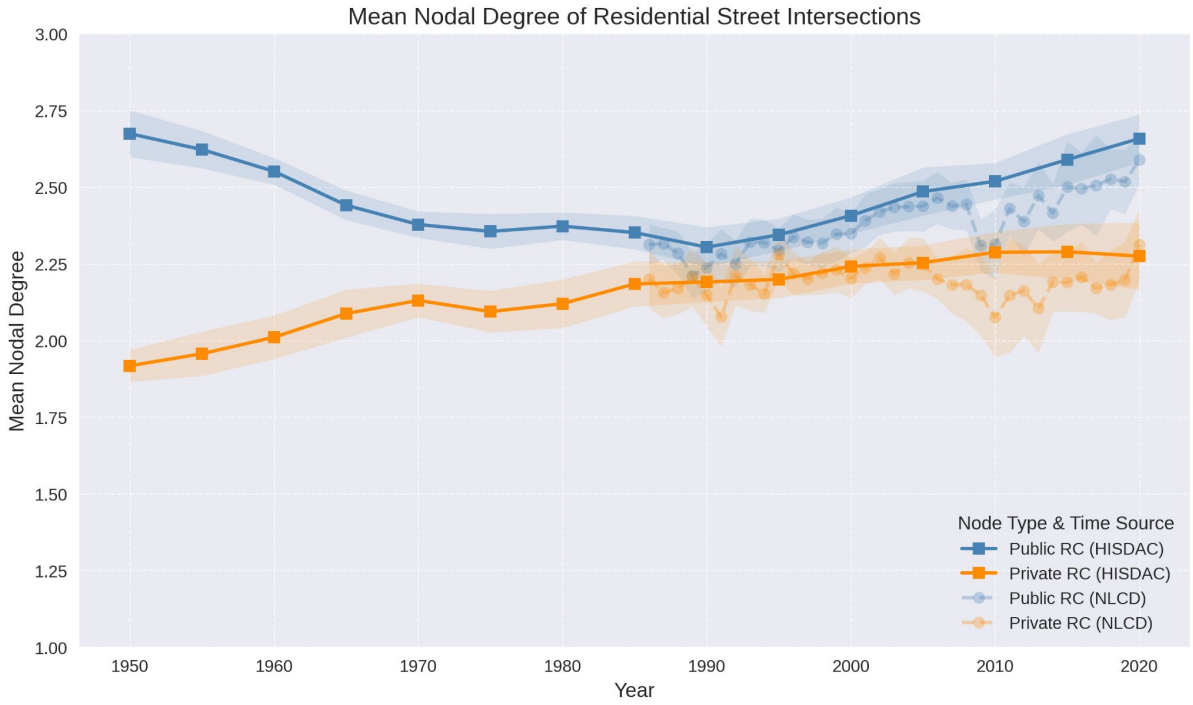
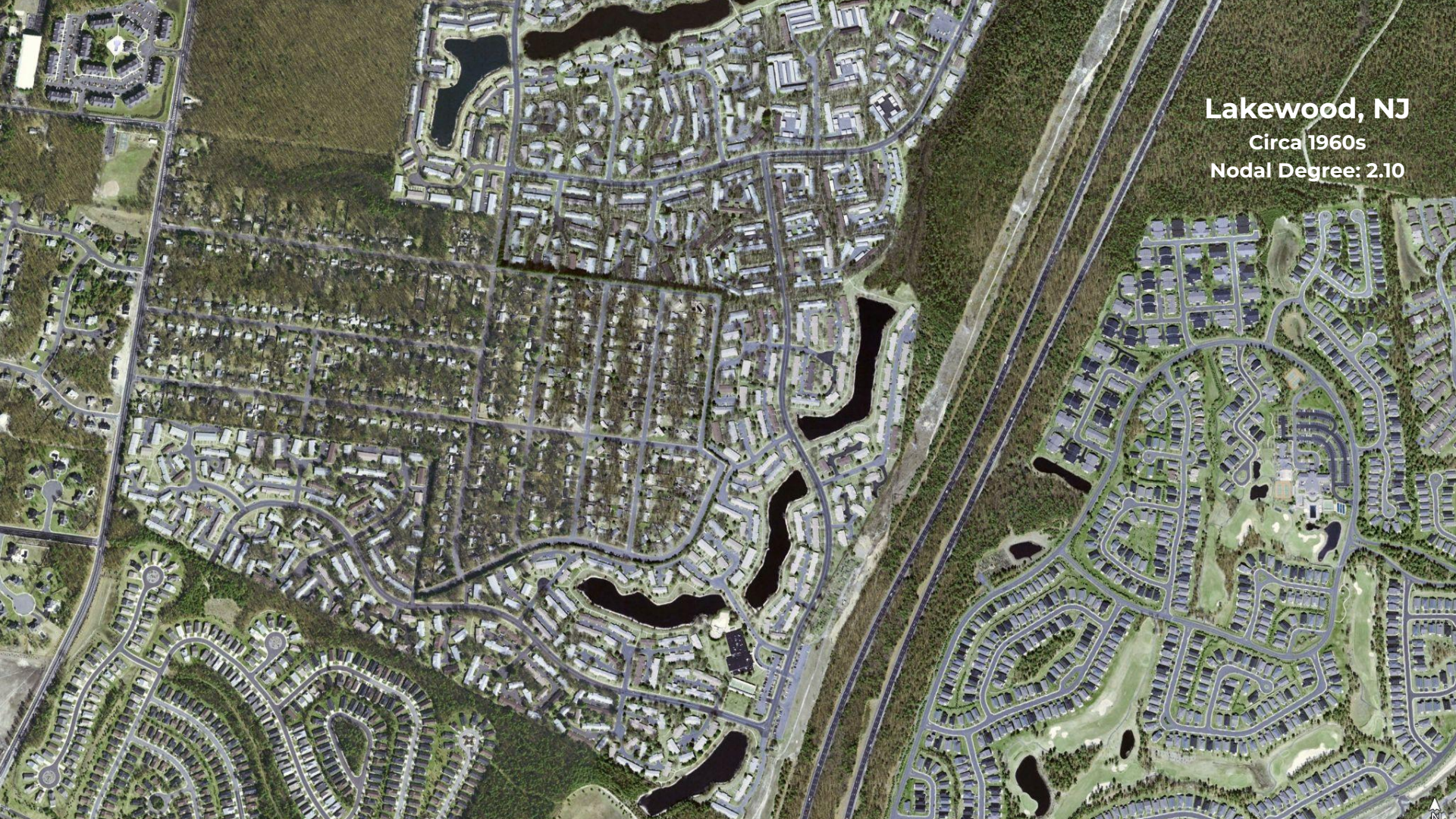
Gap persists among the nation's largest cities

