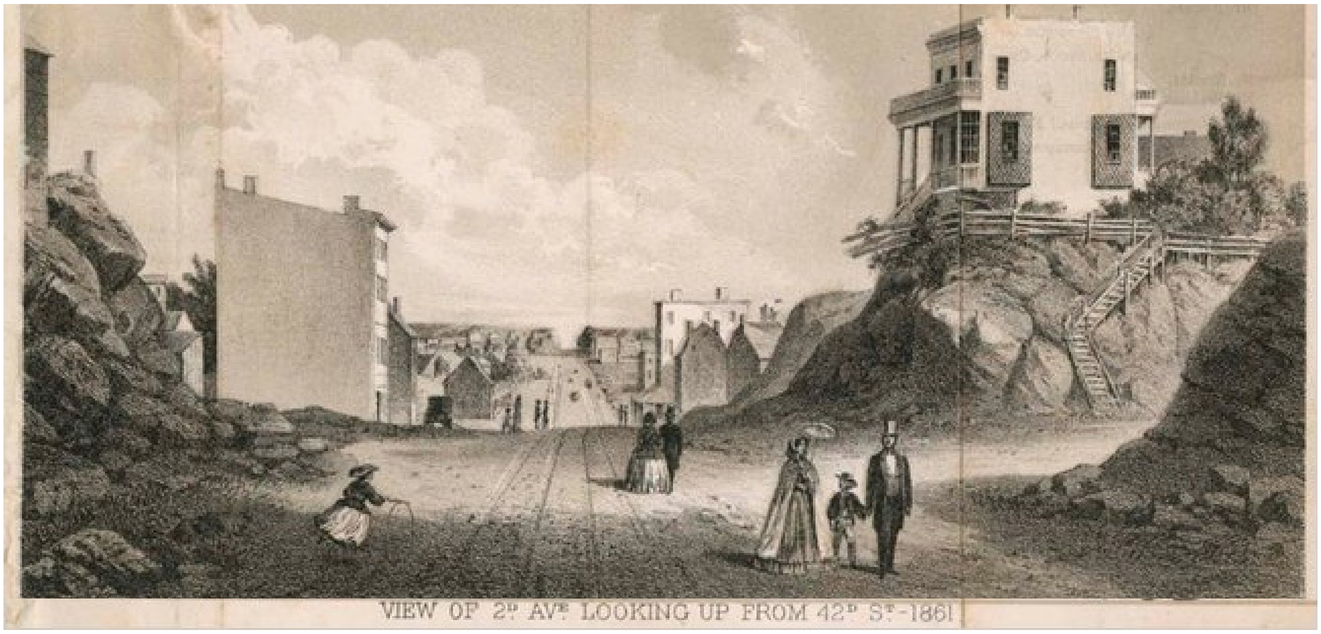


WORKING PAPER #18 / NOVEMBER 2014

THE RISE AND FALL OF MANHATTAN'S DENSITIES, 1800-2010

+ SHLOMO ANGEL AND PATRICK LAMSON-HALL[1]

ABSTRACT

Using a novel methodology, we study the changes in the population densities of the built-up areas of Manhattan and its neighborhoods from 1800 to 2010. Built-up areas were determined from historical maps, insurance maps, and air photographs, while population data were collected for census wards from 1790 to 1910 and for census tracts thereafter. We found that densities remained stable, at 200 persons per hectare, until 1840 when the growth in the built-up area could no longer keep up with rapid population growth. By 1910, average densities in Manhattan were triple those of 1840, while average densities in some neighborhoods were twice as high and more. Densities then started to decline, largely due to three public actions: the annexation of Brooklyn, Queens, the Bronx and Richmond County to Manhattan in 1898; the creation of vast new areas for urban expansion in the 1900 Topographical Bureau plan; and the building of the subway system from 1904 onwards. These actions led to the rapid decongestion of Manhattan's overcrowded neighborhoods, as lower-income workers suburbanized while still commuting to Manhattan on a nickel fare. Densities in Manhattan declined until 1980 and have risen slightly since. New York City is now expecting a significant increase in population, entailing significant densification in Manhattan and elsewhere. Using the lessons learned from our study, we outline a densification program that could accommodate a larger population without recourse to heavy-handed land assembly for large and heavily subsidized housing projects. Our strategy is based on our conviction that we can achieve a more efficient, more equitable, and more sustainable densification in New York City with small actions on the part of the many than with big actions on the part of the few.

The authors wish to thank Matthew Knutzen, Map Librarian at the New York Public Library for his help over the years on this project. We also wish to thank Kevin Thom for his contributions to this work. We are also grateful to Wongyal Shawa and the students at Freshman Seminars at Princeton University for their help in earlier phases of our research. We also wish to thank Professor Kenneth T. Jackson for his valuable insights.

CONTACT

[1]Dr. Shlomo Angel
Senior Research Scholar
Adjunct Professor of Urban Planning
NYU Stern Urbanization Project
sangel@stern.nyu.edu

Patrick Lamson-Hall
Research Scholar
NYU Stern Urbanization Project
plamsonh@stern.nyu.edu

NYU Marron Institute of Urban Management

Introduction

Manhattan is slowly becoming denser and already contains some of the densest urban neighborhoods in the United States. There is an ongoing debate[1] about the merits and demerits of the future 'densification' of Manhattan. The issue that we are debating—not as individuals but as a public acting together in our common interest—is whether or not we should make it possible for more people to live within the limited confines of the island, an island that is now fully built-up. Mayor Bill de Blasio of New York City recently reignited the densification debate, telling a group of real estate executives that "height and density" will be central to his mission to build and preserve affordable housing in New York City in the coming years, a mission he sees as central to his constituents' interests.[2]

The stakes are high: Who would be able to afford, or continue to afford, to live in Manhattan? Who will be pushed out to the outer boroughs or outside New York City altogether? Will Manhattan's colorful neighborhoods and its walkable streets lose their character? Will it continue to attract the most creative and the most productive talent in the world? Will it maintain its economic and ethnic diversity or will it become the playground of the emerging global leisure class?

This study, focused on the history of densities in Manhattan and its neighborhoods over the past two centuries, may shed some light on these important questions. There is little doubt that densification in one form or another may make housing more plentiful, more affordable, and more accessible as it did in the past, and there is also no doubt that densification—insofar as it may involve changes in both the human and the physical character of neighborhoods as it did in the past—is not an unmitigated good for one and all.

Recent calls for the further densification of Manhattan as well as recent objections to such calls are often ignorant of its density history, as well as of the powerful forces—economic, social and political—driving the rise and fall of its densities over time. Those unfamiliar with the historical evidence may have already concluded that densities are always on the rise and always will be or, alternatively, that New York—like other cities the world over—is spreading out at lower and lower densities. Both are wrong. History is not on the side of those who believe that densification is inexorable nor of those who believe that low-density sprawl is inexorable. Our study aims to document the history of the island's densities in a rigorous scientific manner, and—using the results of our global studies of density change as well—to begin to explain how and why its densities have changed over time.

1 See, for example, "Everybody Inhale: How Many People Can Manhattan Hold?" NYT, 1 March 2012.

2 Rubinstein, Dana, 2014. "De Blasio: 'Height and density' key to affordable housing plans", *Capital,* 2 February.

New York's productivity, creativity, and quality of life make it attractive to people everywhere. The more attractive it is, the more people will want to come to work and live here. It is said of King Canute (990-1035AD) that, in an attempt to convince his persistent courtiers that there are limits to what he could do, had his throne placed on the beach and commanded the incoming tide to roll back. If more people want to come to New York, they will come. There is no practical way to prevent them from coming, and when they do come they make New York even more productive and more creative. Manhattan (now 1.5 million), New York City as a whole (now 8 million), and the New York metropolitan area (now 20 million) are expected to grow in the coming decades as the United States adds an expected 100 million people to its urban population by 2050. If the New York metropolitan area maintains its share of the overall urban population of the United States—a not unreasonable assumption—it may add up to 8 million people by 2050.

