Original Research Article

Journal of Urban History
1–22

DOI: 10.1177/0096144220939874
journals.sagepub.com/home/juh
SAGE

Sunlight and Gaslight: Mapping Light in Mid-Nineteenth-Century New York City

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Abstract

This article evaluates the distribution of natural and artificial light in New York City during the mid-nineteenth century. Analysis centers on the interplay between social factors and morphological characteristics of the urban landscape in impacting New Yorkers' access to light. The article employs built environment data and geographic information systems (GIS) mapping methodology as its main approach. First, the article makes an exploration into the distribution of natural light. By analyzing the distribution of built features, the article demonstrates that natural light and darkness dispersed along lines of wealth and poverty, as sunlight commodified into a highly coveted resource. The second section of this article draws from archival sources to construct an unprecedented visualization of the street gas main network in mid-century Manhattan. Analysis demonstrates that spatial patterns of artificial light correlated strongly with commerce, as the new technology was prioritized along commercial streets over residential thoroughfare.

Keywords

sunshine, gas lighting, New York City, historical-GIS

In 1842, Charles Dickens paid a visit to New York City. In his travelogue, *American Notes*, Dickens wrote of Broadway as elegant and sun-filled, a flattering portrayal of the city's prized thoroughfare:

> Was there ever such a sunny street as this Broadway! The pavement stones are polished with the tread of feet until they shine again; the red bricks of the houses might be yet in the dry, hot kilns; and the roofs of those omnibuses look as though, if water were poured on them, they would hiss and smoke, and smell like half-quenched fires.[1]

But then, Dickens turned his attention to the Five Points, the dark heart of the city. Carefully navigating "narrow ways, diverting to the right and left, and reeking everywhere of dirt and filth," Dickens observed "hideous tenements," "lanes and alleys, paved with mud knee-deep," and finally declared, "all that is loathsome, drooping, and decayed is here."[2] Dickens's observations highlighted many urban ailments, but his vivid imagery and sharp characterizations gave

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way to one lasting impression: Gotham, spanning from sunny Broadway to the notorious Five Points, was a metropolis of light and darkness, sunshine and shadow.

In writing of Manhattan along the "lines of light and gloom," Dickens and other authors, from George Foster to James McCabe, laid the roots for a discourse on light that has persisted into the twenty-first century.[3] Indeed, within the contemporary scholarship, historians have given considerable attention to the matter of urban light. The literature has addressed light in both its natural and artificial forms. Discourse on natural light has largely been concerned with the relationship between sunlight and health. Building upon a prolific body of mid-century public health literature, historians like Richard Plunz and John Duffy have famously pinpointed the lack of natural light in New York City tenements as an urban pathology characteristic of the nineteenth century. And more recently, Daniel Freund's scholarship has chronicled the rise of the "darkening city," and highlighted the centrality of natural light to mid-nineteenth-century housing reform movements.[4]

Yet within the existing scholarship, there is a clear schism. While historians like Freund have grappled with the accessibility of natural light, they have paid little attention to the role of artificial light in urban space. Likewise, the story of urban illumination has been written by David Nye and Wolfgang Schivelbusch, who have chronicled the development of artificial lighting beginning in the nineteenth century. In addition, historian Peter Baldwin and geographer Mark Bouman have taken on the nocturnal city in works that set the stage for discussions on the social impact of nocturnal illumination. Yet by focusing on the technical side of artificial light and the changing experience of the urban night, these scholars have confined their analysis to a nocturnal timeframe.[5]

This article makes a contribution to the history of light by joining day and night, and by evaluating the distribution of natural and artificial light in urban space. It suggests that, to the inhabitants of the mid-century city, access to light was dependent on the interplay between social factors and morphological characteristics of the urban landscape. The notion that the built environment plays a role in mitigating light is not a new one; rather, the rise of Manhattan's first zoning law in 1916 directly confronted the role of structures in producing shadows.[6] However, this article brings the conversation of light back to the mid-nineteenth century and evaluates the accessibility of natural and artificial light within Manhattan's largely unregulated built environment.[7]

Working under the premise that variations within the urban landscape produced irregular patterns of light, this article analyzes the allocation of built features in the mid-century city, using geographic information systems (GIS) mapping as its main approach. The article first examines the distribution of natural light by evaluating three key elements of the built environment—street width, building density, and building height. Employing built environment spatial data, this article demonstrates that natural light and darkness dispersed along lines of wealth and poverty, as sunlight commodified into a feature that could be purchased or leased. The second section of this article shifts the analysis from natural to artificial light. It draws from archival sources to construct an unprecedented visualization of gas light placement in Manhattan. Analysis expands upon findings within the existing scholarship to demonstrate that unlike natural light, spatial patterns of artificial light correlated foremost with commercial areas over affluent ones, though lamps were largely absent from Manhattan's poorest neighborhoods. The spatial arrangement of gas lights, therefore, empirically confirms that the technology operated in synergy with the city's economic agenda by illuminating high-value commercial properties and thoroughfares over residential ones.

Natural Light in the Built Environment

The built environment shapes the contours of light and shadows. As the sun rises, and the city comes to life, the width of streets, the density of structures, and the height of buildings form complex patterns of natural light and darkness throughout the urban landscape. The Manhattan built environment underwent a period of transformation during the nineteenth century that had a profound impact on natural light. The population skyrocketed from sixty thousand people in 1800 to half a million by 1850, fueled, in part, by a dramatic rise in immigration.[8] In response to the mass influx of residents, the city broke out of its compact core and expanded north into the realm of the sparsely populated grid.[9] Thus, in a matter of decades, Manhattan's predominantly rural landscape transformed into a densely urbanized one, and the mitigation of natural light proved to be one consequence of Gotham's rapid urbanization.[10]

However, as density intensified and tenement-style apartments became the dominant form of working-class housing, the inaccessibility of natural light in poor neighborhoods grew as a topic of concern among physicians and public health reformers. By the mid-century, deteriorating living conditions in these parts sparked a wave of housing reform.[11] And within the growing public health movement, physicians and city inspectors pinpointed darkness and crowding in neighborhoods like the Five Points as a cause of disease and a cultivator of immorality.[12] As such, the issue of sunlight in nineteenth-century New York has been told through the lens of housing and public health reform movements. Most frequently, historians have considered backlots and cellars, air shafts and darkrooms, and pinpointed the obstructive nature of these tenement features with regard to natural light.

This study approaches the question of natural light distribution from a citywide scale by employing built environment spatial data. The available data allow for natural light to be examined at two levels—horizontally and vertically. By the mid-century, the urban landscape possessed great variation along its horizontal plane; as Manhattan stretched longitudinally, street morphology and built density fluctuated widely. Information on the Manhattan street network and building footprint data in 1852-1854 enables the distribution of narrow streets to be analyzed in conjunction with the density of buildings. Examining these features in tandem identifies the parts of the city where a high concentration of built features obstructed natural light. While Manhattan experienced significant horizontal growth during the first half of the nineteenth century, this horizontal expansion was not accompanied by any remarkable vertical growth. In addition, data on building heights in mid-century Manhattan are limited. However, such information is available for one neighborhood—Manhattan's Fourth Ward. These data will be used to evaluate the role of building heights in shaping sunlight and shadows.

When considering the role of built features in distributing natural light, Gotham's infamous street system offers an ideal place to start. As one of the city's morphological trademarks, the Manhattan grid has been extensively written on, but rarely through the lens of light. The origins of the Manhattan grid can be traced back to 1807, when the New York State Legislature appointed three commissioners to design a plan for the future growth and development of the city.[13] The ensuing plan, known as the Commissioner's Plan of 1811, offered a stark departure from the existing street system; instead of extending the narrow, angular streets of Lower Manhattan, the commissioner proposed an orderly grid system, consisting of perpendicular streets and avenues.[14]

Not only did the establishment of the grid street plan have notable implications for real estate and property development, but the grid also had a profound impact on the distribution of natural light. When instituting the grid layout, the commissioners outlined criteria for street widths and block dimensions. On the grid, north-south avenues were to measure 100 feet wide, and east-west cross streets were to measure 60 feet wide. In addition, by the mid-century four major cross streets punctuated the grid at 14th, 23rd, 34th, and 42nd Streets, each measuring 100 feet wide. Though block dimensions varied slightly, they averaged 200 feet in their north-south lengths, and between 610 and 920 feet along their east-west lengths.[15] Thus, in contrast to the southern part of the city, the newly gridded region of Manhattan created an unprecedented urban order that prioritized uniformity and set a standard for the quantity of space and light that was to exist within the streets.

