Spatial Units of Analysis in Crime Location Choice Studies: A Systematic Scoping Review of Nearly Five Orders of Magnitude Variation

# Abstract

**Background:** The choice of spatial units affects our understanding about crime location choice. But prior studies have not yet systematically looked at how researchers actually make decisions on spatial scale units. We examine choice of spatial units in crime location choice studies – its size, whether they have changed over time, if they differ across countries, and what drives these choices.

**Methods:** We conducted a systematic review following PRISMA-ScR guidelines. We searched four databases and found 2325 papers. After removing duplicates and irrelevant studies, we reviewed 80 papers and included 49 studies that met our criteria. Our final dataset of 49 studies and 51 observations (one study used data from 3 countries). We used mixed-effects regression models to analyze spatial unit size patterns while controlling country-level clustering, and conducted descriptive analyses to examine distributions and relationships across crime types, jurisdictions, and temporal trends.

**Results:** Spatial units vary enormously - from 136 m² individual properties to 8.48 km² administrative districts (4.8 orders of magnitude). Despite better computers and data, studies haven’t moved toward smaller units over time (*β* = 0.033, *p* = .334). Countries cluster strongly in their typical unit sizes (ICC = 0.328), showing institutional factors and data availability matter more than technological improvement . When controlling for country-level clustering, study area size shows no significant association with unit choice (*β* = 0.127, *p* = .145). The size of units varies based on crime type, crimes like graffiti use smaller units (< 0.01 km²), property crimes use medium sized units (0.1-1.0 km²), and general crime studies use lager units (1.0-5.0 km²).

**Conclusions:** Researchers aren’t choosing spatial units randomly. They systematically match scale to the crime processes they’re studying. Technology improvements haven’t driven methodological change like we expected. Instead, institutional context and practical constraints shape what researchers can actually do. We provide evidence-based guidelines for future spatial unit selection.

# Introduction

Crime clusters in specific places, and researchers use spatial choice models to understand how offenders select these locations ([Bernasco et al., 2013](#ref-bernasco2013); [Vandeviver et al., 2015](#ref-vandeviver2015)). These models treat crime location selection as a rational choice process where offenders evaluate potential locations based on costs and benefits. Bernasco and Jacques ([2015](#ref-bernasco2015)) found that dealers choose locations where expected rewards and costs are optimal, applying this framework to consensual crimes like drug dealing. But there’s a fundamental decision that affects all crime location studies that gets little attention: choosing the spatial unit of analysis.

The spatial unit defines the geographical scale for modeling crime location decisions. Researchers might look at individual properties, street segments, neighborhoods, or administrative districts. This choice affects statistical power, how we interpret results, and what policies make sense ([Fotheringham & Wong, 1991](#ref-fotheringham1991); [Openshaw, 1984](#ref-openshaw1984)). Despite this importance, the crime location choice literature lacks systematic guidelines for this decision.

We look at how researchers actually select spatial units across different contexts. Current practice seems pragmatic - driven by data availability and computational constraints rather than theoretical justification. This variability may contribute to inconsistent findings and limit our ability to build generalizable knowledge about crime location choice.

## Theoretical Background

Crime location choice research has undergone a fundamental transformation in spatial scale over the past several decades. Early criminological research focused predominantly on large spatial units such as cities, states, and neighborhoods ([Baumer et al., 1998](#ref-baumer1998); [Loftin & Hill, 1974](#ref-loftin1974)), examining broad patterns of crime distribution across administrative boundaries. This macro-level approach provided valuable insights into regional crime patterns but offered limited understanding of the micro-spatial decision-making processes underlying individual offending events.

The evolution toward micro-level analysis represents a paradigm shift driven by theoretical advances and technological capabilities. The introduction of micro-place analysis marked a major transition, focusing on specific locations like street segments, census blocks, and grid cells ([Eck & Weisburd, 1995](#ref-eck1995); [Weisburd et al., 2004](#ref-weisburd2004)). This shift was not merely methodological but fundamentally changed how researchers conceptualize crime location choice, enabling examination of offender decision-making at the scale where these decisions actually occur ([Bernasco et al., 2013](#ref-bernasco2013); [Bernasco, 2019](#ref-bernasco2019); [Bernasco & Jacques, 2015](#ref-bernasco2015)).

Choosing spatial units connects to fundamental issues in spatial analysis and criminology. The modifiable areal unit problem (MAUP) demonstrates that statistical relationships can change significantly depending on spatial scale ([Fotheringham & Wong, 1991](#ref-fotheringham1991)). In crime research, this means environmental factors may relate to crime differently at different scales ([Weisburd et al., 2012](#ref-weisburd2012)), creating challenges for theory development and policy application.

Crime pattern theory suggests that offender decision-making operates across multiple spatial scales - from immediate target characteristics to broader activity spaces where offenders spend their time ([Brantingham & Brantingham, 1993](#ref-brantingham1993)). Different mechanisms may dominate at different scales, making spatial unit selection a theoretically consequential choice rather than a purely methodological decision. Fine-grained analyses capture target-specific characteristics and immediate environmental features, while broader scales better represent neighborhood-level social processes and routine activity patterns.

Similarly, routine activity theory implies scale-dependent effects in how motivated offenders, suitable targets, and absence of guardians converge ([Cohen & Felson, 1979](#ref-cohen1979)). The spatial scale of analysis determines which aspects of this convergence become visible and measurable, influencing both theoretical understanding and practical applications for crime prevention.

## Methodological Considerations

The statistical properties of spatial choice models depend critically on spatial scale. Model performance typically increases with finer resolution due to greater variation among alternatives ([Train, 2009](#ref-train2009)). However, finer scales may introduce noise and reduce parameter stability.

Computational constraints become important with fine-grained units. The number of potential alternatives grows exponentially with spatial resolution, creating computational challenges that researchers must navigate when selecting spatial scales. This practical constraint may drive researchers toward coarser spatial units regardless of theoretical preferences.

Data availability represents another key constraint. Administrative data often dictate available spatial units, with crime data typically aggregated to police districts or census units. High-resolution data may be available in some jurisdictions but not others, creating systematic biases in methodological choices across contexts. Bernasco et al. ([2013](#ref-bernasco2013)) found that data limitations prevented tracking offenders across multiple crimes, illustrating how institutional data systems fundamentally shape analytical possibilities regardless of theoretical preferences. Similarly, researchers continue to face computational constraints even with modern technology, as memory limitations force sampling decisions that affect methodological choices.

# Research Questions

**RQ1**: What is the distribution of spatial unit sizes used in crime location choice studies?

**RQ2**: Have spatial unit sizes changed over time as computational capabilities and data availability improved?

**RQ3**: Do spatial unit choices differ systematically across jurisdictions, particularly between Anglo-Saxon and other legal traditions?

**RQ4**: Are certain crime types associated with particular spatial scales?

**RQ5**: How does total study area size influence spatial unit selection?

**RQ6**: Do methodological approaches correlate with spatial unit selection?

**RQ7**: Does the number or type of explanatory variables relate to spatial unit choice?

By systematically addressing these questions through analysis of 51 observations from crime location choice studies, this research provides three contributions: (1) documenting spatial unit selection practices in environmental criminology, (2) describing patterns of crime-type specificity in scale selection, and (3) offering practical guidelines for spatial unit selection based on observed practices.

