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SPACES FOR CARS OR PEOPLE? RETHINKING PARKING AND ADDRESSING URBAN HEAT ISLANDS EFFECT TO SUPPORT MIXED-USE DEVELOPMENT FOR SUSTAINABLE COMMUNITY DEVELOPMENT IN OKLAHOMA CITY.

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SPACES FOR CARS OR PEOPLE? RETHINKING PARKING AND ADDRESSING URBAN HEAT ISLANDS EFFECT TO SUPPORT MIXED-USE DEVELOPMENT FOR SUSTAINABLE COMMUNITY DEVELOPMENT IN OKLAHOMA CITY.

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ABSTRACT

In many American cities, parking has been long treated as a necessity, but mandatory parking minimums have often produced excessive underutilized surface parking, which has discouraged mixed-use development. In Oklahoma City, decades of mandatory minimum parking requirements have resulted in an urban landscape where approximately one quarter of downtown land is dedicated to parking. A 2020 study found that 186 acres of off-street parking in downtown OKC were unused during peak hours. This thesis examines the relationship between parking policy, mixed-use development, and urban heat in Oklahoma City. In Oklahoma City, these issues are important because the city's car-oriented urban form and abundant surface parking have shaped development patterns for decades. At the same time, the city's comprehensive planning goals emphasize mixed-use, walkable and more-sustainable development, creating a noticeable planning gap between planning vision and current land use patterns.

The importance of the topic consists of its connection to sustainable community development. Surface parking is associated with land-use, environmental and equity conditions because large asphalt surfaces increase impervious surface, intensify urban heat island effects, and limit opportunities for dense, mixed-use growth. This research asks: How does the allocation and spatial distribution of surface parking in Oklahoma City affect areas designated or suitable for mixed-use development? What are the major environmental impacts, particularly urban heat islands, associated with excess surface parking, and which communities are most at risk? What strategies and best practices from peer cities can Oklahoma City adopt to repurpose parking into climate-resilient, community-serving mixed-use development?

To answer these questions, the study uses a mixed-methods approach that combines GIS mapping, spatial analysis, land-surface temperature analysis, vegetation assessment, zoning review, and comparative policy analysis. Surface parking lots were inventoried and mapped across Oklahoma City, then compared with current mixed-use zoning districts and PlanOKC future mixed-use designations. The research also analyzed heat patterns and vegetation conditions to assess the environmental impact of parking-dominated land uses. Finally, the study reviewed parking reform strategies from cities such as Minneapolis, Portland, and Buffalo to identify transferable policy lessons for Oklahoma City.

The findings show that surface parking is concentrated in precisely the areas where mixed-use development is optimal, including the downtown core and major commercial corridors. These parking-dominated areas also exhibit high land surface temperatures and low vegetation cover, confirming that parking contributes to urban heat and weakens environmental quality. In addition, the review of local policy shows that parking minimums continue to reinforce low-density development and make mixed-use redevelopment more difficult than it needs to be. The research, therefore, identifies a significant policy development gap between Oklahoma City's planning goals and its current zoning regulations.

The study concludes that parking reform can serve as a practical tool for sustainable planning. Reforming parking minimums, introducing parking maximums, and integrating green infrastructure into redevelopment could help convert underused parking land into more livable, walkable, and climate-resilient mixed-use places. More broadly, the thesis demonstrates that parking policy is not just about cars; it is a powerful planning tool for shaping healthier, more equitable, and more sustainable cities.

Key words: Minimum parking requirements, parking reform; mixed-use development; urban heat island; sustainable development; zoning reform; climate resilience, parking policy.

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TABLE OF CONTENTS

LISTS OF FIGURES

LIST OF TABLES

CHAPTER 1: INTRODUCTION

Many cities in the United States are fragmented by empty surface parking lots largely due to mandatory parking requirements creating land-use patterns fundamentally influence the physical structure, environmental performance, and social dynamics of cities (Hess & Rehler, 2021a; Manville & Shoup, 2005a). Moreover, these patterns determine residential, commercial and mobility choices, while also shaping the efficiency of land and infrastructure utilization (Hess & Rehler, 2021a; Sohoni & Lee, 2024). In the United States, transportation planning and zoning have historically prioritized automobile access, resulting in low-density auto-oriented development, and significant land allocation for parking (Sohoni & Lee, 2024; Tylor & Fransis, 2004). Parking, once considered as a secondary support function, has emerged as a primary determinant of urban form, mixed-use development intensity and environmental quality (Manville & Shoup, 2005b; Sohoni & Lee, 2024).

The historical development of parking in American cities underscores the continued significance of this problem as automobile ownership increased throughout the 20th century, municipalities responded by expanding parking provisions and subsequently instituting minimum parking requirements within zoning ordinances (Manville, 2017; Tylor & Fransis, 2004). Although these regulations aimed to alleviate congestion and promote commercial activity, they also established the expectation that all new developments would provide ample parking, irrespective of actual demand (Hess & Rehler, 2021a; Manville & Shoup, 2005b). This approach has resulted in an oversupply of surface parking in car-centric metropolitan regions. By allocating valuable urban land to vehicle parking, parking minimums have inhibited compact mixed-use development, hindered socioenvironmental sustainability (Hess & Rehler, 2021a; Marshall & Garrick, 2006).

Recognizing these problems created by uniform parking minimums, more than 100 cities in the United States have now adopted a range of parking reforms (*Parking Lot Map*, 2023) .

The environmental consequences of parking infrastructure are substantial (Garber et al., 2024a; Moretti et al., 2022). Surface parking lots are predominantly constructed with dark, impervious asphalt, which absorbs and re-emits heat, thereby exacerbating the urban heat island effect (Chester et al., 2015; Onishi et al., 2010a). Due to minimal vegetation and limited shade, these areas frequently represent the hottest surfaces within urban environments, affects not only thermal comfort and overall neighborhood livability (Moretti et al., 2022; Onishi et al., 2010a). In areas promoting mixed-use development, extensive parking can further disrupt urban fabric by creating broad, inactive, and heat-intensive zones between buildings and destinations (Gould, 2022; John & Sarkar, 2021).

This research examines the impact of Oklahoma City's current parking policy on sustainability, mixed-use development, and the urban heat island effect. The city has historically developed as a low-density, automobile-oriented urban area, with surface parking significantly influencing the land use pattern of its downtown and adjacent districts (*Kimley Horn*, 2020). Consequently, Oklahoma City provides a valuable context for investigating how parking reform could enhance land-use efficiency, environmental resilience and sustainability.

The significance of this research is its integration of planning issues that are frequently examined in isolation: parking reform, sustainability, mixed-use development, and urban heat island mitigation. Although each topic is well represented in the literature, limited research addresses their intersection within auto-dependent, mid-sized cities. In contrast, this research investigates the spatial overlap between surface parking and mixed-use opportunity areas in Oklahoma City, as well as the contribution of parking to environmental stress. It further assesses whether parking reform can facilitate more sustainable redevelopment and mitigate heat vulnerability.

This research employs a mixed-method planning framework, integrating spatial analysis, environmental assessment, zoning review, and comparative policy analysis. This methodology enables the identification of surface parking concentrations, their relationship with mixed-use zones, and the evaluation of planning strategies that may advance a more sustainable urban future. The findings of this research indicate that surface parking is concentrated in the same areas where mixed-use redevelopment is most preferable, and that these parking-dominated areas are also associated with higher heat exposure and limited vegetation. This suggests a strong mismatch between current parking supply, land-use priorities, and PlanOKC sustainability goals. The results also show that parking reform can create new opportunities to repurpose underused land for mixed-use infill, public space, and climate-responsive design. In this way, the study demonstrates that parking policy is not simply about managing vehicles; it also shapes the future form, function, and environmental quality of the city.

CHAPTER 2: LITERATURE REVIEW

2.1 Parking History in American Cities

In the early 1900s, cars were an infrequent luxury in U.S. cities, and “parking” as we know it did not exist in reality; instead, people “ranked” vehicles at the curb or angled behind each other (Joseph, 2020a; *Tindell, 1900*). As auto ownership exploded through the 1920s and beyond, urban streets became crowded with “dead” vehicles left unattended while their owners went into stores, offices, or theaters (Manville & Shoup, 2005; *Tylor & Fransis, 2004*). Cities first responded by regulating how long vehicles could stop on curbs, and then by allocating off-street parking and garages. Many cities across the United States were allocating land for parking purposes by the 1920s, whereas one of the earliest municipal lots was established in Los Angeles in 1922 (Garber et al., 2024a; Joseph, 2020; Manville & Shoup, 2005b). Meanwhile, the rise of the automobile reshaped commerce, and suburban shopping centers began pairing large free-surface parking lots with stores to signal convenience to car-driving customers (Marshall & Garrick, 2006; Joseph, 2020b).

In vast areas of downtowns and suburbs, roads were paved for vehicles, creating the “flat sea” of asphalt now recognized as parking lots (Garber et al., 2024a; Marshall & Garrick, 2006). The parking lot emerged not only as infrastructure but also as a symbol of freedom, mobility, and prosperity, and eventually as a land-use inefficiency, a heat island, a loss of urban fabric, and an environmental cost (Litman, 2025.; Marshall & Garrick, 2006). Moreover, parking lots are not just leftover spaces, they are a product of a century of policy, technological change, commercial strategy, and cultural expectations, which helps us to see that what looks like “open space for cars” was once a deliberate planning choice and can therefore be considered for new purposes (Kaw et al., 2020; Joseph, 2020b).

A key policy that emerged during this period was the implementation of minimum off-street parking requirements, mandating that new developments provide a predetermined number of parking spaces regardless of actual demand (Manville & Shoup, 2005b; D. C. Shoup, 1999a). Such mandates became standard practice from the 1950s through the 1970s, primarily based on early engineering research (Manville & Shoup, 2005b; D. C. Shoup, 1999a). Subsequently, they were informed by the Institute of Transportation Engineers' (ITE) Parking Generation Manual, which evaluated parking demand at suburban, car-dependent sites which led to the development of widely accepted formulas such as 1–2 spaces per residential unit, 3–4 spaces per 1,000 square feet of office space, and 10–15 spaces per 1,000 square feet for restaurants that were incorporated into zoning codes with minimal modification (Manville & Shoup, 2005; Sutherland, 2009).

Consequently, numerous American cities established extensive surface parking areas, often replacing existing structures during waves of urban renewal and downtown demolition (Glaeser, 2011; Jacobs, 1961). By the end of the twentieth century, surface parking occupied between 20% and 40% of land within city centers in many U.S. cities, thereby reducing density and impairing walkability (Manville, 2017; Moretti et al., 2022). Therefore, parking regulations also increased development costs, hindered the development of mixed-use infill, and reinforced automobile dependence, particularly in mid-sized, auto-oriented municipalities (Manville & Shoup, 2005b; D. C. Shoup, 1999a).

2.2 Parking Minimums to Parking Reform

While parking is often perceived as a minor or secondary concern, it plays a critical role in urban sustainability (Chester et al., 2015). Much research shows that parking demand has profound implications for supply chain energy consumption and greenhouse gas emissions (Kong et al., 2023; Marshall & Garrick, 2006). In contrast, recent findings from the University of California, Berkeley's Department of Civil and Environmental Engineering indicate that the United States has approximately 3.4 parking spaces for every car (*Chester*, 2011.; Seitelman & Assistant, 2021). However, widely cited estimates suggest the actual figure may be closer to eight spaces per car, which significantly amplifies environmental impacts, underscoring the importance of parking provision in sustainability planning (Galsin, 2015; Marshall & Garrick, 2006).

In cities across the U.S., planners are pushing to eliminate mandates requiring parking spaces in new buildings. The reforms, along with banning street parking or adding meters, help to reduce car dependency, create public and green spaces, and lower housing costs (*Graber*, 2024.; Lehe, 2018). Parking Reform is the use of policies and activism to discourage the construction of excess parking supplies and to encourage more equitable, efficient, and sustainable management of existing parking, often through pricing (Marshall & Garrick, 2006; Siegman, 2025).

Parking reform is rapidly emerging as a transformative force in American urban planning, challenging decades of entrenched assumptions that every new building must be surrounded by ample parking (Marshall & Garrick, 2006; Tam, 2024). In cities like San Francisco, Minneapolis, and Atlanta, the shift away from mandatory minimum parking requirements signals a fundamental cultural and policy reorientation toward more compact, human-centered urban environments (Hess & Rehler, 2021b; D. Shoup, 2021; Tam, 2024). By eliminating minimums, some cities are even introducing parking maximums and dynamic pricing, ensuring parking supply responds to actual demand rather than outdated formulas (Marshall & Garrick, 2006; Sohoni & Lee, 2024). As a result, eliminating parking opens significant land for development that has long been occupied by large parking lots, paving the way for affordable housing, mixed-use infill projects, lively commercial areas, transit-focused neighborhoods, parks, and public spaces (Iannillo & Fasolino, 2021; Tam, 2024). Beyond land redevelopment, parking reform has significant environmental and social implications: reducing car dependency lowers greenhouse gas emissions, decreases infrastructure costs, improves air quality, and expands mobility options for communities that do not own cars or cannot drive (Lowe et al., 2022; Marshall & Garrick, 2006). Moreover, the parking policy becomes a powerful equity tool helping distribute the benefits of urban life more fairly and sustainably (Albalate & Gragera, 2020; Baumgartner & Lanzendorf, 2025). Reducing car dependency lowers greenhouse gas emissions, reduces infrastructure maintenance costs, and improves air quality (Lowe et al., 2022; Sohoni & Lee, 2024). It also broadens mobility access for households without cars, who are disproportionately low-income, younger, elderly, or disabled, ensuring they are not penalized by hidden parking costs embedded in rent and goods (Albalate & Gragera, 2020; Manville, 2017). As cities rethink their parking strategies, reform emerges as a powerful tool to allocate benefits more fairly, reduce systemic inequities baked into car-oriented planning, and support healthier, climate-resilient communities.

In low-density, automobile-dependent metropolitan areas with limited transit options, critics contend that eliminating parking requirements may reduce commercial viability by discouraging customers who lack alternative transportation modes (Chester et al., 2015; Sohoni & Lee, 2024). Empirical evidence indicates that support for parking reform is strongest in high-density, transit-oriented cities, whereas its applicability to Sunbelt regions remains debated (Manville & Shoup, 2005b; D. Shoup, 2021). Moreover, adopting market-rate parking pricing may place a disproportionate burden on lower-income communities without feasible alternatives to driving, suggesting that reform implemented without equity measures may exacerbate, rather than alleviate, spatial inequity (Albalate & Gragera, 2020; Manville, 2017).

The political feasibility of parking reform poses significant challenges (Li & Guo, 2014; Manville & Shoup, 2005b). Persistent opposition from business associations, neighborhood groups, disability advocates, and municipalities reliant on parking revenue has historically hindered reform initiatives (Hess & Rehler, 2021b; Li & Guo, 2014). Research demonstrates that parking reform is most effective when the elimination of minimum requirements is paired with transit investment, inclusive zoning, and structured community engagement, rather than pursued as a standalone policy (D. Shoup, 2021; Sohoni & Lee, 2025). Additionally, the distributional impacts of parking reform are not uniformly progressive. Although market-rate parking pricing is theoretically efficient, it may impose disproportionate costs on lower-income workers who lack viable alternatives to driving and cannot absorb increased parking expenses (Manville & Shoup, 2005b; D. Shoup, 2021).

2.3 Concept of Sustainable Development

The concept of Sustainable development has evolved over several decades and is most commonly traced to the 1987 Brundtland Report, which defined it as meets present needs without compromising the ability of future generations to meet their own needs (*Brundtland Report*, 2016). Since then, sustainable development has developed from a broad narrative idea into a more operational framework that integrates environmental protection, economic viability and social equity (Barrett, 1996; Kadir & Jamaludin, 2013). In urban planning, this framework is significant because cities concentrate population growth, land construction, transportation demand and environmental impacts (Iannillo & Fasolino, 2021; Kadir & Jamaludin, 2013). As a result, sustainable development is now widely understood as a guiding principle for shaping cities in ways that allow growth, environmental quality and social quality of life to coexist over the long term (Gentili et al., 2020; Lowe et al., 2022).

The evolution of sustainable development was reinforced through major global milestones, including the 1992 Rio Earth Summit, Agenda 21, the Millennium Developments Goals in 2000 and the Sustainable Development Goals adopted in 2015 (*Agenda 21; MDGs to SDGs*, 2025; SDGs, 2015). These milestones shifted sustainability from a general policy concern into a measurable international agenda with broader and more explicit objectives. The SDGs expanded the scope of sustainability by emphasizing not only environmental protection, but also poverty reduction, inequality, health, inclusive cities, responsible consumption, and climate action (UN SDGs, 2015). The wider understanding is particularly relevant to urban areas, where planning decisions directly influence land use, mobility, housing, infrastructure and access to urban amenities (Hassan & Lee, 2015; Zheng et al., 2014). Today, the unmanaged growth of cities and the adverse effects of urban sprawl remain key issues, prompting planners, scholars, and governments to find solutions that tackle environmental harm, economic disparities, and social inequality through sustainable development strategies. (Conway, 2021.; Hassan & Lee, 2015; *Purvis & Mao, 2019*).

Sustainability is commonly explained through three interconnected pillars: environmental, economic, and social pillar focuses on reducing pollution, conserving resources and protecting ecosystems (Hassan & Lee, 2015; Purvis et al., 2019). Economic sustainability emphasizes long-term viability, efficient use of land and infrastructure and support for productive growth. Social sustainability addresses equity, inclusion, accessibility and improved quality of life. (Hassan & Lee, 2015; Purvis et al., 2019; Roseland, 2000). According to research, a city can only be considered sustainable when these three dimensions are balanced rather than separately, for instance a city may experience strong economic growth, but if that growth depends on excessive resource consumption, social exclusion or environment degradation, the city is unrecognized as sustainable in the long term (Conway, 2021.; Roseland, 2000; Zheng et al., 2014).

This perspective is highly relevant to urban form and transportation policy where rapid urban growth often leads to increased land consumption, greater automobile dependance, and pressure on infrastructure and natural systems (R. H. Ewing, 2008; Zhao, 2010). When cities expand without adequate planning, they may experience urban sprawl, higher emissions, loss of open spaces and access to housing and public facilities (R. H. Ewing, 2008; Garber et al., 2024a; Noaime & Hamdoun, 2025). Sustainable development therefore requires planners and policymakers to design urban environments that reduce environmental harm, support economic opportunity, and improve social wellbeing (Baobeid et al., 2021; Noaime & Hamdoun, 2025; Purvis et al., 2019).

Minimum parking requirements directly influence how urban land is being used and how development occurs as they are connected to sustainability concerns (Gentili et al., 2020; Sohoni & Lee, 2024). When parking is mandated in large quantities, valuable land is often devoted to vehicles storage rather than urban facilities which encourages low-density, can-oriented development patterns and contributes to urban sprawl, which conflicts with sustainable urban development principles (Garber et al., 2024a; Hess & Rehler, 2021b; Siegman, 2025). Moreover, parking mandates also increases construction costs, reduces housing affordability and worsens walkability and transit-supportive character of urban neighborhoods (Baumgartner & Lanzendorf, 2025; Hess & Rehler, 2021b; Sohoni & Lee, 2024) . These outcomes are complex because they increase environmental pressures such as urban heat island, loss of green space through car dependance, create economic inefficiency through car dependance, create economic inefficiency through higher development costs, and produce social inequality through reduced affordability and accessibility.

Moreover, sustainable development is not only a technical planning approach, but also a human-centered responsibility ensuring that communities have access to clean air, green spaces, efficient mobility systems, resilient infrastructure, and equitable opportunities (Hassan & Lee, 2015; Purvis *& Mao. 2019*). It emphasizes mixed land use, renewable energy, compact forms, community engagement, and long-term thinking so that future generations can inherit cities that are livable, inclusive, resilient, and environmentally balanced, not degraded by the costs of today's choices (Kadir & Jamaludin, 2013; Oldenhuizing et al., 2013).

2.4 Understanding Mixed-use Development for Sustainable Community Development

In recent decades, the concept of mixed-use development has gained significant traction in urban planning. As cities grow and evolve, there is a pressing need for efficient space use that caters to diverse needs. Mixed-use developments provide a solution by combining residential, commercial, and sometimes industrial spaces within a single area (Litman, 2025; Marshall & Garrick, 2006). The approach of mixed land use not only optimizes land use but also fosters vibrant communities and sustainable urban growth. (Marshall & Garrick, 2006; Song, 2022).

Mixed-use environments encourage vibrant urban life by bringing together a range of housing options, shops, workplaces, services, and entertainment in proximity. (Marshall & Garrick, 2006; Wu et al., 2022). Scholars have shown that spatial diversity fosters ongoing street-level activity, increases pedestrian traffic, and enhances safety perceptions through natural surveillance. (Conway,2021; Farjam & Hossieni Motlaq, 2019). Some examples of mixed use developments discussed in the literature are neighborhoods such as the Pearl District in Portland, Downtown Toronto, and Ballston in Arlington, VA, which demonstrate how combining uses creates "24-hour neighborhoods" that remain lively throughout the day due to overlapping routines of living, working, and recreation. (Morris, 2023).

Mixed-use development also promotes sustainable urban expansion by reducing dependence on private vehicles.(Knowles & Nikitas, 2025; Marshall & Garrick, 2006). When homes, workplaces, grocery stores, childcare facilities, and transit options are within walking distance, residents tend to walk, bike, or use public transportation for daily commuting. (Knowles & Nikitas, 2025; Tuffour et al., 2025) . Moreover, car dependency reduces vehicle miles traveled (VMT), greenhouse gas emissions, and household transportation costs. (Marshall & Garrick, 2006; Tuffour et al., 2025). A prominent example is Arlington County's Rosslyn Ballston Corridor, were mixed-use, transit-focused development significantly reduced driving despite population growth (Leach, 2004). Socially, mixed-use neighborhoods foster inclusive community-building by offering a variety of housing options, public spaces, and community amenities.(Battazani & Smith, 2025; Kadir & Jamaludin, 2013). When intentionally designed, mixed-use districts can include affordable housing, community centers, parks, and gathering spaces that enhance social connections and promote equity.(Battazani & Smith, 2025; Farjam & Hossieni Motlaq, 2019).