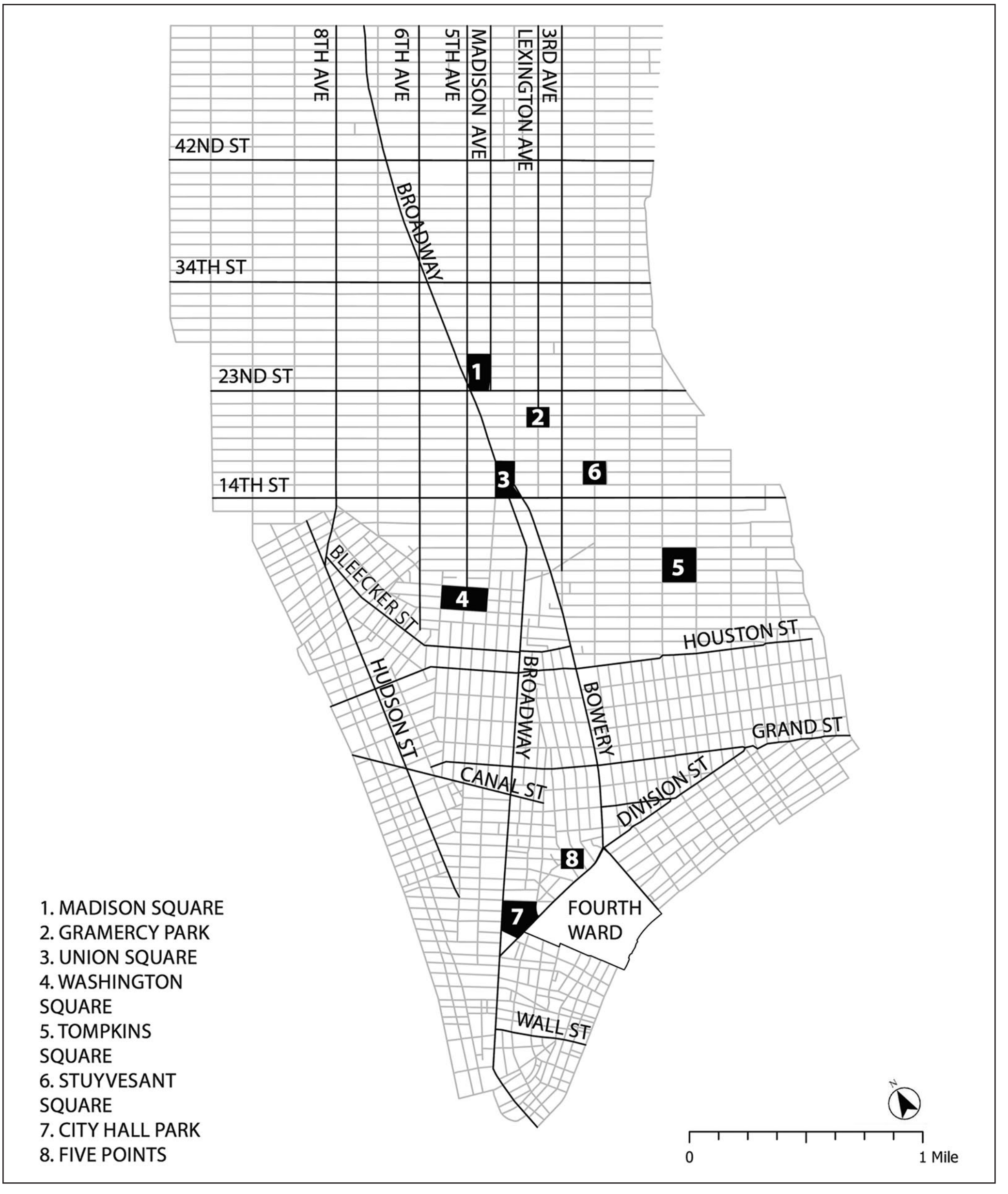

Figure 1. Orientation map.

However, by the mid-nineteenth century, Manhattan had yet to grow into its street plan. Though the commissioners had prescribed a comprehensive grid system that extended through 155th Street, the northern edge of significant development in 1850 was 42nd Street. Consequently, Manhattan comprised two morphologically distinct halves—the "pre-grid" to the south of Houston and the "post-grid" to the north—which were roughly equal in extent.[16] (Figure 1) displays the historic street network, with pertinent streets, avenues, and parks labeled for orientation. The morphological split between the "pre-grid" and the "post-grid" provides ideal conditions to compare access to light in two street systems located within the same urban context. To explore

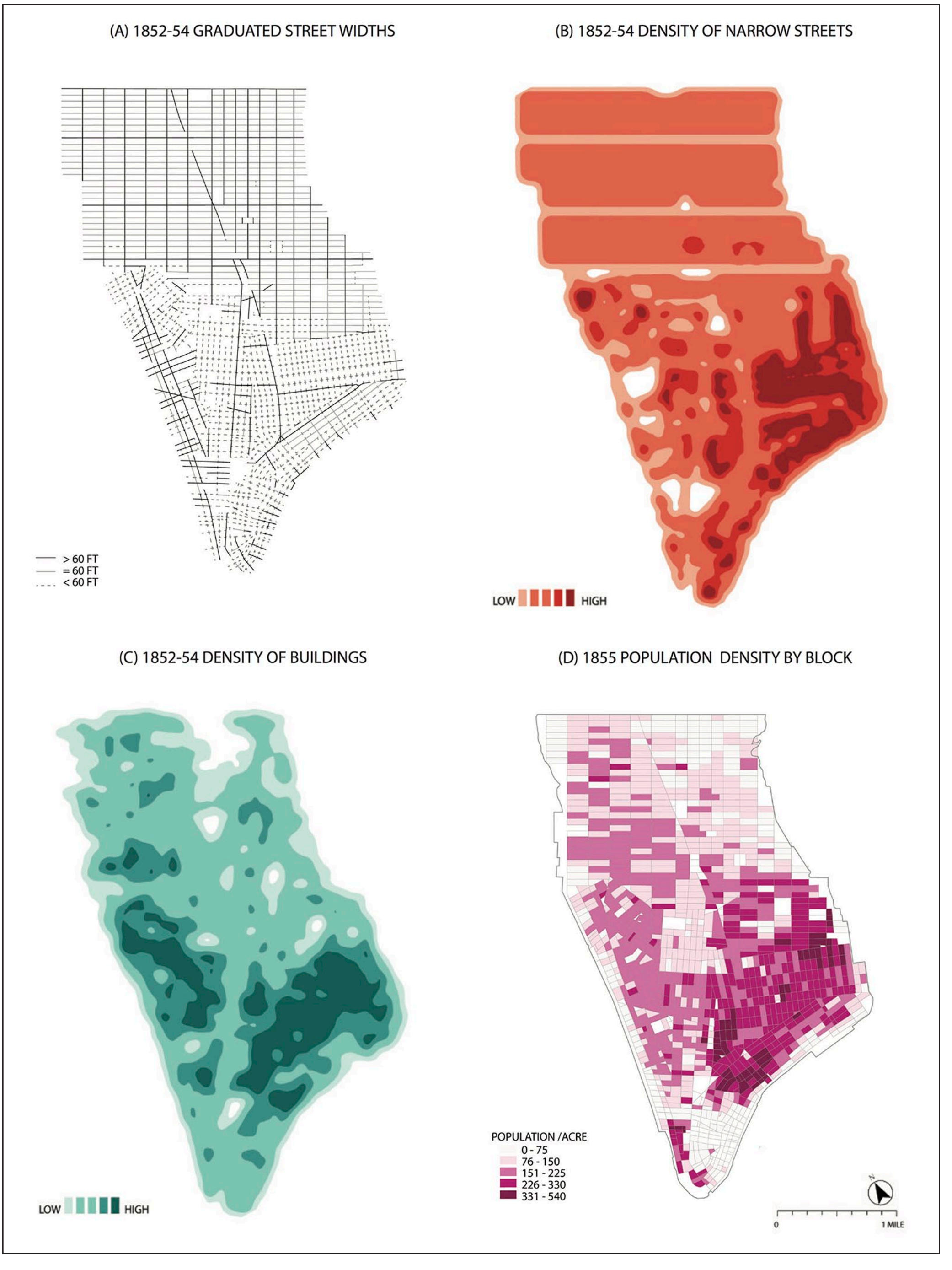

Figure 2. (A) Graduated street widths; (B) density of narrow streets; (C) density of buildings; (D) population density by block.

the distribution of streets, using width as an index for access to light, the street network data were organized into three categories: streets greater than 60 feet wide, equal to 60 feet wide, or less than 60 feet wide (Figure 2A).[17] Figure 2A clearly shows the unequal distribution of wide streets in Manhattan, particularly between the "pre-grid" and "post-grid." Above 14th Street, the breath and uniformity of "post-grid" streets suggest the ample circulation of natural light, due to minimal disruption by built features. Comparatively, the limited width of streets within the "pre-grid" suggests poor natural light distribution.

The uniformity of the Manhattan grid makes the "post-grid" street system an intriguing case with regard to light. In 1811, the commissioners established blocks oriented orthogonally to the Hudson and East Rivers. Due to the angle of the sun and Manhattan's position in the northern hemisphere, shadows in the city were cast to the north. The east-west orientation of blocks thus had a two-tiered effect upon the city; while south-facing structures had direct access to sunlight, north-facing structures did not.[18] Within the "post-grid," the breadth of streets reduced the impact of shadows, but access to direct sunlight was largely binary along the east-west length of blocks. Throughout the rest of the city, fluctuation in street directionality created more varied access to sunlight.

However, while street directionality within the "pre-grid" was nonuniform, street widths were likewise irregular and narrow streets concentrated within specific zones. In particular, the variable street morphology of the "pre-grid" produced an exceptional concentration of narrow streets in the Lower East Side (Figure 2B).[19] As the maps reveal, not all streets in the "pre-grid" were narrow. Rather, Figure 2A shows that wide streets were abundant along the waterfront of Lower Manhattan, a distinct feature of the city's southern half. However, Figure 2B presents the overarching disparity between the "pre-grid" and "post-grid" with regard to natural light; as seen in the figure, narrow streets and the accompanying darkness congregated in the Lower East Side, while a regular pattern of wide streets enabled light into the city's gridded half.