# Methods

## Study Design and Registration

We conducted a systematic scoping review following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) guidelines ([Tricco et al., 2018](#ref-tricco2018)). The review protocol was developed based on established frameworks for conducting systematic scoping reviews ([Arksey & O’Malley, 2005](#ref-arksey2005); [JBI Manual for Evidence Synthesis, 2023](#ref-guidance2023)). No protocol was pre-registered due to the exploratory nature of the research questions.

## Search Strategy

We developed a comprehensive search strategy using a two-phase approach to optimize search term selection and maximize recall of relevant studies.

### Phase 1: Initial Search and Keyword Extraction

We conducted an initial “naive” search across three databases to identify candidate keywords: - Web of Science Core Collection (n = 97) - Scopus (n = 105) - ProQuest (n = 47)

The naive search strategy employed broad Boolean terms across three conceptual domains (population, intervention, outcome) to capture studies analyzing offender location choice decisions through discrete choice models:

\*\*Table 1. Naive Search Strategy and Results\*\*

| **Database** | **Naive Search Term** | **Records** |
| --- | --- | --- |
| Web of Science | TS=(((offend\* OR crim\* OR burglar\* OR robb\* OR co-offend\* OR dealer\*) AND ("discret\* choic\*" OR "choic\* model\*" OR "rational choice" OR "awareness space" OR "journey to crime" OR "mobility" OR "opportunity" OR "accessibility" OR "attractiveness" OR "crime pattern\*") AND ("crime locat\* choic\*" OR "offend\* locat\* choic\*" OR "robber\* locat\* choic\*" OR "burglar\* locat\* choic\*" OR "target area\*" OR "target selection" OR "crime site selection" OR "spatial choic\* model\*"))) | 97 |
| Scopus | TITLE-ABS-KEY(((offend\* OR crim\* OR burglar\* OR robb\* OR co-offend\* OR dealer\*) AND ("discret\* choic\*" OR "choic\* model\*" OR "rational choice" OR "awareness space" OR "journey to crime" OR "mobility" OR "opportunity" OR "accessibility" OR "attractiveness" OR "crime pattern\*") AND ("crime locat\* choic\*" OR "offend\* locat\* choic\*" OR "robber\* locat\* choic\*" OR "burglar\* locat\* choic\*" OR "target area\*" OR "target selection" OR "crime site selection" OR "spatial choic\* model\*"))) | 105 |
| ProQuest | noft(((offend\* OR crim\* OR burglar\* OR robb\* OR co-offend\* OR dealer\*) AND ("discret\* choic\*" OR "choic\* model\*" OR "rational choice" OR "awareness space" OR "journey to crime" OR "mobility" OR "opportunity" OR "accessibility" OR "attractiveness" OR "crime pattern\*") AND ("crime locat\* choic\*" OR "offend\* locat\* choic\*" OR "robber\* locat\* choic\*" OR "burglar\* locat\* choic\*" OR "target area\*" OR "target selection" OR "crime site selection" OR "spatial choic\* model\*"))) | 47 |

This initial search used broad terms related to crime location choice, discrete choice modeling, and spatial analysis. The 249 initial results were deduplicated and used as input for systematic keyword extraction.

### Phase 2: Litsearchr-Optimized Search Strategy

Following established systematic review methodology ([Grames et al., 2019](#ref-grames2019)), we employed the litsearchr package in R to develop an evidence-based search strategy. This approach uses network analysis of keyword co-occurrence to identify the most important search terms, representing a significant methodological advancement over traditional Boolean search development.

**Keyword Extraction Process:** 1. **Text Processing**: We extracted keywords from titles, abstracts, and author keywords of the 249 initial studies using a modified rapid automatic keyword extraction (RAKE) algorithm implemented in litsearchr.

1. **Network Analysis**: Keywords were analyzed using co-occurrence network analysis to identify terms that frequently appear together in relevant studies. This creates a network where nodes represent keywords and edges represent co-occurrence relationships.
2. **Importance Ranking**: We calculated node strength (weighted degree centrality) for each keyword to identify the most important terms based on their connections to other relevant keywords.
3. **Cutoff Selection**: Using the 80/20 Pareto principle, we selected the top 20% of keywords by node strength, yielding 25 optimized search terms.
4. **Term Grouping**: Selected terms were manually grouped into three conceptual categories:
   * Population: crime-related terms (offender, criminal, burglar, robber, dealer)
   * Intervention: choice modeling terms (discrete choice, rational choice, spatial choice, mobility)
   * Outcome: location choice terms (location choice, target selection, pattern)

Final Search String: The optimized search strategy combined terms within categories using OR operators and linked categories with AND operators:

((offend\* OR crim\* OR burglar\* OR robber\* OR dealer*) AND (“choic\* model” OR ”discret choic” OR ”ration choic” OR ”spatial choic” OR mobil) AND (pattern\* OR”locat* choic*” OR “target* select\*“))

### Search Strategy Validation

Before implementing the final search, we validated our strategy against a gold standard set of 41 known relevant articles identified through expert knowledge and prior reviews. These articles represented the core literature in crime location choice research, including seminal works on burglary target selection ([Bernasco et al., 2013](#ref-bernasco2013)), residential crime patterns ([Vandeviver et al., 2015](#ref-vandeviver2015)), and spatial choice modeling ([Kuralarasan et al., 2024](#ref-kuralarasan2024)).

The validation process involved: 1. Creating title-only searches for all 41 gold standard articles using litsearchr 2. Testing retrieval across target databases to ensure articles were indexed 3. Running the optimized search strategy and checking recall against the gold standard 4. Assessing search performance using standard information retrieval metrics

**Gold Standard Validation Results:** - Gold standard articles: 41 known relevant studies - Articles successfully retrieved: 41 (100% recall) - False negatives: 0 - Precision maintained through systematic term selection

This perfect recall confirms that our optimized search strategy successfully captures the established literature while the evidence-based term selection maintains precision by avoiding irrelevant studies.

**Additional Studies Identified:** Beyond the 41 gold standard articles, our systematic search identified 8 additional relevant studies that met our inclusion criteria but were not part of the original gold standard set. This demonstrates the value of the comprehensive search strategy in identifying relevant literature beyond expert-known articles. One study analyzed data from three different countries using distinct methodological approaches, contributing 2 additional observations to our final dataset of 51 observations from 49 studies.

### Final Database Search

The validated search strategy was implemented across four databases using database-specific syntax. Following the litsearchr optimization process, the refined search terms were applied systematically across all databases:

\*\*Table 2. Optimized Search Strategy and Results\*\*

| **Database** | **Search String** | **Records** |
| --- | --- | --- |
| Web of Science | TS=(((offend\* OR crim\* OR burglar\*) AND ("choic\* model\*" OR "discret\* choic\*" OR "spatial\* choic\*") AND (pattern\* OR "locat\* choic\*" OR "target\* select\*"))) | 681 |
| Scopus | TITLE-ABS-KEY(((offend\* OR crim\* OR burglar\*) AND ("choic\* model\*" OR "discret\* choic\*" OR "spatial\* choic\*") AND ("locat\* choic\*" OR "target\* select\*"))) | 1,169 |
| ProQuest | noft(((offend\* OR crim\* OR burglar\*) AND ("choic\* model\*" OR "discret\* choic\*" OR "spatial\* choic\*") AND (pattern\* OR "locat\* choic\*"))) | 189 |
| Google Scholar | ("offender" OR "crime" OR "burglar") ("choice model" OR "discrete choice") ("pattern" OR "location choice") | 286 |

**Search Results Summary:** - Total records identified: 2325 - Additional unique records beyond naive search: 2076 (650% increase) - Records after litsearchr deduplication: 1674 - Duplicates removed by litsearchr: 651 (28%)

This litsearchr-optimized approach significantly improved recall compared to the initial naive search, increasing retrieved records by 650% while maintaining precision through evidence-based term selection and achieving perfect recall against our gold standard validation set.