When we further limit the analysis to large cities (≥10,000 residential nodes) with both types of streets, the result shows the same pattern.

While smaller samples (38 cities) widen uncertainty bands, the magnitude and direction of the difference remain remarkably consistent across all robustness checks.



Visual Examples of Private Street Networks


Lakewood, NJ
Circa 1960s
Nodal Degree: 2.10


Henderson, NV
Circa 2020s
Nodal Degree: 2.12
N


Northlake, TX
Circa 2020s
Nodal Degree: 3.19

Northlake, TX

Circa 2020s

Nodal Degree: 3.19

NEW HOMES COMMUNITY LIFESTYLE **PECAN SQUARE** AMENITIES SCHOOLS LOCATION

Northlake, TX
Circa 2020s
Nodal Degree: 3.19

§ 8.1 Secured (Gated) Communities.

A. Purpose. To achieve orderly development of secured (gated) communities, to promote and develop the utilization of land to assure the best possible community environment in accordance with the Comprehensive Plan and to protect and promote the health, safety and general welfare of the Town.

B. Establishment of a Secured (Gated) Community.

1. Minimum Size. The minimum acreage requirement for a secured (gated) community shall be twenty-five (25) acres.

C. Design Standards. All secured (gated) communities shall be surrounded by a masonry or wrought iron fence with at least two (2) entrances, electronically or manually controlled gates and shall be administered by a Property Owner Association. Entry and exit ways to secured (gated) communities shall have a minimum width of twenty (20') feet when the gate is fully opened and shall be equipped with a Knox key entry system as approved by the Town Manager or his/her designee.

1. Conflict with Thoroughfares.

a. A secured (gated) community shall not cross an existing or proposed thoroughfare as shown on the Town's Master Thoroughfare Plan.

b. A secured (gated) community shall not disrupt or cross an existing or proposed public pedestrian pathway, hike and bike trail, park or other public facility as shown on the Town's Park, Recreation and Open Space Master Plan or Master Thoroughfare Plan.