While analysis of street morphology reveals some distinct patterns, the question of natural light distribution requires that other built features be taken into account. Between 1833 and 1862, the city's footprint increased by over 2,000 acres.[20] As Manhattan stretched along its longitudinal axis, the concentration of buildings throughout the urban landscape varied immensely. Consequently, built density played a vital role in establishing patterns of light and darkness. Figure 2C employs building footprint data to display the density of structures in Manhattan during the mid-century.[21] The figure reveals that the areas with the highest concentration of buildings were largely located in the city's southern half. In particular, Gotham's low eastern wards contained some of the most densely built regions. Examining the location of narrow streets in conjunction with the density of buildings reveals the parts of the city where the accumulation of built features was acute. When viewed in tandem, Figures 2B and 2C notably mirror one another, particularly along the east side. It thus becomes evident that Gotham's low eastern wards contained high concentrations of narrow streets and structures, suggesting that these parts were subjected to disproportionate shadows.

These findings are most significant, however, when Gotham's social geography is taken into account. To explore socio-spatial patterns in relation to the distribution of natural light, this study will appeal to fine resolution population density mapping methodology. As Manhattan grew exponentially during the nineteenth century, extreme density and spacious living conditions characterized the two ends of the residential spectrum.[22] While wealthy New Yorkers could afford the new, single-family homes constructed in elite, uptown neighborhoods, the growth of the city's population overwhelmed the existing housing supply. To satisfy residential demand, existing construction was cut up by landlords into one- or two-room apartments, and middle and working-class families were driven into tenement-style residences in neighborhoods like the Lower East Side.[23] In addition, new immigrant populations arriving in New York settled together, creating notable ethnic enclaves also within the city's low eastern wards.[24] As these parts became denser and poorer, many affluent households abandoned their downtown landholdings in favor of low-density uptown residential enclaves.[25] Consequently, population density patterns can be attributed to Gotham's widening socioeconomic schism. High density can be interpreted as a corollary of poverty and Figure 2D, which estimates population density by block in 1855 can correspondingly be employed as an indirect measure of unequal living conditions.[26]

By presenting density at the block level, Figure 2D conveys citywide residential density information with a degree of detail indiscernible in ward-level maps. While the figure illustrates the nuanced development of high-density and low-density zones, the map unquestionably conveys that Manhattan's Lower East Side contained the highest number of people per acre. In addition, the Fourth Ward and the areas adjacent to City Hall, including the notorious Five Points, also had exceptionally high population densities. In contrast, areas north of 14th Street had comparatively low population densities. By accentuating the exceptionally high density of the Lower East Side and its adjoining areas, Figure 2D reveals growing spatialized class divisions. And as narrow streets and built density corresponded with this area of high population density, spatial analysis suggests a correlation between poverty and darkness, and conversely affluence and light. Thus, by the mid-century, light and air were not assured in all households. Rather, access to light came with a price tag, and natural light, in addition to amenities like water and plumbing, defined the differences between middle-class and working-class housing.[27]

The spatial data have one limitation. While Figures 2C and 2D capture the crowding in Manhattan's low, eastern wards, and the movement of wealthy New Yorker's to uptown neighborhoods, they only encompass the island's region of significant development. Thus, the maps fail to capture Manhattan's periphery—the urban borderland. During the mid-century, a growing belt of shantytowns dotted the landscape on the edge of the city.[28] Clustering on marginal land in the north, shantytowns housed a network of immigrant and African American communities, and offered poor New Yorkers access to a semi-rural lifestyle. As unplanned settlements, they were found on all types of land and often took advantage of unleveled ground and rocky outcroppings where landowners had yet to level their properties to street grade.[29] Thus, from a morphological standpoint, shantytowns stood in sharp contrast to the order and regularity of the Manhattan grid. And in terms of sunlight, shantytowns offered poor New Yorkers a reprieve from the physical darkness that plagued neighborhoods like the Five Points and the Lower East Side.

However, despite the accessibility of sunlight in Manhattan's semi-rural north, shantytowns could not shake their reputation for darkness; though the correlation between darkness, density, and poverty did not apply to these settlements, shantytowns stood in sharp contrast to the chic neighborhoods appearing uptown and were thus commonly depicted in newspapers and magazines as destitute, and morally dark.[30] Indeed by the mid-century, darkness as a metaphor for immorality was widely popular, and writers from Charles Dickens to George Foster probed at Gotham's changing social geography by depicting Manhattan along the lines of light, darkness, and shadows.[31] In the case of shantytowns, darkness was simply metaphoric; while perhaps the homes themselves were gloomy, windowless affairs, the lack of density and crowding in the surrounding landscape suggests that shantytowns uniquely gave plenty of poor New Yorkers access to ample sunshine. However, in other parts of the city, spatial analysis has demonstrated that areas reputed for moral darkness—mostly poor, immigrant neighborhoods like the Lower East Side—were physically dark as well, as their accumulation of morphological features suggests the propensity for shadows.

Thus far, the distribution of natural light has been explored at a citywide level. Spatial analysis has demonstrated that crowding and darkness in the "pre-grid" intensified during the mid-century while the wide streets and low density of the "post-grid" aided in the circulation of natural light. However, the significance of darkness remains in question. To some, the light-darkness paradigm was simply a handy literary device. But to others, particularly physicians and public health reformers, the persistent lack of sunlight in parts of Manhattan was a troubling health concern.[32] By the mid-century, discourse on the importance of sunlight could be found within the public health literature. Appearing first in Dr. John H. Griscom's 1845 report, and again in the 1865 Citizens' Association report, both landmark surveys on housing and sanitary conditions in the city suggested that darkness had consequences for physical and moral health.[33] In addition, the Citizen's Association report provides unique data on another morphological feature—building heights. Such data allow for an investigation into the verticality of structures and their impact on the distribution of natural light.

Within the Citizens' Association report, Dr. Ezra Pulling's survey of the Fourth Sanitary Inspection District, which comprised all of the Fourth Ward, includes a detailed map, complete with statistics on building types, number of residents per building, and most significantly for this study, building heights in number of stories. While Pulling's map only encompasses the Fourth Sanitary Inspection District, the findings from this map are applicable at a broader scale. Within the 1865 Citizen's Association report, descriptions of other districts, such as the Seventh and Tenth Sanitary Inspection Districts, suggest that conditions within were comparable to the Fourth. Pulling's map is thus indicative of the types of conditions found throughout Lower Manhattan's residential regions. The map reveals that the Fourth Ward comprised over 1,500 buildings in 1865. Pulling categorized 50 percent of these buildings as tenements, and another 40 percent as businesses, churches, or schools (Figures 3A and 3B).[34] The average building height in the ward was 3.25 stories tall, and only 20 percent of all buildings measured over four stories tall. Thus, vertical variability within the ward was limited.

Spatial analysis suggests that in the Fourth Ward, significant building height came from structures along the heavily commercial Pearl Street, and from other retail-oriented catchment areas. Within the study area, buildings over four stories tall clustered along the western side of the ward (Figure 3C). Over half of these buildings were businesses, churches, or schools. In contrast, tenements clustered to the south-east of Pearl Street, suggesting that tenement structures were shorter on average than their commercial or mixed-use counterparts (Figure 3A).[35] However, these building height patterns were not unique to the Fourth Ward. During the 1830s, most new commercial structures measured at least three stories tall. Due, in part, to the enlargement of commercial buildings, new residential structures also began to increase their building heights. By the late 1830s, fine three and four-story town houses emerged on Broadway and Fifth Avenue, and in the vicinity of Union and Washington Squares. Three-story buildings also began to appear in the Lower East side, filling in vacant lots and replacing two-story artisan homes. However, the pace of construction in old, working-class neighborhoods was slower than in the north. In addition, landlords sought to increase the productivity of their old housing stock by adding rear houses and courts. As back-lot construction proliferated, the urban landscape cluttered, producing patterns of built density apparent in Figure 2C.[36] To explore the interplay between building heights, built density, and street morphology on natural light, this study will turn to a three-dimensional rendering of the Fourth Ward.

The building height data allow for a complete reconstruction of the Fourth Ward, which will be used to simulate the role of the urban landscape in casting sunlight and shadows. Figure 4 depicts the three-dimensional rendering and visualizes shadows in the ward at three times of day: 9:00 a.m., 12:00 p.m., and 3:00 p.m.[37] As the sun moved from the east at sunrise, to the west by sunset, shadows moved from west to east. In visualizing the natural movement of shadows, Figure 4 exhibits the role the built landscape played in mitigating light. In the morning, most of the streets were cast in some shadow (Figure 4B). As seen in the figure, the part of the ward exempt from shadows was the north-west oriented Chambers Street, which bisected the ward at a diagonal. Also notably unshaded were parts of the exceptionally wide Bowery and Pearl Streets. Figure 4B thus suggests that while shadows pervaded in the morning, wide streets and streets not oriented along a north-south binary were largely spared and received some direct sunlight. By mid-day, shadows in the ward had receded overall (Figure 4C). However, most north-facing facades remained shaded, while south-facing facades, by and large, were shadow-free. Here, the benefit to

Figure 3. (A) Percent tenement buildings per block; (B) percent commercial buildings per block; (C) density of buildings over 4 stories; (D) buildings with known cases of typhus, typhoid fever, and smallpox.

south-facing structures in Manhattan is revealed; throughout the day, south-facing facades received considerable direct sunlight, while north-facing facades received none. However, sunshine and shadows were never absolute. By the afternoon, shadows pervaded everywhere (Figure 4D). While some south-facing structures remained in sunlight, narrow streets and significant built density meant these structures were often cast in the shadow of adjacent buildings.