There are only three ways to accommodate this growth in an orderly, efficient, equitable and sustainable manner: By expanding the metropolitan area into green fields at its edges while making these new urban extensions accessible to the rest of the metropolitan area; by filling in the remaining vacant spaces in built-up areas; and by densification, namely by accommodating more people in areas that are already built-up. There is no doubt that the expansion of the metropolitan area and the provision of good access to the urban edge will play an important role in absorbing the expected population growth. At the same time, a significant part of this growth will need to be absorbed by New York City proper. But New York City in general and Manhattan in particular have few vacant lands that can be filled in with new residential buildings. For better or worse, absorbing more people into New York City as well as into Manhattan in the coming decades will therefore require densification of one kind or another.

We believe that public policy prescriptions that aim at real-world density change in real time could benefit from a better understanding of the ebb and flow of densities of our cities and neighborhoods as they evolved so that we could be more modest, more precise, more sensitive, and more realistic in our interventions to change them.

1 The Context: The Study of Urban Density Dynamics

The study of urban densities was launched by Colin Clark in a 1951 paper to the Royal Statistical Society in which he observed that urban population densities—simply defined as *the population inhabiting a unit area of land*, say people per square kilometer or people per hectare (1 km^2 = 100 hectares)—declined in a systematic fashion as distance from the city center increased. His insights have led to an avalanche of articles confirming his observations in different cities, as well as to key contributions in urban economics seeking to explain this recurring regularity (see figure 1). Sad to say, not much has been added to Clark's original insight in the ensuing decades.

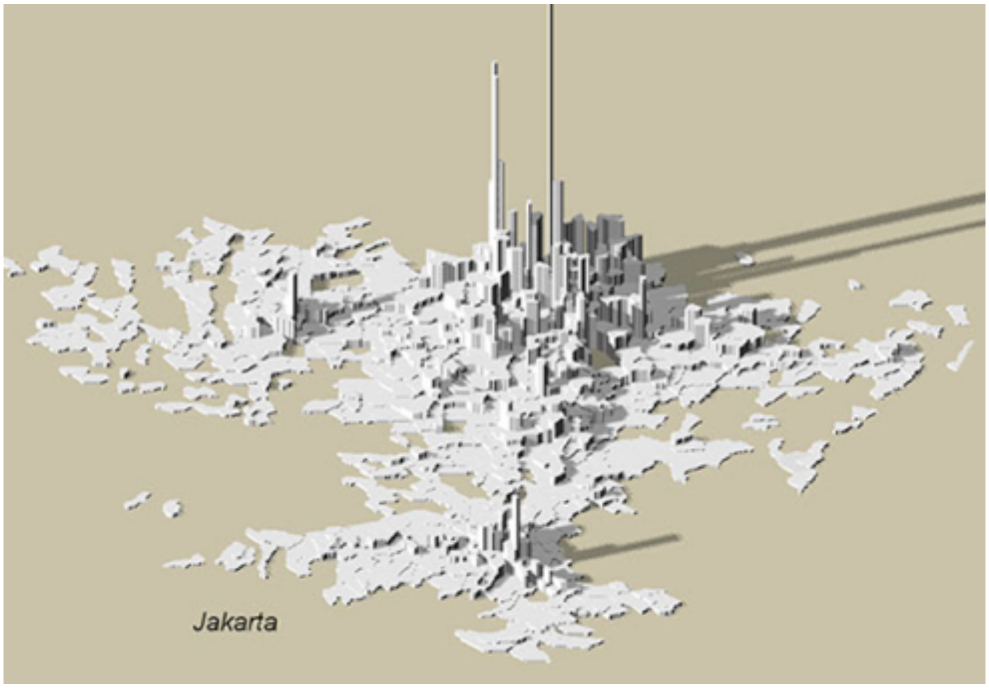


Figure 1: Densities are highest at the center and decline away from it, Jakarta, Indonesia, 1990
Source: Courtesy of Alain Bertaud

There is very little systematic—i.e. rigorous, inclusive, and comparable—information on urban densities, and virtually no information on their changes over time. Together with our colleagues, we have set out, beginning almost a decade ago, to fill these gaps. In a 2005 study for the World Bank, titled *The Dynamics of Global Urban Expansion*, we used satellite imagery for two dates—1990 and 2000—to map the territorial extent (i.e. the built-up areas) of a global sample of 120 cities, 3% of the 3,646 cities and metropolitan areas that had 100,000 people or more in the year 2000 (see figure 2).

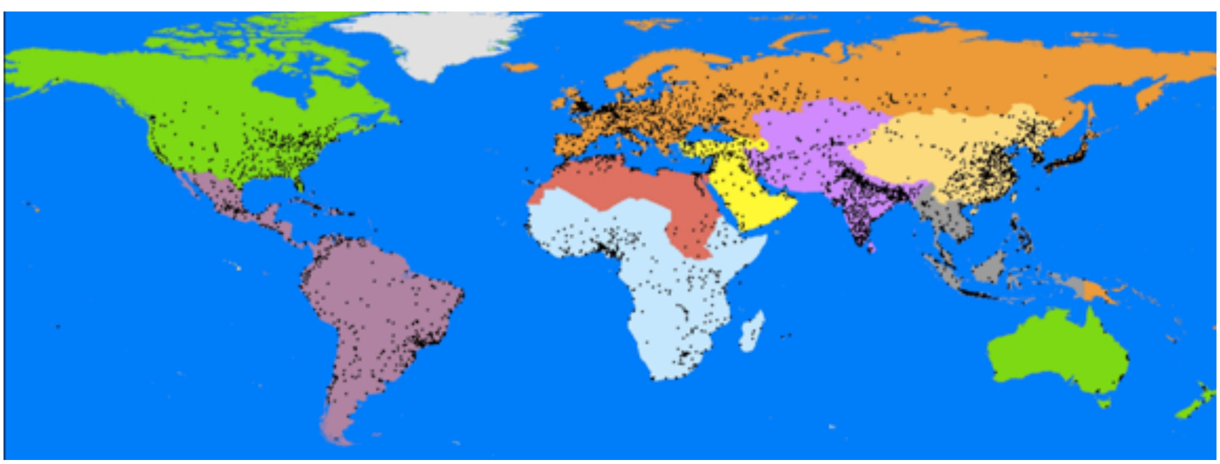


Figure 2: The universe of 3,946 cities and metropolitan areas that had 100,000 people or more in the year 2000

Using these maps, in conjunction with data on the population corresponding to these territorial extents, we were able to calculate the average population densities—namely, total population divided by total built-up area—in these cities and their change between 1990 and 2000.