D. Property Owner Association (POA).

1. A POA shall be established for a secured (gated) community and creation shall be so noted on the plat. The following "Maintenance Agreement" statement shall appear on the final plat:

"Streets within this subdivision shall be constructed in accordance with the Town of Northlake public streets standards. The upkeep and maintenance to include the mowing of shoulders and right-of-way, removal of weeds and unclogging of culverts shall be the responsibility of the Property Owners' Association (POA). The Town of Northlake is released from any liability of these streets. Periodic inspection by a public official who is authorized to enforce complaints about poor maintenance is permitted."

Fragmented local standards shape what gets built

Most cities regulate connectivity indirectly—through block length, intersection spacing, or cul-de-sac limits.

But these rules vary widely and are often relaxed through negotiations with private developers, especially in master-planned or HOA-governed areas.

Such variation suggests the observed connectivity gap reflects not just design preferences, but institutional flexibility and uneven regulatory enforcement.

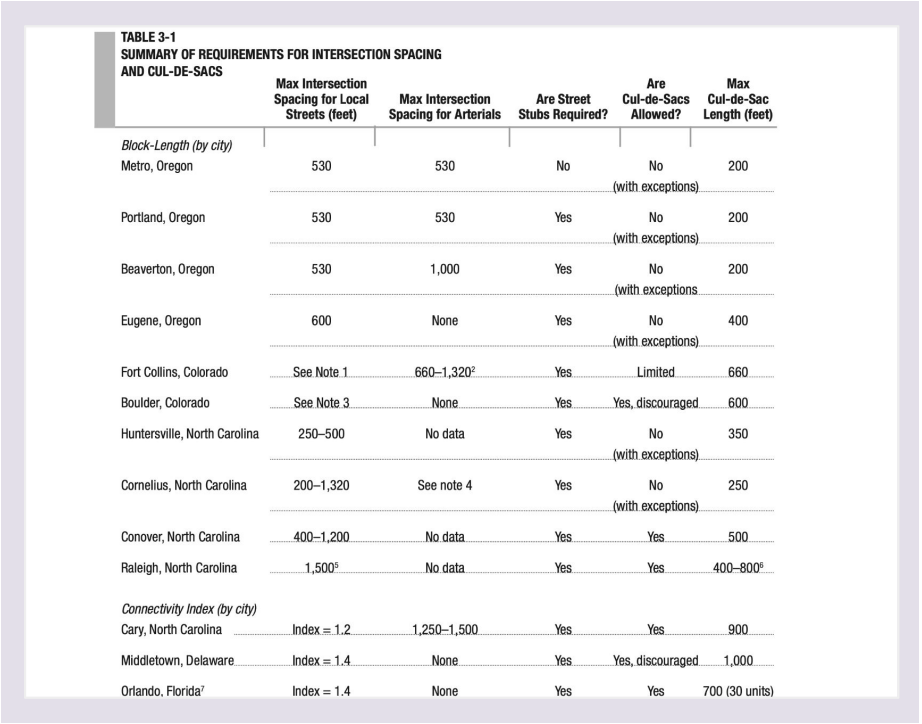


TABLE 3-1
SUMMARY OF REQUIREMENTS FOR INTERSECTION SPACING AND CUL-DE-SACS

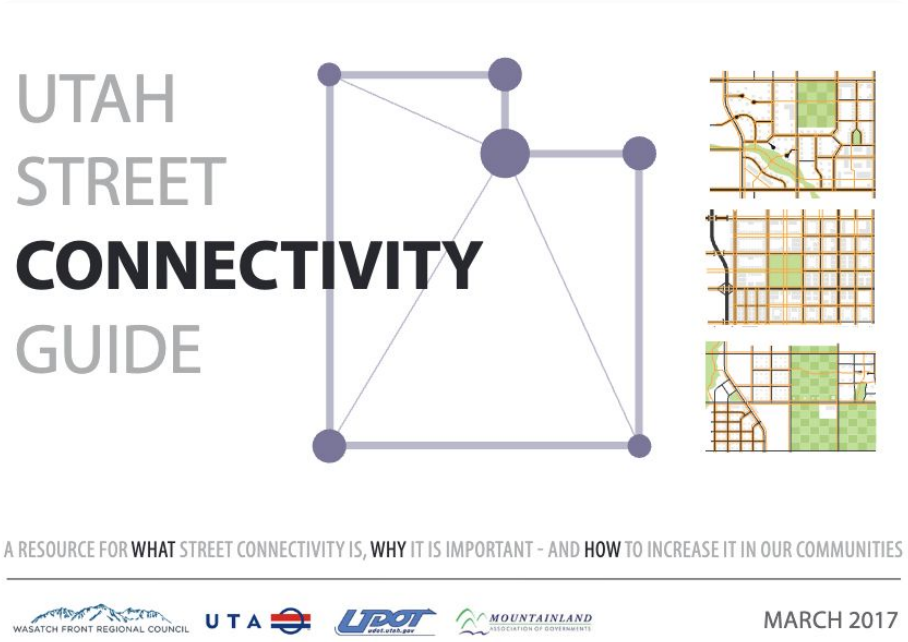
	Max Intersection Spacing for Local Streets (feet)	Max Intersection Spacing for Arterials	Are Street Stubs Required?	Are Cul-de-Sacs Allowed?	Max Cul-de-Sac Length (feet)
Block-Length (by city)					
Metro, Oregon	530	530	No	No (with exceptions)	200
Portland, Oregon	530	530	Yes	No (with exceptions)	200