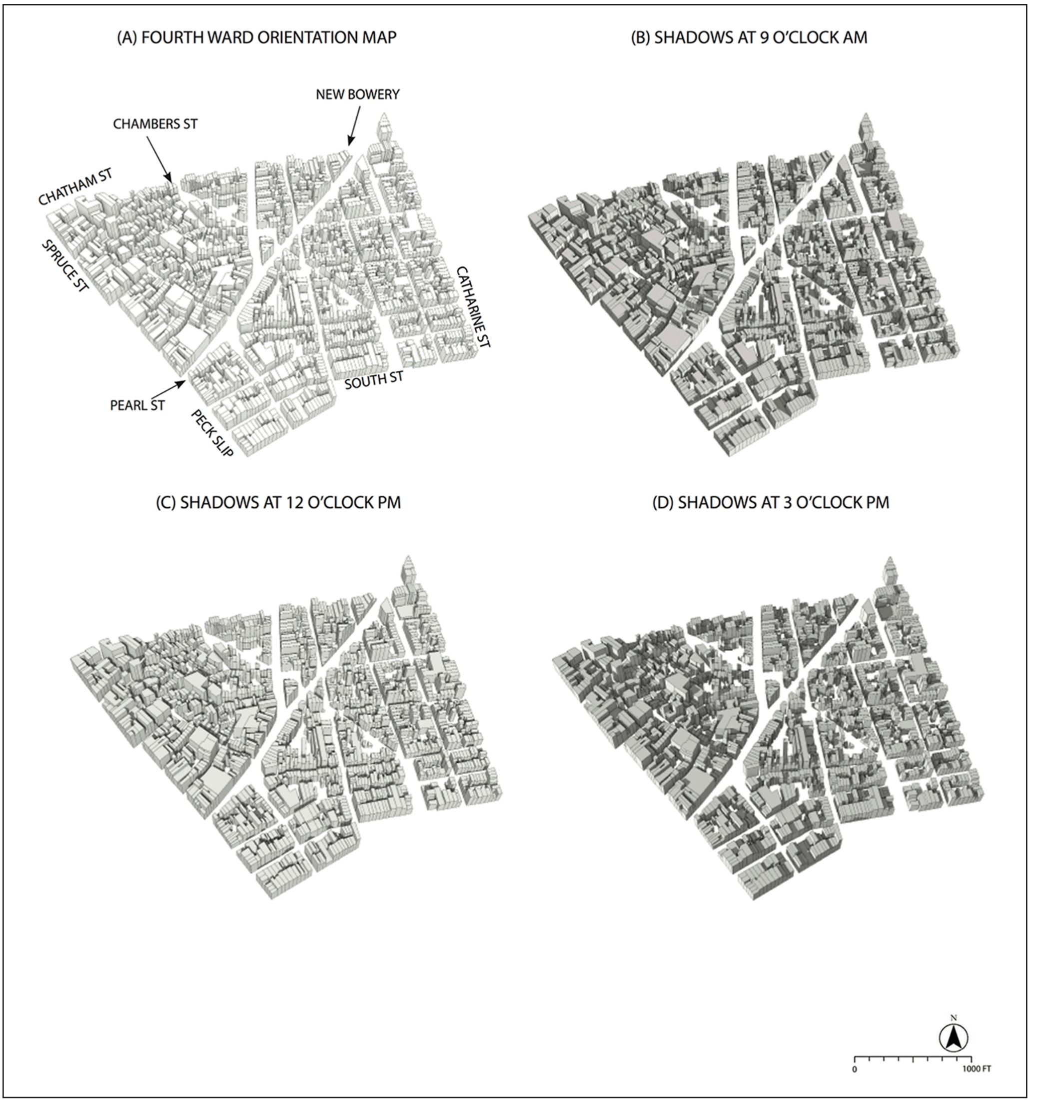

Figure 4. (A) Fourth ward orientation map; (B) shadows at 9:00 a.m.; (C) shadows at 12:00 p.m.; (D) shadows at 3:00 p.m.

In the Fourth Ward, the highest density blocks were composed primarily of commercial or mixed-use structures. However, residential blocks also carried significant built density, and the irregular placement of construction within these blocks resulted in the nonuniform diffusion of natural light. When surveying an intensely built residential block, Inspector Ezra Pulling described in his report, "Through a narrow alley, we enter a small courtyard which the lofty buildings in front and rear keep in almost perpetual shade. Entering it from the street on a sunny day the atmosphere seems like that of a well."[38] Figure 4 displays that such rear lot construction was detrimental to natural light, particularly within the ward's north-west corner. A high concentration of rear lot tenement construction within this part of the ward contributed to significant built density. Yet the considerable height and building volume of commercial blocks along the ward's western edge was the most problematic, as these buildings produced an abundance of shadows for the low-rise tenement structures within the neighboring blocks to the east. Thus, as commercial properties maximized the capacity of their building lots, they disadvantaged proximal residential development with regard to sunlight.

By the mid-nineteenth century, density and crowding consumed the Fourth Ward and other neighborhoods in the Lower East Side, and public health and housing reformers openly worried about the lack of fresh air and sunlight that tenements afforded. At a time when the miasmatic theory of disease prevailed, "the poisonous air, the darkness, and the damp" nature of tenement apartments were hailed as the ultimate sanitary evil.[39] Thus, the importance of sunlight derived from the notion that light was essential to physical and moral health. Pulling's sanitary map of the Fourth Ward allows for the relationship between darkness and disease to be considered; in addition to the invaluable building height data, Pulling's map includes coding for tenements that had known cases of typhus, typhoid fever, or smallpox in the previous year. Figure 3D displays buildings in the Ward that were flagged for disease. The map reveals that buildings with known cases of infectious disease were mostly found in high density, residential blocks. Of the 86 buildings, nearly 15 percent were located in rear-lots and another 25 percent were north-facing structures. Consequently, nearly 40 percent of these buildings were likely subjected to near constant shadow. And while the other 60 percent of structures did not have a notable predisposition for exceptional darkness, only 20 percent of buildings with disease were south-facing, suggesting that shadows were abundant within the majority of the condemned structures.

To mid-century physicians and reformers, brightness seemed to suggest wellness, and spatial analysis indicates a correlation between darkness and disease, though the data are limited. Of course, darkness was not the cause of disease, but merely a symptom of its mechanisms, specifically crowding and unhealthy living conditions which often accompanied poverty. And regardless, these findings do not change the way darkness was understood. During the mid-century, darkness not only had implications for physical health, but was also regarded as the root of "moral degradation."[40] As a geography of sunshine and shadow took root in the urban landscape, locations of darkness became firmly attached to notions of vice, while light embodied virtue and morality. The Fourth Ward, a site of deep shadow in both popular literature and public health works, presents one such location where pervasive darkness suggested a propensity for vice among the inhabitants of this dark space—the poor, often foreign-born groups that populated this low, eastern ward. The implications of darkness thus imposed an additional geography of light upon the city—a moral geography—that imperfectly matched spatial patterns of light as governed by the built landscape.

This study has focused on the distribution of one environmental resource in the mid-century city—natural light. Spatial analysis reveals that the accumulation of morphological features in Gotham's low, eastern wards made these parts prone to darkness and shadows. In contrast, the less intensely built "post-grid" region of the city granted residents improved access to light. In an urban landscape that widely reflected class inequalities, light was thus not assured in all households, but remained an amenity disproportionately enjoyed by the wealthy. Given the spatial correlation between poverty and darkness, and affluence and light, writers and journalists widely wrote of darkness as a symptom of working-class immorality. However, small-scale, high-resolution analysis of the Fourth Ward, as seen in Figure 4, complicates their generalizations of omnipresent darkness. By revealing nuances to the distribution of sunlight, analysis indicates that high variability within the urban landscape made the diffusion of natural light nonuniform. And, of course, light in the city was always changing; as the sun went down, and sunlight gave way to gas light, the geography of light in the mid-century metropolis changed once more.

Artificial Light and the Built Environment

To comprehend how New Yorkers experienced light during the mid-century, it is imperative to explore light in both its natural and artificial forms. Similar to natural light, artificial light underwent a major transformation during the mid-nineteenth century, which uniquely made the issue of unequal light distribution relevant, both during the day and at night. Prior to the invention of gas lights, nightfall plunged the streets of New York into nearly complete darkness; though oil lamps were scattered throughout the city, casting compact spheres of light within the streets, these lamps were few and weak, and most were extinguished after midnight or on moonlit nights.[41] Consequently, gas light technology revolutionized Manhattan's system of public lighting and established a new urban geography of light and dark within the metropolis.[42]

The prospect of lighting New York City streets with gas first entered the conversations of the Common Council in 1823, when the pioneering New York Gas Light Company was granted a charter that stipulated exclusive privileges to install gas mains in Lower Manhattan south of Grand Street through 1853.[43] In 1830, the Common Council granted privileges to the competing Manhattan Gas Light Company to lay gas pipes in the city north of Grand Street.[44] Gas lights were first introduced into the Manhattan streetscape in 1827, when 120 lamps were installed on Broadway from Battery to Grand Street.[45] Throughout the following decades, gas mains were gradually installed into select streets throughout the city at the approval of municipal authorities.