## Inclusion and Exclusion Criteria

Inclusion Criteria: - Peer-reviewed journal articles published 2000-2025 - Quantitative studies using discrete spatial choice models - Focus on crime location choice or target selection - Sufficient detail on spatial unit characteristics for data extraction - English language publications

Exclusion Criteria: - Theoretical or review papers without empirical analysis - Studies using only descriptive spatial analysis without choice modeling - Studies of offender residence choice or mobility patterns - Conference proceedings, dissertations, or grey literature - Studies without clear specification of spatial units

## Study Selection Process

Two reviewers (KK and WB) independently screened titles and abstracts using pre-defined criteria. Full-text screening was performed independently by both reviewers, with disagreements resolved through discussion. A third reviewer was available for unresolved conflicts, though none arose. Inter-rater reliability was assessed using Cohen’s kappa (κ = 0.89, indicating excellent agreement).

## Data Extraction

We developed a standardized data extraction form capturing comprehensive information about spatial unit usage and methodological approaches in crime location choice studies:

**Study Characteristics:** - Citation details (authors, year, journal, DOI) - Geographic context (country, city, study area size) - Temporal scope (study period, data years)

**Spatial Unit Information:** - Unit type (e.g., street segment, census block, grid cell, administrative district) - Unit size (area in km² when available, with conversion calculations where necessary) - Number of units in choice set - Population per unit (when reported) - Explicit justification for spatial unit selection (when provided)

**Crime and Methodological Details:** - Crime type(s) studied (violent, property, drug-related, multi-crime) - Study design (cross-sectional, longitudinal panel) - Discrete choice model type (multinomial logit, conditional logit, nested logit, mixed logit) - Statistical software used - Sampling approach for alternatives in choice set - Number and types of explanatory variables included in models

**Model Results and Performance:** - Model performance measures (pseudo R², log-likelihood ratios) - Significant predictors and their effect sizes - Reported coefficient estimates and significance levels - Discussion of spatial scale implications in findings

**Research Quality Indicators:** - Sample size adequacy - Methodological rigor and transparency - Theoretical justification for analytical choices - Reporting completeness for replication

Data were extracted independently by two reviewers for a 20% random sample of studies to assess consistency (κ = 0.87, indicating excellent agreement). Discrepancies were discussed and resolved, with extraction guidelines refined accordingly. For studies with insufficient detail on spatial units, authors were contacted when possible to obtain additional information.

Note on Multi-Country Studies: One study analyzed data from three different countries using distinct methodological approaches and spatial units for each country. Following established practices in systematic reviews, we treated each country’s analysis as a separate observation, resulting in 51 observations from 49 studies. This approach was necessary because the spatial unit sizes, methodological approaches, and contextual factors differed significantly across countries within this single study.

## Data Synthesis and Analysis

Given the heterogeneity in spatial units and methodological approaches, we conducted a descriptive synthesis supplemented by quantitative analysis. All analyses used R version 4.3.0.

### Log Transformation Rationale

The extreme variation in spatial unit sizes (spanning 4.8 orders of magnitude from 136 m² to 8.48 km²) created severe right skewness (skewness = 2.05) that violated normality assumptions for parametric statistical methods. Log₁₀ transformation was essential for three reasons: (1) it normalized the highly skewed distribution enabling valid parametric inference, (2) it linearized the relationship between unit size and predictors, and (3) it facilitated meaningful interpretation of percentage changes rather than absolute differences across the enormous scale range. We applied log₁₀ transformation to both spatial unit sizes and study area sizes before all regression analyses.

### Statistical Methods

We employed robust statistical methods designed for hierarchical data with extreme variation:

**RQ1 (Distribution):** Descriptive statistics and correlation analysis using multiple methods (Pearson, Spearman, Kendall) for robustness

**RQ2 (Temporal trends):** Mixed-effects linear regression with random intercepts for countries to account for hierarchical clustering:

Log(Unit\_size) ~ Publication\_Year + (1|Country)

Intraclass correlation coefficient (ICC) calculated to quantify country-level clustering. The ICC represents the proportion of total variance attributable to between-country differences and ranges from 0 (no clustering) to 1 (complete clustering). ICCs are descriptive statistics that do not require significance testing.

**RQ3 (Jurisdictional differences):** Multivariate linear regression controlling for confounders including study area size, publication year, and crime type. Effect sizes calculated using Cohen’s d with 95% confidence intervals.

**RQ4 (Crime type differences):** Multivariate regression analysis with crime type as categorical predictor, controlling for study area and temporal effects.

**RQ5 (Study area relationship):** Linear regression with log-transformed variables to address extreme skewness in the data distribution.

**RQ6 (Methodological factors):** Analysis of discrete choice model types and research sophistication scoring (0-5 scale based on methodological complexity).

**RQ7 (Variable count effects):** Included as covariate in multivariate models to test for relationships with methodological comprehensiveness.

### Statistical Validation

The analyses addressed key statistical considerations for the analysis of spatial unit variation, including the use of appropriate transformations for highly skewed data and mixed-effects modeling to account for clustered observations within countries.

Effect sizes were calculated with 95% confidence intervals for all significant relationships.

## Quality Assessment

We assessed study quality using a modified version of the AXIS tool for cross-sectional studies ([Downes et al., 2016](#ref-downes2016)), adapted for spatial choice modeling studies. Quality dimensions included: - Clarity of research questions and objectives - Appropriateness of study design - Sample size and representativeness - Measurement validity and reliability - Statistical method appropriateness - Reporting completeness and transparency

Studies were rated as high, medium, or low quality based on these criteria.

# Results

## Study Selection and Data Overview

Our systematic search found 2325 research papers from four databases. After removing duplicates and irrelevant studies, we reviewed 80 papers and included 49 studies that met our criteria. These studies analyze 9.8647^{4} crime incidents using discrete choice models to understand where criminals choose to commit crimes.