Beaverton, Oregon	530	1,000	Yes	No (with exceptions	200
Eugene, Oregon	600	None	Yes	No (with exceptions)	400
Fort Collins, Colorado	See Note 1	660–1,320[2]	Yes	Limited	660
Boulder, Colorado	See Note 3	None	Yes	Yes, discouraged	600
Huntersville, North Carolina	250–500	No data	Yes	No (with exceptions)	350
Cornelius, North Carolina	200–1,320	See note 4	Yes	No (with exceptions)	250
Conover, North Carolina	400–1,200	No data	Yes	Yes	500
Raleigh, North Carolina	1,500[5]	No data	Yes	Yes	400–800[6]
Connectivity Index (by city)					
Cary, North Carolina	Index = 1.2	1,250–1,500	Yes	Yes	900
Middletown, Delaware	Index = 1.4	None	Yes	Yes, discouraged	1,000
Orlando, Florida[7]	Index = 1.4	None	Yes	Yes	700 (30 units)

Planning for Street Connectivity: Getting From Here to There PAS Report 515. (2023). American Planning Association.

Emerging efforts toward coordination and reform

Recognizing these inconsistencies, some states have begun issuing connectivity guidelines—like Utah's 2017 Street Connectivity Guide—to harmonize standards across municipalities.

These frameworks signal a shift toward proactive, system-level planning, yet adoption remains voluntary, leaving wide room for local discretion and regulatory double standards.



Summary and Takeaways

- Developed a **three-part analytical framework** and built the **first national dataset** that systematically distinguishes **public and private residential streets**
- Revealed a **persistent and measurable connectivity gap**—private streets remain less connected across eras, regions, and city sizes.
- Highlights the **underlying regulatory double standards** that shape how connected, accessible, and equitable residential communities are