As gas lights emerged throughout the city, they seemed to transform the urban landscape after dark; the brightness of gas lights obliterated the opaque night, indicating their ability to offer surveillance and security within the streets.[46] As declared by the New York Times, "if we had an abundance of light in the streets at night, the rascality which lurks in the dark corners would find no place to hide."[47] Indeed since their inception as a method of illuminating New York City streets, gas lights were justified by the City Council as a means of reducing crime by "exposing offenders" and preserving peace.[48] As gas lights slowly spread throughout the city, the municipal government affirmed the necessity of their installation for security, protection, and control. As stated by the Board of Aldermen, it was believed that "if the streets were better lightened, it would operate directly to the diminution of crime, by exposing offenders to the detection."[49] The Common Council also expressed this conviction when they stated that "comfort and convenience, and the preservation of the peace in the night requires that it should be done."[50]

As the municipal documents suggest, the New York City Council sanctioned the installation of public gas lights with the hope that improved lighting would tame the unruly night. Existing scholarship on the urban night has touched upon the relationship between light, crime, and policing. Historian Mark Bouman has written that gas lights, by conquering darkness, were regarded as powerful tools in deterring crime and preserving security.[51] In chronicling the growing demand for street lighting in nineteenth-century cities, Bouman states that the policing function of lamps dominated the lighting debate from the start. However, Bouman reveals that as gas lamps spread in cities, the areas where people did not feel "safe" were lit first, and the areas where middle- and upper-class people were likely never to go were lit last.[52] And though the ideology that light could tame the night prevailed throughout the early nineteenth century, gas lights were reserved largely for downtown commercial and entertainment districts.

Additional scholarship on the topic of nocturnal illumination supports Bouman's assertion that gas lights were predominantly found in commercial areas. Scholars like Peter Baldwin and David Nye have written extensively on urban lighting in American cities during the nineteenth century. While Baldwin touches upon the role of gas lights in urban policing, his work notably provides evidence that gas lights made new institutions like "theaters, saloons, shops, [and] restaurants" economically viable, as the new lighting system precipitated an increase in street traffic.[53] While Nye's scholarship foremost chronicles the technological progress of artificial illumination, his work also highlights the impact of new illumination systems in growing the commercial sphere.[54] Thus, these scholars have shown that gas lights were disproportionately found along busy streets in the commercial sectors of nineteenth-century cities.[55]

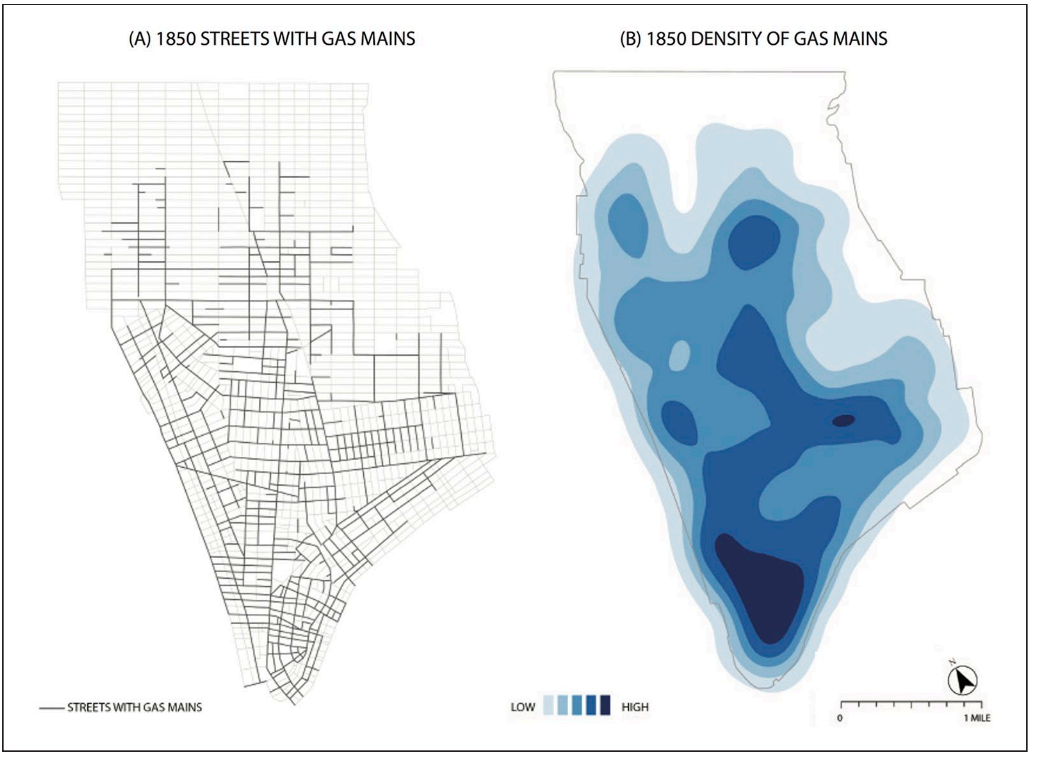

Figure 5. (A) Streets with gas mains; (B) density of gas mains.

This study takes up many of the points made by these authors, while employing spatial research methods to explore the topic of artificial light in the historical city. GIS mapping allows for an estimated reconstruction of the gas main network in Manhattan. By 1850, 285 gas main segments had been installed in the streets, illuminating over 5,000 lamps (Figure 5A).[56] While the documents of the municipal government emphasized the importance of installing gas lamps under the pretense of improving nighttime security, spatial patterns of gas light installation corroborate the existing scholarship. As Figure 5A demonstrates, gas mains were notably absent from areas like the Five Points and the Lower East Side, sectors of the city synonymous with poverty, immorality, and crime. Rather, the region with an unparalleled concentration of gas mains was Lower Manhattan, a notable commercial and business district, thus indicating a powerful relationship between light and commerce.

Still, a spatial approach provides crucial insight into the geography of light and darkness in the mid-century city. In addition, urban land use data, derived from the 1852-1854 Perris Fire Insurance Atlases, allow for nuanced analysis of the streets that received the new technology, providing confirmation that gas lights were foremost found along commercial thoroughfares. Figure 6A displays streets with gas lamps in conjunction with land use data; on this map, buildings are categorized based on their designated land use.[57] Outlined buildings indicate that they were commercial or mixed-use (commercial and residential) in 1852-1854, and non-outlined buildings were noncommercial (industrial, residential, educational, worship). By the mid-nineteenth century, New York possessed a consolidated central business district that was almost entirely composed of commercial buildings. Within this business district were a number of specialized zones.[58] Financial services clustered along Wall Street and administrative services around City Hall. A dry goods and shopping district consolidated to the north along Broadway, while wholesale provisioning could

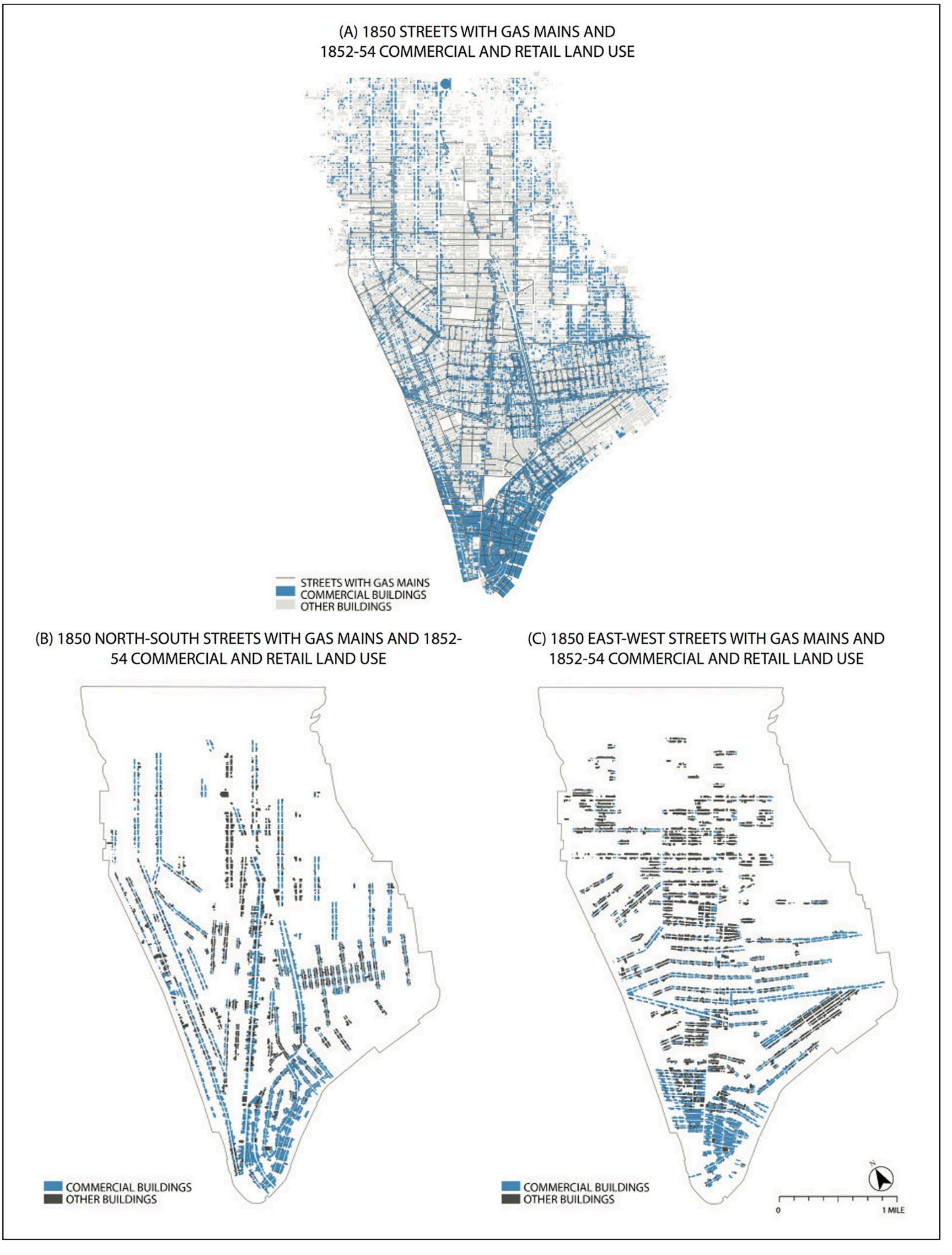

Figure 6. (A) Streets with gas mains and commercial land use; (B) north-south streets with gas mains and commercial land use; (C) east-west streets with gas mains and commercial land use.

be found near Washington and Fulton Markets, and warehouses clustered in the south along the East River.[59] As seen in Figure 6A, gas lights could be found in all these areas, indicating a positive correlation between artificial light and commercial land use.