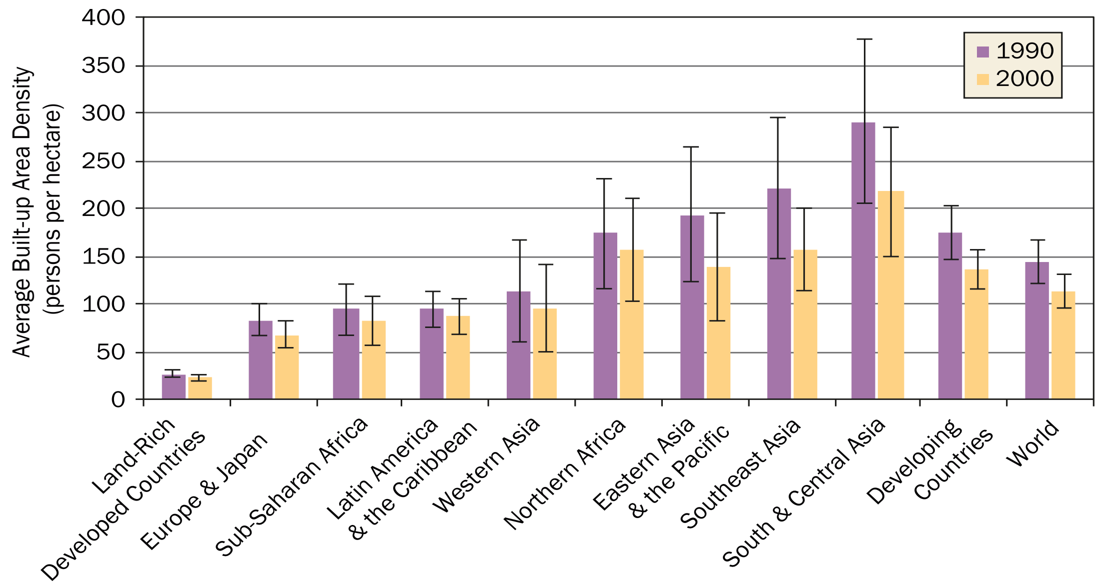


Figure 3: Average Built-up Area Densities in World Regions, 1990-2000

Densities were found to be highest in developing countries and lowest in Land-Rich developed countries: the United States, Canada, and Australia. On the whole, we found that average population densities in the cities and metropolitan areas of Europe and Japan were triple those of the land-rich developed countries, and that densities in developing countries were double those of Europe and Japan. Much to our surprise, we also found that between 1990 and 2000 densities *declined* in all world regions (see figure 3). On average, they declined by 2% per year in the sample as a whole and that decline was statistically significant. That was unexpected and it raised a larger question: Was this decade a fluke or a typical decade?

This question led us to the study of densities over longer periods of time. In a study of a global representative sample of 30 metropolitan areas from 1800 to 2000—using a novel methodology that we later applied to the study of Manhattan's densities—we found that densities tended to increase during the 19th century and to decline in the 20th century. In some cities, we found a persistent decline in density over the entire 200-year period. Paris, France, for example, had a population of 500,000 in an area of 11 km^2, in 1800, during the time of Napoleon. By 2000, its built-up area increased 200-fold to 2,000 km^2 while its population increased 20-fold to 10 million people (see figure 4[3]). Its average density thus declined ten-fold during this period, from 50,000 persons per km^2 (or 500 persons per hectare) to 5,000 persons per km^2 (or 50 persons per hectare). In other cities we studied, average densities increased in the 19th century and declined in the 20th

3 For an animation of this expansion, please see http://bit.ly/1E2VILi

century (see figure 5[4]). Clearly, densities were found to both increase and decline over time, and density decline was certainly not limited to the last decade of the 20th century.

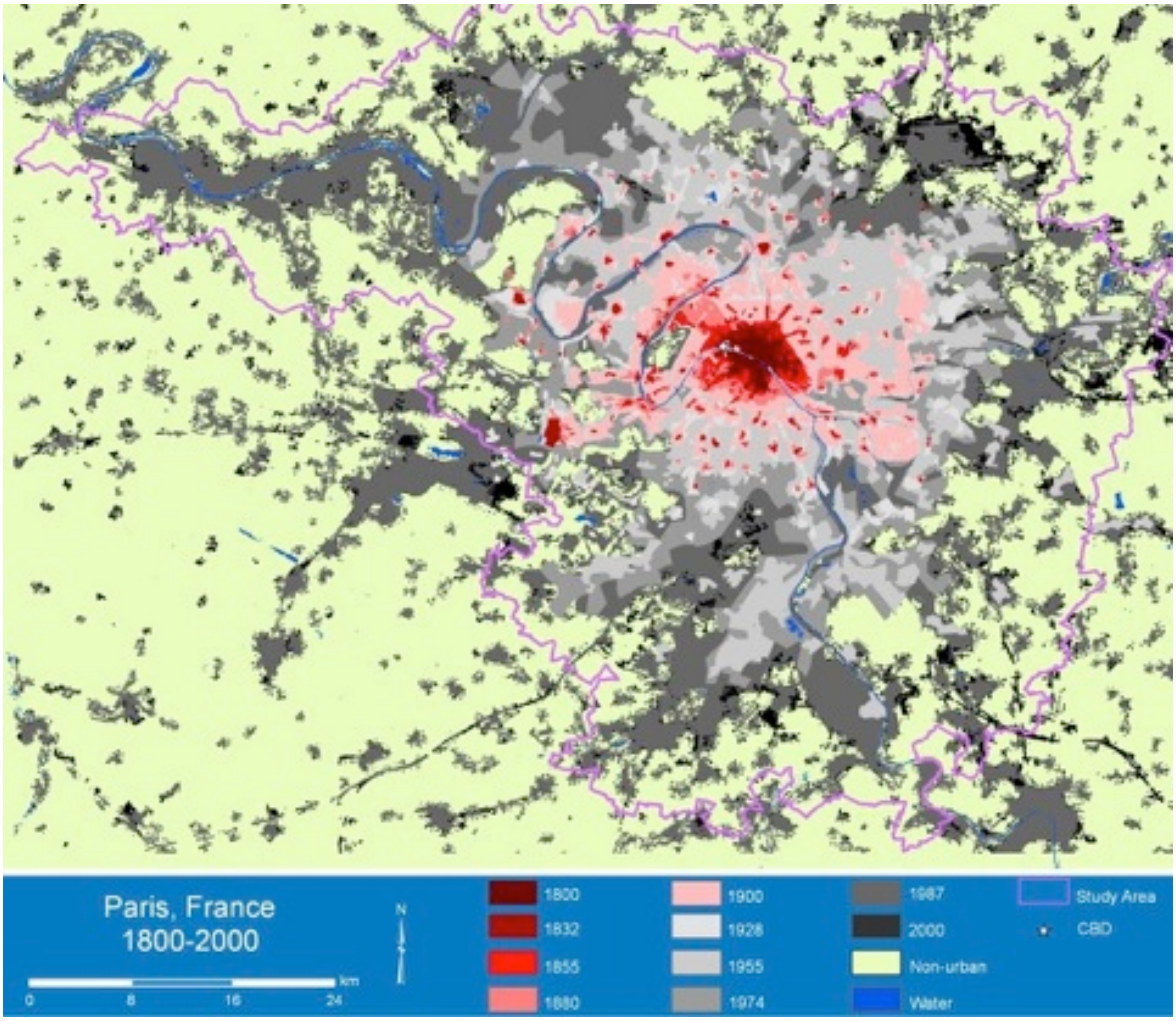


Figure 4: The Expansion of Paris, France, 1800-2000

[4] Each figure caption contains the reference to the appropriate table in Appendix 1 that contained the data used to construct the figure. This information is permanently archived online at http://hdl.handle.net/2451/33846

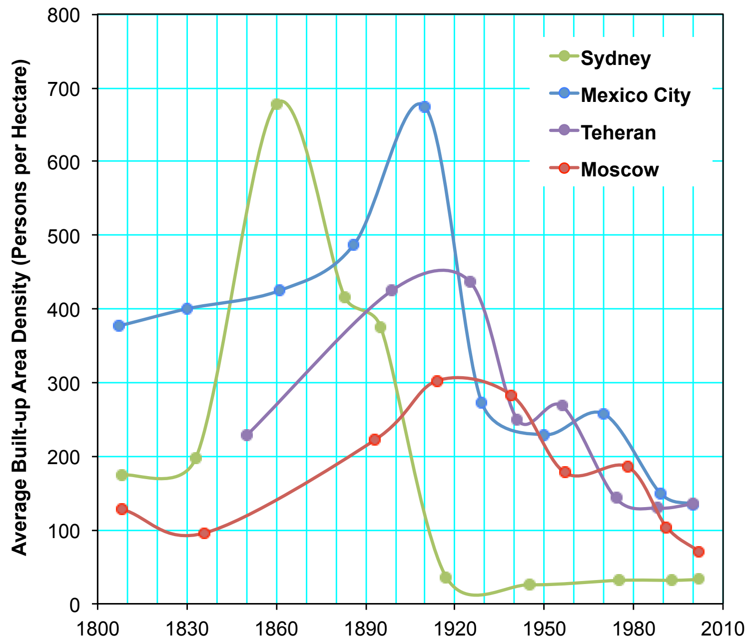


Figure 5: Increasing and then decreasing built-up area densities in selected cities, 1800-2010 (For data, see Appendix 1)

We were also able to confirm the prevalence of long-term density decline in the United States by calculating the average population densities in 20 U.S. cities in every decade between 1910 and 2000, using historical census tract data from the National historical Geographical Information System (NHGIS). Average census tract densities in these cities declined five-fold, on average, during the 20th century (see figure 6).