For example, the Fruitvale Transit Village in Oakland combines housing, retail, offices, and affordable units, while the broader Fruitvale area includes community-serving resources such as childcare and youth programs. Moreover, Fruitvale Village is walkable and inclusive because its compact, transit-oriented layout brings housing, retail, and community services together near the BART station, making daily destinations easy to reach on foot. Its mixed-income housing, pedestrian plaza, and culturally responsive public spaces also support residents of different ages, incomes, and backgrounds. Together, these features show how mixed-use development can support cultural preservation, economic mobility, and a more pedestrian-friendly environment (*Fruitvale Transit Village*, 2021)

Over the past few decades, parking lots have rapidly expanded, covering acres of land with impervious asphalt that contributes to multiple environmental issues, such as urban heat islands (Gould, 2022; Onishi et al., 2010a). Forest Service research from the late 1990s found increased temperatures in neighborhoods up to a quarter mile downwind of unshaded parking lots (Cotrone, 2025; Onishi et al., 2010a; Scott et al., 1999). The asphalt absorbs and re-radiates heat during the day and into the evening. Consequently, homes near large parking lots heat up faster, potentially increasing summer air conditioning energy use (Cotrone, 2025; Onishi et al., 2010a).

Sustainable community development supplements mixed-use development goals by emphasizing the interconnectedness between built environments and long-term social and environmental outcomes (Conway, n.d.; Farjam & Hossieni Motlaq, 2019; Iannillo & Fasolino, 2021). Much research indicates that neighborhood spatial patterns affect health, pollution exposure, access to daily resources, emotional well-being, socioeconomic opportunities, and environmental resilience (Farjam & Hossieni Motlaq, 2019; Kadir & Jamaludin, 2013; Kaw et al., 2020). Furthermore, sustainable development emphasizes land stewardship, viewing land as a limited public resource that must be managed responsibly across generations to balance development with long-term environmental and social goals (Barrett, 1996; Roseland, 2000). The protection of ecological resources is a key element of sustainability planning because conserving wetlands, urban forests, watersheds, and biodiversity is vital for climate resilience, environmental health, and the ecosystem (Barrett, 1996; Hassan & Lee, 2015). Finally, fair access to amenities, including parks, transit, healthy food, and housing, is widely recognized as a key factor in community quality and social sustainability, ensuring that all residents benefit from public investments regardless of income, race, or neighborhood location (Iannillo & Fasolino, 2021; Mbata, 2024).

However, mixed-use development requires land supply, and in many American cities, the land most available and centrally located is currently locked into surface parking (Albalate & Gragera, 2020; Chester, 2016; Marshall & Garrick, 2006). Thus, while mixed-use development and sustainable community development are conceptually reinforced, their real-world scalability depends heavily on the regulatory, physical, and political structures that determine how cities allocate land (Farjam & Hossieni Motlaq, 2019; Noaime & Hamdoun, 2025). Parking reform emerges here as a critical enabling condition because, without reshaping how cities regulate parking, mixed-use development struggles to materialize at a scale necessary to achieve sustainable community outcomes (Baumgartner & Lanzendorf, 2025; Hess & Rehler, 2021b).

2.5 Integration of Parking Reform in Mixed-use Development for Sustainable Development

The literature on parking reform, mixed-use development, and sustainable community development reveals a strong theoretical interdependence: Parking reform serves as the key catalyst that enables mixed-use density, and implementing mixed-use development acts as the spatial process through which sustainability results are achieved (Baumgartner & Lanzendorf, 2025; *Yale,2025*; Marshall & Garrick, 2006). Parking reform is thus more than just a zoning measure; it represents a fundamental shift in the city's land use, moving from automobile storage to more productive, equitable, and socially beneficial uses (Lehe, 2018; Manville & Shoup, 2005b; Yudhishthu, 2023). Scholars argue that the built environment cannot move towards low-carbon, resilient, health-supportive patterns unless the regulatory system stops allocating disproportionate amounts of urban land to cars (Baumgartner & Lanzendorf, 2025; Garber, Benmarhnia, et al., 2025a; Marshall & Garrick, 2006). At the same time, parking reform is a precondition for enabling new spatial logics in which land is flexible, adaptable, and economically feasible for compact development (Dindar, 2025; Manville & Shoup, 2005b).

The mixed-use development literature shows that when land can be reallocated toward housing, urban amenities, small businesses, transit-supportive density, and pedestrian-oriented design, the city becomes more socially cohesive, economically resilient, and environmentally regenerative (Litman, 2025.; Speck, 2013). Furthermore, researchers indicate that even small decreases in parking supply can release substantial amounts of unused, buildable land, where parking reform not only frees up space but also establishes the physical and economic conditions necessary for mixed-use development to thrive and ensures public health and safety (Chester, 2016; *Grabar* , 2024; Marshall & Garrick, 2006).

Sustainable community development highlights the importance of outcomes for achieving climate objectives, health equity, social inclusivity, environmental justice, and long-term resilience. (Kadir & Jamaludin, 2013; Roseland, 2000). Although the built environment influences exposure to pollution and heat, access to resources, transit options, and household expenses, shifting from car-centric land use to compact, mixed-use neighborhoods is a key environmental justice strategy (Garber, Benmarhnia, et al., 2025a; Westlin, 2024; Zheng et al., 2014). Therefore, parking reform, mixed-use development, and sustainable growth are interconnected: sustainable community development relies on the feasibility of mixed-use areas, which in turn depend on parking reform.

2.6 Urban Heat Island Effects and the Role of Parking in Mixed-Use Development

The Urban Heat Island (UHI) effect describes how built-up areas experience higher temperatures than nearby rural or less developed areas due to heat-absorbing materials, limited vegetation, and concentrated human activity (Karimi et al., 2023; US EPA, 2014; Westlin, 2024). In modern American cities, asphalt-dominated land uses, primarily surface parking, play a key role in amplifying this thermal imbalance (Onishi et al., 2010a; Westlin, 2024). Unlike buildings that can include shading, green roofs, or reflective surfaces, surface parking lots act almost entirely as open heat reservoirs, absorbing solar energy during the day and slowly releasing it at night. (John & Sarkar, 2021; Westlin, 2024). However, minimum parking requirements have played a decisive role in the expansion of surface parking across U.S. cities (Hess & Rehler, 2021b; Yudhishthu, 2023). By mandating a fixed number of spaces per land use, zoning codes have embedded large expanses of impervious pavement into urban form, regardless of actual demand. (D. Shoup, 2018, 2021).

Parking infrastructure has a disproportionate impact on urban heat because of both its spatial scale and its material properties (Onishi et al., 2010a; Scott et al., 1999). Asphalt generally has a solar reflectance (albedo) of only 0.05–0.15, meaning it absorbs up to 95% of solar radiation, while vegetated surfaces reflect and dissipate considerably more heat (García Mainieri et al., 2022; US EPA, 2014). Field measurements indicate that surface temperatures on asphalt parking lots often reach 140–160°F (60–71°C) during summer afternoons, compared to 85–95°F (29–35°C) on shaded or vegetated land nearby (*Schilling*, 2024; Onishi et al., 2010). This intense surface heating raises near-ground air temperatures, prolongs nighttime heat retention, and worsens localized heat stress for pedestrians and nearby structures.

The role of surface parking becomes especially critical in areas designated for mixed-use development (Stubbs, 2002; Wu et al., 2022). Mixed-use districts aim to combine housing, retail, offices, and public spaces near support walkable, vibrant urban environments. However, large parking lots disrupt this intended character by creating wide, heat-intensive gaps between buildings and public spaces (Baumgartner & Lanzendorf, 2025; Onishi et al., 2010a; Stubbs, 2002). In cities such as Oklahoma City, where zoning codes have historically encouraged low-density, automobile-oriented development, surface parking often occupies prime land that could otherwise support mixed-use growth (Fieldcamp, 2025a). Understanding the spatial relationship between parking lot distribution and urban heat patterns is therefore essential for assessing how current land use decisions affect both climate resilience and the quality of mixed-use development (D. Shoup, 2018; Sohoni & Lee, 2024; Stubbs, 2002).

2.7 Parking Reform as Urban Heat Mitigation Policy

Parking reform strengthens the climate potential of mixed-use development by removing regulatory barriers that historically forced developers to overbuild parking. (Marshall & Garrick, 2006; D. Shoup, 2018). The elimination of minimum parking requirements allows parking supply to respond to real demand rather than rigid formulas rooted in suburban travel behavior (Shoup, 2021; Siegman, 2025). When fewer parking spaces are required, developers gain flexibility to retain permeability, preserve trees, integrate shade structures, or redirect land toward climate-resilient public space. (John & Sarkar, 2021; Onishi et al., 2010a; Westlin, 2024).

Furthermore, the environmental benefits of parking reform are multiple and interconnected(Garber et al., 2024b; Gentili et al., 2020). First, reducing parking supply directly decreases the amount of heat-absorbing asphalt, which can lower surface and air temperatures in affected areas (Cotrone, 2025; Garber et al., 2024b; Joshi et al., 2026). Second, it opens opportunities to access green infrastructure such as trees, permeable paving, rain gardens, and shade structures that provide natural cooling and improve stormwater infiltration(Joshi et al., 2026; Nolon, 2016) . Third, parking reform supports broader sustainability goals by making walking, cycling, public transit, and shared mobility more practical alternatives to driving, thereby reducing vehicle-related heat and emissions(Garber et al., 2024c; Nolon, 2016) .

Recent research increasingly recognizes parking reform as part of climate adaptation policy, emphasizing that reducing parking oversupply directly lowers urban temperatures by decreasing impervious surface area, minimizing vehicle use, and improving stormwater performance.(Cotrone, 2025; Karimi et al., 2023; Marshall & Garrick, 2006). For example, Minneapolis eliminated parking minimums in 2021 while encouraging cool pavements and tree planting. San Jose and Los Angeles have paired parking reductions with solar canopies and reflective surface programs (Marshall & Garrick, 2006; Tam, 2024). For Oklahoma City, parking reform offers a practical way to reduce heat exposure, enhance the appeal of mixed-use districts, and align development practices with broader climate resilience objectives. This approach transforms parking policy from transportation into a tool for creating healthier, more livable sustainable urban environments.

3. Conclusion

While scholars have laid solid foundations in parking reform, mixed-use development, and sustainable community growth, they have primarily evolved separately, with limited integration. Much of our current understanding is derived from cities with transit-rich, higher-density environments, such as San Francisco, New York, and Los Angeles, as well as international examples such as Amsterdam, Shanghai, and Tokyo, where alternatives to driving are common, land for parking is limited, and redevelopment pressures are intense (Chester et al., 2015; *Chen,& Xiao, 2017*; Manville & Shoup, 2005; Technology, 2025; Zheng et al., 2014). As a result, most academic research reflects environments that are fundamentally different from the majority of American urban landscapes.

Most American cities differ from case studies. They resemble Oklahoma City, sprawling, car-centric, low-density developments shaped by decades of parking-first zoning and suburban norms. Parking in the United States emerged in the 1920s–1930s, when automobiles became symbols of wealth and streets were filled with unregulated parked cars. The first parking meter was installed in 1935 in Oklahoma City and eventually, cities developed off-street parking and structured garages to handle demand (Belmore, 2019). However, as zoning codes evolved, minimum parking requirements became standard, forcing developers to build a set number of spaces based on building size or use (Litman, 2021.; D. C. Shoup, 1999b). Such minimums created excessive parking supply, which spread buildings farther apart, reduced walkability, and contributed to traffic congestion, since around 25–30% of downtown traffic comes from drivers circling for parking (Belmore, 2019). In many cities around the US, parking minimums influence not only land use but also culture, identity, daily mobility, and perceptions of value in space.(Marshall & Garrick, 2006; D. Shoup, 2018). Nevertheless, research has largely neglected the effects of parking reforms on these environments, particularly regarding mixed-use redevelopment and sustainability. The gap matters because it indicates that cities with the most significant parking demand and land use are the least understood when it comes to how reforms might influence the future.

The literature review includes limited findings demonstrating how parking reforms can increase land capacity, improve development feasibility, and facilitate mixed-use, sustainable redevelopment in auto-dependent mid-sized U.S. cities. Additionally, there is limited evidence on how parking reform can reduce environmental and health vulnerabilities at the neighborhood level, although heat and environmental exposure are most severe in areas with high asphalt prevalence.

Although parking reform, mixed-use development, and urban heat island mitigation have each been widely studied, limited research has examined how parking policy directly contributes to urban heat exposure or how parking reform can function as a heat-mitigation strategy within mixed-use redevelopment. Most UHI studies focus on land cover and vegetation at broad geographic scales, while parking reform research prioritizes affordability and transportation outcomes, leaving their thermal and climate-resilience connections underexplored particularly in auto-dependent cities like Oklahoma City.

This study fills that gap by spatially linking parking supply, surface temperatures, and mixed-use redevelopment, offering an integrated framework for climate-responsive parking reform. Moreover, the research fills the gap by measuring surface parking in Oklahoma City, examining its connection to environmental vulnerability, and assessing the redevelopment and sustainability potential enabled by targeted parking policy changes. By combining land-use measurement, environmental impact assessment, and policy analysis within a unified framework. Furthermore, the research progresses the concept of planning scholarships from mere theoretical support for reforms to supplying tangible, spatially grounded evidence. The developed analytical framework can be followed in other mid-sized, auto-oriented cities, broadening the scope of parking reform research beyond coastal, transit-dense environments and offering new insights into how land allocation influences sustainable community development.

CHAPTER 3: METHODOLOY

3.1 Study Area

Oklahoma City (OKC), the capital and largest city in Oklahoma, has a population of approximately 700,000 residents according to 2020 census data (*U.S. Census Bureau QuickFacts*, 2020).It is among the largest cities by land area in the United States. The city exhibits a low-density, auto-oriented urban form, where parking supply has significantly influenced land use and development patterns. In Oklahoma City, this combination of environmental, social, and economic inefficiencies poses a threat to the community's long-term sustainability. In Oklahoma, the central city has 25% of its parking spaces off-street (*Parking Lot Map*, 2024.). While an exact figure for all of Oklahoma City is not publicly available, a 2020 study found that 186 acres of off-street parking in downtown OKC were unused during peak hours (Francis-Smith, 2020).

Another study on downtown parking in Oklahoma City concluded that off-street parking was "heavily underutilized and overbuilt (*OKC_Downtown_Parking_Study.2020,p. 3*.).” Moreover, the study found that out of 37,000 off-street parking spaces downtown, about 23,000 sat empty between noon and 3 p.m., which is the equivalent of roughly 186 acres of unused parking about the size of 141 football fields, even during peak hours. (Francis-Smith, 2020). Downtown Oklahoma City has far more parking than it needs, especially in garages and surface lots. About a quarter of downtown space is devoted to parking. A consultant’s study examined 30,000 private parking spaces and found that only about 36 percent were used during peak hours.(Hutchinson, 2020). This research focuses on the Oklahoma City area with their own opportunities and challenges.

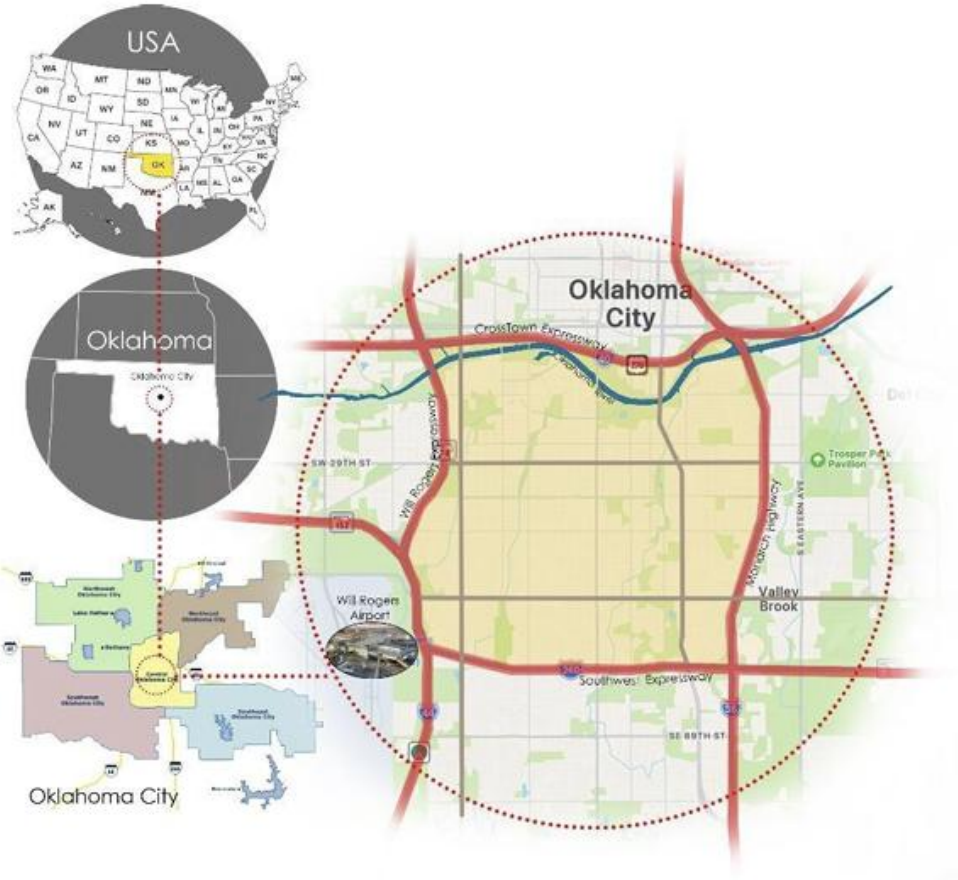


Figure 1: Oklahoma City

3.2 Research Design

Parking spaces themselves are ubiquitous (we notice them most when they are absent), in part because cities require parking almost everywhere (Litman, 2021.; Manville & Shoup, 2005). This study emphasizes that parking in Oklahoma City is more than just a transportation detail; it is a significant land-use decision that subtly shapes the city's development potential. The research design integrates several focus areas using a coordinated mixed-methods approach. The study systematically examines land use by mapping and quantifying parking areas, evaluates environmental and social impacts through analysis of heat exposure and demographic overlays, and interprets the policy mechanisms underlying these patterns through zoning and parking code analysis. The findings are contextualized through comparative case studies of cities that have implemented successful parking reforms. Collectively, these steps establish an applied framework that connects observed spatial patterns to measurable impacts and policy-driven solutions, with relevance for mid-sized American cities such as Oklahoma City.

3.1.1 Urban Land in Parking Lots

The first component involves mapping and quantifying surface and underutilized parking across Oklahoma City using geographic information systems (GIS), aerial imagery, and parcel-level data. Following quantification, the analysis evaluates the spatial distribution of parking relative to land-use zoning, mixed-use districts, transit corridors, and activity centers to identify patterns of concentration and underutilization. This process addresses the research question regarding the extent of land dedicated to parking, its specific locations, and the relationship between parking distribution and areas suitable for mixed-use development and redevelopment. This study identifies parking lots, measures their size, and evaluates their overlap with mixed-use corridors, zoning districts, and transit access points. This analysis establishes a physical baseline of the current extent and distribution of parking land. GIS serves as a central tool in this spatial analysis, facilitating the assessment of the quantity, location, and proximity of parking areas to relevant urban features (Davis et al., 2010; Fan, 2024).

Across multiple comparative urban studies, there is a *strong negative correlation* between population density and Vehicle Miles Traveled (VMT) per square mile (R. Ewing et al., 2018; Liu & Shen, 2011) This means that as population density increases, VMT tends to decrease, and the relationship is statistically significant in most national datasets (Brownstone, 2012.; Ewing et al., 2018). Comparative studies found that dense cities consistently exhibit much lower VMT; low-density, sprawling cities in the U.S. produce higher levels of driving per person and per square mile (Kim & Brownstone, 2010).

One spatial mechanism through which low density outcomes are perpetuated is the prevalence of surface parking (Garber, Benmarhnia, et al., 2025b; Manville & Shoup, 2005a). Much research shows that surface parking lots occupy large amounts of land which otherwise could support higher intensity residential and commercial land uses, effectively suppressing development density in areas intended for mixed-use growth (Davis et al., 2010; Garber, Benmarhnia, et al., 2025b). This study examines the relationship in Oklahoma City by measuring urban density through a combination of population, residential and commercial land use indicators and spatially overlays with surface parking locations across areas designated for mixed-use development. This analysis evaluates whether the extensive allocation of land to surface parking corresponds with lower density outcomes in zones where denser, more transit-supportive development is anticipated.

Surface lot data was obtained from OpenStreetMap, a community maintained geospatial database widely used in urban planning and transportation research. The OSM dataset was downloaded with a polygon shapefile in which each feature represents an individual surface parking lot. But OSM data are community-generated and subject to completeness variation across neighborhoods, the dataset was systematically supplemented through manual digitization. I compiled a comprehensive surface parking inventory for Oklahoma City through manual digitization of 2680 individual parking lots drawing Using NAIP aerial imagery loaded as a reference basemap in ArcGIS Pro, the investigator visually inspected the study area and digitized surface parking lots that were absent from the OSM dataset across Oklahoma City.

This study utilizes two complementary spatial frameworks to delineate areas designated or suitable for mixed-use development: the current zoning layer and the PlanOKC Future Land Use Typology. These datasets provide distinct, yet related, mixed-use land-use designations and are analyzed separately.

The zoning layer constitutes the legally binding land-use designation for Oklahoma City, specifying the types of development currently permitted. As the primary framework for this analysis, zoning directly governs current land-use decisions and development outcomes. The mixed-use zone polygons extracted from the zoning layer delineate the core study area for measuring surface parking presence and density outcomes.