While Figures 5A and 6A support that gas mains predominantly clustered in the highly commercial Lower Manhattan, spatial analysis suggests that the ties between gas mains and commercial land use remained strong beyond the city's compact commercial core. During the mid-nineteenth century, the commercial geography of Manhattan north of Houston street profoundly shifted, as retailers moved to north-south avenues from smaller crosstown streets.[60] Thus, to further explore the relationship between streets with gas lights and commercial thoroughfares, the gas light data were divided based on the geographic orientation of the streets that received light. Figures 6B and 6C present streets with gas mains that ran north to south and east to west, respectively, and their corresponding land use data.[61] As Gotham's retail geography shifted, not all avenues attracted street commerce. In particular, avenues toward the center of the island, such as Fifth, Madison, Fourth, Irving Place, and Lexington, lacked virtually any business activity; by intersecting the affluent enclaves surrounding Washington, Gramercy, Union, and Madison Squares, commercial activity along these avenues was often impaired by restrictive covenants, which barred nonresidential land use to preserve architectural uniformity and social exclusivity.[62] However, as urban development codified into the regularized street system of the Manhattan grid, Third and Eighth Avenues became some of the busiest commercial thoroughfares. Intersections along avenues running north to south occurred three to four times more frequently than on streets running east to west. Consequently, once the population of Manhattan began to move north, avenues ensured retailers access to several times more customers than if they were located on crosstown streets. In addition, the greater width of avenues allowed for a higher volume of pedestrians and street traffic, securing north-south avenues with an additional advantage as commercial thoroughfares.[63] Figures 6B and 6C display this profound shift in retail geography; while commerce stretched along the entirety of north-south oriented thoroughfares as displayed in Figure 6B, Figure 6C reveals that on east-west oriented cross streets, commerce was notably lacking north of Bleecker Street.

Examining the geographic orientation of streets with gas mains in conjunction with urban land use data attests to the enduring relationship between commerce and gaslit streets. Figure 6B displays that 46 percent of gas main segments were installed in streets running north to south, and Figure 6C displays that 54 percent of gas main segments were installed in streets running east to west.[64] In 1850, roughly one-third of all streets in Manhattan ran north to south, while two-thirds ran east to west (above Houston street the ratio of east-west streets to north-south streets was even higher). Given the greater number of east-west streets, a higher number of gas mains on streets running east to west is logical. However, the data indicate that gas mains were installed on north-south avenues and east-west cross streets in roughly equal numbers, indicating that gas lights were prioritized in north-south corridors.

In addition, an investigation into the composition of buildings along gaslit streets further quantifies the relationship between light and commerce. Analysis of urban land use data indicates that gas light served a large number of residential properties, particularly along east-west oriented cross streets where 50 percent of structures were residential. However, on these east-west gaslit streets, nearly 40 percent of properties were commercial or mixed-use (residential with ground-floor retail). And along north-south streets with gas lights, nearly 60 percent of properties were commercial or mixed-use, while only 33 percent of buildings were residential (no ground-floor retail).[65] Thus overall, the land use data indicate that commercial properties were served at a proportionately higher rate than residential ones. By the mid-century, over 40 percent of all commercial buildings and one-third of all mixed-use buildings in the city were located on north-south gaslit streets. In addition, 36 percent of all commercial buildings and a quarter of all mixed-use buildings were located on east-west gaslit streets. Consequently, over 75 percent of all commercial buildings and nearly 60 percent of all mixed-use buildings in Manhattan fronted gaslit streets. In contrast, only 28 percent of the city's residential buildings and 17 percent of industrial buildings faced gaslit streets, illuminating Manhattan's profit-based agenda as gas lights were predominantly found along commercial thoroughfares.

These findings substantiate and nuance the findings of the previous scholarship by quantifying the relationship between commerce and artificial light; while the Common Council promised gas lights to enhance citizen safety, spatial patterns of gas mains instead suggest that the new illumination technology offered protection to properties within the city's centralized business district and along other commercial thoroughfares. However, it is pertinent to acknowledge the role retailers played in attracting the new technology. Although gas lights first appeared in New York in 1827, their installation was piecemeal. Prior to laying gas mains, petitions for gas light installation were submitted to the Committee on Lamps and Gas, a subcommittee of the Common Council. Once a petition was approved, the gas companies could then begin to install their cast-iron pipes, establishing a gas distribution network.[66] Despite the municipal council's professed interest in accommodating the community at large, aldermen had to inquire into whose property benefited when deciding where to install gas mains and other new utilities. Public works projects were then funded through the system of special assessment; adjacent proprietors were assigned the cost of introducing utilities, because despite what larger public advantages the amenities provided, the property holders were the ones to benefit immediately from the enhanced convenience, and rising rents and land values that the development afforded.[67] While aldermen had the legal right to initiate their own projects, in practice the Common Council waited for the petitions of private individuals before they took action. In addition, corruption within city government was widespread; by the mid-century, market-oriented aldermen frequently sold off public assets to the highest bidder, in a practice that earned the Common Council the nickname "Forty Thieves."[68] Thus, patterns of gas main installation, in addition to other public works projects, were shaped by the local government; in a political process that offered no system for consulting property-less New Yorkers, decisions regarding the location of utilities rested on the aldermen, who weighed proprietors' competing petitions.[69] Thus, the high concentration of gas mains in commercial areas reflects an interplay between municipal government and property owners, whose joint actions led the gas light companies to favor commercial areas.[70]

Yet this relationship between gas lights and commerce raises another question: if gas mains dominated commercial areas at the hand of landowners, were they favored in affluent areas as well, where propertied New Yorkers possessed the means to petition? To assess the spatial relationship between artificial light and class, we return once more to the population density map (Figure 2D). As previously discussed, population density in nineteenth-century Manhattan was a fairly accurate representation of socioeconomic standing, as high density can be interpreted as a corollary of poverty.[71] Thus, examining the density map in conjunction with streets with gas lamps allows for an exploration into the relationship between affluence and artificial light. Figure 5B displays the density of streets where gas mains had been installed by 1850.[72] When comparing Figure 2D with Figure 5B, there is an inverse relationship between the two maps. While the Fourth Ward and the Lower East Side possessed high population densities, they contained low concentrations of gas mains. In comparison, the low-density regions south of Chambers Street and north of 14th Street contained relatively high concentrations of gas mains.

These areas of high gas main density are notable for separate reasons. First, in the mid-century, commerce and industry dominated Lower Manhattan and created a functionally specialized area that encompassed the downtown central business district and the industrial waterfront. Residential land use and population density within Lower Manhattan was consequently minimal. The high concentration of gas mains in this area thus speaks again to the relationship between artificial light and commerce; the compelling presence of artificial illumination in a region dominated by banks, warehouses, and other citywide profit-producing resources suggests that the transactional focus of the city warranted the new technological amenities. In addition, the low population density and high gas main density in the central-northern areas above 14th Street speaks to the relationship between affluence and artificial light; the high concentration of illuminated streets in the neighborhoods surrounding Washington Square Park, Gramercy Park, and southern Fifth Avenue, all known affluent enclaves, reveals a positive correlation between affluence and access to light.

The spatial patterns of gas light installation seen in Figure 5B, therefore, demonstrate that gas lights did not benefit all New Yorkers equally. Analysis suggests that the City Council, in part, fulfilled their objective to bring “comfort and convenience,” and enhanced nighttime security on behalf of some wealthier residents.[73] However, the inverse relationship between population density and density of gas mains suggests that the City Council failed to address the second goal of gas street lighting; though they stated “the diminution of crime” as one of their expectations for the improved lighting technology, light was not installed in the city’s most notorious segment—Five Points—or in the densely packed Lower East Side. Instead, gas lights foremost offered their protection to commercial properties, particularly within the city’s centralized business district. Thus, the spatial placement of gas lights in Manhattan illuminates the city’s prioritization of profit-producing resources, the lifeblood of the metropolis, and consequently first priority within the gaslit city.