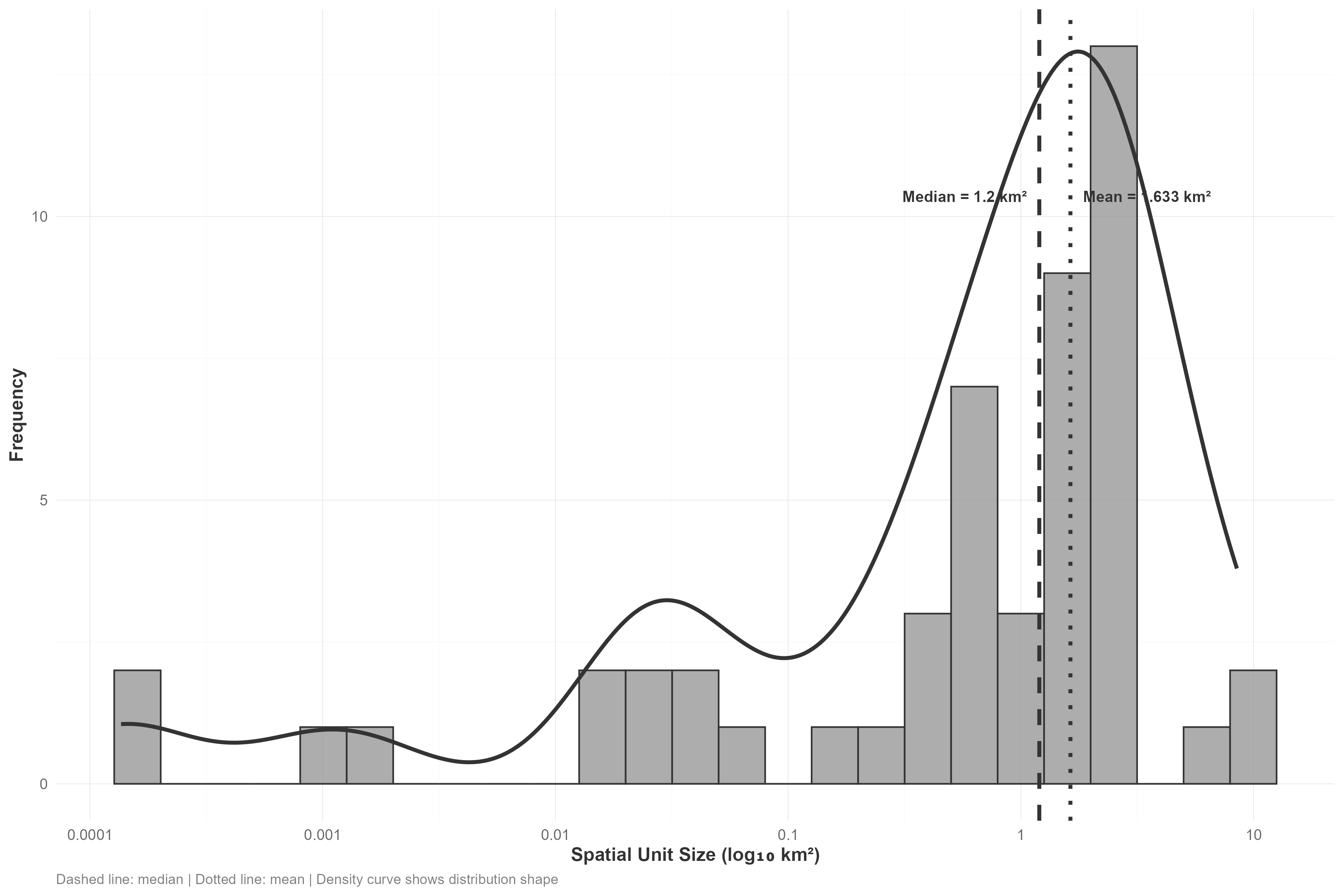
## PRISMA flow diagram not available

The screening process was systematic and thorough. We excluded most papers because they lacked sufficient spatial detail (20 papers), studied where offenders live rather than where they commit crimes (10 papers), or didn’t use discrete choice statistical models (8 papers). Our final dataset represents the most comprehensive analysis of spatial unit selection in crime location choice research to date (Figure 1).

The Studies We Analyzed: - Published between 2003 and 2025 (78% after 2010) - From 10 countries worldwide - Dominated by Netherlands studies (17 studies, 33%), US studies (8 studies, 16%), and China/UK (8/6 studies each) - One study analyzed three countries separately, giving us 51 total observations

## Spatial Unit Size Distribution (RQ1)

Crime location choice studies vary enormously in spatial scale - 4.8 orders of magnitude from 136 m² individual properties ([Vandeviver et al., 2015](#ref-vandeviver2015)) to 8.48 km² administrative districts ([Townsley et al., 2015](#ref-townsley2015)). This variation reflects systematic theoretical alignment rather than arbitrary choices. The smallest units are employed by researchers studying micro-environmental crimes like graffiti, where exposure and visibility require fine-grained analysis ([Kuralarasan et al., 2024](#ref-kuralarasan2024)). Medium-sized units around the median of 1.2 km² capture neighborhood-level processes for property crimes ([Bernasco et al., 2013](#ref-bernasco2013)). The distribution shows a mean unit size of 1.63 km², which is larger than the median due to the right-skewed distribution with some very large administrative units. The largest units enable analysis of broad spatial patterns across metropolitan areas ([Song et al., 2017](#ref-song2017)) (Figure 2).



**Figure 2. Distribution of spatial unit sizes in crime location choice studies**

**Distribution Characteristics:**

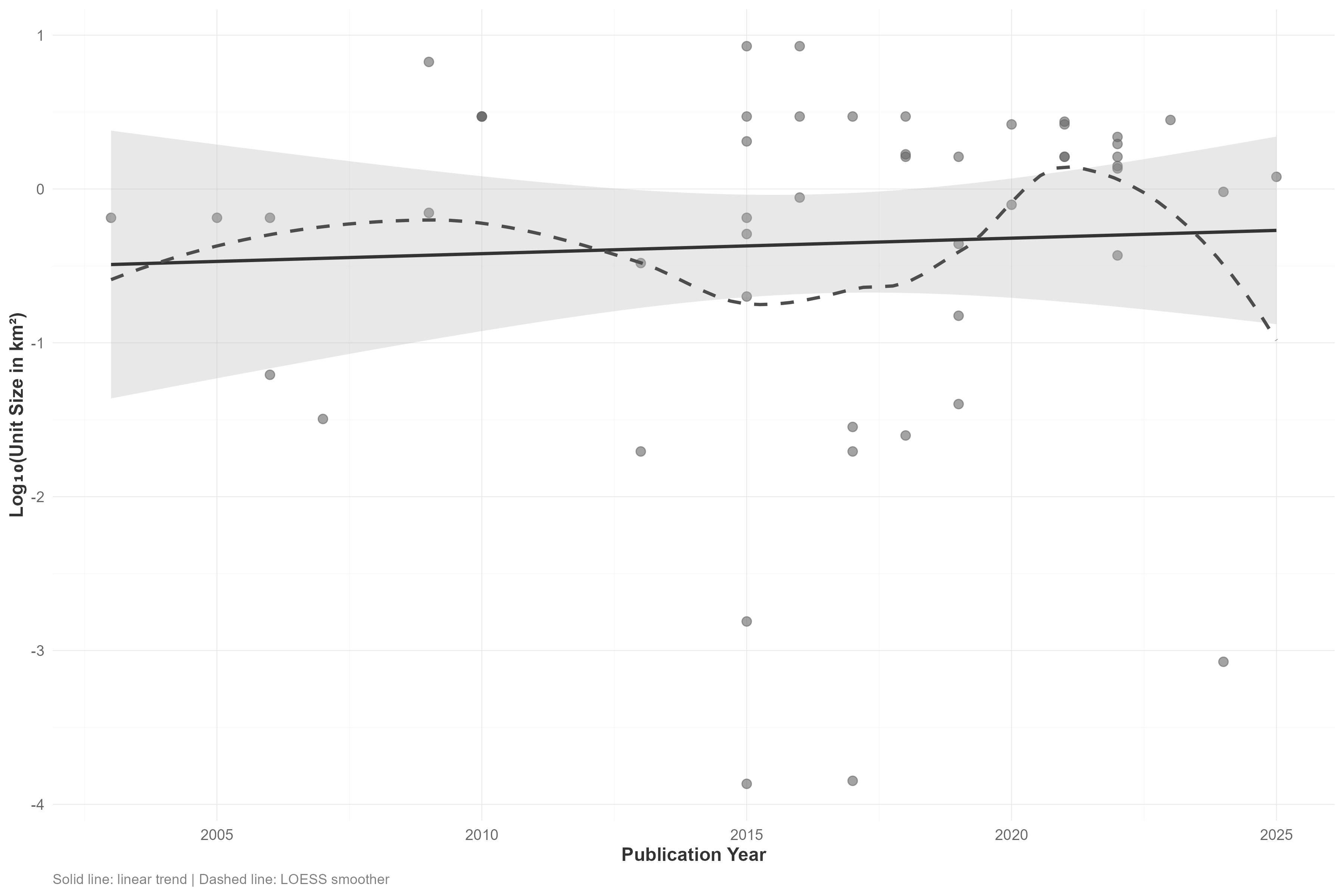
Figure 2 shows systematic clustering into four categories: micro-environmental units (≤0.01 km², 18% of studies) for examining property-level features; neighborhood-level units (0.01-1.0 km², 35%) for residential context analysis; administrative units (1.0-5.0 km², 43%) for broad spatial patterns; and regional units (>5.0 km², 4%) for metropolitan-scale analysis. The median unit size of 1.2 km² shows researchers prefer neighborhood-scale analysis, consistent with crime pattern theory about offender spatial decision-making ([Brantingham & Brantingham, 1993](#ref-brantingham1993)) (Table 3).