In contrast, the PlanOKC Future Land Use Typology articulates the cities officially adopted vision for long-term land use change and identify areas formally prioritized for future mixed-use and higher-density development. Examining surface parking across both frameworks enables evaluation of the parking issue within the current regulatory context and in relation to the city's long-term planning objectives. When both frameworks indicate high parking presence in currently zoned and future-designated mixed-use areas, the evidence supporting parking as a barrier to mixed-use development is reinforced.

For Oklahoma City, the city's open data portal was used which contains all official zoning districts and boundaries within the city. The dataset's attributes identified zoning features and land distribution, including residential, commercial, industrial, and public spaces. However, the unique zone classification values confirmed the absence of explicit mixed-use zone codes such as MU-I or MU-C in Oklahoma City's zoning classification. Mixed-use relevant zones were therefore identified through a structured query of the Zoning Classification targeting the following classifications: C-CBD (Central Business District), DBD (Downtown Business District), DTD-1 (Downtown Transitional General), DTD-2 (Downtown Transitional Limited), BC (Bricktown Core Development), C-1 (Neighborhood Business), C-2 (Community Commercial), C-3 (General Commercial), NB (Neighborhood Business), and NC (Neighborhood Commercial).

The PlanOKC Future Land Use Topology shapefile was obtained from the Oklahoma City Planning Department. This polygon data set represents the city's officially adopted comprehensive plan land use designations and identifies areas designated or suitable for future mixed-use development under the planOKC framework. The dataset contains Land Use the following typology: urban mixed-use infill (UMI), downtown, urban commercial, transit-oriented development UMI (TOD UMI), urban high intensity (UHI), and transit-oriented development ULI (TOD ULI), yielding six distinct future mixed-use planning area features.

3.2.1 Environmental Impact Assessment

Paved surfaces are ubiquitous in the urban environment, and a large proportion of them has several environmental implications, including the urban heat island (UHI) effect (Moretti et al., 2022; Onishi et al., 2010a). Paved surfaces absorb more heat and retain it longer than vegetated surfaces, leading to higher air temperatures on their surfaces (Fan, 2024; Onishi et al., 2010a; Sen et al., 2020). The UHI effect also leads to other negative environmental impacts, such as reduced thermal comfort, increased water use, and higher energy consumption. (Onishi et al., 2010a; Sen et al., 2020). Downtown Oklahoma City has far more parking than it needs, especially in garages and surface lots. About a quarter of downtown space is devoted to parking. A consultant's study examined 30,000 private parking spaces and found that only about 36 percent were used during peak hours.(Hutchinson, 2020). Environmental overlays help connect parking to public health and climate vulnerability (Irfeey et al., 2023; Moretti et al., 2022). This study uses remote sensing and GIS-bas raster analysis to examine spatial relationship between land surface temperature (LST) and surface parking areas within the Oklahoma City Boundary. By analyzing satellite imagery and applying spatial overlay techniques, comparing parking areas with heat exposure to identify locations with the highest surface temperatures and communities most at risks. By showing where surface parking is associated with higher land surface temperatures and reduced vegetation cover provides evidence that surface parking contributes to the urban heat island effect (*Landsat Collection 2 | U.S. Geological Survey*, 2023; Miracle & Perkl, 2025; Onishi et al., 2010b).

I obtained Remote sensing data from the United States Geological Survey (USGS) Earth Explorer portal Landsat 8 Collection 2 Level 2 satellite imagery was selected for this analysis due to its inclusion of both optical surface reflectance bands and thermal infrared surface temperature bands, processed to standardized physical units suitable for direct scientific analysis. Scene selection was conducted using the Earth Explorer search interface with a point of interest defined at latitude 35.4676°N, longitude 97.5164°W, a date range of June 1, 2023, to August 31, 2023, and a maximum cloud cover threshold of 10 percent to ensure data quality representing peak summer thermal conditions in Oklahoma City. This method specifically selects from June through August to capture peak urban heat conditions, when surface temperatures are highest, and the urban heat island effect is most pronounced. The decision to focus on a single summer period was methodologically justified: summer months represent the season of maximum thermal stress in Oklahoma City's continental climate, when surface parking lots absorb and re-emit solar radiation at significantly higher rates than vegetated or built surfaces, produce their greatest thermal impact on surrounding communities

Four specific band files were downloaded from the Level 2 product bundle as GeoTIFF raster files, and surface reflectance) bands were obtained for vegetation analysis using the Normalized Difference Vegetation Index (NDVI). The surface temperature band and Thermal Radiance) band were obtained for urban heat island analysis using Land Surface Temperature (LST) derivation.

3.2.3 Policy Review

Although surface parking is experienced as a physical element of the built environment, it is fundamentally a regulatory product, a direct outcome of zoning codes, development standards, and transportation policies (Litman, 2021.; Marshall & Garrick, 2006; *Stutevelle,2022*). To understand why Oklahoma City has such extensive parking areas, the research conducts a systematic review of the city's zoning ordinance, off-street parking requirements, mixed-use development regulations, and transportation planning frameworks. The document analysis is an established qualitative method for examining how laws, standards, and policies shape land-use outcomes (Bowen, 2009; Hess & Rehler, 2021c)

Oklahoma City's current zoning code includes mandatory parking minimums for most land uses, often requiring developers to build more parking than market demand justifies (Fieldcamp, 2025b; Steuteville, 2024). These requirements reflect a mid-20th-century planning paradigm that equated abundant parking with economic vitality and consumer convenience (Shoup, 2011; Manville, 2017). However, such codes unintentionally suppress density, increase development costs, and make mixed-use infill less feasible (Litman, 2008.; Marshall & Garrick, 2006; D. Shoup, 2018; Speck, 2013). By examining Oklahoma City's off-street parking ratios, shared-parking provisions, exemption zones, and district-specific standards, this study shows how parking regulations influence land allocation and continues to support auto-oriented development patterns. Additionally, the policy review evaluates mixed-use zoning designations, transit-oriented development (TOD) provisions, and the city's mobility policies within PlanOKC. This study focused on whether local regulations support or constrain, walkable, mixed-use development, an essential lens, as zoning determines which urban forms are legally possible (American Planning Association, 2019).

The policy and regulatory documents from Oklahoma City were obtained and reviewed for the Oklahoma City policy analysis. First, the Oklahoma City Municipal Code Article X was reviewed for the mandatory minimum parking ratios applicable to commercial, mixed-use, and residential land uses within the city. The planOKC Comprehensive Plan was reviewed to evaluate the city's stated policies regarding mixed-use development, transit-oriented development (TOD), mobility, and future land use. This document provides the normative planning framework against which current parking provision in OKC is impacting the development of areas designated for mixed-use development.

3.2.4 Best Practices Synthesis

This study synthesizes comparative best practices to envision more sustainable, community-oriented land currently used for parking. The analysis compares examples from other U.S. and international cities that have successfully reformed parking codes, eliminated minimum parking requirements, or redeveloped parking lots into housing, public spaces, or mixed-use districts. The cross-city comparison is a widely used planning research method for identifying transferable strategies and reform pathways for policy awareness (Yang et al., 2025; Yin,2018).

Cities such as Minneapolis, Buffalo, and Portland have eliminated parking minimums citywide, demonstrating that parking reform can increase housing production, lower development costs, and support walkability (Hess & Rehler, 2021; Manville, 2017; *Susan*, 2025). Austin and Denver offer examples of integrating green infrastructure, such as shade trees, stormwater facilities, and permeable paving, into parking redevelopment to mitigate urban heat (*Carlson, 2025*; *Susan*, 2025). International cases, such as Tokyo, Melbourne, and Barcelona, illustrate alternative parking management systems that reduce land consumption and prioritize transit, cycling, and public realm improvements (R. Ewing et al., 2018).

Comparative planning documentation was assembled for cities that have implemented parking code reform, eliminated parking minimums, or successfully redeveloped surface parking into mixed-use or climate-resilient development. For local cases reviewed include Minneapolis, Minnesota and Buffalo, New York, which eliminated citywide parking minimums, and Portland, Oregon, which has implemented progressive parking reform strategies linked to transit investment.

For Portland, data were collected from the City of Portland Zoning Code (Title 16), particularly Chapter 16.20 (Off-Street Parking and Loading), as well as adopted ordinances related to parking reform. These documents provide detailed regulatory frameworks governing parking requirements, pricing, and transportation demand management (TDM) strategies.

For Buffalo, the primary source includes the Unified Development Ordinance (Green Code, 2016), which eliminated minimum off-street parking requirements citywide and introduced TDM-based planning approaches. This document serves as the foundational policy reference for understanding Buffalo's regulatory shift toward multimodal transportation and reduced automobile dependency.

In addition, supporting evidence was drawn from the Minneapolis parking reform memorandum (2021), which outlines the elimination of minimum parking requirements, expansion of parking maximums, and integration of TDM strategies. As illustrated in the memorandum, Minneapolis explicitly links parking reform to broader goals such as reducing greenhouse gas emissions, improving housing affordability, and promoting multimodal transportation.

3.3 Limitations

Although the research focuses on a comprehensive, multi-methodological approach, it acknowledges certain limitations typical of spatial and policy planning research. Primarily, the environmental analysis relies on Land Surface Temperature (LST) data, which measures ground surface temperature rather than the ambient air temperature (Balas et al., 2023; Shetty & Kumar, 2015). Although LST is useful for identifying heat-absorbing materials like asphalt, it may over- or underestimate the actual heat people experience (Garber, Teyton, et al., 2025; Gu et al., 2025). The limitation is standard in urban heat island studies; however, LST remains a robust and widely accepted proxy for pinpointing heat-prone areas. Heat-prone areas (Elmarakby & Elkadi, 2024; Udel, 2024).

The interpretation of zoning codes is highly dependent on local context, as regulations vary significantly across American cities and municipalities (Cheshire, 2023.; Salazar Miranda & Talen, 2025). Regulatory language varies in how it is applied, enforced, and implemented on the ground, providing helpful insights into institutional frameworks (Bowen, 2009; Yang et al., 2025). However, it might not reveal all the subtle aspects of administrative practices (Bowen, 2009; Cheshire, 2023). As a result, the analysis primarily reflects the written policy intentions but does not fully account for informal or political factors that influence actual development results.

Finally, the research does not include a financial feasibility analysis of parking reform and mixed-use development. While the spatial and environmental findings can identify where redevelopment *could* occur, economic feasibility ultimately determines whether redevelopment will occur in practice (*Mangalji,* 2017; Rabianski et al., 2009). Without analyzing land values, construction costs, infrastructure capacity, or developer incentives, the study cannot predict which opportunity sites are financially feasible for attracting investment to convert surface parking into mixed-use development in the real world.

Despite these limitations, integrating GIS analysis, environmental assessment, policy review, and best-practice synthesis provide a solid framework for exploring the research questions and understanding the broader effects of parking reform.

CHAPTER 4: ANALYSIS & FINDING

4.1 Quantifying Surface Parking on Mixed-Use Designated Areas in Oklahoma City

Urban planning research has long grappled with a deceptively simple question: how much land does parking consume? The challenge is not conceptual but empirical. Parking lots are not designated in administration datasets such as parcels, buildings, or zoning districts. As shown in Table 1 the analysis proceeded through sequential stages and provides a description of where parking is allocated in Oklahoma City, but a spatial argument about how its distribution relates to

Research question	Data sources	Analysis methods
RQ1 Surface parking & mixed-use development *How does parking impact areas zoned for mixed-use?*	OpenStreetMap parking lots	Surface parking inventory (GIS)
	Manual digitization (2,680 lots)	Select by attributes (SQL query)
	OKC Zoning Shapefile —City Open Data Portal	Pairwise intersect + clip
	PlanOKC Future Land Use —OKC Planning Dept.	Kernel density analysis
	OKC City Boundary	Calculate geometry (acres)
		Spatial overlay analysis
RQ2 Environmentalimpacts of surface parking *What are the Urban heat island & vegetation loss impacts?*	Landsat 8 OLI/TIRS C2 L2 —USGS Earth Explorer	Clip raster to OKC boundary
	August 2, 2023| Path 028 / Row 035	LST: B10 ×0.00341802 + 149 − 273.15
	Band 10 —Thermal infrared (LST)	NDVI = (B5 − B4) / (B5 + B4)
	Bands 4 + 5 —Optical (NDVI)	Raster Calculator (Spatial Analyst)
	OKC surface parking layer (from RQ1)	Jenks classification (5 classes)
	OKC city boundary	Spatial overlay with parking layer
RQ3 Bestpractices & policy reform *What strategies can OKC adopt to repurpose parking for climate-resilient mixed-use?*	OKC Municipal Code (parking minimums)	Policy document review (Bowen, 2009)
	PlanOKC —TOD + mobility policies	Zoning ordinance analysis
	Minneapolis, Buffalo, Portland (parking reform)	Off-street parking ratio review
		MU + TOD regulation analysis
		Cross-city comparative analysis
		Best practices synthesis
		Transferable reform identification

Table 1: Data Analysis Framework

the city's planning framework for mixed-use development.

4.1.1 Surface Parking Inventory and Verification

The surface parking inventory was established through a two-phase process to balance the efficiency of existing geospatial data with the accuracy demands of a study in which the completeness of the parking layer directly affects the reliability of all subsequent spatial analysis. Initially, the OSM parking polygon shapefile was imported into ArcGIS and reviewed against NAIP aerial imagery loaded as a reference basemap to assess its completeness across the study area. In the second phase, a systematic visual inspection of the imagery identified several surface parking lots, particularly larger institutional and commercial lots, that were absent from the OSM dataset. These features were manually digitized using the ArcGIS Editor toolbar, adding 183 parking features and providing a final dataset of 2680 surface parking polygons. The Calculate Geometry Attributes tool was applied to compute the area of each parking polygon in US Survey Acres using the Oklahoma State Plane projected coordinate system, producing lot-level area measurements that serve as the basis for all subsequent area quantification. Manual digitization accuracy is subject to interpreter variability where different analysts may draw polygon boundaries differently whether a feature qualifies as a surface parking lot. To particularly address this limitation digitization was conducted by a single analyst throughout the study to ensure internal consistency and all manually added features qualifies were reviewed against NIAP aerial imagery at a minimum zoom scale 1:2000 to ensure the boundary accuracy.

Nevertheless, the manual inventory likely undercounts the total surface parking supply in Oklahoma City. Several categories of parking lots are likely underrepresented in the dataset, including parking areas situated within gated institutional, commercial properties, unpaved parking surfaces and new constructed parking areas that do not present the spectral characteristics of conventional impervious surface lots under visual inspection. The final dataset of 2,680 surface parking polygons should therefore be interpreted as a minimum estimate of surface parking supply rather than a complete census

4.1.2 Mixed-Use Zone Extraction and Classification

Mixed-use designated areas were extracted from both spatial datasets using SQL queries in ArcGIS. The choice to use both the straight zoning and the PlanOKC future land use reflects a substantive distinction between two different conceptions of mixed-use designation. Zoning represents the city's current legal framework, in which mixed-use development is formally permitted under the municipal code. The PlanOKC future land use represents the city's planning aspirations, the areas where the comprehensive plan envisions mixed-use growth occurring over the coming decades, regardless of whether current zoning has fully aligned with that vision. From the Zoning classification, the ten zone classification codes associated with commercial and mixed-use activity were through the attribute table and cross reference with the Oklahoma City Municipal codes.

4.1.3 Spatial Intersection and Clip Analysis

In this research, two analyses were conducted to identify and quantify parking features within each category of mixed-use designated area. First, the Pairwise Intersection tool was applied to identify spatial overlaps between the surface inventory and each of two mixed-use datasets, producing intermediate outputs that preserved the combined attribute information of the parking and zoning layers. Second, the Clip tool was applied to extract the precise geometry of parking sitting on each mixed-use boundary, producing the final analysis for both current zoning and future land use plans. Then, Area calculations were recomputed on all clipped outputs using Calculate Geometry Attributes to obtain parking acreage figures accurately representing the area of parking surface within each zone type, rather than the area of the zone polygons themselves.

4.1.4. Kernel Density Analysis

A Kernel Density was conducted to examine the spatial concentration of surface parking across Oklahoma City and to identify and cluster patterns in relation to the urban core and mixed-use designated corridors. Kernel Density was calculated using the projected centroids of all 2,680 surface polygons within a 0.5-mile radius. The selection of a 0.5-mile radius is supported by extensive scholarship on pedestrian planning and transit-oriented development research. This distance is widely recognized as the standard for a walkable catchment area in urban planning, representing the maximum distance most pedestrians are willing to walk before opting for vehicular travel. Much empirical research indicates that land uses, density, and amenities located within 0.5 miles of transit nodes and urban activity centers exert the greatest influence on mode choice, walkability, and the viability of mixed-use development patterns. Areas with high parking density within a 0.5-mile radius are characterized by surface parking occupying a disproportionate share of the walkable land, hindering the development of residential, commercial, civic, and transit uses in mixed-use development frameworks. Identifying these areas provides spatially explicit evidence of the extent to which surface parking competes with and potentially displaces the land to achieve mixed-use development objectives in Oklahoma City. The resulting density raster was classified into five concentration categories using Natural Breaks classification: Low Density, Low-Medium Density, Medium Density, High Density, and Very High Density.

4.1.4 Opportunity Area Identification

This analytical stage synthesized the outputs of all preceding stages into a composite spatial query designed to identify the highest-priority redevelopment opportunity sites in Oklahoma City, parcels where surface parking simultaneously occupies land designated for mixed-use development under both the current zoning framework and the long-range PlanOKC planning vision. The Select by Location tool was used to identify surface parking features that fall within both the Zoning and PlanOKC future land use plans, thereby identifying the opportunity area for supporting mixed-use development.

4.1.6 Surface Parking Spatial Overlay

To quantify the presence of surface parking within mixed-use zones, the intersect geoprocessing tool was applied with mixed-use designated area in the Oklahoma City Municipal codes C-CBD (Central Business District), DBD (Downtown Business District), DTD-1 (Downtown Transitional General), DTD-2 (Downtown Transitional Limited), BC (Bricktown Core Development), C-1 (Neighborhood Business), C-2 (Community Commercial), C-3 (General Commercial), NB (Neighborhood Business), and NC (Neighborhood Commercial) and the reprojected surface parking layer. The Intersect tool identifies spatial overlaps between features, in this case, identifying which surface parking polygons fall within or overlap with each mixed-use zone.

4.1.7 Residential Density

Residential land-use intensity was measured by spatially joining residential zoning designations from Oklahoma City's straight zoning. Residential zones were selected using zoning classification: R-1 (Single-Family Residential), R-2 (Medium-Low Density Residential), R-3 (Medium Density Residential), R-4 (General Residential), R-A (Single-Family One-Acre Rural Residential), and PUD (Planned Unit Development). The Spatial Join was conducted with Mixed-use zones as the target and Residential Zones as the join feature class using the Intersect tool. The result represents the number of residential zone polygons intersecting each mixed-use zone and serves as a proxy measure of residential land use intensity adjacent to or within mixed-use areas.

4.1.8 Employment Density

Employment density was measured using an analogous spatial joining methodology applied to commercial and office zoning designations. Commercial zone polygons were selected from the full zoning layer using the following classifications: C-1 (Neighborhood Commercial), C-2 (Shopping Center), C-3 (Community Commercial), C-4 (General Commercial), O-1 (Limited Office), and O-2 (General Office). These zone types represent the primary employment-generating land use categories in Oklahoma City's zoning framework, encompassing retail, office, and industrial uses. The selected Spatial Join was conducted with Mixed-use zones as the target feature class using the Intersect tool. The result represents the number of commercial and employment-generating zone polygons that intersect each mixed-use zone, serving as a proxy for employment density and commercial land-use intensity.

4.1.9 Urban Heat Analysis of Surface Parking

Land Surface Temperature

Land Surface Temperature was derived from Surface Temperature Band 10 (ST_B10) in the USGS Landsat 8-9 Collection level 2 data 2, which was specially designed for monitoring Urban Heat Island. The formula was applied using the ArcGIS Pro Raster Calculator as follows:

LST (°C) = B10 × 0.00341802 + 149.0 − 273.15

This expression applies to the official USGS multiplicative scale factor (0.00341802) and additive offset (149.0) to convert raw sensor digital number values into Kelvin, then subtracts 273.15 to express the result in degrees Celsius. The resulting LST raster was classified into five temperature classifications: Cool (28.79–34.87°C), Warm (34.87–40.67°C), Hot (40.67–44.59°C), Very Hot (44.59–48.10°C), and Extreme Heat (48.10–63.22°C). The actual distributional structure of surface temperature values recorded across Oklahoma City on August 2, 2023, provides a data-driven foundation for interpreting spatial patterns of urban heat.

Normalized Difference Vegetation Index (NDVI) Derivation

The Normalized Difference Vegetation Index (NDVI) was calculated from the Surface Reflectance Band (SR_B4) in the USGS Landsat 4-5 Collection level 2 data 2 applied through the ArcGIS Pro Raster Calculator as follows:

NDVI = Float (B5 − B4) / Float (B5 + B4)

NDVI exploits the well-established spectral behavior of vegetation, which absorbs red light during photosynthesis and strongly reflects near-infrared radiation. Healthy, dense vegetation, therefore, produces high NDVI values, while impervious surfaces such as asphalt and concrete, which reflect both spectral bands more uniformly, produce values near zero. The resulting NDVI raster was classified into five vegetation categories: No Vegetation (−0.284 to 0.090), Sparse Vegetation (0.091 to 0.192), Moderate Vegetation (0.193 to 0.271), Good Vegetation (0.272 to 0.341), and Dense Vegetation (0.342 to 0.719). These categories provide a structured framework for characterizing the spatial distribution of vegetative cover across the study area and for evaluating the degree to which surface parking lots are associated with the absence of substantial vegetation.