Conclusion

New York is a metropolis of light and shadows. For in the city, light does not touch all streets evenly but filters into some spaces while leaving others in darkness and gloom. New York City provides an ideal backdrop to explore the history of urban light; a dynamic metropolis, marked by its growth and constant want for more living and working space, the accessibility of natural light has been a topic of concern since the mid-nineteenth century. In addition, Manhattan provides ideal conditions to explore natural and artificial light in tandem, for the unprecedented rise of gas light technology during the mid-century uniquely made the issue of unequal light distribution relevant, both during the day and at night. Mapping methodology brings a new framework to the study of light in the historical city. This new approach allows for explorations of light to go beyond narrative descriptions, by incorporating built environment spatial data.

The article first demonstrates that natural light distribution in Manhattan was contingent on the morphological idiosyncrasies of the urban landscape. Spatial analysis reveals that the distribution of built features, from the width and orientation of the streets, to the density of construction, to the height of buildings, shaped the diffusion of sunlight and shadows. However, the city’s feverish growth during the mid-century had dire consequences for natural light. As Gotham grew exponentially, changes in the urban environment made sunlight disperse inequitably. Moreover, as socio-spatial divisions intensified, natural light and darkness began to disperse along the lines of wealth and poverty, as sunlight commodified into a coveted resource.

As Manhattan’s built environment intensified, New Yorkers complained of a city engulfed by darkness. The rise of gas light technology actually alleviated the issue of darkness during nighttime hours. But while gas lights transformed the way New Yorkers experienced the urban landscape after dark, the distribution of the new technology was unequal. An investigation into the spatial distribution of artificial light substantiates the finding that gas light companies bypassed impoverished neighborhoods in favor of commercial districts or affluent areas.[74] Thus, during the mid-century, access to all light, both natural and artificial, defined the difference between the living environments of the rich and the poor. Analysis reveals that the presence of light marked the social inequalities of the urban landscape. As such, Gotham came to be defined by its reputation for light, darkness, and shadows; whether natural or artificial, light was entwined within the fabric of the metropolis, due to its ability to transform urban space and shape the rhythm of the city.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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Notes

1. Charles Dickens, *American Notes for General Circulation* (New York: D Appleton, 1868), 67-81.
2. Ibid.
3. Matthew Hale Smith, *Sunshine and Shadow in New York* (Hartford: J.B. Burr, 1868), 706.
4. Richard Plunz, *A History of Housing in New York City*, rev. ed. (New York: Columbia University Press, 2016); John Duffy, *A History of Public Health in New York City* (New York: Russell Sage Foundation, 1968); Daniel Freund, *American Sunshine: Diseases of Darkness and the Quest for Natural Light* (Chicago: University of Chicago Press, 2012).
5. Peter C. Baldwin, *In the Watches of the Night: Life in the Nocturnal City, 1820-1930* (Chicago: University of Chicago Press, 2015); Mark J. Bouman, "Luxury and Control," *Journal of Urban History* 14, no. 1 (1987): 7-37; Mark J. Bouman, "The 'Good Lamp Is the Best Police' Metaphor and Ideologies of the Nineteenth-Century Urban Landscape," *American Studies* 32, no. 2 (1991): 63-78; Also see Christopher Otter, *The Victorian Eye: A Political History of Light and Vision in Britain, 1800-1910* (Chicago: University of Chicago Press, 2008); Joachim Schlör, *Nights in the Big City: Paris, Berlin, London 1840-1930* (London: Reaktion Books, 2016).
6. New York passed its first comprehensive zoning ordinance in 1916, which marked the city's first attempt at light preservation in public spaces. The 1916 Zoning Ordinance regulated heights by establishing the setback rule; under the new regulations, buildings had to be set back from the sidewalk once they reached a maximum vertical height in accordance with a fixed angle drawn from the center of the street; Carol Willis, *Form Follows Finance: Skyscrapers and Skylines in New York and Chicago* (New York: Princeton Architectural Press, 1995), 68; Gergely Baics and Leah Meisterlin, "Zoning before Zoning: Land Use and Density in Mid-Nineteenth-Century New York City," *Annals of the American Association of Geographers* 106, no. 5 (2016): 1152-75.
7. Regarding Manhattan's largely unregulated built environment: Though land use controls in nineteenth-century New York were comparatively weak by modern-day standards, they were not entirely absent. Fire codes and building codes imposed some regulatory standards for building within protected districts. Moreover, nuisance laws placed restrictions on land use on a case by case basis, but their reach was limited. Restrictive covenants perhaps had the greatest impact; private deeds could exclude noxious industries and undesirable land use within select areas, and mandate specific construction standards. Overall, however, land use controls in mid-nineteenth-century New York remained highly fragmented and generally limited, which allowed the real estate market to operate under minimal restrictions; Elizabeth Blackmar, "Accountability for Public Health: Regulating the Housing Market in Nineteenth-Century New York City," in *Hives of Sickness: Public Health and Epidemics in New York City*, ed. David Rosner (Rutgers University Press, 1995), 47; David M. Scobey, *Empire City: The Making and Meaning of the New York City Landscape* (Temple University Press, 2002), 218-19.
8. Blackmar, "Accountability for Public Health," 42.
9. Hilary Ballon, *The Greatest Grid: The Master Plan of Manhattan 1811-2011* (New York: Museum of the City of New York, 2012), 127.
10. Baics and Meisterlin, "Zoning before Zoning," 1154.
11. Blackmar, "Accountability for Public Health," 56.
12. Freund, *American Sunshine*, 1.
13. Ballon, *The Greatest Grid*, 17.

14. Ibid., 17; Catherine McNeur, *Taming Manhattan: Environmental Battles in the Antebellum City* (Cambridge, MA: Harvard University Press, 2014), 46.
15. Ballon, *The Greatest Grid*, 33.
16. Gergely Baics and Leah Meisterlin, "The Grid as Algorithm for Land Use: A Reappraisal of the 1811 Manhattan Grid," *Planning Perspectives* 34 (2019): 391-414.
17. The street width data used to create Figure 2A were generously provided by Baics and Meisterlin, who assembled the dataset for their article, "The Grid as Algorithm for Land Use." Using the 1852-1854 Perris Fire Insurance Atlas, Baics and Meisterlin manually obtained data on street widths per segment from the atlas's plates to create a dataset detailing the dimensions of streets throughout the Manhattan street network south of 42nd street. These data were brought into geographic information systems to create a shapefile. This shapefile containing street widths per segment was then manipulated for the purpose of this article to display graduated street widths. Gergely Baics and Leah Meisterlin, *Manhattan Street Width Shapefile*, 2017, Columbia University; Baics and Meisterlin, "The Grid as Algorithm for Land Use."
18. Manhattan Island is oriented approximately 29 degrees off true north. In the "post-grid" street system, avenues run parallel to the Hudson and East Rivers. Consequently, the Manhattan grid is rotated 29 degrees northeast, and avenues run on a slight diagonal. Plunz, *A History of Housing in New York City*, 11.
19. Figure 2B displays the kernel density of narrow streets in Manhattan. Kernel density is a density analysis function in GIS which calculates the magnitude-per-unit area of a feature throughout a defined geographic area. The kernel function in kernel density analysis creates a smoothed density raster for each input feature. Figure 2B was created using Baics and Meisterlin's street width shapefile as the input feature for kernel density analysis. This shapefile was manipulated so that only street segments that measure less than or equal to 60 feet were included. Baics and Meisterlin, *Manhattan Street Width Shapefile*.
20. Jason M. Barr, *Building the Skyline: The Birth and Growth of Manhattan's Skyscrapers* (New York: Oxford University Press, 2018), 92.
21. The data for this figure derive from the 1852-1854 Perris Fire Insurance Atlases. These maps, georeferenced through crowdsourcing and digitized by the New York Public Library Map Division, provide building-footprint level information on land use in the city south of 42nd Street. Kernel density of the building footprints was calculated using this shapefile to produce Figure 2C. New York Public Library, Perris Buildings Shapefile, NYPL Map Warper, 2015, http://maps.nypl.org/warper/.
22. Baics and Meisterlin, "Zoning before Zoning," 1166.
23. Sam Bass Warner and Andrew H. Whittemore, *American Urban Form: A Representative History* (Cambridge, MA: MIT Press, 2012), 41.
24. Blackmar, "Accountability for Public Health," 50.
25. McNeur, *Taming Manhattan*, 61.
26. Figure 2D was calculated using methodology developed by Gergely Baics and Leah Meisterlin in their article "Zoning before Zoning." This map estimates population density by block, first by taking the residential building area per block from the Perris Atlas building footprints, and then multiplying residential building area per block as a proportion of a wards total residential building area by population per ward from the 1855 census. Baics and Meisterlin, "Zoning before Zoning."
27. Blackmar, "Accountability for Public Health," 48.
28. McNeur, *Taming Manhattan*, 177.
29. Ibid., 185.
30. Ibid., 184.
31. Mike Wallace and Edwin G. Burrows, *Gotham: A History of New York City to 1898* (New York: Oxford University Press, 1998), 700; also see George G. Foster, *New York by Gaslight: With Here and There a Streak of Sunshine* (New York: Dewitt & Davenport, 1850); George Lippard, *New York: Its Upper and Lower Million* (Cincinnati: E. Mendenhall, 1854); James D McCabe, *New York by Sunlight and Gaslight: A Work Descriptive of the Great American Metropolis* (New York: Edgewood Publishing, 1882).
32. Freund, *American Sunshine*, 12.
33. Dr. John H. Griscom published his landmark report, "The Sanitary Condition of the Laboring Population of New York," in 1845. Griscom's report singled out the crowded conditions in tenement housing as

a principal cause of poor health, which launched a new phase of sanitary reform in New York City. Following the precedent set by Griscom, the newly established Council of Hygiene and Public Health of the Citizen's Association of New York produced a systematic survey of their own. Published in 1865, this survey fixated on the relationship between tenements, sanitation, and the environment, thus representing the culmination of decades of public health thinking. Like Griscom, the report identified the lack of light and ventilation in the tenements an urban pathology that hampered healthy living. John H. Griscom, *The Sanitary Condition of the Laboring Class of New York with Suggestions for Its Improvement* (New York: Arno Press, 1845); *Report of the Council of Hygiene and Public Health of the Citizens Association of New York upon the Sanitary Conditions of the City* (New York: D. Appleton, 1865).