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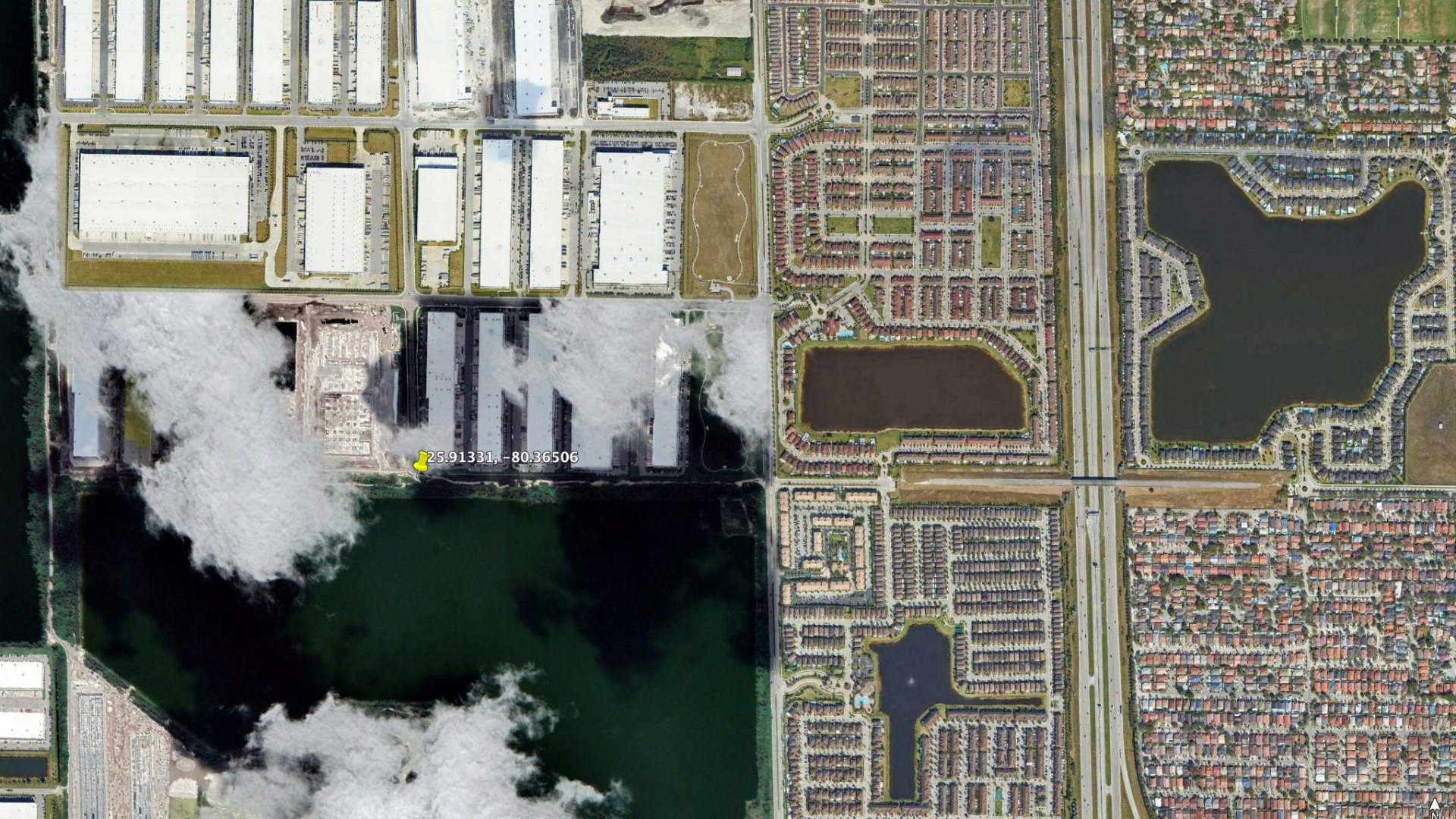
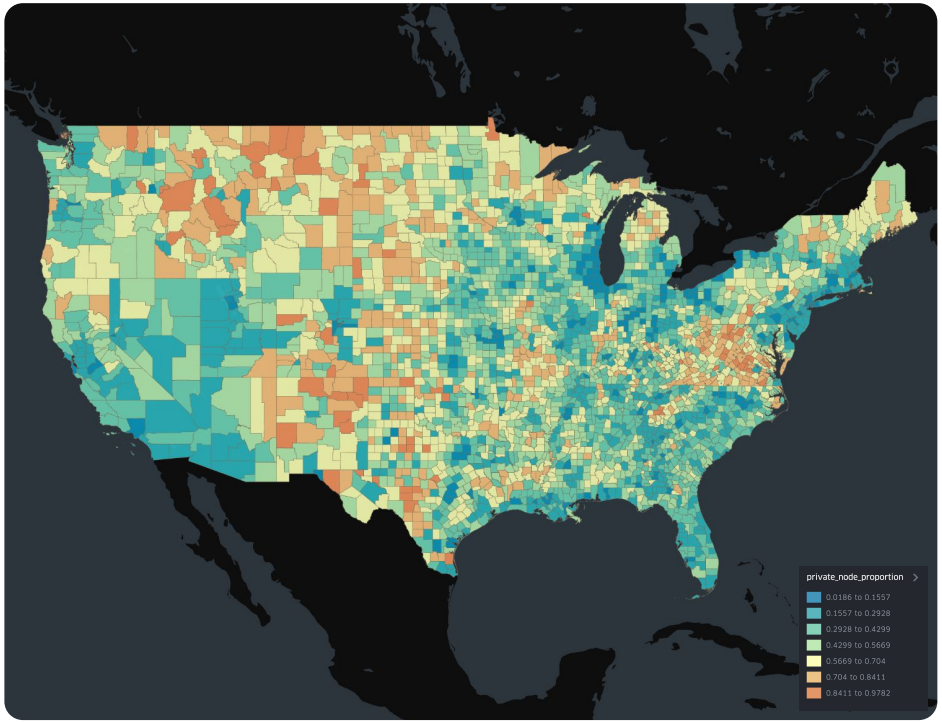

25.91331, -80.36506


A
Painted Prairie

Mapping private street prevalence across the U.S.