4.2 Finding

4.2.1Surface Parking Distribution, Oklahoma City

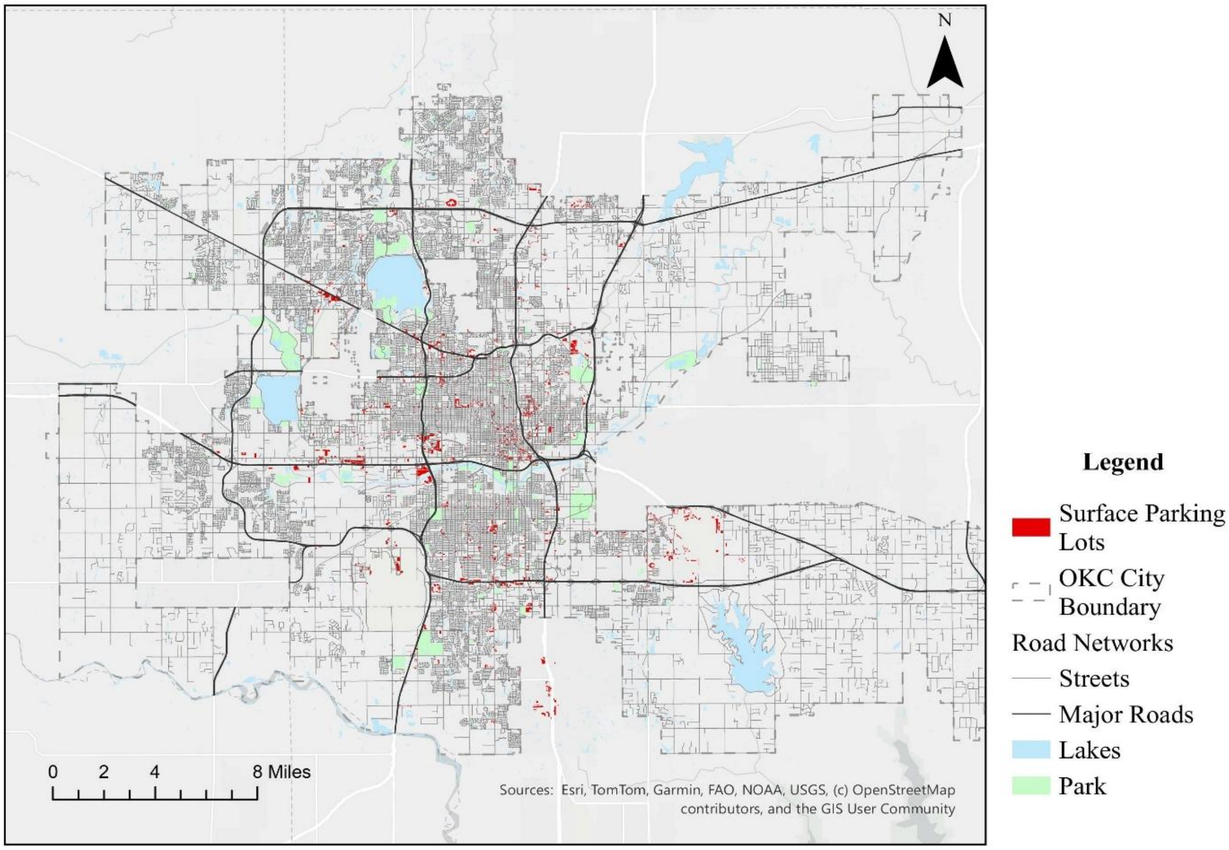


Figure 2: Surface Parking Distribution

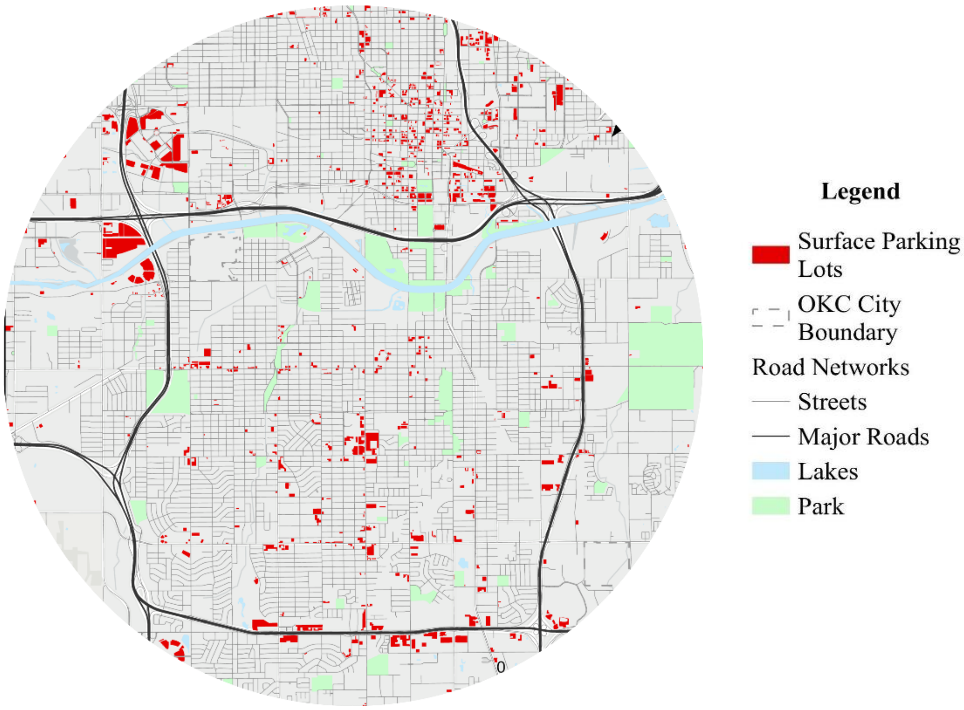


Figure 3: Surface Parking Distribution

Figure 3 reveals the surface parking of all 2,680 identified surface parking lots across Oklahoma City, symbolized in red on a light-gray topographic basemap, a pattern that is both spatially coherent and historically legible. The density of surface parking lots is highest in and immediately around the central business district, thins along the major commercial corridors radiating northward, southward, and eastward from the urban core, and diminishes further as the street grid gives way to the residential fabric of the suburban periphery. This pattern is intense at the center and dispersed at the edges, showing the physical imprint of decades of deliberate policy, from urban renewal demolitions to zoning codes that mandated parking with structures.

In the zoomed inset figure 4, the downtown core emerges as densely clustered, so that individual lots appear to merge into a continuous paved surface. This concentration distributes unevenly across the core but tends to peak along the street grid immediately north of the corridor and along the major east-west arterials following through the center of the city. As shown in figure 4, the density of parking increases markedly within the central boundary of the city, approximately by the interstate highway, with the highest spatial clustering occurring in the downtown business district and commercial corridors radiating northward along North Western Avenue, North Classen Boulevard, and North May Avenue. Toward the suburban periphery of the city, the distribution becomes progressively more dispersed, with smaller individual lots scattered across the residential and commercial grid in a pattern consistent with the parcel-level parking minimum requirements applied to individual commercial development sites.

This distribution pattern is consistent with findings documented in comparable studies of surface parking in American cities. The tendency of surface parking to concentrate on urban cores is precise because mandatory minimum requirements have historically been applied to the commercial and institutional land uses that dominate these areas. In figure 3 and 4, this pattern shows Oklahoma City 2680 lots covering 255.22 acres of urban land distributed across the city in a pattern that is compact in the locations where land values are the highest and where the opportunity cost of surface parking is therefore greatest.

In table 5, Oklahoma City has 2,680 surface parking lots covering 255.22 acres. A total of 752 parking lots representing 28.1% of the city's inventory are located within occupy about 635 acres. A total of 752 parking spaces, representing 28.1% of the city's inventory, are located within designated for mixed-use development and occupy 635 acres. This trend is even more evident in PlanOKC mixed-use designated areas, which reflect the city's long-range vision for dense mixed-use growth. Within these areas, 1,221 parking lots, or 45.6% of the total, occupy 1,001 acres.

Metric	Value
Total surface parking lots identified	2,680
Total surface parking acreage	255.22 acres
Parking lots within Mixed-Use Zoning Districts	752 lots (28.1% of total)
Parking lots within PlanOKC Mixed-Use Designated Areas	1,221 lots (45.6% of total)
Total Parking lots within Mixed-Use Zoning Districts	635 acres
Total Parking lots within PlanOKC Mixed-Use Designated Areas	1,001 acres

Table 2: Summary of Surface Parking Analysis

4.2.2 Impact of Surface Parking Within Mixed-Use Zoning and PlanOKC Future Land Use Designations in Oklahoma City, Oklahoma

Figure 5 and 6 present two dimensions of the mixed-use development within Oklahoma City, the most strategically important development areas.

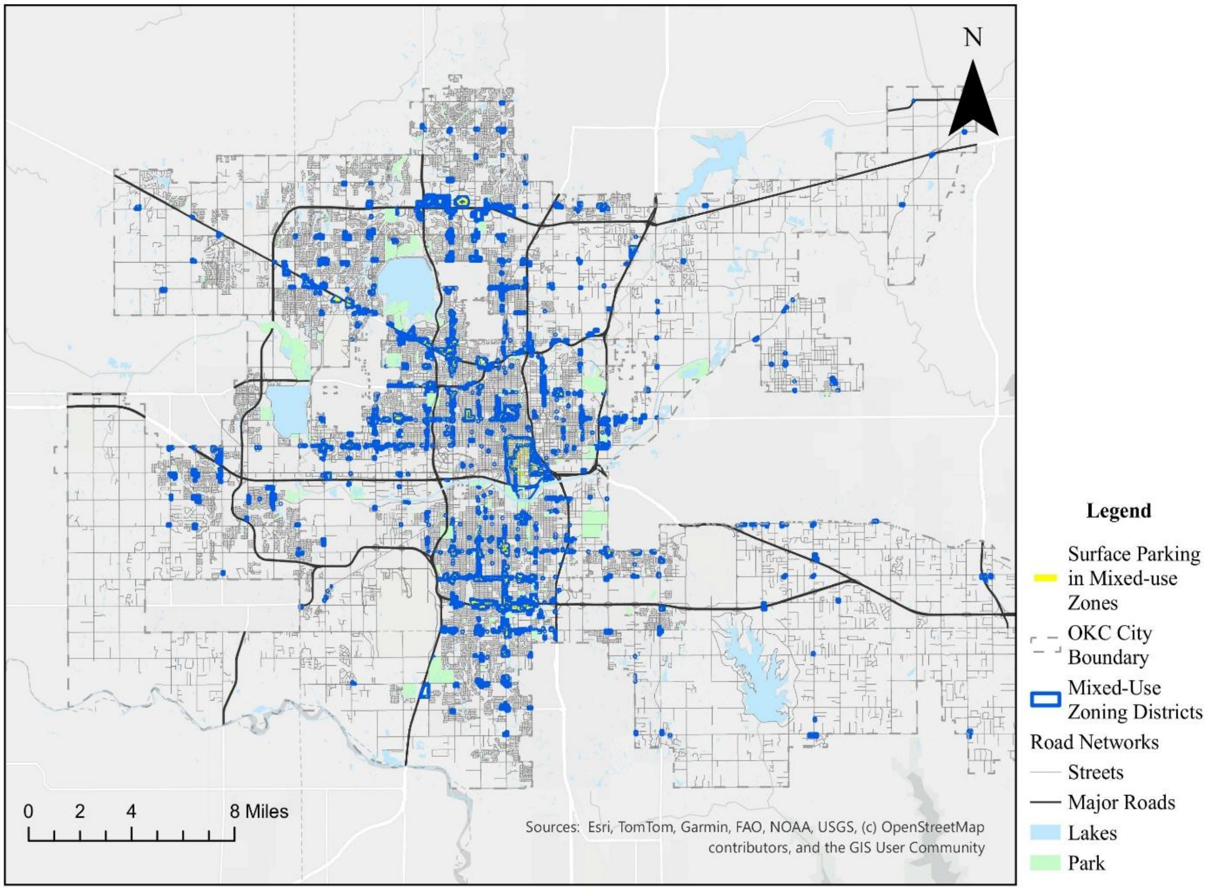


Figure 4: Surface Parking within Mixed-use Districts- Oklahoma City

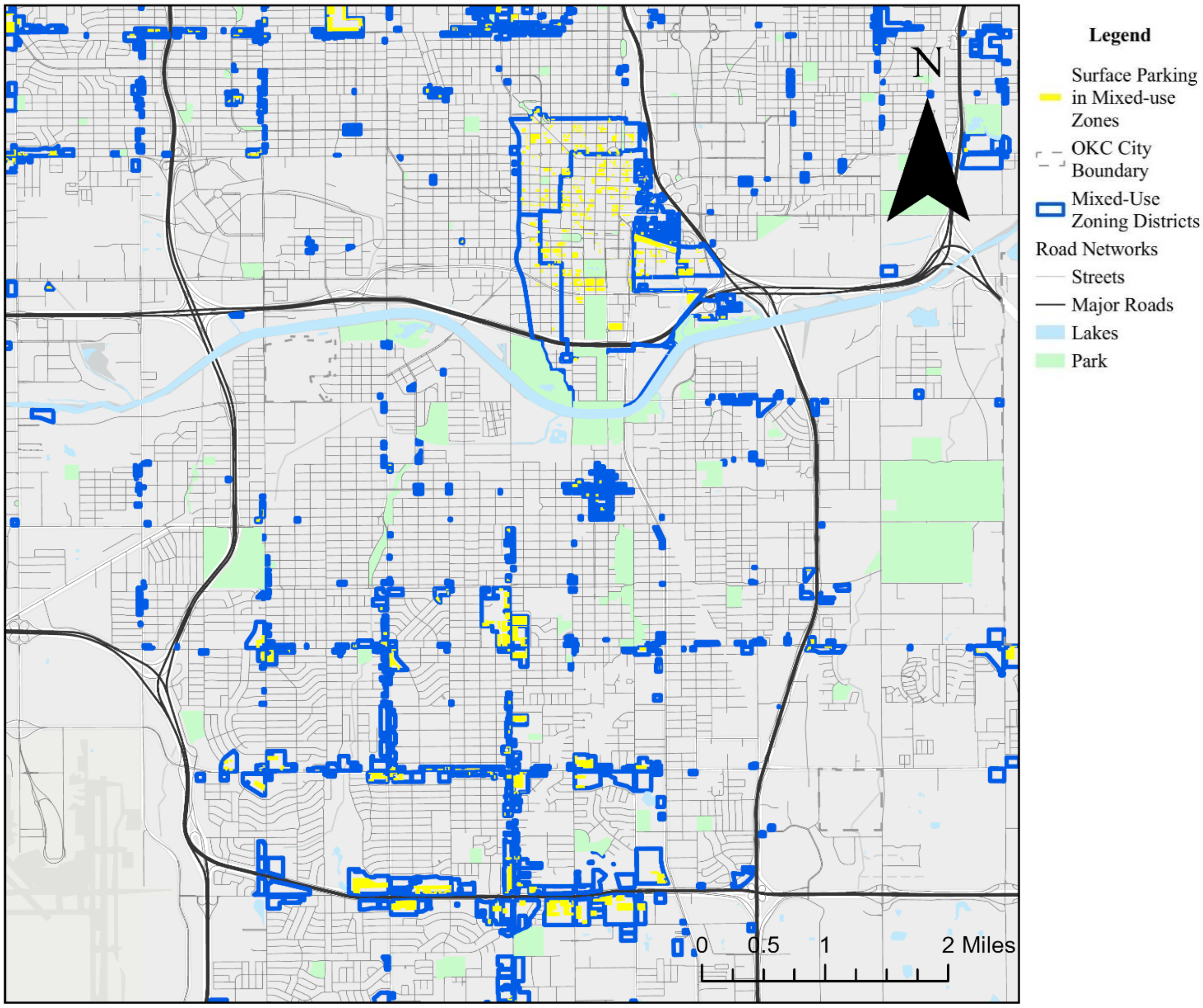


Figure 5: Surface Parking within Mixed-use Districts- Oklahoma City

Figure 6 presents the spatial relationship between surface parking and Oklahoma City's current mixed-use and commercial zoning districts. The surface parking inventory is represented by blue polygons that overlap with the mixed-use zoning boundaries shown in yellow. As shown in Figure 6, the mixed-use zoning is concentrated primarily in the downtown core and along the major commercial arterial corridors. The yellow parking features within these zones, representing the 752 surface parking lots identified through the Pairwise Intersect and Clip analyses, are visually concentrated in the downtown business district, Bricktown core, and along North Western Avenue and South Western Avenue, precisely the corridors that Oklahoma City's zoning framework designates for higher-density, mixed-use commercial activity.

The spatial evidence presented in figure 6 demonstrates that surface parking physically occupies its interiors, creating gaps in urban landscapes that interrupt building continuity, pedestrian connectivity, walkability, and density to support mixed-use development. Second, it illustrates the direct regulatory origin of this pattern: the presence of 752 parking spaces within zoning districts that legally permit and, in many cases, require mixed-use development reflects the operation of mandatory parking minimums that have historically overridden the mixed-use development potential those districts nominally encourage (D. Shoup, 2018; D. C. Shoup, 1999b). The visual concentration of yellow parking features in the downtown core and inner commercial corridors provides direct cartographic evidence of the gap between the development outcomes intended by Oklahoma City's zoning framework and the auto-oriented land use patterns that parking requirements have produced on the ground.

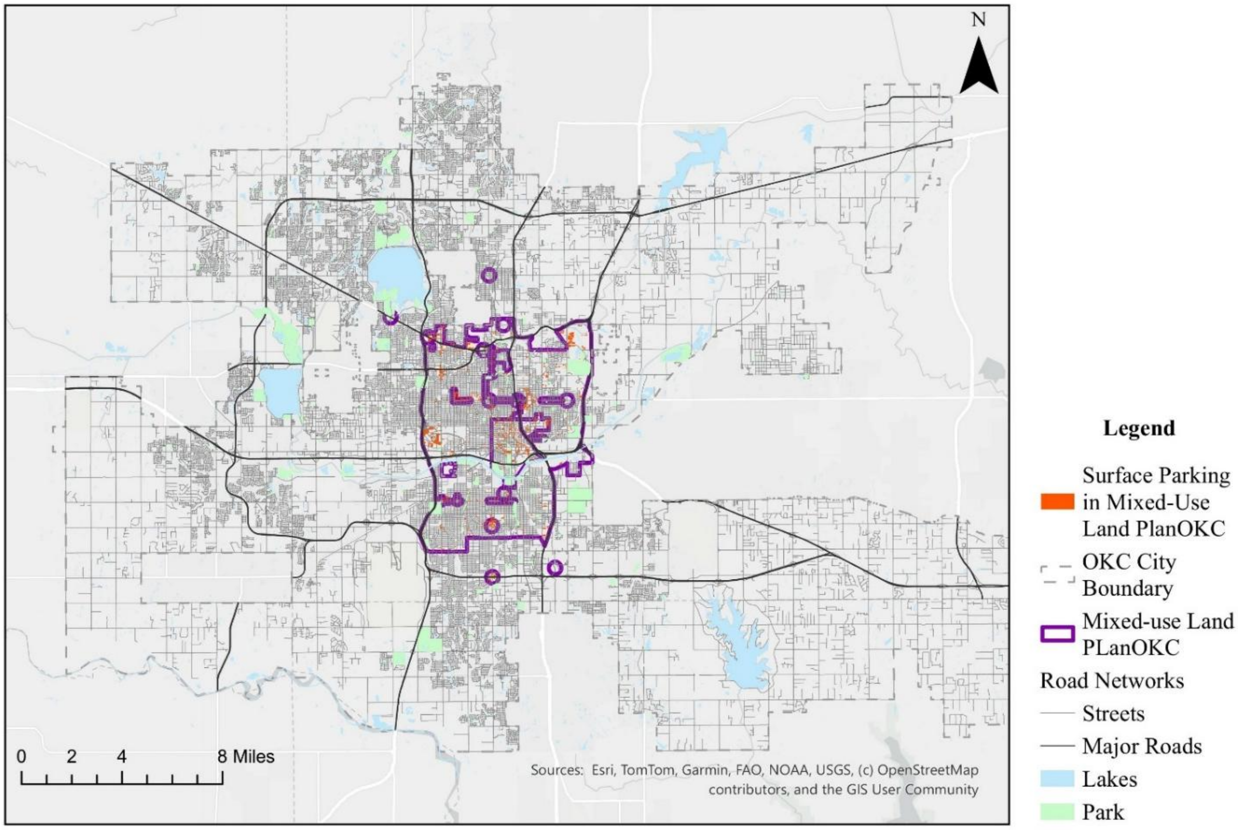


Figure 6: Surface Parking within Plan OKC Mixed Land Use Topology

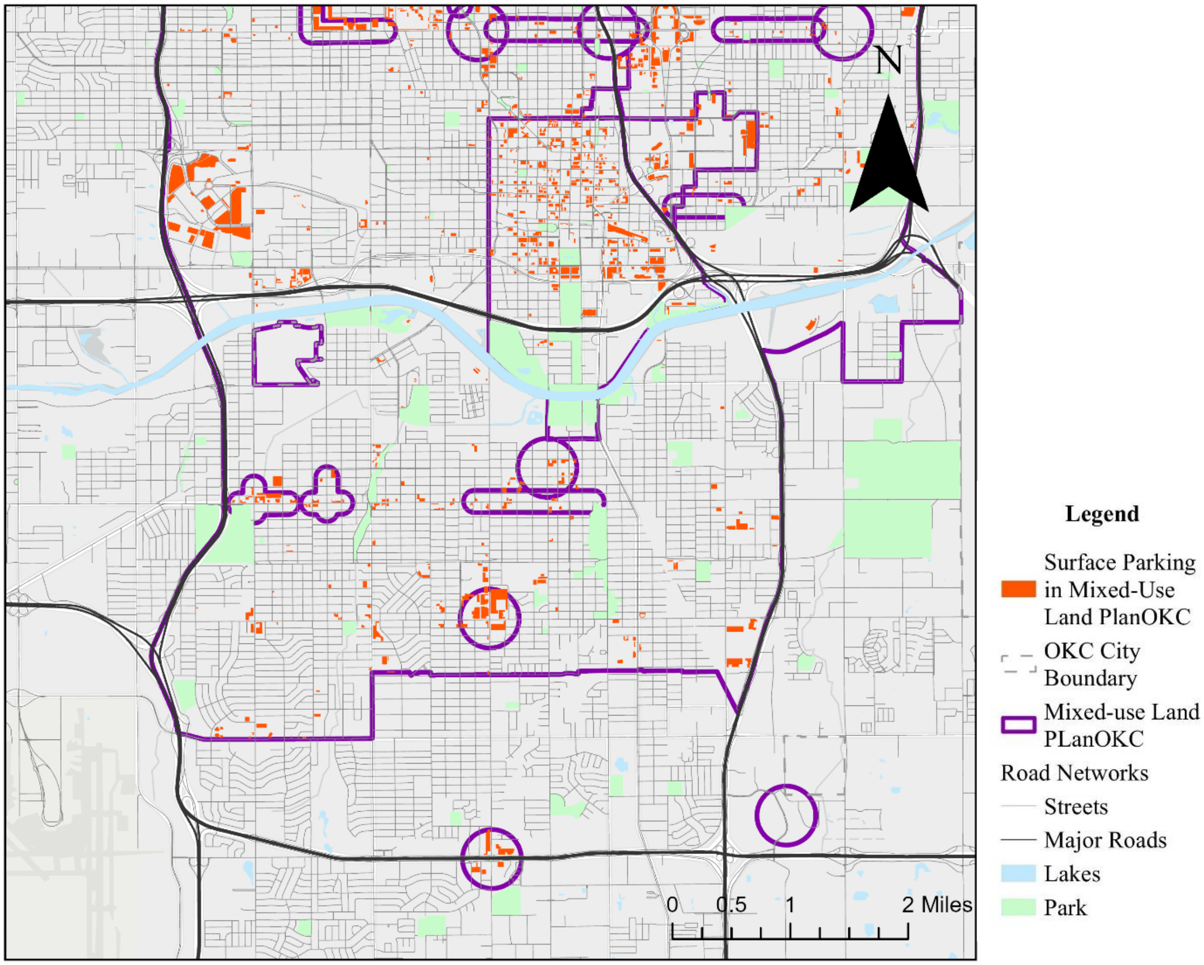


Figure 7: Surface Parking within PlanOKC Mixed Land Use Topology

Figure 7 illustrates the relationship between surface parking and the future mixed-use land use designations established in Oklahoma City's PlanOKC comprehensive plan. The PlanOKC Mixed-Use Land Topology is delineated with a purple polygon boundary, surface parking within these planned growth areas is symbolized in orange, and the surface parking inventory is displayed in the background. The PlanOKC mixed-use growth envelope encompasses a substantially larger geographic area, as shown in figure 8, reflecting the comprehensive plan that together defines the areas where the Oklahoma City planning framework envisions for land enhancement, investment in transit accessibility, and transit-oriented development patterns.