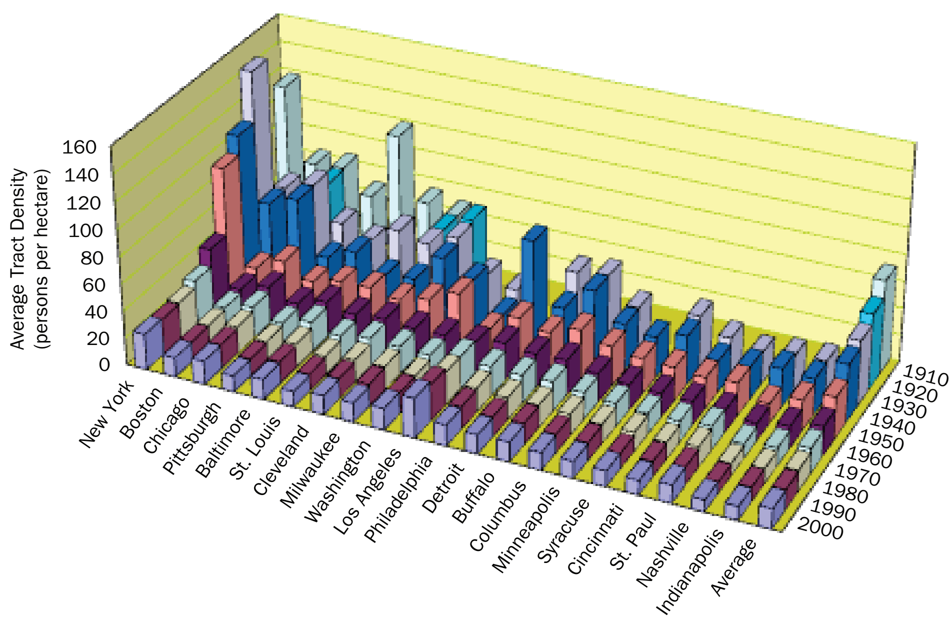


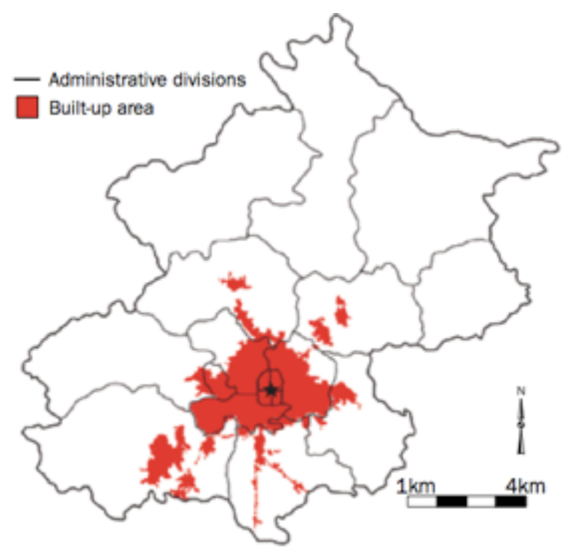
Figure 6: The General Decline in Average Densities in 20 U.S. Cities, 1910-2000

To the best of our knowledge, studies of urban densities now fall into two categories: They either document the variations in density within an urban area at a single point in time, as we saw in the image of Jakarta earlier, or—as we have done in our own studies of density—they document the change in the average density in the entire metropolitan area over time. As far as we know, there are no studies that document the variations in density within an urban area and their change over a long period of time. Our study of the rise and fall of Manhattan's densities over a two hundred year period begins to fill this gap.

2 Methodology: Density, Census District Boundaries, and Built-up Areas

Research on urban population densities has long suffered from a serious methodological flaw, largely due to the way data on density is collected. As we noted earlier, the density of a city or a neighborhood is the ratio of the population living there and its land area. Namely, Density = Population/Area. Population data is usually collected once every decade in a decennial census. The census, we must keep in mind, collects data on where people live, not on where they work, and when we speak of densities we always speak of nighttime densities, which are quite different than daytime densities. The census collects residential population data for districts designated by well-defined boundaries—either the middle of streets or lines drawn on a map—and the boundaries of these districts are often redrawn when a new census takes place, sometimes changing quite radically from one census period to the other.

We cannot speak of the population density of an urban district, large or small, in a rigorous manner without taking into account the share of the area of the district that is built-up. Facts pertaining to urban population densities make sense only when they refer to the density of built-up area. Take, for example, the case of Beijing, the capital of China. In 1999, the administrative area of Beijing was 11 times its built-up area, identified by satellite imagery (see figure 7). The average density of its built-up area in that year was 75.3 persons per hectare. The average density of its administrative area as a whole would be much lower, less than 7 persons per hectare, and would have no meaning, especially since its boundaries could change overnight by administrative fiat. When administrative areas include large expanses of vacant land, the result is an artificially low density figure that has no meaning.



Sources: Divisions redrawn from a base map in Wikipedia; and built-up area map adapted from Angel et al. (2012, 48).

Figure 7: The Administrative Divisions and the Built-up Area of Beijing, China, 1999

In the U.S. census of 1800, to take another example, Manhattan's 7th ward—one of the census districts for which residential population data was collected at that time—stretched from approximately Canal Street to the very northern edge of the island, making it by far the largest ward in terms of area. The 7th ward (see figure 8[5]) also boasted the largest population of any ward in that year—approximately 15,000 people. However, historical maps show that less than 2% its land area was actually occupied by structures at that time. As a consequence, its administrative area density was 1.55 persons per hectare, but its built-up area density was much higher—92.7 persons/hectare, not that different from the average built-up area density of Beijing in 1999. This is an extreme example, but it illustrates the fundamental usefulness of built-up area density. Built-up area density bases the calculation of density only on the land containing structures within the administrative area, with an underlying assumption that the majority of the population is living within the area occupied by buildings. Built-up area densities are thus comparable both over space and over time. Administrative areas, by contrast, change over time for a variety of reasons, often in arbitrary ways. These are often political, and not necessarily tied to the actual amount of land occupied by structures. Defining urban population density as the ratio of the population of an administrative district and the built-up area within that district is thus a major methodological innovation that renders the study of urban densities more precise. For the first time, we can compare densities between cities, neighborhoods, or city blocks for that matter, or at different points in time in a rigorous and consistent manner.