By integrating both identification strategies, we map private street proportions nationwide.

Results reveal both broader presence and regional variation, underscoring the importance of accounting for private networks in planning and policy analysis.

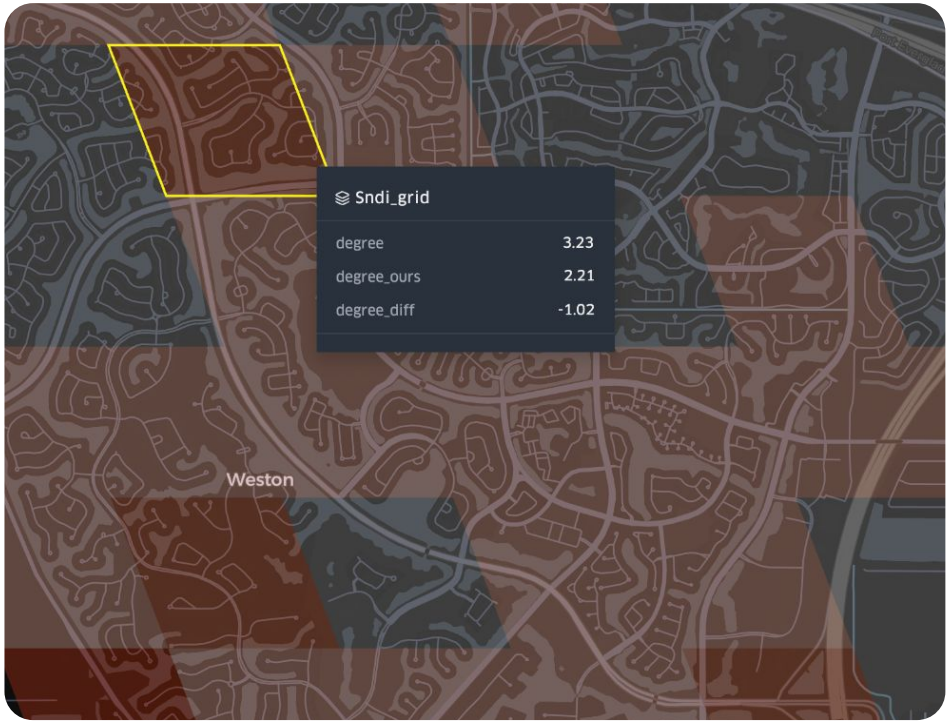


Cleaner data, clearer results

Our customized preprocessing improves upon the overestimation in existing datasets that are designed for broader street networks and global coverage.

Compared with data released by prior studies, our results better reflect true intersection patterns in residential areas.

The improved accuracy strengthens the reliability of connectivity measures used in this study.



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Associations with Regulatory and Demographic Variables

Placeholder

	Private Node Proportion	Mean Nodal Degree Public	Mean Nodal Degree Private
Accessory Apartments Allowed	0.01	-0.18	0.01
Flexible Zoning By Right	0.01	-0.05	-0.03
Flexible Zoning By Permit	-0.09	-0.12	0.02
Affordable Incentive	0.03	-0.17	0.11
Affordable Mandate	0.04	-0.10	-0.02
Zoning District Count	-0.11	-0.09	0.07
Permit Cap Or Phasing	-0.00	-0.10	0.03
Longest Frontage Requirement	0.02	-0.10	-0.04
Max Res Min Lot Size	0.06	-0.11	0.02
Mean Res Min Lot Size	0.09	-0.14	-0.00
Minimum Res Min Lot Size	0.14	-0.17	-0.07
Mandatory Approval Steps	0.03	-0.02	-0.02
Distinct Approval Bodies	0.06	0.00	0.01
Public Hearing Requirements	0.02	-0.07	0.00
Max Review Waiting Time	0.02	-0.06	0.04
Multifamily Allowed	-0.10	0.09	0.05
Mixed-Use Buildings	-0.05	-0.00	-0.00
Conversion To Multifamily	-0.09	0.08	-0.11
Townhouses Allowed	-0.04	-0.05	0.04
Age-Restricted Provisions	-0.07	-0.11	0.02

	Private Node Proportion	Mean Nodal Degree Public	Mean Nodal Degree Private
total_population	-0.16	0.09	0.02
median_fam_income	0.06	-0.49	-0.08
median_year_structure_built	0.17	-0.43	0.21
car_owner_share	0.19	-0.45	0.06
avg_commute_minutes	0.14	-0.35	0.05

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