However, the 1,221 surface parking lots within PlanOKC-designated areas shown in orange on Figure 8 are concentrated most heavily on the downtown core and along the North Western Avenue, Classen Boulevard, and South May Avenue corridors, which PlanOKC identifies as priority areas for urban commercial and transit-oriented development.

The density of parking features within the PlanOKC boundary constitutes the central planning paradox documented in this study: the land that Oklahoma City most urgently needs to develop, as defined by its own formally adopted comprehensive plan, is the land most thoroughly occupied by surface parking infrastructure. The 1,221 parking lots within PlanOKC's future growth areas provides direct spatial evidence that achieving the development envisioned in the comprehensive plan will require enabling policy changes, such as minimum parking reform, while the physical removal or replacement of existing parking infrastructure across hundreds of sites in the city's most strategically important development corridors.

4.2.3 Opportunity Area, Oklahoma City

Figure 9 presents the composite opportunity area analysis, the most complex cartographic output consists of spatial datasets: the mixed-use zoning district boundaries in blue, the PlanOKC mixed-use land in purple, and the identified opportunity areas for future mixed-use development in magenta. These opportunity areas were identified through a spatial selection process that isolated features simultaneously located within the current mixed-use zoning depicted in figure 5 and the PlanOKC future mixed-use land depicted in figure 7

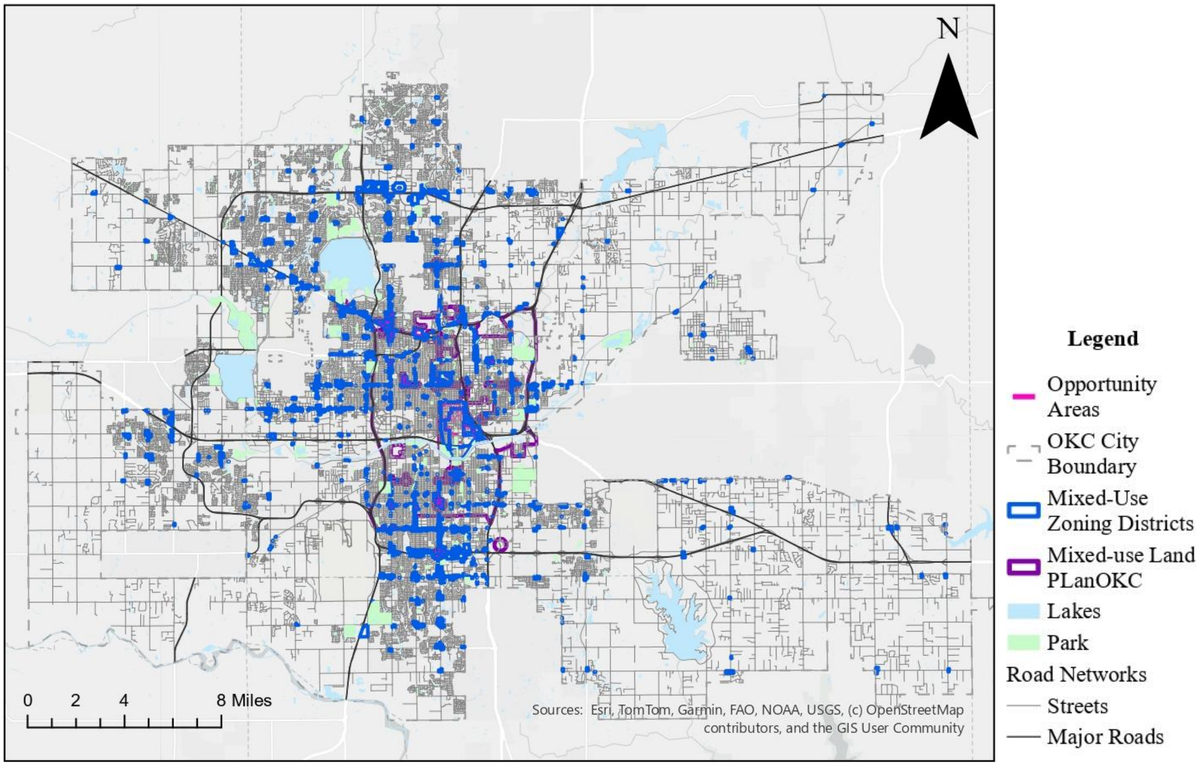


Figure 8: Surface Parking Redevelopment Opportunity Area

As shown in figure 9 and 10, opportunity areas are concentrated in a geographically tight cluster centered on the downtown core, extending northward along primary commercial corridors, with secondary concentrations in the Bricktown and Midtown districts and along South Western Avenue. This spatial concentration is consistent with the findings of figure 5 and 7 in that current zoning-designated and PlanOKC-designated mixed-use areas overlap most heavily in the central urban core, where both designations are simultaneously satisfied and where surface parking is also present, concentrated in the central part of the city, which provides a grounded evidence base for targeted parking policy intervention.

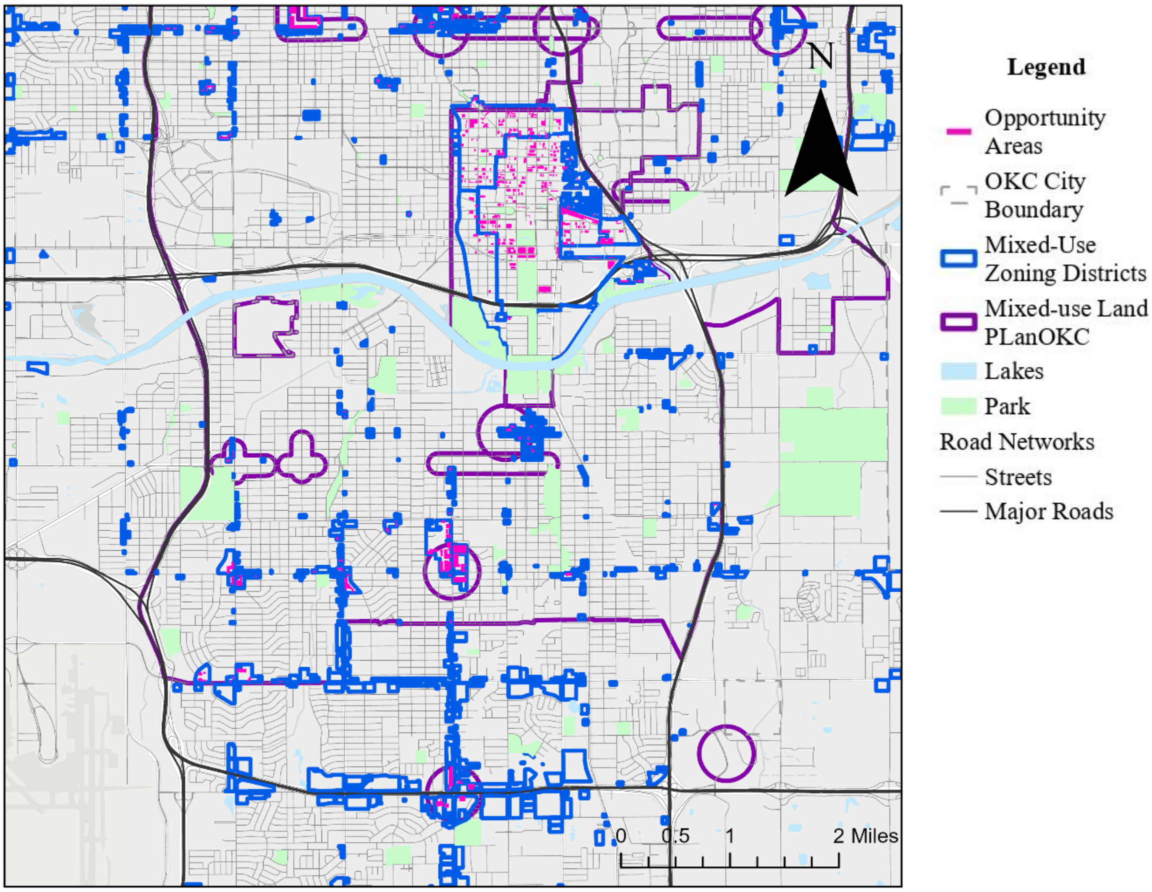


Figure 9: Surface Parking Redevelopment Opportunity Area

4.2.4 Surface Parking Concentration, Oklahoma City

As shown in figure 11, the analysis of surface parking concentrations across Oklahoma City, classified into four density categories: Low-medium Density in yellow, Medium Density in orange, High Density in dark orange, and Very High Density in red, overlaid with mixed-use zoning district boundaries in blue outline.

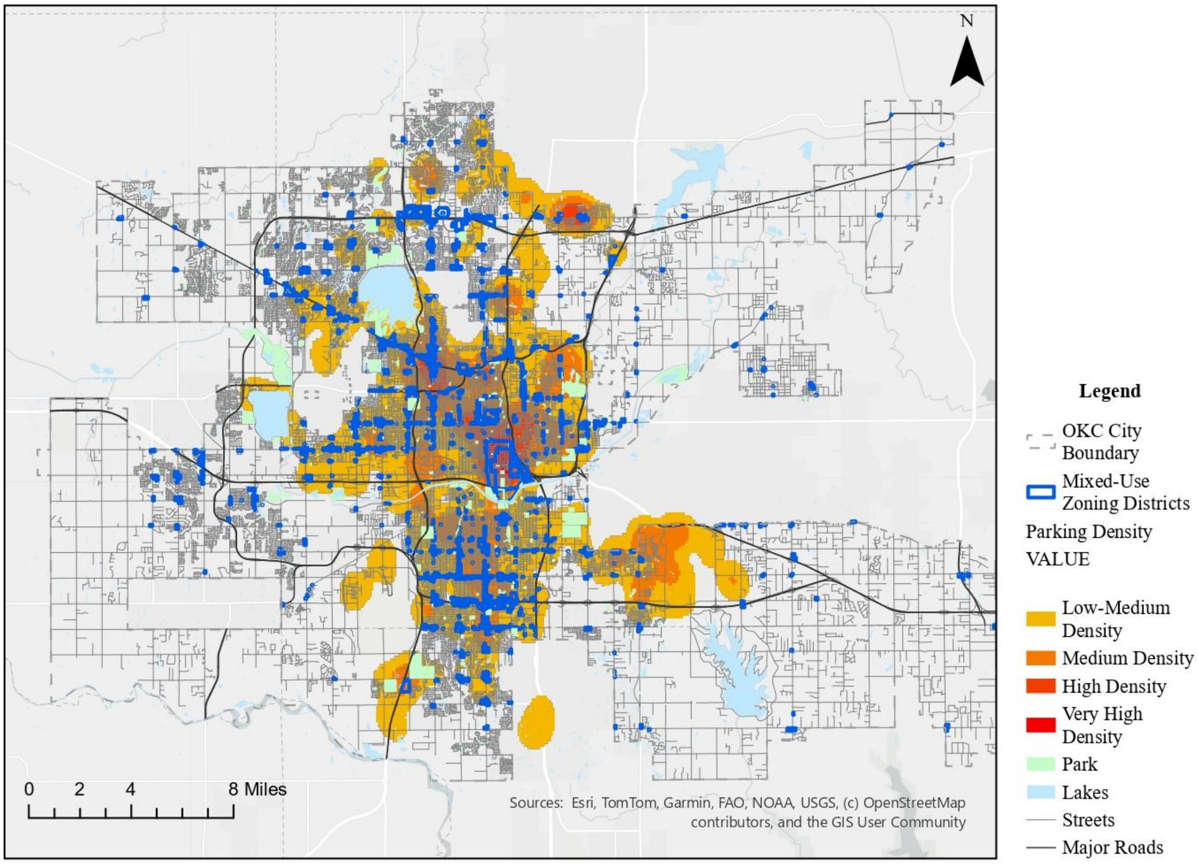


Figure 10: Surface Parking Concentration

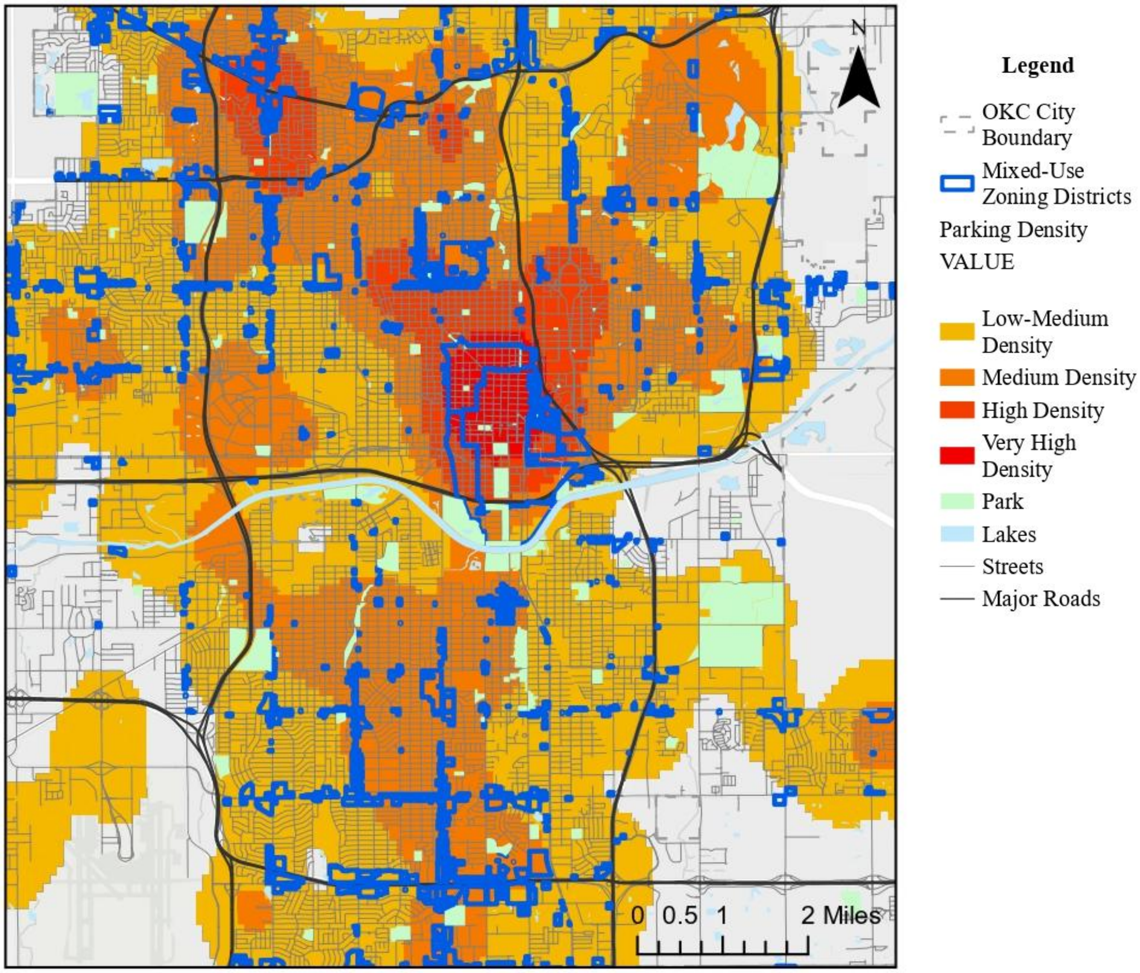


Figure 11: Surface Parking Concentration

The density analysis in figure 12 reveals a hot spot of Very High-Density parking concentration centered on the downtown core, corresponding to the geographic area bounded by Interstate 235, 40, and 35. This hot spot extends outward from the downtown center along the primary arterial corridors, with high-density zones particularly concentrated along the North Western Avenue corridor, around the health center campus in the northwest, and along South Western Avenue to the south. Medium-density zones around the core high-density areas, reflecting the cumulative effect of parking minimum requirements applied across the commercial and institutional land uses of the inner city. Low-Medium Density zones cover the outer portions of the urban grid, corresponding with the more dispersed parking distribution visible in figure 12. This spatial pattern demonstrates that parking is systematically concentrated in Oklahoma City's highest-opportunity development zones, where land values, transit proximity, and planning designations would otherwise create the strongest conditions for mixed-use investment. The alignment between peak parking density and peak mixed-use development potential represents the core spatial finding of this research analysis.

4.2.5 Housing and Employment Intensity

The choropleth figure 13 reveals that surface parking concentration is geographically concentrated in the downtown core, where the City of Oklahoma City explicitly anticipates and promotes higher-intensity mixed-use development. The presence of 87 to 183 surface parking lots within individual zones in this area indicates that a substantial portion of developable land in Oklahoma City's most density-supportive zones is currently occupied by surface parking rather than buildings. The five-class graduated color scheme reveals a clear spatial gradient from low parking in peripheral mixed-zones to high parking in the downtown core, consistent with prior research documenting the concentration of surface parking in urban cores.