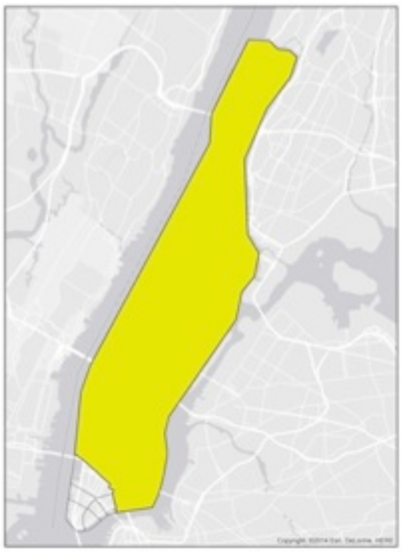


Figure 8: Manhattan's 7th Ward in 1800 (For data, see Appendix 2)

In our studies of the average density of cities in recent decades, we have identified their built-up areas by classifying satellite imagery, as shown earlier for Beijing, China (figure 7). Built-up area maps drawn from satellite imagery are comparable because the same method for drawing them was used for all cities. But such maps are not available before 1970-1980. To identify the built-up areas of cities before 1970, we needed a reliable source of information other than satellite imagery. In Manhattan, for example, aerial photogrammetric surveys, where the built-up areas can be clearly identified, were conducted as early as 1924. The earliest plot-by-plot survey, in the form of detailed fire insurance maps that show individual buildings on every city block, dates from the late 1850s. For earlier periods, we had to rely on historical maps.

Historical maps provided the most important source of information on the built-up area of Manhattan, as they have done earlier in our study of the territorial expansion of 30 cities the world over between 1800 and 2000 in the *Atlas of Urban Expansion* (Angel, Parent, Civco and Blei, 2012). In the 18th and 19th centuries, mapmaking conventions called for identifying the built-up area of a

[5] Source files for GIS-based images is available online at http://hdl.handle.net/2451/33846

city on the map, typically as a shaded area or, more rarely, as individual buildings. For Manhattan, using the extensive historical map collection of the New York Public Library, we were able to find detailed and accurate maps showing its built-up area at roughly ten-year intervals. Maps showing built-up area were found for 1797, 1803, 1811, 1824, 1836, 1842, and 1852. The 1836 Colton map of Manhattan is shown in figure 9.

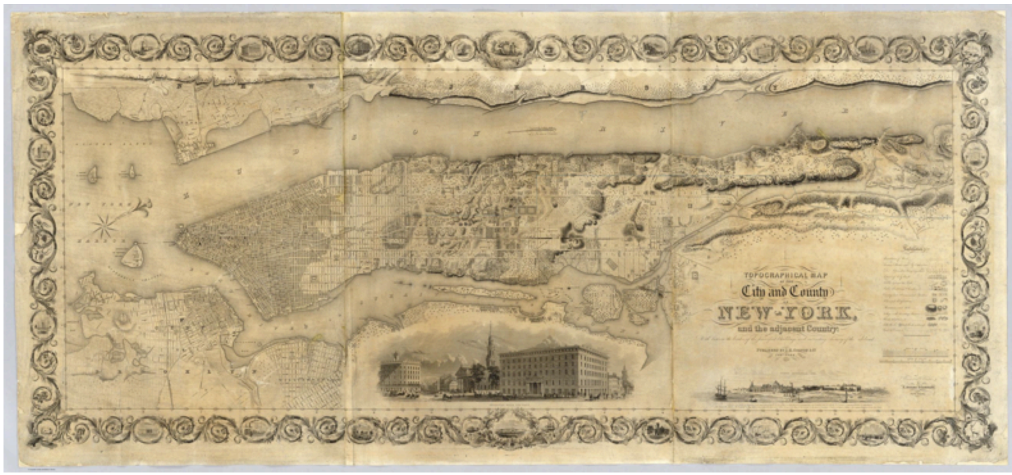


Figure 9: The 1836 Colton map of Manhattan showing its built up area at that time.

After 1852, the historic Sanborne Atlases were used to identify the built-up area in Manhattan. The maps in these atlases showed every building in the city and were originally used for fire insurance (see figure 10, left). These maps are publicly available up to 1974, and were published in 1867, 1879, 1885, 1897, and 1911. For the remainder of the 20th century, we used aerial photography from the years 1924, 1934, and 1951 (see figure 10, right). These aerial photographs answered, for the first time, a question of some interest: When was Manhattan fully built? The answer: 1951, if you ignore the fact that Battery Park City was built on landfill and completed only in 1980.

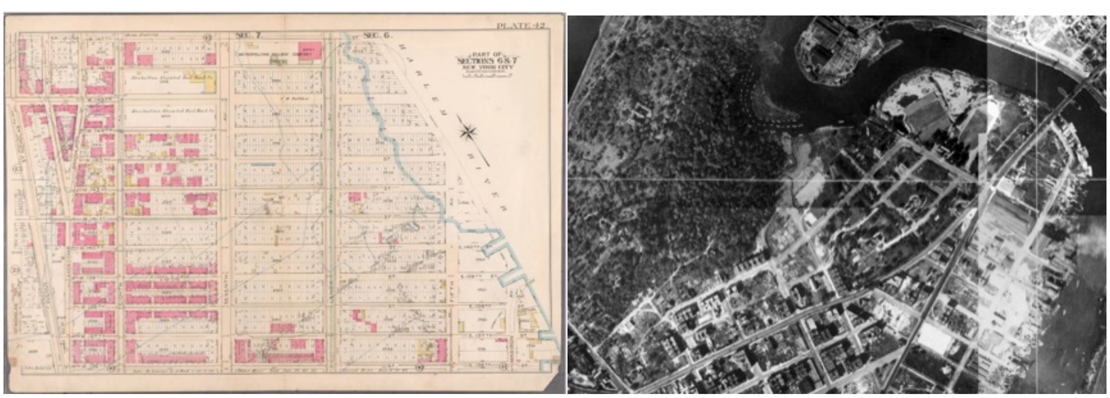


Figure 10: An 1897 Sanborne fire insurance map of East Harlem and a 1924 aerial photograph of the northern tip of Manhattan showing built-up and vacant areas.

To conclude, we were able to obtain information on the built up area of Manhattan from 1797 to 1951 using historical maps, insurance maps, and aerial photographs. We collected built-up area data for 12 map dates in total, at dates that were, on average, 13 years apart. Data on the built-up area of the island was recorded for each city block, to identify when it was first built. As a convention, when a city block in one of the maps was found to be more than half built at a given time period, we considered it fully built; when it was less than half built, we considered it empty. A city block has the advantage of maintaining the same geography throughout the entire study period (1800-2010), allowing it to be compared from one year to the next. Blocks can also be re-aggregated into neighborhoods—the Lower East Side, for example—allowing us to study density change at the neighborhood level, as well as density change in the island as a whole. Parks were excluded at the outset from this analysis, focusing it only on built or buildable city blocks that were built by 2010.

Using a digitized base map that showed and enumerated all the built blocks in Manhattan in 2010—3,371 blocks, excluding parks, compared to 356 in 1797—we created an initial built-up area dataset. This data set—the 'built certain' map—assigned a date to each block corresponding to the *initial year* that we were certain it was already built. The city block was thus used as a unit of analysis, to determine when it was built. For example, all the blocks in Manhattan that were found to be vacant in 1824 and built in the following map year, the 1836 map, were assigned the 'built certain' date of 1836. The 'built certain' map—showing which blocks (and, therefore, how many of them) were built between any two map periods—contained all the area input necessary, from the perspective of the denominator of the equation *Density = Population/Area*, to calculate the density of each block in each of 13 map periods. To calculate that density, we only needed population data for each block in each map period. That, as we explain below, proved to be impossible.