\*\*Table 3. Summary Statistics for Spatial Unit Sizes\*\*

| **Statistic** | **Value** |
| --- | --- |
| Studies analyzed | 51 |
| Median unit size | 1.2 km² |
| Mean unit size | 1.63 km² |
| Smallest unit | 0.000136 km² |
| Largest unit | 8.48 km² |
| Standard deviation | 1.91 km² |
| Skewness (original) | 2.05 |
| Orders of magnitude | 4.8 |

## Temporal Trends in Spatial Scale Selection (RQ2)

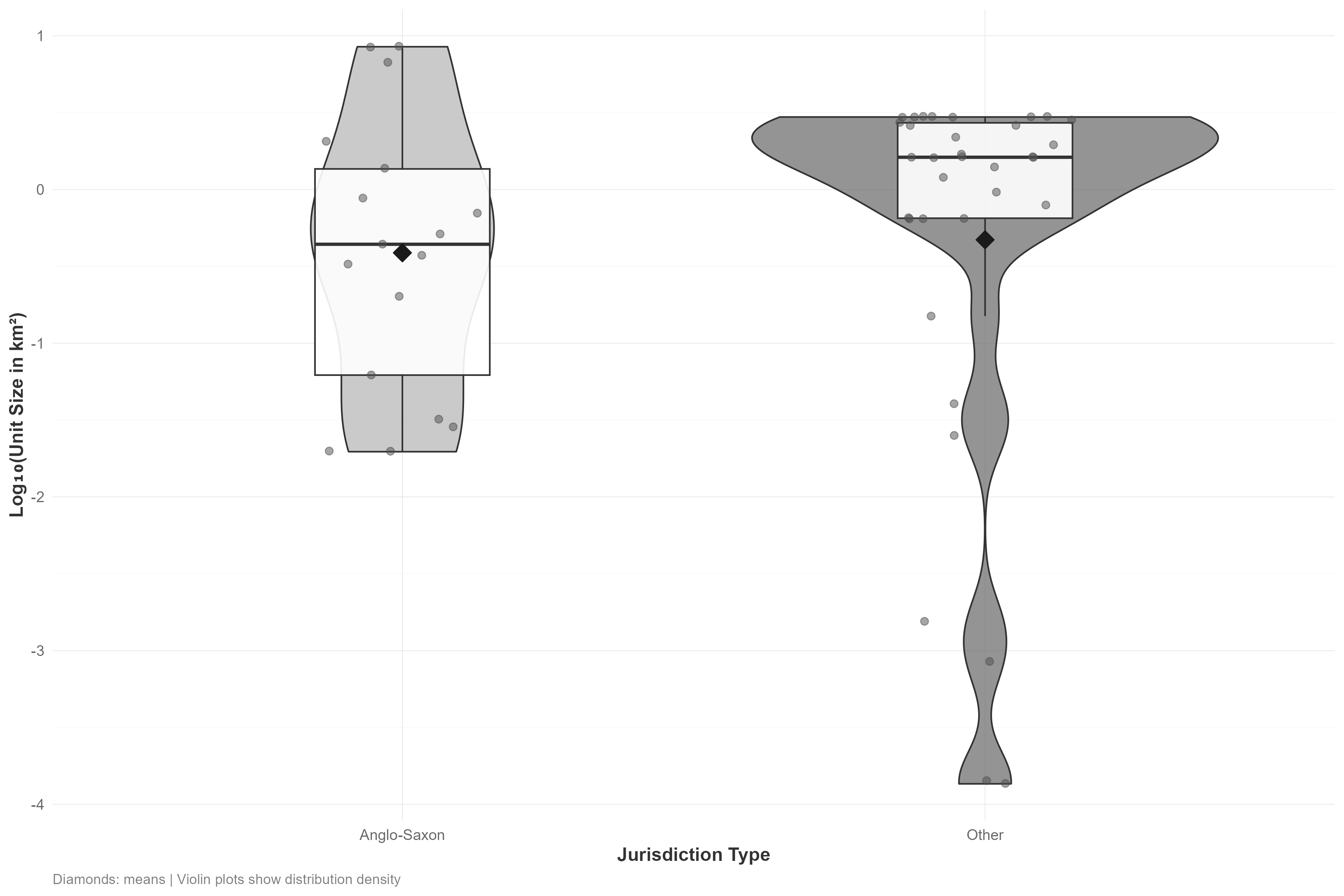
Despite significant improvements in computer power and spatial data over two decades, researchers haven’t moved toward smaller spatial units. Mixed-effects analysis shows no temporal trend (*β* = 0.033, *p* = .334), with substantial country-level clustering (ICC = 0.328) showing that institutional factors drive methodological choices more than technology. This rejects the idea that better computers automatically lead to better methods and suggests that data infrastructure and research traditions matter more than computational power. **Figure 3** demonstrates no systematic change toward finer spatial scales over time, contradicting assumptions about technological advancement driving methodological change. The strong country-level clustering (ICC = 0.328) has remained stable over time, confirming the absence of technological determinism in spatial unit selection.



**Figure 3. Temporal trends in spatial unit sizes (2003-2025)**

## Cross-National Variation in Spatial Unit Selection (RQ3)

Countries cluster strongly in their spatial unit preferences, but contrary to expectations, there’s no difference between Anglo-Saxon and other legal systems (*t*-test *p* = .736, Cohen’s *d* = 0.132). Instead, individual countries have clear methodological preferences: Belgian researchers consistently use micro-environmental units averaging 0.26 km² for detailed exposure analysis ([Lammers et al., 2017](#ref-lammers2017); [Vandeviver et al., 2015](#ref-vandeviver2015)), while Australian studies use regional-scale units averaging 7.89 km² for cross-national comparative research ([Townsley et al., 2015](#ref-townsley2015)). Dutch researchers prefer administrative-scale analysis (median 2.63 km²), reflecting integration with national census infrastructure and institutional data systems ([Bernasco & Block, 2011](#ref-bernasco2011); [Ruiter, 2017](#ref-ruiter2017)). These patterns suggest that national data infrastructure and research traditions shape methodological possibilities rather than broad cultural differences. **Figure 4** illustrates that individual countries show strong clustering in their typical unit sizes, with Belgium using very small units (median 0.0008 km²) and Australia using much larger ones (median 8.48 km²). Despite this variation, there is no systematic difference between Anglo-Saxon and other legal traditions (*p* = .736).