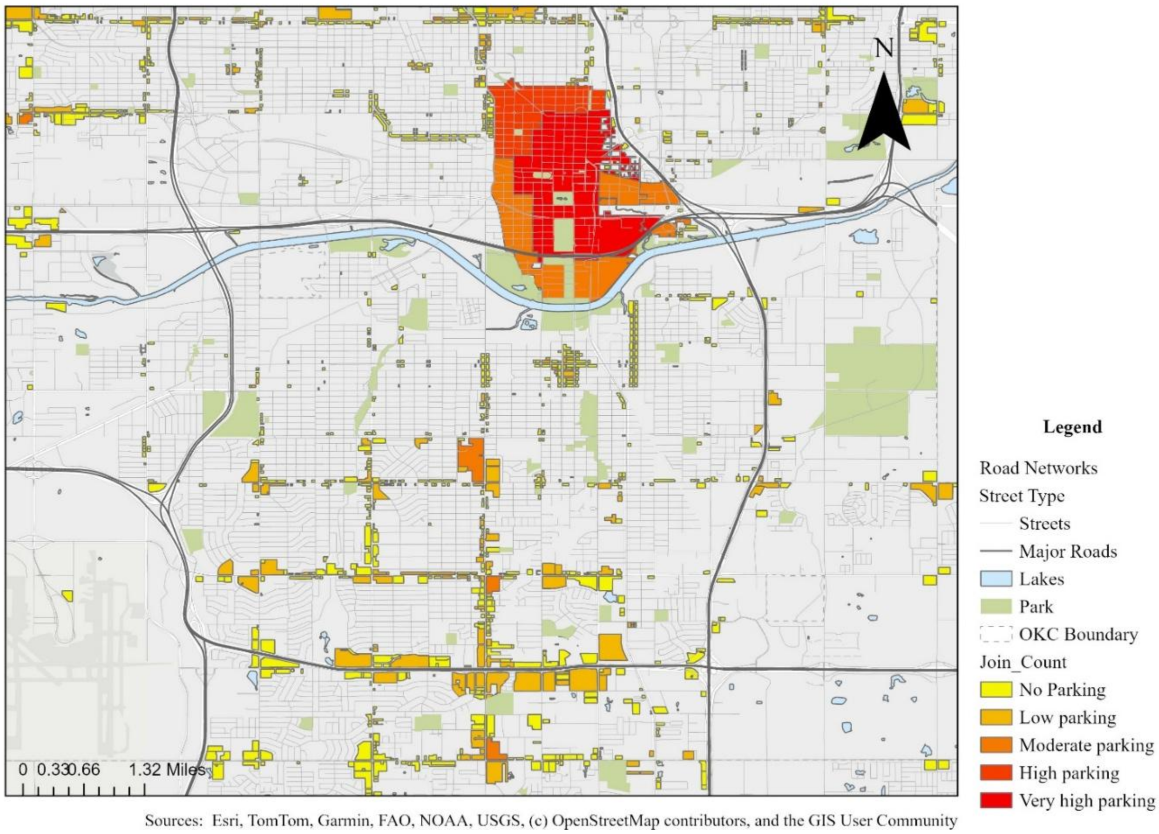


Figure 12: Surface Parking Distribution in Zoning

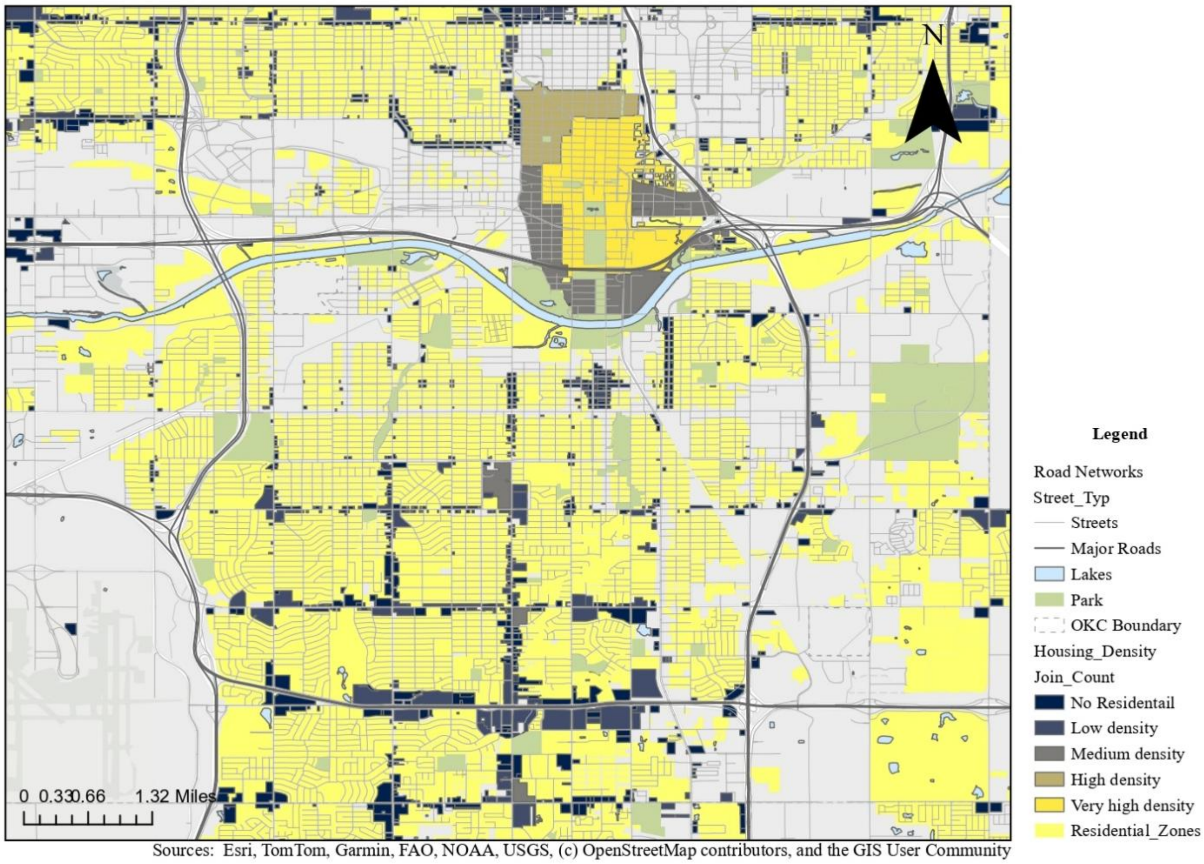


Figure 13: Housing Density intersecting Mixed-use Zones in Oklahoma City

As shown in figure 14, the Housing Density map displays the count of residential zone polygons (R-1, R-2, R-3, R-4, R-A, PUD) intersecting each mixed-use zone, representing the intensity of residential land use overlapping mixed-use designated areas. The results reveal a dispersed pattern of residential zone adjacency across the study area, with moderate to high residential zone counts observed in middle-ring mixed-use corridors and lower counts in the downtown core.

Notably, the downtown mixed-use zones with the highest surface parking counts on Map 7 correspond to areas with lower residential zone adjacency on Map 8. This spatial pattern is consistent with the hypothesis that surface parking occupies land in mixed-use zones that could otherwise support residential development. Mixed-use zones along major commercial corridors such as North Western Avenue, Classen Boulevard, and NW 23rd Street show moderate residential zone adjacency, reflecting the transitional nature of these areas between established residential neighborhoods and commercial strips.

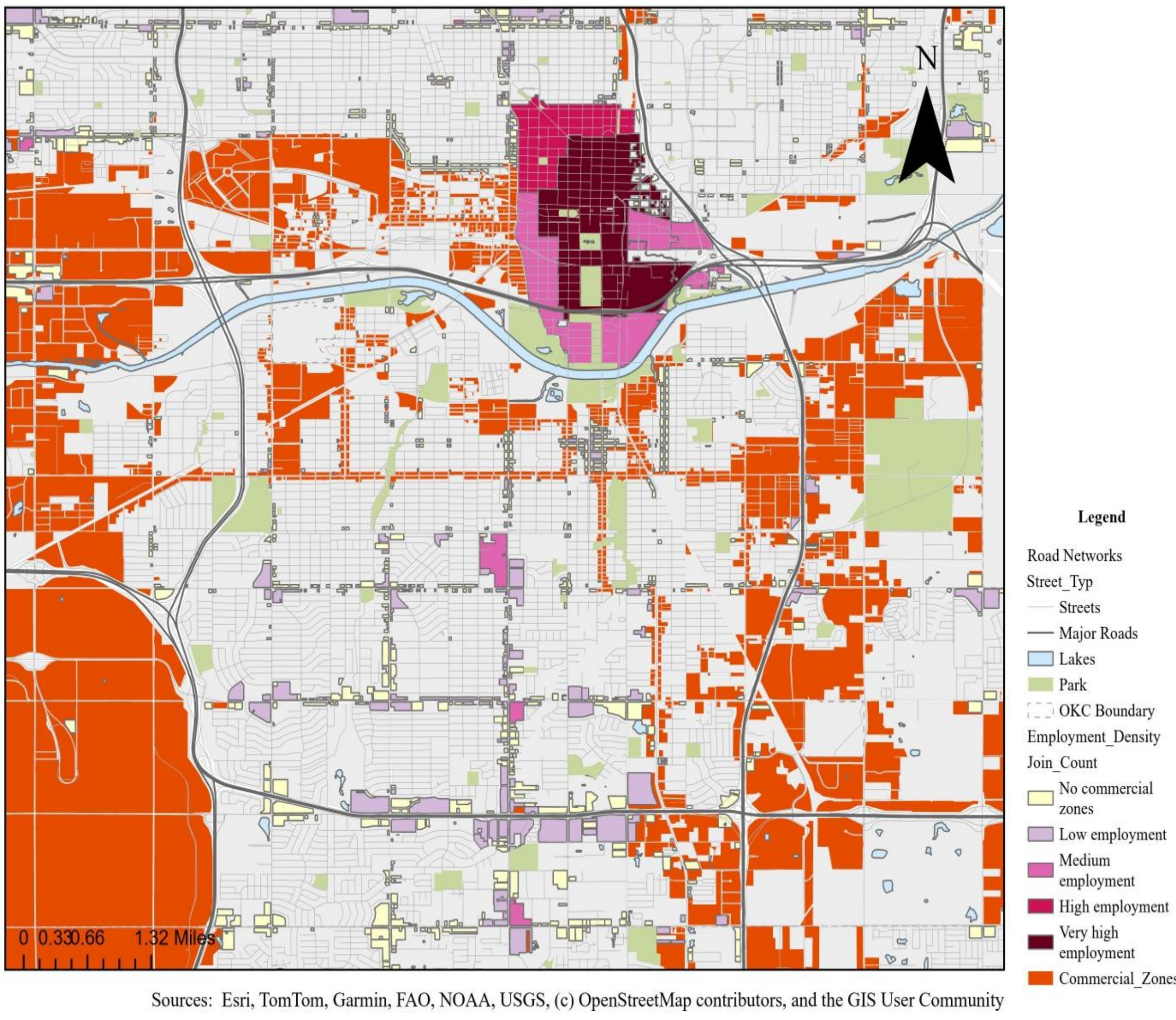
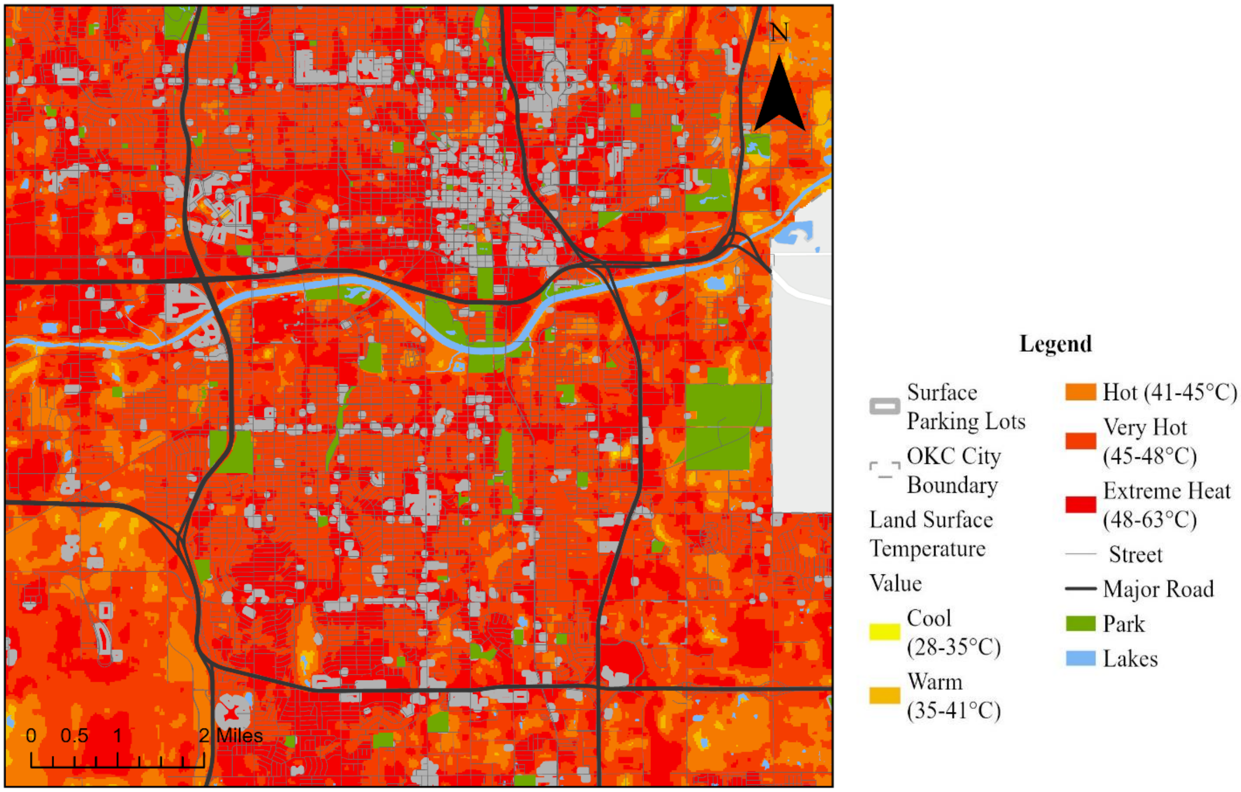


Figure 14: Employment Density intersecting Mixed-use Zones in Oklahoma City

On the other hand, figure 15 represents employment density, the count of commercial, office, and industrial zone polygons (C-1 through C-4, I-1, I-2, O-1, O-2) intersecting each mixed-use zone, representing employment-generating land use intensity. The results reveal a highly concentrated pattern of commercial zone adjacency, with the highest employment density class (87 to 183 commercial zone polygons) concentrated in a dense cluster in the downtown core and along the I-35 and I-40 corridor.

The spatial overlap between the highest parking zones in Map 7 and the highest commercial zone concentration in Map 9 in the downtown core reveals that the areas with the greatest concentration of employment-generating zoning designations are also the areas with the highest surface parking intensity. This distribution pattern of employment density across the broader mixed-use zone network shows that most zones outside the downtown core fall in the lowest employment intensity class, indicating limited commercial land use adjacency despite their mixed-use zoning designation. Moreover, this pattern clearly reinforces the characterization of Oklahoma City as a low-density, auto-oriented metropolitan area, with commercial activity concentrated in discrete nodes.

4.2.6 Urban Heat Island Effect and Ecological Costs of Surface Parking, Oklahoma City, Oklahoma

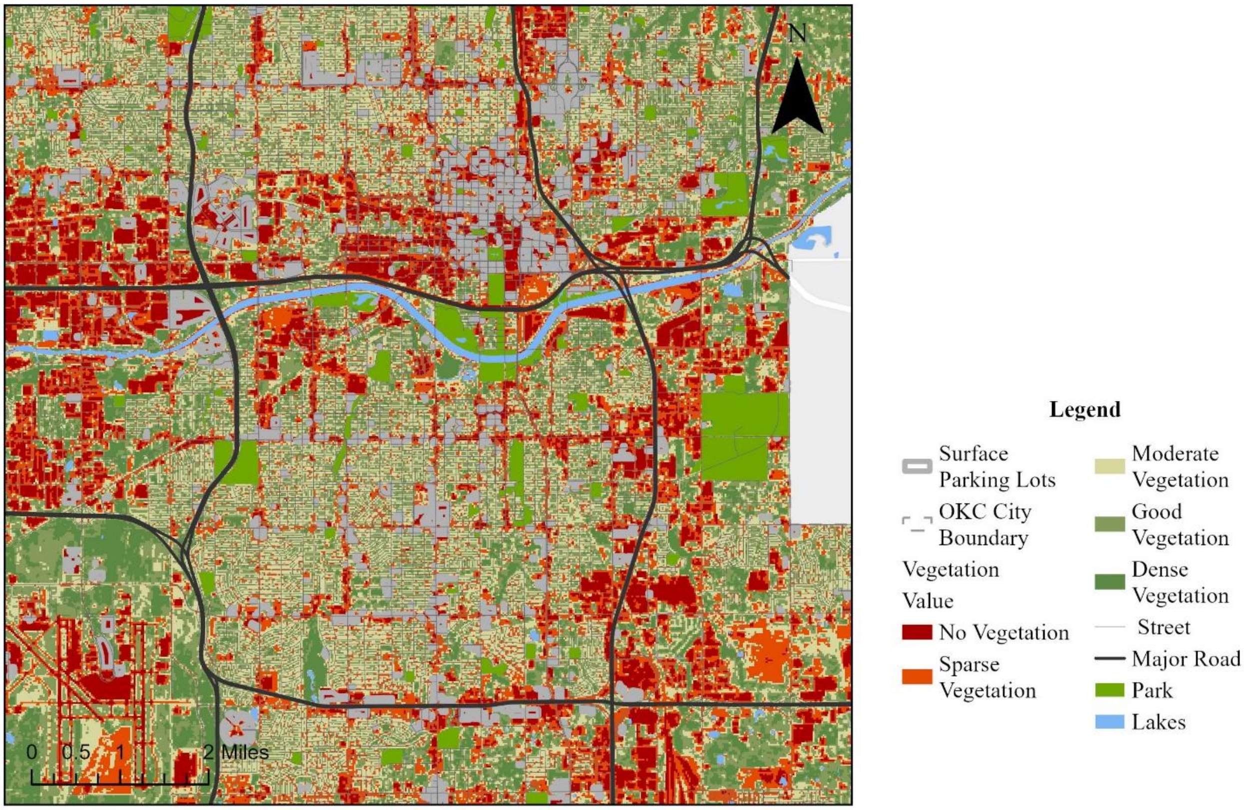


Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, (c) OpenStreetMap contributors, and the GIS User Community

Figure 15: Urban Heat Island Effect of Surface Parking

As shown in the temperature in figure 16, an urban heat island pattern across Oklahoma City, with the highest land surface temperatures concentrated in the downtown core and extending along the primary commercial and transportation corridors characterized by high densities of impervious surfaces. The spatial pattern of Extreme Heat zones shown in red closely matches the geographic distribution of surface parking identified in Map 10, with the most intense heat concentrated in the downtown business district, along the Northwestern Avenue commercial corridor, and around major institutional campus parking areas. The areas of lowest temperature, shown in yellow and light orange, correspond to vegetated open spaces, including parks, corridors along the North Canadian River, and lower-density residential neighborhoods with significant tree canopy coverage.

Overlaying the grey parking lot outlines the temperature data provides spatial correspondence between surface parking locations and extreme heat zones. Large contiguous parking lots in the downtown stadium district, state capitol complex, and major hospital campuses record temperatures in the Extreme Heat category, approaching or exceeding 60°C .This thermal profile is physically consistent with the known radiative properties of dark asphalt pavement: asphalt surfaces exhibit albedo values of approximately 0.05–0.10, absorbing 80–95 percent of incident solar radiation and storing thermal energy that is re-emitted as long-wave radiation during both daylight and evening hours, sustaining elevated surface and ambient temperatures in the surrounding urban environment well beyond the daylight period of maximum solar input (Santamouris, 2013; Taha, 1997; Akbari et al., 2009). The areas with the highest surface parking concentrations are simultaneously recording the most extreme land surface temperatures. This spatial shows that surface parking suppresses mixed-use development potential in Oklahoma City's planning priority areas and actively degrades the environmental quality and pedestrian livability of those areas, creating conditions of extreme thermal stress that further undermine the walkability and outdoor comfort necessary for successful mixed-use urbanism (Speck, 2013; Gehl, 2010; Stone, 2012).



Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, (c) OpenStreetMap contributors, and the GIS User Community

Figure 16: Vegetation Loss from Surface Parking

As shown in figure 17, the NDVI analysis complements the temperature findings by quantifying ecological reality: that surface parking lots are, in vegetation terms, dead zones. NDVI values recorded over 2,680 parking features in the inventory range uniformly from approximately a range that falls entirely within the No Vegetation classification applied in this study.

Map 1, the identified 255.22 acres of surface parking of urban land from which all vegetative cover has been replaced with impervious asphalt. The dominant land cover across Oklahoma City's residential and open space areas is in medium to dark green Good Vegetation and Dense Vegetation categories, reflecting the city's extensive residential tree canopy, riparian corridors along the North Canadian River and its tributaries, municipal parks and golf courses, and the agricultural and grassland margins of the urban periphery. However, it is interrupted throughout the urban core and along the major commercial corridors by concentrations of dark red and orange pixels representing No Vegetation and Sparse Vegetation zones, the thermal and ecological signature of impervious surfaces, rooftops, roadways, and, most conspicuously, surface parking lots. The surface parking visual concentrated in the urban core, where the ecosystem service value of vegetation is highest. This represents an absence of greenery but a structural ecological deficit, a quantifiable reduction in urban cooling capacity that the vegetated land surfaces replaced by parking.

4.2.7 Best Practices and Policy Reform Strategies for Oklahoma City

This section addresses the strategies and best practices Oklahoma City can adopt from peer cities to repurpose surface parking into more climate-resilient, community-serving mixed-use development. To answer this question, the analysis draws on two inquiries. The first is a systematic review of Oklahoma City's regulatory framework, including the mandatory parking provisions of Article X of the Municipal Code and the policy goals articulated in PlanOKC, the city's comprehensive plan. The second is a comparative analysis of parking reform strategies adopted by three U.S. cities: Minneapolis, Minnesota; Portland, Oregon; and Buffalo, New York, each of which has eliminated minimum parking requirements or implemented significant regulatory changes affecting how parking is planned and managed.

Together, these analyses reveal a fundamental conflict: a comprehensive plan that embraces compact, multimodal, and climate-conscious urban growth, while a zoning code that continues to mandate automobile-oriented parking provision for most land uses. The comparative cases demonstrate that other cities have developed transferable regulatory tools to address issues associated with current parking policy.

4.2.7 .1 Oklahoma City Policy Analysis: Regulatory Constraints on Mixed-Use Development

Land Use Type	Specific Use	Parking Ratio	Min or Max	Spaces per 1,000 sf
Residential	Single-Family Detached	2 spaces/du + garage	Maximum	2.67
	Multi-Family (1–2 BR)	1.5/du (1BR); 2/du (2BR+)	Maximum	1.5 – 2.0
	Multi-Family (3+ BR)	2 spaces/du	Maximum	2.0
Retail / Mixed-Use	Retail (first 12,000 sf GLA)	1 space per 200 sf	Minimum	5.0
	Retail (12,001–48,000 sf)	1 space per 225 sf	Minimum	4.4
	Commercial (first 8,000 sf)	1 space per 200 sf	Minimum	5.0
Industrial / Warehouse	Industrial (first 20,000 sf GFA)	1 space per 500 sf	Minimum	2.0
	Warehouse (first 20,000 sf)	1 space per 1,000 sf	Minimum	1.0

Table 3: Oklahoma City's off-street minimum parking requirement, Article X, Refer to Table 10

Table 2. Oklahoma City's Municipal Code Article X establishes mandatory off-street parking minimums for nearly all land uses across the city. In mixed-use zones, retail development requires one space per 200 square feet of gross leasable area for smaller buildings and one per 325 square feet for larger ones. Commercial uses follow a comparable sliding scale, while industrial and warehouse development applies ratios that begin at 1 space per 500 square feet of gross floor area.

The additive nature of these requirements creates a compounding effect for mixed-use projects that combine retail, residential, and office uses.