Population information for Manhattan—beginning with the first national census of 1790—was collected for *wards* at 10-year intervals until 1910, when census data collection shifted to the much smaller census *tracts*. An 1824 Plan map of Manhattan showing the ward boundaries of the 1820 census is shown in figure 11. In the history of the U.S. Census, two censuses have been lost to history: the census of 1810, which was partially burned during the war of 1812, and the census of 1890, which was lost due to unforgivable carelessness on the part of Congress (its destruction was the motivation for the creation of the National Archives). Fortunately for the purposes of this study, the State of New York kept separate copies of both censuses, including the original census schedules and the original published tabulation volumes. Thus, while this information is lost for the nation as a whole, it is available for New York.

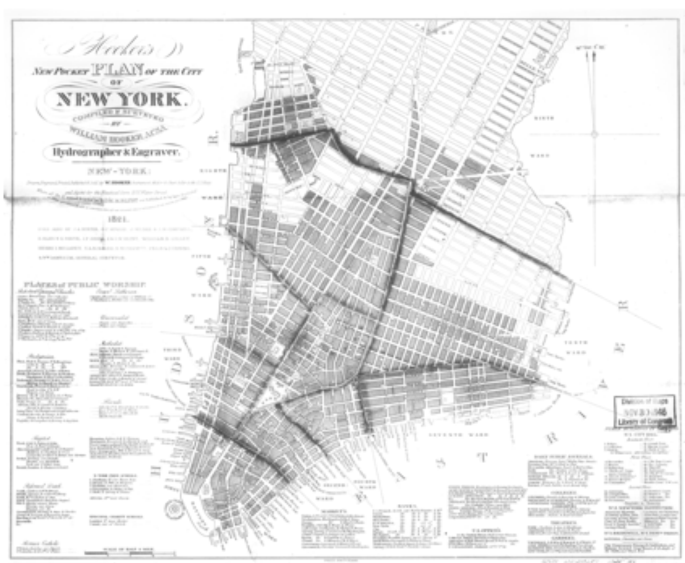


Figure 11: The 1824 Plan map of Manhattan showing the 1820 census ward boundaries.

The size of wards, their enumeration, and the number of wards in Manhattan varied considerably from one census year to the next. Their geographies also varied from one census year to the next. The 7th ward in 1800 covered a much larger area than the 7th ward in 1810. The island's 7 wards of the 1800 census blossomed into 23 wards by 1890 (see figure 12, left and middle). This changing geography of wards posed a fundamental challenge. Our built-up area map dates do not correspond to census dates, but ward population data for census dates cannot be interpolated to obtain population estimates for map dates if wards change their geography. For example, imagine trying to calculate the built-up area density for Ward 7, using population information from the censuses of 1800 and 1810, and a built-up area map from 1808. The most intuitive way of doing this would be to interpolate the population to the year 1808, and then divide that population figure by the built-up area shown on the map. Unfortunately, as we noted earlier, the area of Ward 7 decreased considerably between 1800 and 1810; it stayed the same only in name. Indeed, the population of the 7th ward is reported as 15,394 in 1800, but only 12,120 in 1810. That is why the population and density comparisons for Manhattan wards presented in www.demographia.com, for example, cannot be correct.[6]

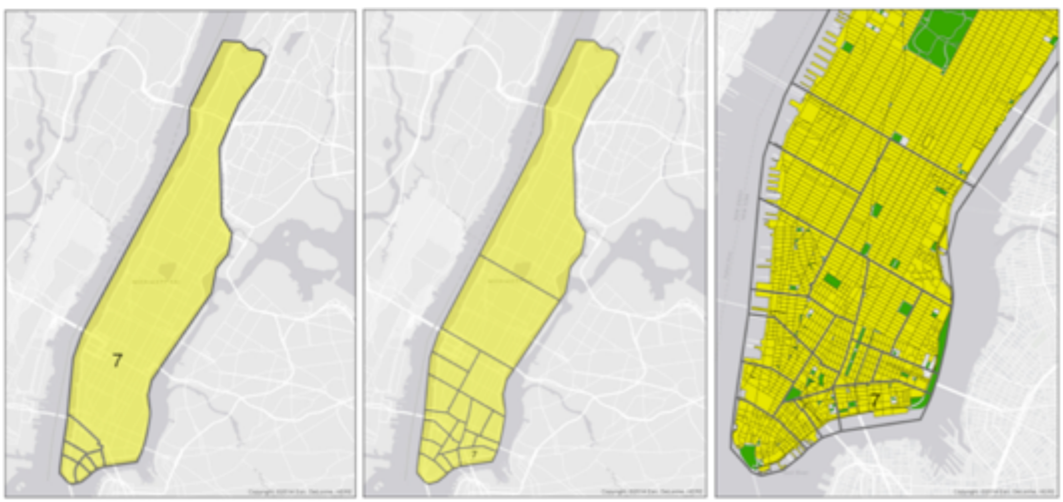


Figure 12: The changing boundaries, sizes, and number of Manhattan's wards between 1800 (left) and 1890 (middle); and the assignment of blocks to 1890 city wards (right) (For data, see Appendix 2).

Because the population figures of wards cannot be interpolated so as to obtain population estimates for 'built certain' map years, we were left with a second possible strategy for matching population and built-up area dates, in order to calculate the built-up area density in a given year: Interpolating the built up area in census years from block data in the 'built certain' map at non-census years. This interpolation was done by simulation. We simulated the process of adding built-up blocks between any two 'built certain' map periods. This simulation was based on three assumptions: (1) that if N blocks were to be built-up between two 'built certain' map periods that were T years apart, then N/T blocks would be added to the built-up area in each intervening each year; (2) that blocks would be added in a random fashion in the area built between the two map

[6] http://www.demographia.com/db-nyc-ward1800.htm

periods; and (3) that the probability of a block being built at a given year was a function of its neighboring blocks and its distance from the southern tip of the island. Namely, this probability was higher the higher the proportion of its neighboring blocks (blocks within 600 meters) that were already built, and the closer it was to the southern tip of the island, since the development of the island generally proceeded northwards. The results of the simulation provided us with 'year built' information on every block on the island.

This interpolation strategy required the disaggregation of the population information to the block level as well, shifting the unit of analysis from the census collection area (the ward or, after 1910, the census tract) to the city block, as we did for the built up area data (see figure 12, right). Given the 'year built' information for all blocks, we assigned a population for every built-up block in a given ward in a given census year by making the simplifying assumption—in the absence of additional information—that the population of the ward in a given census year was evenly distributed across all its built-up blocks. The share of each built-up block's population in a census year is thus the total population of the ward in that year divided by its share of the ward area, implying that at any given census year the population density of all built-up blocks in a given ward or census block is assumed to be the same. In this manner, we assigned a population to each block in Manhattan in each census year, assigning it a population of zero if it was still un-built.

We then interpolated block populations for every single year by making a second simplifying assumption: that each year one-tenth of the total population added to the block between census years would be added to the block population. When a block was built between two census periods, we assumed it had a population of 0 before the year it was built and assigned it an equal share of its later census year population every year. For example, if a block was built in 1846 and was found to have a population of 1,000 in the census year 1850, we assigned it a population of 200 in 1846, 400 in 1847, 600 in 1848, and 800 in 1849.

To conclude, given the 'built-certain' date for each Manhattan block (see figure 16, right), we were able to determine its estimated 'year built' using a simulation that added built-up blocks year by year so that in each 'built certain' map year the built-up blocks built in previous years corresponded exactly to the built-up blocks in the 'built certain' map. Similarly, we were able to determine the population of each block in each year, both in census years and between census years, ensuring that in each census year the population of all built-up blocks in a ward added up to the total ward population. This methodology allowed us to calculate the population density of each block in Manhattan for every year in the study period as a ratio of its population and its land area. The results of this analysis are presented and explained in the remainder of this paper.