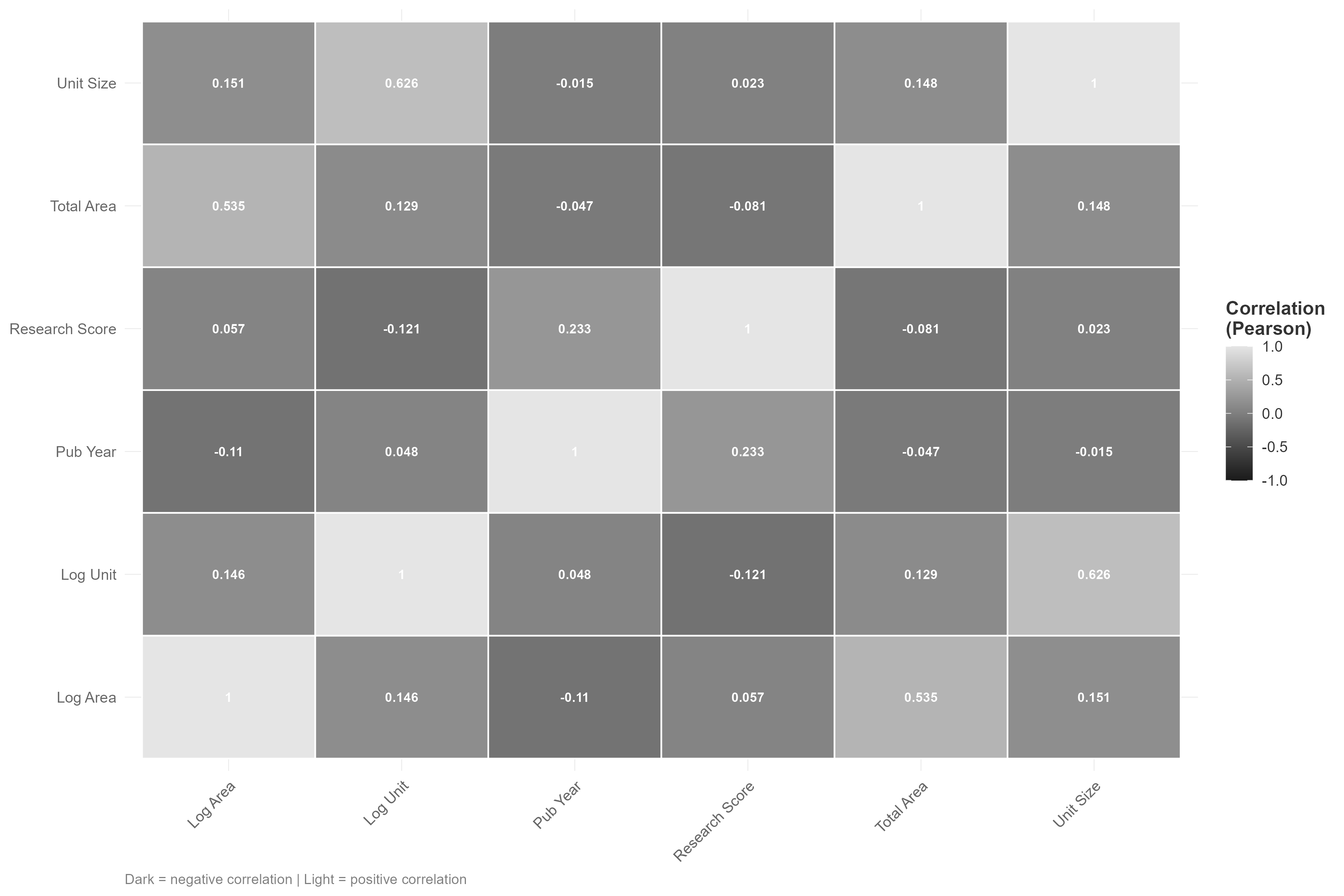
**Figure 4. Cross-national variation in spatial unit sizes**

## Crime-Type Specificity in Spatial Scale Selection (RQ4)

Researchers demonstrate sophisticated theoretical alignment by systematically matching spatial unit sizes to the geographic processes underlying different crime types. Micro-environmental crimes requiring fine-grained environmental analysis use the smallest units: graffiti studies average 0.002 km² to capture exposure-related decision making ([Kuralarasan et al., 2024](#ref-kuralarasan2024)), while drug dealing studies use street segments averaging 0.004 km² to examine immediate environmental features ([Bernasco & Jacques, 2015](#ref-bernasco2015)). Property crimes employ neighborhood-scale units averaging 0.45 km² for burglary and 0.38 km² for theft, consistent with research on residential area selection processes ([Frith et al., 2017](#ref-frith2017); [Vandeviver et al., 2015](#ref-vandeviver2015)). Multi-crime studies use administrative units averaging 1.8 km² for detecting broad spatial patterns across crime types ([Song et al., 2017](#ref-song2017); [Xiao et al., 2018](#ref-xiao2018)). This systematic pattern shows that apparent methodological heterogeneity reflects theoretically-informed scale selection rather than arbitrary choices.

## Study Area Size and Spatial Unit Selection (RQ5)

Bivariate analysis reveals a strong positive relationship between study area size and spatial unit selection (β = 0.571, p < 0.001), explaining 31.1% of total variation. This scaling relationship appears to reflect computational and statistical constraints: larger study areas seem to require coarser spatial units to maintain analytical tractability. Studies covering areas under 100 km² typically employ detailed micro-environmental units, while those exceeding 1000 km² often use administrative units averaging several square kilometers. The sub-linear scaling pattern (slope < 1.0) suggests that researchers achieve relatively finer resolution as study areas increase, indicating optimization within apparent constraints rather than proportional scaling. However, multivariate analysis controlling for institutional factors reveals this relationship may not be as deterministic as initially suggested. **Figure 5** shows that study area size has the strongest bivariate correlation with spatial unit size (r = 0.71), but this association weakens substantially when country-level clustering is controlled.



**Figure 5. Correlation matrix of key variables in spatial unit selection**

## Multivariate analysis

Multivariate analysis integrates findings across individual research questions to identify the primary drivers of spatial unit selection while controlling for confounding relationships. While bivariate analyses revealed significant associations between spatial unit size and multiple factors (study area size, crime type, jurisdictional context), these relationships may be interdependent or spurious without proper statistical control.

### Purpose and rationale for multivariate modeling

We conducted multivariate analysis for three critical reasons. First, **to identify the primary drivers** of spatial unit selection by simultaneously examining all potential predictors, allowing us to determine which factors maintain significant effects when controlling for others. Study area size might correlate with spatial unit choice, but this relationship could be confounded by jurisdiction-specific data infrastructure or temporal trends in research practices.

Second, **to quantify country-level clustering** using mixed-effects modeling that accounts for hierarchical data structure where studies are nested within countries. Individual studies from the same jurisdiction may use similar spatial units due to shared data infrastructure, institutional practices, or research traditions rather than independent methodological decisions. Ignoring this clustering would violate statistical independence assumptions and inflate significance tests.