4.2.7.2 Limited Exemptions and the Geography of Parking Reform

Code Section	District / Overlay	Parking Minimum Status	Zoning Allowance	Urban Form Impact
§10600.3	Fringe Parking Overlay District	EXEMPT — No minimum required	Mixed-use infill allowed without mandatory parking	Compact development made feasible
NB District	Neighborhood Business District	EXEMPT — No minimum required	Small-scale commercial without parking mandate	Supports walkable neighborhood centers
DTD-1 / DTD-2	Downtown Transitional District (Limited & General)	EXEMPT — No minimum required	Mixed-use downtown transition areas	Enables transit-adjacent infill
C-CBD	Central Business District	EXEMPT — No minimum required	Core commercial and mixed-use downtown	Highest intensity urban form supported
§59-7150 / §59-7200	Bricktown Core / Downtown Design Districts	EXEMPT — Design controls apply	Mixed-use; buildings must face street; min. heights; high lot coverage	Strong pedestrian urban form enforced
§59-7250	Historic Preservation District	NOT EXEMPT — Article X applies	Controls demolition, alterations; preserves existing form	Full minimums constrain sensitive infill
§59-7300 / §59-7350	Neighborhood Conservation / Stockyards City	NOT EXEMPT — Article X applies	Regulates scale, massing, setbacks; district character standards	Mixed-use constrained by full parking minimums

Table 4: Parking Minimum Exemptions, Special Districts & Overlays, Article X

Table 3. Oklahoma City's zoning code does provide parking minimum exemptions in a defined set of downtown and urban overlay districts. Under Section 10600.3, the following districts are exempt from minimum off-street parking requirements: the Fringe Parking Overlay District; the Neighborhood Business (NB) District; Downtown Transitional Districts DTD-1 and DTD-2; the Central Business District (C-CBD); the Neighborhood Conservation District (NC); the Urban Design Overlay (UD); the Bricktown Core (BC); and the Farmers Market District within the Scenic River Overlay. In these areas, mixed-use and infill development can proceed without a mandated parking supply, substantially reducing the land area and development cost associated with parking provision.

The special-purpose district provisions further reflect this uneven geography. Sections 59-7150 and 59-7200 eliminate parking minimums in the Bricktown Core and Downtown Design Districts, respectively, while imposing strong pedestrian-oriented design requirements. By contrast, Sections

59-7250 through 59-7350 governing the Historic Preservation District, the Neighborhood Conservation District, and the Stockyards City Development District default to Article X minimums with no additional parking exemption. The result is a two-tiered regulatory system in which only the most central, already-walkable districts benefit from reform, while mixed-use corridors and neighborhood commercial centers throughout the broader city remain subject to automobile-oriented parking standards. This geographic limitation constrains the reach of infill development and reinforces low-density patterns in areas that PlanOKC has designated for intensification.

4.2.7.3 PlanOKC: Progressive Goals and the Policy-Regulation Gap

Policy Area	PlanOKC Goal	Article X	Implication
Transportation & Mobility	Shift from car-only planning to balanced multimodal system	Requires extensive off-street parking + auto-oriented design standards	Reinforces auto-dependence; prioritizes cars over people
Land Use & Urban Form	Promote compact, efficient, connected development patterns	Parking minimums increase land consumption and push sites toward low-density layouts	Parking rules directly undercut compact urban form goals
Infill Development	Encourage infill and reuse of underutilized urban land	Infill projects must meet full parking minimums unless in narrow exempt districts	Parking requirements make infill more difficult and costly
Mixed-Use & Downtown	Support mixed-use development; 71% of residents surveyed support Downtown mixed-use	Article X requires additive parking for each separate use in mixed-use projects	Mixed-use penalized with higher parking totals; discourages use integration
Street Connectivity	Improve connectivity, access management, and multimodal corridors	Design standards prioritize driveway widths, aisle dimensions, and vehicle circulation	Design standards still center the car as primary user of the street
Overall Pattern	Move toward people-oriented, efficient, and sustainable growth	Zoning code still institutionalizes parking-heavy, car-first development	**Policy Mismatch**

Table 5: PlanOKC Goals vs. Article X

PlanOKC Table 4, Oklahoma City's adopted comprehensive plan, articulates a development vision that is inconsistent with the requirements of Article X. The Comprehensive plan calls for a transition from automobile-dominated planning to a balanced, multimodal approach focused on moving people efficiently and equitably. A citizen survey conducted as part of the planning process found that 71% of respondents supported mixed-use downtown development, reflecting broad community alignment with the plan's goals.

However, a comparative review of PlanOKC's policy directions and Article X's operative provisions reveals a persistent gap between planning intent and regulatory reality. The plan promotes compact, efficient development, while the zoning code reveals parking-heavy site layouts that increase land consumption and reduce development density. In effect, the zoning code functions as a physical offset to the city's stated planning goals, and this misalignment constitutes one of the primary regulatory obstacles to redeveloping surface parking into mixed-use, climate-resilient land uses.

4.2.7.4 Lessons from Minneapolis, Portland, and Buffalo

The following subsections present findings from the comparative analysis of parking reform policies in Minneapolis, Minnesota; Portland, Oregon; and Buffalo, New York. All three cities have eliminated mandatory minimum parking requirements at the citywide level, and each offers a distinct reform model with different strategic emphases and regulatory tools. Taken together, they provide a practical framework for evaluating what reform strategies are most transferable to Oklahoma City's planning context.

4.2.7.5 Minneapolis, Minnesota: A Comprehensive, Equity-Driven Reform, Refer to *Table 12*

City	Policy Area	Pre-Reform Condition	Reform Action	Key Mechanism	Outcome
Minneapolis	Parking Minimums	Mandatory minimum parking requirements	Eliminated citywide (2021 reform)	Zoning reform linked to 2040 Plan	Reduced development cost, improved housing flexibility
Minneapolis	Parking Caps	Unregulated oversupply	Tiered parking maximums	Transit-based zoning thresholds	Efficient land use near transit
Minneapolis	Surface Parking	Large underutilized lots	Max 100 spaces per lot	Direct regulatory cap	Reduced land consumption
Minneapolis	TDM	Car-dependent travel	Points-based TDM system	Behavior-based planning	Encourages multimodal shift
Minneapolis	EV Infrastructure	No requirement	Mandatory EV-ready + chargers	Sustainability integration	Supports electrification

Table 6: Parking Reform Strategies, Minneapolis

Table 2. Minneapolis eliminated citywide minimum parking requirements as part of a comprehensive 2021 zoning reform, directly linking the policy change to the goals of the Minneapolis 2040 Comprehensive Plan and the city's Transportation Action Plan. The reform identifies parking reform as an explicit climate and equity strategy, connecting reduced parking supply to lower greenhouse gas emissions, improved housing affordability, and expanded access to multimodal transportation (Minneapolis Department of City Planning, 2021).

The Minneapolis approach is distinguished by its spatial differentiation and reliance on measurable thresholds rather than applying a uniform citywide standard; the city adopted tiered maximum parking caps that vary by zone and transit service intensity. In Core 50 and Transit 30 zones, defined as areas within a half mile of frequent transit service, non-residential parking is capped at one space per 1,000 square feet. In Transit 10, 15, and 20 zones, the cap rises to one space per 500 square feet, and in lower-density areas, one space per 300 square feet. Residential caps follow a similar order, with a maximum of 1.5 spaces per dwelling unit in transit and core areas and 2.0 spaces elsewhere. This tiered structure ensures that parking supply is calibrated to transit accessibility rather than applied uniformly across land uses, preventing oversupply near transit corridors while preserving flexibility in lower-density contexts (Minneapolis Department of City Planning, 2021).

Minneapolis also adopted a citywide limit of 100 parking spaces per surface lot, directly targeting the large, underutilized parking areas that consume significant urban land. Bicycle parking minimums were simultaneously increased to one space per dwelling unit in residential buildings and at least three spaces for most non-residential uses, while large projects exceeding 200,000 square feet are required to provide cyclist amenities, including showers and lockers, extending the functional viability of cycling as a commute mode (Minneapolis Department of City Planning, 2021).

The city's Transportation Demand Management (TDM) framework is among the most comprehensive of the three cases reviewed. The reform distinguishes between Minor TDM, which applies to projects with 50 to 249 dwelling units or 25,000 to 199,999 square feet, and Major TDM, which applies to larger developments. Compliance is achieved through a points-based strategy system rather than traditional traffic study requirements. Available strategies include zero parking provision, transit pass programs, shared vehicle access, and pedestrian realm improvements, among others. This approach shifts regulatory emphasis from parking supply to travel behavior management, creating measurable incentives for mode shift. Electric vehicle infrastructure requirements complete the reform package: 10% of applicable parking spaces must be equipped with Level 2 EV chargers, and an additional 5% must be EV-ready (Minneapolis Department of City Planning, 2021).

4.2.7.6 Portland, Oregon: Climate Integration and Performance-Based Management

City	Policy Area	Pre-Reform Condition	Reform Action	Key Mechanism	Outcome
Portland	Parking Minimums	Mandatory minimums	Eliminated citywide (2023)	Climate policy integration	Supports density and affordability
Portland	Parking Caps	Weak limits	Strengthened maximum caps	Zone & transit-based	Prevents oversupply
Portland	Green Parking	No environmental control	Tree canopy or solar requirement	Climate-responsive design	Reduces heat island
Portland	Curb Pricing	Static pricing	Performance-based pricing	Demand-responsive	Reduces cruising
Portland	Revenue Use	General fund	Local reinvestment (50%)	Equity-focused funding	Improves infrastructure

Table 7: Parking Reform Strategies, Portland, Refer to Table 13

Table 3. shows Portland's parking reform, enacted to achieve compliance with Oregon's Climate-Friendly and Equitable Communities (CFEC) rules by June 30, 2023, represents the most climate-integrated regulatory model of the three cities examined. The reform removed minimum motor-vehicle parking requirements citywide across all zones and for all new development, while simultaneously strengthening maximum parking caps that vary by zone, transit access, and whether parking is provided in structured or surface form (CFEC, 2023).

Portland's reform is notable for two regulatory innovations with direct relevance to Oklahoma City. The first is a set of green lot standards that requires surface parking lots of one-quarter acre or more to provide either 50% tree canopy shade coverage or on-site solar generation at 0.5 kilowatts per parking space. This requirement embeds climate resilience directly into the surface parking regulatory framework by addressing the urban heat island effect, managing stormwater runoff, and advancing renewable energy generation (CFEC, 2023).

The second innovation is a performance-based curbside pricing system designed to maintain parking occupancy between 65% and 85%, equivalent to 1 to 3 open spaces per block. By adjusting meter rates to reflect demand, the system reduces cruising behavior and improves parking availability without requiring additional parking construction. Significantly, Portland earmarks at least 50% of net revenue from new meter districts for local reinvestment in non-automobile infrastructure, including sidewalks, bicycle facilities, and transit access improvements. This reinvestment provision builds political support for reform by redistributing its fiscal benefits within the neighborhoods most affected. Additional design controls limit parking placement between buildings, and along street frontages on pedestrian and transit priority corridors, and EV-ready requirements for new parking structures further integrate the city's electrification goals into the development review process (CFEC, 2023).

4.2.7.7 Buffalo, New York: A Streamlined Development-Feasibility Model

City	Policy Area	Pre-Reform Condition	Reform Action	Key Mechanism	Outcome
Buffalo	Parking Minimums	Mandatory minimums	Eliminated citywide (2016)	Green Code reform	Reduced development barriers
Buffalo	Regulation	Complex zoning	Simplified framework	Streamlined code	Easy implementation
Buffalo	TDM	Limited use	Required for large projects	Mobility planning	Encourages alternatives
Buffalo	Pricing	Bundled parking	Unbundled pricing	Market-based approach	Improves affordability
Buffalo	Bicycle Parking	Minimal standards	Secure design-focused standards	Active transport support	Encourages cycling

Table 8: Parking Reform Strategies, Buffalo, Refer to

Table 4. illustrates Buffalo's parking reform, enacted through the Unified Development Ordinance, commonly known as the Green Code, in 2016. It adopted the most direct approach: eliminating all minimum off-street parking requirements citywide, without the spatially tiered framework of Minneapolis or the curbside pricing mechanisms of Portland. The reform is framed primarily around development affordability and reinvestment feasibility, premised on the recognition that parking minimums impose significant cost burdens on housing production and commercial development in a city confronting significant disinvestment pressures (City of Buffalo, 2016).

In place of parking minimums, the Green Code requires Transportation Demand Management plans for developments above a defined threshold. These plans must analyze travel demand across all modes of transit, cycling, walking, and shared mobility, and demonstrate how trips will be managed. TDM strategies available under the Green Code include transit incentives, parking cash-out programs, unbundled parking pricing, shared parking arrangements, and access to bicycle and car-share services. Bicycle parking standards require secure, visible, and weather-protected facilities, with waivers available only where actual demand is demonstrably low.

While the Buffalo model is less prescriptive to environmental standards than Portland's and less spatially differentiated than Minneapolis's, its regulatory simplicity is itself a transferable quality.

The Green Code demonstrates that a citywide shift from parking minimums to mobility management is achievable without a complex multi-tiered framework, and that such a shift can be framed effectively around development cost reduction rather than primarily as a climate resilience and equity intervention (City of Buffalo, 2016).

CHAPTER 5: DISCUSSION & CONCLUSION

5.1. Discussion

This discussion synthesizes the analytical results across research objectives, situates those results within the broader scholarly literature on parking, climate responsive planning and develops a framework of relevant policy recommendation to address the urban issues the Oklahoma City is facing this research has documented. The discussion is organized around three overarching themes that correspond to the study's primary research questions: the spatial relationship between surface parking and mixed-use development potential; the environmental consequences of parking-dominated land use; and the regulatory and strategic pathways available to Oklahoma City as it seeks to align its physical development patterns with the goals of the PlanOKC comprehensive plan.

5.1.1 Surface Parking as a Structural Impediment to Mixed-Use Development

This Study on Oklahoma City, OK, presents an example of what mid-sized American cities can achieve by reforming parking to support mixed-use development to create a sustainable community. The spatial analysis documented in Chapter 5 provides a comprehensive answer to this question. The inventory of 2,680 surface parking lots covering 255.22 acres of urban land reveals a pattern that is not random but structurally concentrated in precisely those areas of the city where mixed-use development potential is highest. The identification of 752 parking features within current mixed-use zoning districts and 1,001 features within PlanOKC future land use designations provides direct cartographic evidence that surface parking lots dominate land-use patterns in Oklahoma City.

Much previous research has argued that minimum parking requirements function as a hidden subsidy for automobile use, effectively mandating a form of land consumption incompatible with the density thresholds necessary to support mixed-use urbanism (Shoup citation). The current zoning ordinance demonstrates that the legacy of Article X's mandatory parking provisions has produced a land-use pattern in which nearly 30% of all inventoried surface parking is located within current mixed-use zoning boundaries, and over 37% falls within PlanOKC's designated mixed-use growth areas.

The analysis presented deepens this finding by revealing that the highest concentrations of surface parking align almost precisely with the geographic footprint of the city's downtown core and its primary commercial arterial corridors, which are simultaneously the locations where both current zoning and PlanOKC designations call for the most intensive mixed-use investment. This alignment between peak parking density and peak development potential is correlated. It reflects the historical implications of parking minimums for commercial and institutional land uses that, by their nature, cluster in urban cores, generating cumulative parking reserves that now dominate the very parcels where development pressure and planning intention are strongest. The impact of such parking minimums creates a self-reinforcing cycle of auto-oriented development that increases vehicle dependence while simultaneously reducing the density and land-use diversity necessary to support alternatives to driving.

The concentration of opportunity areas in the downtown core and along North Western Avenue, Classen Boulevard, and South Western Avenue establish a clear geographic focus for targeted parking reform. These are the corridors where the regulatory misalignment between Article X's parking mandates and PlanOKC's development vision is most consequential, and where the redevelopment of even a modest number of surface parking sites could yield compounding returns in terms of density, walkability, and mixed-use vitality. The composite spatial query employed in our analysis provides a methodological framework for identifying comparable opportunity areas in other American cities facing comparable planning issues.

The employment and residential density correspondence between the highest parking concentrations and the highest commercial zone adjacency scores in the downtown core confirms that surface parking is most heavily embedded in areas with the greatest employment-generating potential, while residential zone adjacency is lower in these same areas, consistent with the hypothesis that parking has displaced housing as well as commercial development. This low employment intensity observed outside the downtown core, despite mixed-use zoning designations, suggests that the regulatory benefits of mixed-use zoning remain unfulfilled across the city's commercial corridor. Therefore, parking minimums substantially impose development cost burdens that reduce the feasibility of compact, mixed-use infill developments.

5.1.2 Environmental Costs of Surface Parking: Urban Heat Island, Vegetation Loss

Our research examines the major environmental impacts of surface parking in Oklahoma City, with particular attention to urban heat islands. The LST analysis demonstrates a clear and consistent spatial correspondence between the locations of surface parking lots and zones of extreme thermal stress across the city. Large contiguous parking areas in the downtown core, around major hospital campuses, and adjacent to the state capitol complex record surface temperatures approaching 60°C, placing them in the Extreme Heat classification applied in this study. The visual alignment between blue parking lot outlines and red thermal zones on Map 9 provides direct cartographic confirmation of the urban heat island effect of impervious asphalt surfaces at the citywide scale.

In the context of an Oklahoma City summer, when ambient temperatures frequently exceed 100°F, the additional heat load imposed by 255.22 acres of asphalt parking represents a measurable and consequential degradation of outdoor environmental conditions. At the metropolitan scale, increasing albedo across urban surfaces can reduce local air temperatures by measurable increments, suggesting that replacing surface parking with vegetated or reflective surfaces is a viable urban cooling strategy.

On the other hand, the NDVI analysis reinforces this environmental assessment by demonstrating that surface parking lots are, in ecological terms, functionally barren landscapes. NDVI values recorded across all 2,680 parking features in the inventory fall uniformly within the absence of Vegetation. The 255.22 acres of urban land occupied by surface parking, therefore, represent a structural ecological deficit, a quantifiable reduction in evapotranspiration, carbon sequestration, stormwater retention, and urban cooling capacity that vegetated land surfaces would otherwise provide. The replacement of pervious vegetated surfaces with impervious materials is among the primary contributors of urban thermal amplification, and the Oklahoma City data demonstrate this relationship with spatial precision across a large American metropolitan area (Heat Gov.,2024.).

The areas where parking most severely constrains the potential for mixed-use development are also those where it imposes the greatest environmental and public health burdens. The downtown core and primary commercial corridors that PlanOKC designates for mixed-use intensification are simultaneously recording the city's most extreme land surface temperatures, the lowest NDVI values, and the highest concentrations of impervious surface coverage. This spatial convergence means that the redevelopment of surface parking into mixed-use buildings with permeable surfaces, urban tree canopy, and green infrastructure would generate simultaneous benefits across the planning, environmental, and public health domains. Urban heat is among the most significant barriers to pedestrian activity and outdoor vitality in car-oriented American cities (Garber, Teyton, et al., 2025; Joshi et al., 2026).

5.1.3 Policy-Development Gap

This analysis synthesizes the regulatory review between Oklahoma City's stated planning goals and its operative zoning standards. According to the PlanOKC Comprehensive Plan, a citizen survey conducted as part of the planning process found that 71 percent of respondents supported mixed-use downtown development, reflecting genuine community alignment with these goals. However, Article X's mandatory parking minimums impose a regulatory structure that is functionally incompatible with realizing this vision on a scale.

The analysis of Article X's provisions reveals that the code's additive parking calculation methodology creates a compounding burden for exactly the type of mixed-use projects that PlanOKC prioritizes. When retail, residential, and office uses are combined on a single site, each use generates its own minimum parking obligation, producing aggregate requirements that can consume substantial portions of the developable area and significantly increase per-unit development costs. The incremental reductions available through the code's alternative compliance provisions, capped at a cumulative maximum of 30%, including administrative discretion, are insufficient to resolve this structural tension. The development cost implications of minimum parking requirements are most severe precisely in the transit-accessible, walkable urban environments where parking utilization rates are typically lowest, creating a regulatory perversity in which the area's best suited for mixed-use development are made least financially feasible by the parking requirements (Farjam & Hossieni Motlaq, 2019; Mbata, 2024).

Moreover, the exemptions provided under Section 10600.3 are effectively limited to the downtown core and a small set of specialized overlay districts, leaving the mixed-use corridors along North Western Avenue, Classen Boulevard, and South Western Avenue, which PlanOKC identifies as priority areas for urban commercial and transit-oriented development, subject to the full weight of

Article X's automobile-oriented parking standards. This geographic limitation means that the regulatory environment is most permissive for development precisely, while imposing the greatest barriers in the transitional corridors where planning intervention would have the highest marginal impact on urban form.

5.1.4 Recommendation

The integration of the spatial, environmental, and regulatory findings documented in this study supports a set of evidence-based recommendations organized around three strategic scales: immediate regulatory reform, corridor-scale planning interventions, and city-wide policy and institutional mechanisms. These recommendations draw on the comparative analysis of parking reform strategies in Minneapolis, Portland, and Buffalo, which have successfully reformed parking minimums.

5.1.4.1 Cross-City Comparison and Reform Dimensions Transferable to Oklahoma City

The three comparative cases reveal a set of shared reform dimensions that intersect across different city sizes, political contexts, and regulatory traditions. Table 8 presents a structured cross-city comparison of these dimensions. The following analysis elaborates on the seven most applicable reform pathways for Oklahoma City.