One final methodological note before we proceed: Density measures the number of people per unit of land area, not per unit of floor area. It is therefore only an indirect measure of overcrowding. Overcrowding is measured by the number of people per unit of *floor area*, or more commonly by its reciprocal, *Floor Area per Person (FAPP)*. Residential floor area per person, a more precise measure of overcrowding, can be estimated by focusing only on the share of gross floor area in residential use. We cannot calculate the Floor Area per Person if we only have information on densities; we need additional information, specifically information on the *Floor Area Ratio (FAR)* of buildings.

The Floor Area Ratio is a common measure, typically used in the issuance of building permits. It measures the ratio between the floor area of a building and the area of the plot on which it is built. For example, if a plot of 2,000 square feet is occupied by a 6-story building that has 1,000 square feet on every floor, the its Floor Area Ratio is 3.0: *FAR = (6 x 1,000)/2,000 = 3.0.* If the plot is occupied by a 2-story building with the same floor area on every floor, then its FAR is 1.0, and if it is occupied by an 18-story building with the same floor area on every floor, then its FAR is 9.0. If any building on that plot is occupied by 20 people, its *density* would always be the same (approximately 1,076 persons per hectare) regardless of the number of floors, but its level of overcrowding will vary with its number of floors: the 18-story building will have 900 sq. ft. of floor area per person; the 6-story building will have 300 sq. ft. per person; and the 2-story building will have 100 sq. ft. per person. If, in addition to information on the densities of Manhattan blocks, we had FAR information, we could learn something about the changing levels of overcrowding in Manhattan over the years as well.

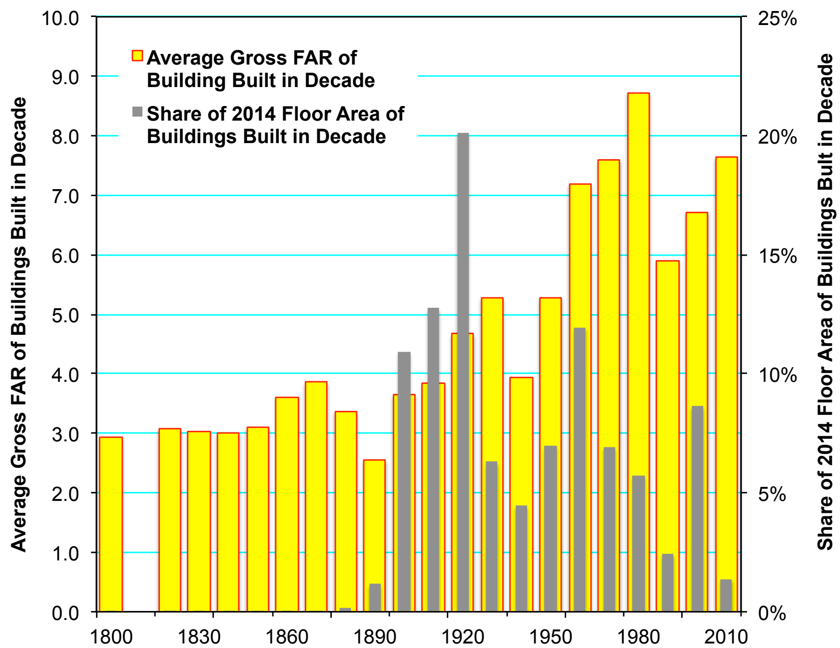


Figure 13: The Average Gross Floor Area Ratio (left axis) and the share of Total 2014 Floor Area (right axis) in Buildings Constructed in Different Decades, 1800-2010 (For data, see Appendix 1)

The PLUTO (Primary Land Use Tax Lot Output) database provides up-to-date information on the year built, the plot area, the built floor area, the residential floor area, the gross Floor Area Ratio (FAR), and the residential Floor Area Ratio for all 40,631 buildings in Manhattan, all constructed between 1765 and 2013. The list is complete and includes every building in Manhattan. It is not a random sample of buildings. This comprehensive database allowed us to estimate the average FAR for buildings built in a given decade (see figure 13, left axis). Figure 13 shows that, on average, the FAR in Manhattan remained quite stable in the 19th century—averaging 3.2±0.3—and increased substantially in the 20th century, more than doubling the 19th century values by the end of the century.

We can use this information to model the average residential FAR in Manhattan in a given decade—of all buildings, not only those built during that decade—by making two simple assumptions: First, that this average is computed as the *cumulative average FAR* in all decades preceding that decade; and second, that the average residential FAR is a fixed share of the general FAR, amounting to 63%, the average ratio of residential FAR and overall FAR for buildings built in any decade since 1800. The resulting model yields the graph shown in figure 14. While the FAR of buildings built in the 2010 decade in Manhattan is figure 13 was 7.6, the cumulative average FAR according to our model is only 4.7. The actual cumulative FAR in Manhattan in 2013 was 4.4, a figure very similar to that predicted by the model.

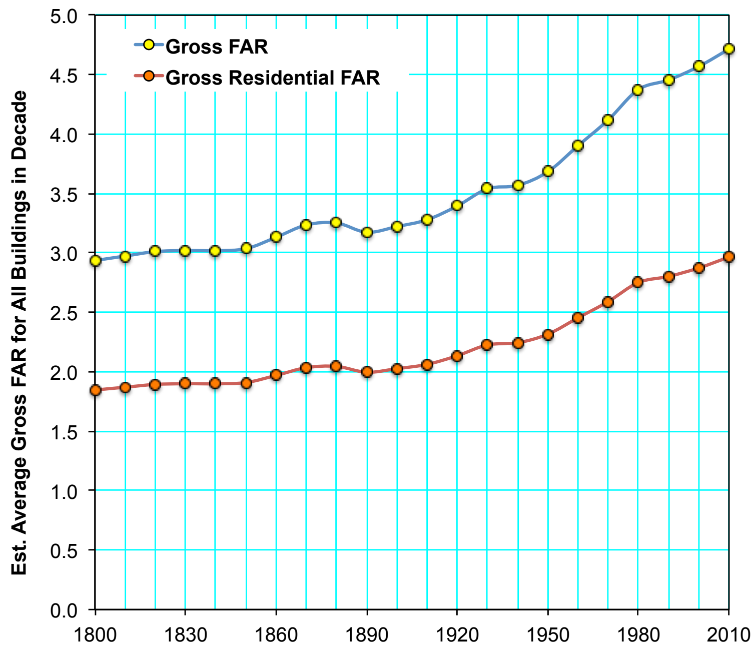


Figure 14: Model estimates of the average floor area ratio and the average residential floor area ratio in different decades, 1800-2010 (For data, see Appendix 1)

We know the total area of building plots in Manhattan in 2013, as well as the total built-up area. The former amounts to 3,140 hectares and the latter to 4,466 hectares. The total plot area thus amounts to 70.3% of the total built-up area, with the remaining area, almost 30% of it, devoted to streets and avenues. There are 107,639 square feet per hectare. The average residential Floor Area per Person (FAPP), calculated in square feet, in a given decade can thus be estimated from the average built-up area density and the average residential FAR in that decade from the following formulas:

(1) *Floor Area per Person = Total Plot Area × 107,639 × Residential FAR / Population =*

(2) *= 0.703 × Built-up Area × 107,639 × Residential FAR / Population =*

(3) *= 0.703 × 107,639 × Residential FAR / Built-up Area Density.*

To take one example, in the year 1800 the Residential FAR was 1.85 and the built-up area density was 207 persons per hectare. Formula (3) yields 675 square feet as the average residential floor area per person during that decade (the reader should keep in mind that this measure is that of the *gross* floor area per person, including the area for corridors and stairs and, later, elevators).

We used this model to estimate the average Residential Floor Area per Person in every decade from 1800 to 2010. This information, limited though it may be in the absence of better data, adds an important dimension to our study of the rise and fall of Manhattan's densities. It explains how densities can fall even while the amount of building increases and while new buildings get higher and higher: They can fall if fewer people inhabit the same land area but occupy more living area per person; they can fall when poorer people who occupy less floor area per person leave for the suburbs while richer people who occupy more floor space per person stay put and more of them move in.