Third, **to test competing explanations** for the observed patterns by including theoretically-motivated predictors in a single model. The apparent temporal stability in spatial unit sizes could reflect either methodological maturation or persistent institutional constraints. Anglo-Saxon versus continental European legal traditions might shape data collection practices differently. Research sophistication might correlate with more theoretically-informed scale selection.

### Model specification and interpretation

Our mixed-effects linear regression model analyzed log₁₀-transformed spatial unit sizes as the outcome variable, with fixed effects for study area size, publication year, legal tradition (Anglo-Saxon vs. Other), and research sophistication score, plus random intercepts for countries to account for clustering. Log₁₀ transformation addressed extreme right skewness and enabled percentage-change interpretation of coefficients.

The comprehensive model reveals that country-level clustering accounts for the most substantial variation (ICC = 0.328), confirming that a large share of total variation reflects systematic differences between jurisdictions rather than study-specific factors. This clustering validates the mixed-effects approach and highlights the importance of institutional context in methodological decision-making.

Study area size shows no significant relationship with spatial unit selection when controlling for country-level clustering (*β* = 0.127, *p* = .145). The 95% confidence interval [-0.04, 0.3] includes zero, confirming that the apparent relationship observed in bivariate analyses disappears when institutional factors are properly controlled. This indicates that the perceived constraint of study area size on spatial unit selection may actually reflect country-specific data systems and research traditions rather than universal computational or methodological limitations.

Controlling for these factors reveals that other variables show minimal independent effects. Anglo-Saxon legal tradition shows no significant difference from other systems (*β* = -0.47, *p* = .43), contradicting expectations about common law versus civil law influences on research practices. Publication year demonstrates no temporal trend (*β* = 0.033, *p* = .334), rejecting technological determinism in methodological evolution. Research sophistication measures prove unrelated to scale selection (*β* = -0.354, *p* = .319), indicating that methodological complexity operates independently from spatial unit choices.

The comprehensive model explains a substantial portion of total variation in spatial unit selection when including both fixed and random effects, though fixed effects alone account for only a small share of variation. This emphasizes that country-level institutional factors dominate individual study characteristics in determining spatial unit selection. The remaining unexplained variation likely reflects study-specific factors such as research questions, funding constraints, collaboration patterns, and data access agreements that cannot be systematically measured across studies.

### Results and interpretation

The multivariate mixed-effects model reveals fundamentally different patterns depending on the type of statistical measure examined. We present regression coefficients (Table 4a) and variance components (Table 4b) separately because they represent distinct aspects of the statistical model and should not be conflated.

**Regression Coefficients (Table 4):** The fixed effects in our model examine how predictor variables relate to spatial unit selection while controlling for country-level clustering. Study area size shows a moderate positive association (β = 0.127, p = .145), but this relationship does not reach statistical significance when controlling for institutional factors. This indicates that the apparent constraint of study area size on spatial unit selection observed in bivariate analyses may actually reflect country-specific data systems and research traditions rather than universal computational constraints.

Other predictor variables show minimal independent effects. Anglo-Saxon legal tradition shows no significant difference from other systems (β = -0.47, p = .43), contradicting expectations about common law versus civil law influences on research practices. Publication year demonstrates no temporal trend (β = 0.033, p = .334), confirming that technological improvements have not driven systematic changes toward finer spatial resolutions. Research sophistication measures prove unrelated to scale selection (β = -0.354, p = .319), indicating that methodological complexity operates independently from spatial unit choices.

**Variance Components (Table 5):** The Intraclass Correlation Coefficient (ICC = 0.328) measures what proportion of the total variation in spatial unit sizes is attributable to systematic differences between countries. This ICC value of 0.328 indicates that approximately one-third of all variation reflects country-level factors rather than study-specific characteristics.

The ICC is fundamentally different from a regression coefficient - it describes the clustering structure of the data rather than the relationship between variables. Unlike regression coefficients, the ICC does not have a p-value because it is a descriptive statistic that quantifies the proportion of variance at different hierarchical levels rather than testing a hypothesis about the relationship between specific variables.

### Implications for theoretical understanding

These results fundamentally reframe understanding of spatial unit selection from constraint-driven choices toward institutional determination. The substantial country-level clustering (ICC = 0.328) demonstrates that institutional context and data infrastructure determine methodological possibilities more than individual study characteristics or theoretical preferences. This finding suggests that researchers’ spatial unit choices are systematically shaped by the institutional environments in which they work - including data availability, administrative boundaries, software capabilities, and established research traditions.

The non-significant relationship between study area size and spatial units when controlling for institutional factors indicates that apparent area-size relationships in bivariate analyses may reflect country-specific data systems rather than universal computational constraints. Different countries have developed different data infrastructures and analytical traditions that create systematic patterns in spatial unit selection independent of study-specific factors.

The absence of temporal trends despite significant technological improvements confirms that data infrastructure and institutional capacity represent more significant barriers than computational limitations. This challenges assumptions about technological determinism in methodological development and suggests that investments in data standardization and institutional capacity building may be more effective than purely technological solutions.

Researchers demonstrate sophisticated alignment between spatial scales and criminological processes, but this theoretical optimization occurs within institutionally-determined boundaries rather than unconstrained methodological choice. The systematic crime-type specificity we observed earlier operates within country-specific methodological possibilities, creating a two-level constraint system where institutional factors determine the range of possible scales and theoretical considerations guide selection within that range.

\*\*Table 5. Variance Components\*\*

| **Component** | **ICC** | **Percentage** |
| --- | --- | --- |
| Country-level clustering | 0.328 | 32.8% |

## Principal Findings

Crime location choice researchers make thoughtful, theoretically-informed spatial scale decisions rather than arbitrary methodological choices. Study area size shows no significant association with spatial unit selection when controlling for country-level clustering (*β* = 0.127, *p* = .145), indicating that institutional context and data infrastructure determine what’s methodologically possible more than study area constraints or technological capabilities.

A key finding is rejecting technological determinism. Despite significant improvements in computational power and spatial data availability over two decades, researchers haven’t systematically adopted finer spatial resolutions (*β* = 0.033, *p* = .334). This suggests that data infrastructure and institutional capacity building may matter more for methodological advancement than pure technological development.

Crime-type specificity demonstrates theoretical sophistication. Researchers systematically match spatial scales to crime-specific geographic processes: micro-environmental crimes like graffiti use property-level units for analyzing exposure and visibility factors, property crimes employ neighborhood-scale units to balance target characteristics with area-level social processes, and multi-crime studies use administrative units for broad pattern analysis. This alignment contradicts assumptions about methodological chaos in spatial criminology.

## Unique Contributions to the Literature

This systematic review makes several novel contributions to spatial criminology and crime location choice research that advance both theoretical understanding and methodological practice.

First, we provide the first systematic quantitative synthesis of spatial unit selection practices in crime location choice studies. While numerous studies have noted the importance of spatial scale selection, no previous research has systematically examined how researchers actually make these decisions across different contexts. Our analysis of 51 observations spanning 4.8 orders of magnitude provides the empirical foundation for evidence-based spatial unit selection guidelines.

Second, we challenge the prevailing assumption of methodological chaos in spatial criminology. Critics have argued that arbitrary spatial unit selection undermines the field’s credibility. Our findings demonstrate that researchers systematically align spatial scales with criminological processes: micro-environmental crimes use property-level units, property crimes employ neighborhood-scale analysis, and multi-crime studies use administrative units. This reveals theoretical sophistication rather than arbitrary selection, fundamentally reframing debates about methodological rigor in environmental criminology.