34. Other building categories include private dwellings, shanties and untenantable buildings, and stables. Buildings categorized as business, church, or school were likely residential mixed-use with ground-floor retail; however, the residential capacity of these structures is not identified in the data source; to create Figures 3 and 4, the author digitized the *Sanitary and Social Chart of the Fourth Ward of the City of New York.* This map was originally created in 1864 by city inspector E.R. Pulling, to accompany his report of the Fourth Sanitary Inspection District to the Council of Hygiene of the Citizens' Association. Pulling's map was georeferenced through crowdsourcing at the NYPL. The building footprints when then traced by the author in GIS. This map notably contains information on building heights for most structures, making a three-dimensional rendering of the map possible. Lionel Pincus and Princess Firyal Map Division, The New York Public Library, "Sanitary and Social Chart of the Fourth Ward of the City of New York, to accompany a report of the 4th Sanitary Inspection District, made to the Council of Hygiene of the Citizens' Association by E.R. Pulling, M.D. assisted by F.J. Randall," New York Public Library Digital Collections, accessed March 6, 2019, http://digitalcollections.nypl.org/items/fc8b9560-f3a1-0130-679f-58d385a7b928.
35. The mean building height for tenement buildings in the Fourth Ward was 3.35 stories, while the mean building height for businesses, churches, and schools was 3.56 stories.
36. Elizabeth Blackmar, *Manhattan for Rent, 1785–1850* (Ithaca, NY: Cornell University Press, 1989), 201.
37. The autumnal equinox in 1850 was September 21. This date was selected for this study, as the autumnal equinox falls between the summer and winter solstices, the times of the year when the sun reaches its highest and lowest points in the sky. The angle of the sun in the sky is a principal factor in determining shadows; the higher the sun in the sky, the less shadow a structure will cast. Consequently, the shadows cast in the winter are drastically different in angle and length than the shadows cast in the summer, and some parts of the city receive different quantities of light between winter and summer. On the equinoxes, the sun rises due east and sets due west. The autumnal equinox was selected as the preferred date for this study as the date serves as a medial point between the summer and winter solstices, the two extremes when it comes to light and shadows.
38. *Report of the Council of Hygiene and Public Health of the Citizens Association of New York upon the Sanitary Conditions of the City*, 48.
39. Ibid., 49.
40. Ibid, 64.
41. Baldwin, *In the Watches of the Night*, 10.
42. Ibid., 16.
43. New York (N.Y.). Common Council, *Minutes of the Common Council of the City of New York, 1784-1831* (New York: M. B. Brown Printing & Binding, 1917), 13:60.
44. *Minutes of the Common Council of the City of New York*, 19:2.
45. Ibid., 15:664-66.
46. Bouman, "The 'Good Lamp Is the Best Police,'" 66.
47. "How the City Is Lighted," *The New York Times*, February 22, 1854.
48. New York (N.Y.). Board of Aldermen, *Documents of the Board of Aldermen of the City of New York* (New York: The Board, 1834-1835), Vol. 1, Doc. 48, 602.
49. Ibid.
50. *Minutes of the Common Council of the City of New York*, 15:666.
51. Bouman, "The 'Good Lamp Is the Best Police,'" 66.

52. Bouman, "Luxury and Control," 28.
53. Baldwin, *In the Watches of the Night*, 17; Also see Peter C Baldwin, "In the Heart of Darkness," *Journal of Urban History* 30, no. 5 (July 5, 2004): 749-68.
54. David Nye, *American Illuminations: Urban Lighting 1800-1920* (Cambridge, MA: The MIT Press, 2018), 35-43.
55. Ibid., 36-43; Baldwin, *In the Watches of the Night*, 15-20.
56. New York (N.Y.). Board of Aldermen, *Documents of the Board of Aldermen* (1849-1850), Vol. 16, Doc. 1, 12; The location of gas lights in Manhattan has been largely unknown. Consequently, this study relied on a number of documents to gather information on the location and placement of gas lights in the city. Ultimately, a comprehensive list of streets where gas mains had been installed by the Manhattan Gas Light Company and the New York Gas Light Company was found in the Documents of the Board of Alderman and the Proceedings of the Board of Assistant Alderman. Using data compiled from these sources, a data set was assembled for this study containing a comprehensive list of streets where gas lights were installed by the year 1850 and the intersections delineating the beginning and end of where gas lights were installed on certain streets. GIS was then used to map these streets where gas mains had been installed. Charles Roome, *Document No. 7*, vol. 32, Part 1 (New York: Board of Assistant Aldermen, May-September 1848), 95-102; Herman W Childs, *Document No. 52*, vol. 17, Part 2 (New York: Board of Aldermen, 1850), 792-96; Herman W Childs, *Document No. 6*, vol. 18, Part 1 (New York: Board of Aldermen, 1851), 183-94.
57. A shapefile of the digitized building footprints from William Perris's 1852-1854 *Maps of the City of New York*, compiled by librarians from the New York Public Library, was used as the principal data source on land use patterns in mid-nineteenth-century Manhattan. The Perris Atlas building footprints shapefile contains information on land use; each building is categorized as residential, commercial, industrial, educational, worship, or mixed use. Using GIS, the buildings categorized as commercial or mixed use (commercial and residential) were selected, in order to display commercial land use patterns in mid-century Manhattan. New York Public Library, Perris Buildings Shapefile, NYPL Map Warper, 2015, http://maps.nypl.org/warper/.
58. Scobey, *Empire City*, 98.
59. Ibid.
60. Baics and Meisterlin, "Zoning before Zoning," 1163.
61. Figure 6B was created using the Perris Atlas building footprints shapefile (see Figure 6A) and the gas light shapefile (see Figure 5A). Streets with gas lights that possessed a north-south orientation were selected. Buildings facing these north-south gaslit streets were isolated from the Perris Atlas building footprints. These street facing buildings were then categorized by land use, with commercial and mixed-use buildings highlighted in blue. Figure 6C was created using the Perris Atlas building footprints shapefile (see Figure 6A) and the gas light shapefile (see Figure 5A). Streets with gas lights that possessed east-west orientation were selected. Buildings facing these east-west gaslit streets were isolated from the Perris Atlas building footprints. These street facing buildings were then categorized by land use, with commercial and mixed-use buildings highlighted in blue.
62. Baics and Meisterlin, "The Grid as Algorithm for Land Use," 16; Blackmar, *Manhattan for Rent*, 164.
63. Baics and Meisterlin, "The Grid as Algorithm for Land Use," 9-14.
64. North-South thoroughfares had 131 gas main segments installed by 1850, while east-west streets had 154 gas main segments.
65. Along north-south gaslit avenues, 14 percent of buildings were commercial, 43 percent of buildings were mixed-use (residential with ground-floor retail), 33 percent of buildings were residential (no ground-floor retail), and 10 percent were other (industrial, educational, worship). Along east-west gaslit streets, 11 percent of buildings were commercial, 26 percent of buildings were mixed-use, 53 percent of buildings were residential and 9 percent were other.
66. *Minutes of the Common Council of the City of New York*, 13:60.
67. Blackmar, *Manhattan for Rent*, 159.
68. In 1852, a committee of aldermen came into power in Manhattan, who quickly earned themselves the nickname of the "Forty Thieves." The group became known for the practice of overcharging for various projects and pocketing the profits. During the era of the "Forty Thieves," the Common Council leased city piers, sold off profitable properties, and granted streetcar and ferry franchisees to a favored

few—businessmen who capitalized on the de facto partnership with city politicians by out-bribing their rivals. However, the relationship between aldermen and their favored entrepreneurs were reciprocal. Aldermen routinely blocked government actions that might hamper their favored businessmen. For instance, in 1850 the newly established Gas Consumers Association demanded that the Common Council build and operate a municipal gas plant. Hostility toward the New York Gas Light Company and the Manhattan Gas Light Company was growing; the two old monopolies, who divided business in the city, charged rates that were much higher than those charged by their counterparts in other cities like Philadelphia. However, "friendly authorities" put an end to the plan for public power; to appease favored customers, the Common Council even forestalled the chartering of any new competitors until 1855, when the Harlem Gas and Metropolitan Gas companies were established. Wallace and Burrows, *Gotham*, 825-28.

69. Blackmar, *Manhattan for Rent*, 168.
70. Ibid., 159.
71. Baics and Meisterlin, "Zoning before Zoning," 1167.
72. Figure 5B displays kernel density of streets with gas mains. This map was created using the gas light shapefile. See Figure 5A.
73. *Minutes of the Common Council of the City of New York*, 15:666.
74. Baldwin, "In the Heart of Darkness," 752.

Author Biography

Rachel Eu graduated from Barnard College in 2020, where she majored in History. The article began as her undergraduate senior thesis. Following its completion, the piece was reworked into a research article. The author is grateful to her advisor, Gergely Baics, whose guidance and support made the article possible.