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Reform Dimension	Minneapolis	Portland	Buffalo	Oklahoma City (current)
Minimum Parking Requirements	Eliminated citywide (Minneapolis 2040)	Eliminated citywide (CFEC mandate 2023)	Eliminated citywide (Green Code 2016)	Required by use (Article X minimums)
Maximum Parking Caps	Tiered by transit zone 1/1,000 sf (core) → 1/300 sf	Context-sensitive caps by zone + transit access	Moderate caps less spatially granular	No caps enforced Only minimums
Surface Lot Limits	100-space maximum citywide hard cap	Green lot standards 50% shade or 0.5kW solar/space	Design + landscaping No hard space cap	No limits Surface lots unrestricted
TDM Framework	Points-based system Minor/Major thresholds	TDM via impact review 10+ DU projects	TDM plans required larger projects only	No TDM requirement Not in Article X
Climate Integration	Land efficiency + VMT reduction	Heat island, stormwater + GHG reduction	Indirect via urban form improvement	No climate linkage in parking code
Bicycle Parking	1/DU residential 3+ spaces non-residential	Long-term secure + short-term visible	Secure + visible waivers allowed	1 bike = 2 car space reduction (limited)
EV Infrastructure	10% Level-2 + 5% EV-ready	EV-ready required by use and size	Not found in Green Code	No EV requirement in zoning code
Policy Framing	Climate + equity + housing affordability	State climate mandates + access reinvestment	Development feasibility + cost reduction	Auto-oriented supply model (mid-20th c.)

Table 9: Cross-City Parking Reform Comparison

Elimination of Minimum Parking Requirements: All three cities eliminated citywide parking minimums, demonstrating that this foundational reform is achievable across varied political and geographic contexts. Oklahoma City already applies parking minimum exemptions in its downtown and overlay districts, establishing a regulatory precedent. Extending these exemptions to mixed-use corridors, transit-adjacent neighborhoods, and underutilized commercial areas represent the most direct near-term reform available to the city.

Maximum Parking Caps in Transit-Proximate Areas: Minneapolis's geographically tiered cap system and Portland's context-sensitive maximums demonstrate that replacing minimums with caps prevents oversupply and concentrates density near transit infrastructure. Oklahoma City could adapt this approach by calibrating maximum caps to existing and planned transit corridors identified in PlanOKC, creating a spatially differentiated framework that supports transit investment and walkable development patterns.

Surface Lot Size Limits: Minneapolis’s 100-space maximum per surface lot and Portland's green lot standards for lots exceeding one-quarter acre provide direct regulatory tools for addressing the large, underutilized parking areas that characterize much of Oklahoma City's built environment. A surface lot cap, combined with phased redevelopment incentives, could redirect land currently dedicated to surface parking toward housing production, public space, and mixed-use infill.

Green Lot Standards for Climate Resilience: Portland's requirement that large surface lots provide either tree canopy coverage, or solar generation directly targets the urban heat island conditions associated with surface parking. This standard is particularly applicable to Oklahoma City, given the documented heat island effects of its extensive parking infrastructure. Integrating shade tree requirements, permeable paving standards, and solar-readiness provisions into parking regulations would advance the climate resilience goals articulated in PlanOKC while reducing stormwater runoff and energy costs.

Transportation Demand Management Frameworks: These three peer cities replaced or supplemented parking supply requirements with TDM frameworks that require active management of travel demand across all modes. Minneapolis's points-based strategy system, Portland's Transportation Impact Review process, and Buffalo's TDM plan requirement each offer adaptable models for incorporating TDM as a condition of development approval in Oklahoma City, particularly for larger mixed-use and commercial projects where mode shift potential is greatest.

Bicycle Parking and Multimodal Infrastructure Standards: All three cities maintain or increase bicycle parking minimums while eliminating motor vehicle minimums, signaling a regulatory shift in the hierarchy of transportation modes. Strengthening bicycle parking requirements and complementary pedestrian infrastructure standards in Oklahoma City would support the multimodal access goals articulated in PlanOKC and reduce the automobile dependency that current parking standards reinforce.

Alignment Between Comprehensive Plans and Zoning Codes: In each comparative city, parking reform was explicitly framed as an implementation mechanism for the city's comprehensive plan goals, whether related to climate resilience, housing affordability, equity, or multimodal mobility. Oklahoma City's PlanOKC articulates equivalent goals, but Article X has not been revised to reflect them. Closing this alignment gap is the foundational reform priority identified by this research, since without regulatory change, the city's stated planning vision cannot be fully realized.

5.2 Conclusion

This research has demonstrated that surface parking constitutes a significant structural, environmental, and regulatory barrier to achieving sustainability and mixed-use development in Oklahoma City. Integrating spatial analysis with geospatial inventory, zoning, comprehensive plan evaluation, density analysis, and environmental assessments, the study provides grounded evidence that low-intensity development and car-centric land-use patterns continue to shape the city's urban form.

The surface parking analysis of Oklahoma City reveals that parking lots are systematically distributed, covering approximately 255.22 acres of urban land, with a substantial proportion located within both current mixed-use zoning districts and the future mixed-use growth areas designated by the PlanOKC comprehensive plan. This spatial alignment underscores a fundamental planning paradox: the lands suitable for compact, walkable, and transit-supportive development are simultaneously occupied by surface parking. Oklahoma City's current zoning ordinance for mandatory parking minimums under Article X of the Oklahoma City Municipal

Code has historically incentivized low-density, automobile-dependent development and limited the feasibility of mixed-use development.

Beyond their spatial implications, surface parking lots impose high environmental and ecological costs. The Land Surface Temperature (LST) analysis demonstrates a compelling correspondence between parking concentrations and zones of extreme urban heat, with temperatures exceeding 60 °C. Moreover, the NDVI analysis shows that these areas are characterized by an almost complete absence of vegetation, representing a significant loss of green spaces that support urban cooling, carbon sequestration, and improved air quality. These environmental burdens are disproportionately concentrated in areas identified for future growth, thereby undermining the livability and resilience fundamental to fostering mixed-use development.

The study also identified a pronounced policy–development gap between the progressive vision articulated in PlanOKC and the regulatory framework governing land use. While the Comprehensive Plan promotes transit-oriented, multimodal, and climate-responsive mixed-use development, the persistence of parking minimums continues to impose financial and spatial constraints on mixed-use development, particularly along key commercial corridors outside the downtown core. The analysis of parking reforms in Minneapolis, Portland, and Buffalo provides transferable policy models, including the elimination of parking minimums, implementation of maximum parking caps, integration of Transportation Demand Management strategies, and adoption of climate-responsive design standards that can direct Oklahoma City to adopt parking reform toward a more sustainable and equitable mixed-use development.

Collectively, the research contributes to the broader scholarly discourse on parking policy, urban sustainability, and land-use planning by offering a replicable methodological framework for identifying redevelopment opportunity areas in mid-sized American cities. The integration of spatial, environmental, and regulatory analyses provides a comprehensive approach for understanding how parking infrastructure influences urban development patterns and environmental outcomes. Furthermore, the study advances the argument that parking reform is not merely a transportation or land-use issue but a multidimensional strategy with implications for housing affordability, economic development, climate resilience, and social equity. While this research provides a comprehensive spatial and policy analysis of surface parking and its implications for mixed-use development and sustainability in Oklahoma City, several limitations should be acknowledged for future research.

5.2.1 Limitations and Future Research

Several methodological limitations of this study require explicit acknowledgment. The most significant is the numerical disparity between the total surface parking acreage calculated for Oklahoma City (255.22 acres) and the acreage figures produced by the mixed-use zone intersection analyses: 635 acres for the Mixed-Use Zoning layer and 1,001 acres for the PlanOKC Mixed-Use layer. Both figures substantially exceed the total parking inventory. This disparity does not indicate a calculation error but rather reflects a distinction in measurement. Specifically, 'area affected by parking' refers to the total amount of mixed-use digitated land that overlaps with any surface parking, while 'actual parking surface area' refers strictly to the footprints of the parking lots themselves. For example, if a single 1-acre parking lot overlaps the edge of three adjacent mixed-use zone parcels for 0.5 acres each, the affected area in zoning analysis would sum to 1.5 acres, even though only 1 acre of physical parking exists. The larger figures from the Pairwise Intersect and Clip analyses represent the total area of mixed-use designated zone polygons that spatially overlap with parking features, measuring the extent of mixed-use planned land affected by surface parking, rather than the area of parking lot surfaces themselves. For quantifying land area consumed by surface parking, the figure of 255.22 acres, computed directly from parking polygon geometry using the Calculate Geometry Attributes tool, remains the correct and authoritative measure and should be interpreted accordingly throughout this study.

Second, the surface parking inventory primarily relies on OpenStreetMap data, which varies in completeness across urban contexts and feature types. Although systematic manual digitization supplemented features identified as absent through aerial imagery review, adding 183 polygons for a final inventory of 2,680 features, smaller, recently constructed, unpaved parking lots or access-restricted parking facilities may remain undetected. As a result, the surface parking data may underrepresent actual parking areas in some locations, particularly in districts with limited data coverage and rapid development. This limitation introduces the possibility of geographic bias in estimated parking concentrations and associated analyses, potentially underestimating the magnitude of parking impacts in under-mapped neighborhoods. Consequently, the final dataset should be interpreted as a conservative lower-bound estimate of total surface parking supply, and the actual extent of parking-density relationships documented in this study may be more pronounced than the findings suggest.

Third, the environmental analysis is based on a single Landsat image acquired on August 2, 2023. While this date was selected to represent peak summer thermal conditions in Oklahoma City's continental climate, it does not capture temporal variability in land surface temperature across different seasons and meteorological conditions. A multi-temporal analysis incorporating imagery from multiple dates throughout the year would provide a more comprehensive characterization of the thermal environment associated with surface parking and enable more precise separation of parking-specific heat signatures from broader seasonal climatic patterns.

Fourth, this study does not incorporate socioeconomic or demographic data for communities adjacent to high-density parking areas. The distributional equity dimensions of surface parking, including whether parking-induced heat exposure, reduced walkability, and constrained housing supply disproportionately burden lower-income or minority communities, remain unexamined and represent a critical gap in the evidence base for equitable parking reform.

Regarding future research priorities, this study identifies a hierarchy of investigative needs based on their policy relevance and potential to advance parking reform implementation in Oklahoma City. The highest-priority research need is a systematic equity analysis documenting the relationship between surface parking concentration, urban heat exposure, and the socioeconomic and demographic characteristics of surrounding neighborhoods. To operate this equity analysis, a combination of quantitative and spatial methods could be employed. Multivariate regression analysis can be used to assess the strength and significance of associations among parking density, land surface temperature, and key demographic variables, such as income, race, and age. These approaches, complemented by mapping and visualizing parking exposure overlaid on socioeconomic data, would provide a robust foundation for distributional justice and help prioritize reform interventions in communities most affected by parking-dominated land use.

Secondly, A feasibility assessment should directly examine the financial viability of surface lot redevelopment under current Oklahoma City land market conditions, the institutional capacity of the city's planning department to administer and enforce reformed parking standards, the availability of federal and state funding mechanisms such as HUD Community Development Block Grants, EPA Brownfields programs, and federal TOD infrastructure grants to support parking lot conversion and infill development, and the level of political and community support or opposition among key stakeholder groups, including downtown business associations, neighborhood organizations, and major institutional landowners. Future feasibility studies could employ a combination of research designs to address these questions, including structured stakeholder interviews to assess political will and perceived barriers, financial modeling of redevelopment scenarios, institutional capacity assessments, and comparative policy analysis of cities with similar reform efforts. Utilizing both qualitative and quantitative methods would provide a comprehensive understanding of implementation prospects and inform targeted policy recommendations.

Thirdly research could priority a longitudinal analysis of development activity on former surface parking sites in comparable Sunbelt cities, such as Dallas, Phoenix, and San Antonio, that have implemented parking minimum reforms or targeted parking lot redevelopment programs in recent years (*Parking Lot Map*, 2023). To guide comparative studies, future research should employ specific metrics that capture both quantitative and qualitative impacts of redevelopment include changes in residential and commercial density, for instance dwelling units and jobs per acre, shifts in assessed land value, improvements in walkability scores. Employing these metrics in a longitudinal comparative analysis would provide a direct empirical basis for projecting the likely density and land-use outcomes of parking reform in Oklahoma City and for communicating the tangible development benefits of reform to policymakers and the public.

Despite these limitations, this study offers a meaningful and transferable methodological contribution to research on surface parking, mixed-use development, and urban environmental planning in the American Sunbelt. The integrated analytical framework, which combines spatial inventory methods, GIS overlay analysis, remote-sensing-derived environmental indicators, and comparative regulatory analysis, provides a multidimensional approach to assessing the cumulative land-use, density, and environmental impacts of a parking-dominated urban form. While this framework is directly applicable to other mid-sized Sunbelt and automobile-dependent cities facing similar planning challenges and seeking an evidence base for parking policy reform, it can also be adapted for use in cities with varying data availability or different governance structures. Where detailed GIS data or remote-sensing imagery are limited, the core approach can be scaled using alternative data sources, such as municipal records, satellite imagery, or participatory mapping. In municipalities with more centralized or decentralized governance, the framework can be tailored to include policy analysis at the regional level and adapt stakeholder engagement strategies to fit local decision-making processes. These potential adaptations broaden the framework's utility, enabling its application across a diverse range of urban contexts.

CHAPTER 4 APPENDIX

Land Use Type	Spesific Use	Parking Ratio	Minimum Parking	Minimum/ Maximum	Shared/ Joint Parking	Parking Exemptions
Residential	Residential Single-Family Detached Units	2/du + garage		Maximum		
	Residential Multi-Family (1-2 br) Units	Per Efficiency and One Bedroom Unit 1.5/du Per Two or More		Maximum		
	Residential Multi-Family (3+ br) Units	2/du		Maximum		
Mixed-use Zone	Retail	Based on gross leasable area (GLA) Table 10600.2 I: • 1 space per 200 sf for first 12,000 sf GLA • 1/225 sf for 12,001–48,000 sf GLA • 1/300 sf for 48,001–120,000 sf GLA • 1/325 sf over 120,001 sf GLA	1. Parking must be calculated separately for each use (retail, office, industrial, etc.). 2.Required spaces for each use are added together to get the total. 3. Uses cannot be combined to qualify for lower, large-building parking ratios. 4. If any space changes use, parking must be recalculated based on the new use. 5. If a manufacturing or industrial use operates more than one work shift, parking must be sized to accommodate overlapping shifts during changeover periods. 6. If a retail or industrial user can show they need less parking than the standard, the Public Works Director may allow a smaller paved parking area. 7. The remaining land that would have been required for parking must be kept in reserve, later if the business expands or the land use changes.	Mimimum Parking / Direct Approval	The required parking space for any number of separate uses may be combined in a joint parking facility under the following conditions. A.Multiple Ownerships or Structures. Where there are multiple ownerships or structures, each owner shall provide evidence of a permanent legal instrument, which has been filed on record with	1. The number of required parking spaces may be reduced by one space for every two bicycle parking spaces installed
	Commercial Units	Also based on gross leasable area Table 10600.2 II: • 1/200 sf for first 8,000 sf • 1/250 sf for 8,001–12,000 sf		Mimimum Parking / Direct Approval	Shared Parking: Different uses in a mixed-use project may share parking if they operate at different times (e.g., up to 50% of spaces for certain night uses like	2. The number of required parking spaces may be reduced by one space
	Industrial Units	Based on gross floor area (GFA) Table 10600.2 III: • 1 space/500 sf GFA for first 20,000 sf • 1/1,000 sf GFA over 20,000 sf		Mimimum Parking / Direct Approval		3. The number of required parking spaces may be reduced by one space for every one delineated on-street parking space immediately abutting the site, provided:(a)The on-street parking space is located within 200 feet of the building; and(b)Pedestrian access is provided from the on-
	Warehouse Units	1/1,000 sf GFA for first 20,000 sf		Mimimum		

Table 10

Table 11

Reform Area	Policy Change	Best Practice	Reform Outcome
Minimum Parking	No minimum off-street parking requirements	Developers are not required to build a fixed number of parking spaces; parking is optional	Reduces land waste, lowers development cost, supports compact and walkable development
TDM Requirement	Transportation Demand Management (TDM) plans required for certain large projects	Projects must analyze travel demand and show how trips will be managed (parking, transit, bike, walk, etc.)	Shifts focus from supplying parking to managing travel demand
TDM Strategies	Encourages non-car travel and shared mobility strategies	Includes transit incentives, parking cash-out, unbundled parking, shared parking, bike/car-share, etc.	Reduces single-occupancy vehicle trips and vehicle miles traveled (VMT)
Bicycle Parking	Clear standards for short-term and long-term bicycle parking	Requires secure, visible, and sheltered bicycle parking; waivers possible if demand is low	Promotes cycling as a viable transportation mode
Overall Approach	From parking minimums to mobility management	City regulates travel behavior and access, not just parking supply	Supports multimodal, sustainable, people-focused urban development

Table 12

Reform Area	Policy before 2021	Policy Change	Best Practice	Policy Outcome
Minimum Parking Requirements	Minimum parking required by use and location	Eliminate minimum parking requirements citywide	Developments no longer required to provide off-street parking; acknowledges parking will still be built but not mandated	Reduce housing costs, improve land-use efficiency, support walkable urban design
Maximum Parking Limits (General)	Typical max: 1 space per 200 sq ft (non-residential) and 1.5 spaces per DU (residential)	Adopt tiered, stricter maximums by geography and intensity	Core 50 & Transit 30: 1 space per 1,000 sq ft for non-res; Transit 10/15/20: 1 per 500 sq ft; Elsewhere: 1 per 300 sq ft	Prevent over-parking, encourage transit-oriented development
Residential Parking Caps	Max generally 1.5 spaces per dwelling unit	Set clearer caps by area	Proposed: 1.5 spaces/DU in Transit & Core; 2 spaces/DU elsewhere; 3+ unit developments exempt from minimums	Lower housing costs, reduce car dependence
Surface Parking Lots	No clear universal cap in all areas	Institute a maximum of 100 spaces per surface lot	Applies citywide to address outlier large surface lots	Reduce land consumption and support urban form
Bicycle Parking Requirements	Minimums vary by use and location; residential typically 1 space per 2 DU	Increase minimum bicycle parking requirements	Residential: increase to 1 space per DU; Non-res: minimum 3 spaces for most uses; higher for high-demand uses	Support cycling and multimodal transportation
Bicycle Facilities (Showers/Lockers)	Triggered at >500,000 sq ft, downtown only	Lower threshold and apply citywide	>200,000 sq ft; require bike parking, showers, and lockers (scaled by size)	Make biking practical for commuters
Electric Vehicle (EV) Charging	Limited or incentive-based provisions	Require EV charging and EV-ready spaces	10% of spaces with Level-2 chargers; 5% of other spaces EV-ready; smaller projects EV-ready only	Support electrification and reduce emissions
Loading Requirements	Higher loading requirements for some uses (e.g., grocery)	Reduce loading requirements in key cases	Allows negotiation through TDM to lower loading needs, especially for urban sites	Improve development feasibility and urban logistics
Travel Demand Management (TDM) – Applicability	Triggered at 100,000+ sq ft or 50+ parking spaces; traffic studies common	Expand applicability and shift focus to strategies	Minor TDM: 50–249 DU or 25k–199,999 sq ft; Major TDM: 250+ DU or 200k+ sq ft; Discretionary in special cases	Reduce auto trips and vehicle miles traveled
TDM – Structure	Primarily study-based compliance	Points-based strategy system	Strategies include zero parking, transit passes, shared vehicles, pedestrian realm improvements, etc.	Ensure measurable mode-shift outcomes
Overall Policy Alignment	Incremental parking reforms over past decades	Comprehensive reform aligned with Minneapolis 2040 & Transportation Action Plan	Focus on climate, equity, housing affordability, and multimodal access	Advance climate resilience, equity, and complete neighborhoods

Table 13

Reform Area	Policy Changed	Best Practice	Outcome
Minimum Parking (All zones, new development)	Minimums removed	No minimum motor-vehicle parking required citywide	Reduce car dependence; lower development cost; improve land-use efficiency
Maximum Parking (Most zones; varies by context)	Caps strengthened/retained	Parking is capped by maximum limits (varies by zone, transit access, and structure vs. surface)	Prevent oversupply; support walking, biking, transit; protect air/water quality
Transit Proximity (Frequent transit corridors & station areas)	Transit-sensitive standards	Areas near frequent transit allow much lower or zero parking; some structured parking can relax caps	Align parking with transit access
Large Parking Lots (Green Standards)	New environmental requirements	Surface lots ≥ 1/4 acre must provide either 50% tree canopy shade or on-site solar (0.5 kW per space)	Reduce heat island; manage stormwater; support climate goals
Parking Design & Frontage (transit/pedestrian streets	Stronger design controls	Limits on parking between buildings and streets; frontage caps; access and layout standards	Improve pedestrian safety and streetscape quality
Landscaping (Perimeter & Interior)Surface parking, especially >10 spaces	Requirements expanded/clarified	Surface lots require perimeter and interior landscaping (area per space + setbacks)	Visual quality, shade, heat reduction, stormwater control
Transportation Demand Management (TDM)Commercial/mixed-use & multi-dwelling zones (with exemptions)	Broader application	Projects adding >10 dwelling units must meet TDM (via Transportation Impact Review or objective standards)	Reduce single-occupancy vehicle trips; shift modes
Bicycle Parking (Minimums) Most new development	Emphasis maintained	Minimum bike parking required; long-term secure, short-term visible	Support mode shift to cycling, support bicycle use and secure storage
EV-Ready ParkingMulti-dwelling & commercial parking	New/updated requirements	New buildings must provide EV-ready spaces (percent varies by use and size)	Support transition to electric vehicles
Curbside Meter Pricing (Performance-Based)Metered curbside areas	Pricing method changed	Meter rates adjusted to keep 65–85% occupancy (1–3 open spaces per block)	Reduce cruising; improve availability
Curbside Revenue Reinvestment(New meter districts)	Earmarking added	≥50% of net revenue from new meter districts reinvested locally (sidewalks, bike, transit, etc.)	Build local support; fund non-car access
Enforcement Framework (Public right-of-way & city property)	Clearer prohibitions	Detailed rules on where stopping/parking is prohibited; violations ticketed	Safety, access, traffic flow
CFEC CompliancePortland Zoning Code (Title 33)	State-driven reform	City code aligned to remove/restrict minimums, add caps, and green lot standards by 6/30/2023	Cut GHG emissions (transport 38% of OR emissions)

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