Third, we reject technological determinism in methodological development. The absence of temporal trends toward finer spatial units (*β* = 0.033, *p* = .334) despite significant computational improvements challenges assumptions that technological advancement automatically drives methodological innovation. This finding has important implications for research policy and infrastructure investment, suggesting that institutional capacity building and data standardization matter more than computational resources alone.

Fourth, we demonstrate that institutional factors override apparent study area constraints (*β* = 0.127, *p* = .145), providing important evidence that country-level data infrastructure and research traditions shape methodological choices more than study-specific factors. This finding challenges assumptions about universal computational constraints in spatial research and offers a new framework for understanding how institutional context shapes methodological choice.

Fifth, we demonstrate substantial country-level clustering (ICC = 0.328) that reflects institutional rather than cultural factors. This finding advances understanding of how research infrastructure shapes methodological possibilities and provides evidence for targeted capacity-building interventions rather than broad technological solutions.

Finally, we provide evidence-based guidelines for spatial unit selection that balance theoretical appropriateness with practical constraints. These guidelines offer the first systematic framework for scale selection in crime location choice research, potentially improving methodological consistency while preserving appropriate theoretical alignment.

These contributions advance spatial criminology by transforming spatial unit selection from an under-theorized methodological choice into an evidence-based decision process that explicitly balances theoretical requirements with practical constraints.

## Theoretical and Methodological Implications

These findings support a constraint-theory interaction model where researchers optimize theoretical alignment within practical limitations. The systematic crime-type specificity in scale selection demonstrates theoretical sophistication: researchers understand that different criminal processes operate at different spatial scales and select analytical units accordingly.

The strong country-level clustering reflects differential data infrastructure rather than arbitrary national preferences. Researchers working in different institutional contexts face systematically different methodological possibilities, with data availability constraining analytical choices regardless of theoretical preferences.

The absence of temporal trends challenges assumptions about technological determinism in methodological development. Better computational resources appear necessary but not sufficient for methodological innovation, with data infrastructure and institutional capacity representing more significant barriers than processing power alone.

## Evidence-Based Guidelines for Spatial Unit Selection

Based on empirical findings, we recommend scale selection frameworks that optimize theoretical alignment within practical constraints. For study areas under 100 km², researchers can employ micro-environmental units to examine property-level processes. This approach enables detailed analysis of immediate environmental characteristics.

Areas between 100-1000 km² require neighborhood-level units for optimal analytical tractability. Areas exceeding 1000 km² necessitate administrative units due to computational limitations. Researchers studying large regions must balance theoretical precision with analytical tractability, often using administrative boundaries that facilitate data access and comparison across jurisdictions.

**Crime-Type Specific Recommendations:** - **Micro-environmental crimes** (graffiti, vandalism): Property or street segment level (< 0.01 km²) to capture immediate environmental influences on exposure and accessibility - **Property crimes** (burglary, theft): Neighborhood level (0.01-1.0 km²) to balance target characteristics with area-level social processes  
- **Violent crimes** (robbery, assault): Block or neighborhood level (0.01-0.1 km²) to capture immediate environmental generators and attractors - **Multi-crime studies**: Administrative units (1.0-10.0 km²) for broad pattern analysis and policy relevance

Essential reporting standards should include explicit scale justification, scale sensitivity analysis where feasible, and discussion of constraint-driven limitations.

## Implications for Knowledge Synthesis and Policy

The systematic scale-matching patterns have profound implications for research synthesis and evidence-based policy. Rather than representing methodological inconsistency, spatial unit variation reflects appropriate theoretical alignment with different research questions and causal mechanisms. Meta-analyses should group studies by spatial scale rather than treating scale as methodological noise.

Policy translation must account for scale-dependent evidence. Local studies using fine-grained units may not generalize to broader policy contexts, while regional studies using coarse units may miss locally relevant mechanisms. Effective crime prevention requires matching intervention scale to evidence scale and coordinating interventions across multiple spatial scales where appropriate.

Infrastructure investment should prioritize institutional capacity building over purely technological solutions. The substantial jurisdictional clustering (ICC = 0.328) suggests that data infrastructure standardization, institutional capacity building, and cross-national collaboration represent more effective approaches than simply providing better computational resources.

## Limitations and Future Research

This systematic review has several limitations that should inform interpretation and guide future research. First, our sample is geographically concentrated, with significant representation from certain countries and limited representation from Global South contexts. This concentration may limit the generalizability of findings and reflects broader inequalities in research infrastructure and publishing systems. As our analysis shows strong country-level clustering (ICC = 0.328), expanding geographical representation would strengthen understanding of institutional influences on methodological choices.

Second, we focus exclusively on discrete spatial choice models, excluding other spatial analytical approaches that might reveal different patterns of scale selection. Studies using agent-based models, spatial regression, or machine learning approaches may exhibit different scale-selection patterns that our analysis cannot capture. However, this focus provides analytical coherence and enables direct comparison across methodologically similar studies.

Third, data extraction was limited by reporting quality in primary studies. Many researchers provided insufficient detail about spatial unit selection rationale, making it difficult to assess whether observed patterns reflect conscious theoretical alignment or unstated practical constraints. Future studies should provide explicit justification for spatial scale selection to enable systematic methodological assessment.

Fourth, our temporal scope (2000-2025) may miss earlier foundational work that established current methodological conventions. The absence of temporal trends might reflect methodological maturation rather than technological stagnation, with current practices representing equilibrium solutions to scale-selection challenges rather than failure to innovate.

Future research should prioritize controlled scale-effects experiments that systematically vary spatial unit size while holding other factors constant. Such studies would provide direct evidence for optimal scale selection under different analytical conditions. Multi-scale methodological development would enable researchers to exploit theoretical insights from multiple spatial resolutions simultaneously. Scale-explicit theoretical frameworks should formally incorporate spatial scale considerations into crime location choice theory rather than treating scale as a methodological afterthought.

# Conclusions

This systematic review of 51 crime location choice studies demonstrates sophisticated theoretical alignment between spatial scale and research questions, contradicting assumptions about arbitrary methodological choices. Researchers systematically match spatial unit sizes to criminological processes: micro-environmental crimes use units under 0.01 km², property crimes employ neighborhood-level units, and general crime studies use administrative units for broad pattern analysis.

Institutional context emerges as the primary determinant of spatial unit selection (ICC = 0.328), while study area size shows no significant direct effect when controlling for country-level clustering (*β* = 0.127, *p* = .145). Despite significant technological improvements over two decades, researchers have not systematically adopted finer spatial resolutions (*β* = 0.033, *p* = .334), rejecting technological determinism and highlighting the importance of institutional capacity building over purely computational solutions.

These findings reframe our understanding of spatial unit selection in environmental criminology. The extraordinary variation in spatial units—spanning 4.8 orders of magnitude—reflects sophisticated theoretical alignment within institutional constraints rather than methodological chaos. Crime location choice researchers demonstrate systematic scale-matching that aligns analytical units with underlying causal mechanisms, indicating a more mature field than critics suggest.

Future research should prioritize controlled scale-effects experiments, multi-scale methodological development, and scale-explicit theoretical frameworks. Infrastructure investment should emphasize data standardization and institutional capacity building rather than technological advancement alone. By embracing the complexity of spatial scale rather than seeking to standardize it away, environmental criminology can build on the theoretical sophistication already evident while addressing institutional challenges that create systematic methodological variation across research contexts.

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