3 The Rise of Manhattan's Densities, 1800-1910

The density history of Manhattan can be divided into two phases: A period of rising densities, and a period of falling densities. During the first phase, which lasted from 1800 to 1910, the population of the island increased steadily, its built-up area expanded steadily and the average density of its built-up area was generally on the rise. To understand why density behaved in this way, it is useful to think of density as a ratio: The ratio of the island's population to its built-up area. That ratio remains the same if both grow at the same rate, or if both double in size. It increases when the population grows faster than the built-up area, and it decreases when the built-up area grows faster than the population. Indeed, as figure 15 shows, between 1800 and 1840 both the population and the built-up area of Manhattan grew 5-fold at the same rate—approximately 4% per year—and, therefore, the density of the island remained stable. However, between 1840 and 1910, the expansion of the built-up area—at a more modest average rate of 1.5% per year—could not keep pace with the growth of the island's population, a population that grew at double that rate, 3% per year on average, during this period. In essence, the island's population grew by 7.4 times in these decades to reach its historic peak of 2.3 million in 2010, while its built-up area expanded only 2.9 times. This had led to a substantial increase in the average density in Manhattan as well as to serious overcrowding in some of its neighborhoods (shown on the map in figure 16, left).

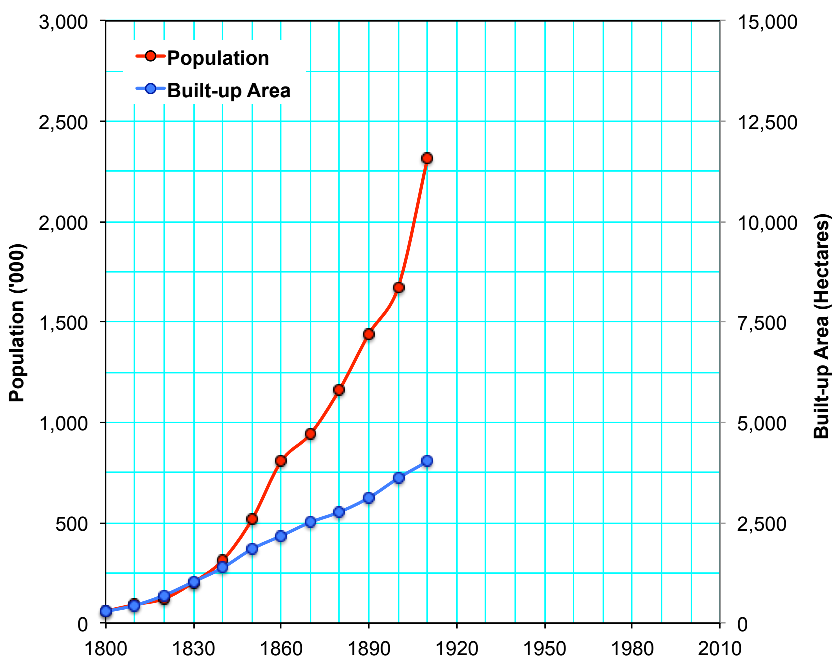


Figure 15: The increase in the population (left axis) and in the built-up area (right axis) in Manhattan, 1800-1910 (For data, see Appendix 1)

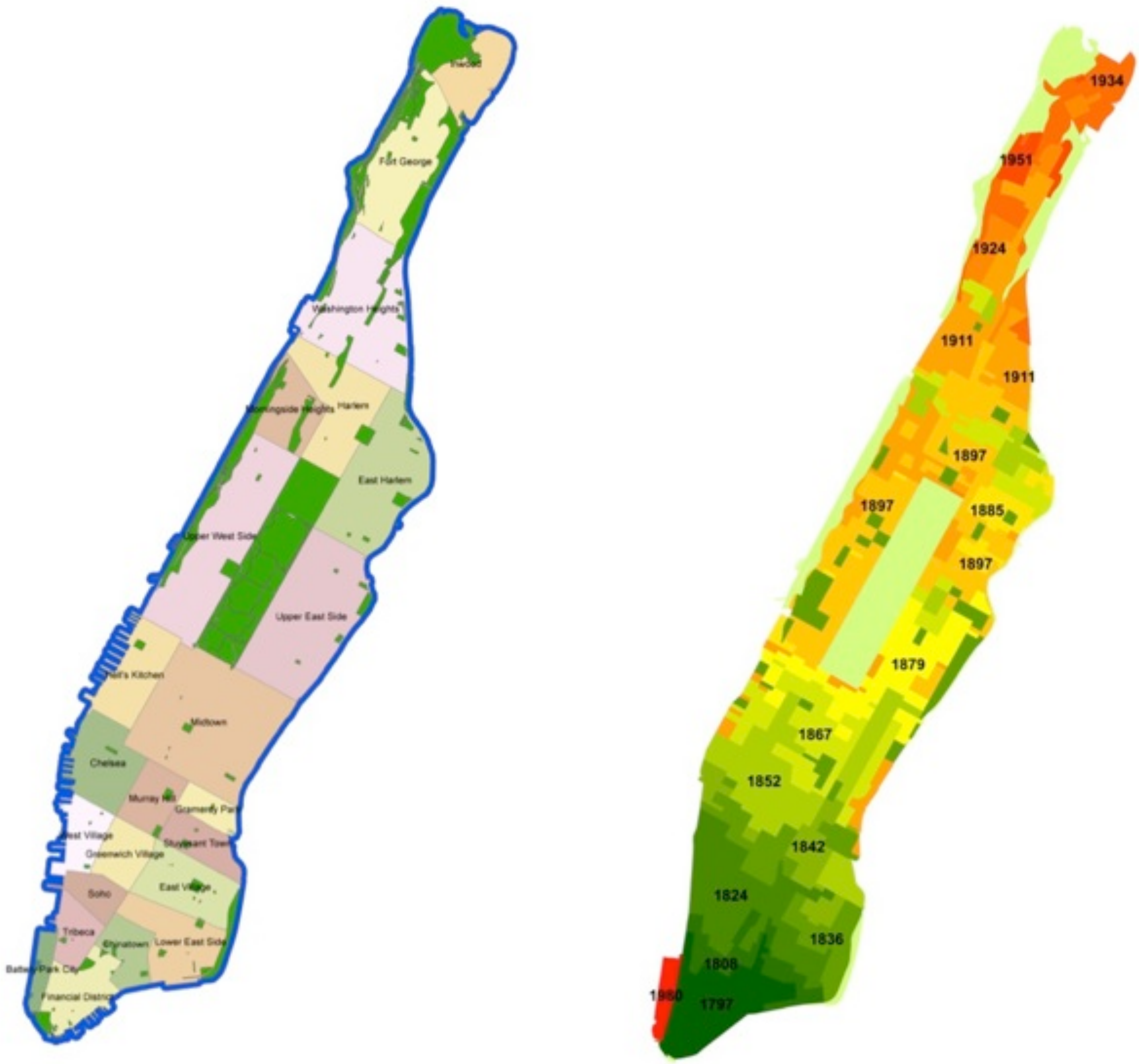


Figure 16: The neighborhoods of Manhattan (left) and the 'built-certain' map of Manhattan blocks (right) (Appendix 2)[7]

On average, the density of the built-up area of Manhattan remained stable at approximately 200 persons per hectare from 1800 to 1840 but then began to climb steadily, tripling in value to 600 persons per hectare in 1910 (see figure 17). It reached 1,530 persons per hectare in the Lower East Side, 1,320 persons per hectare in the East Village, and 1,075 persons per hectare in Chinatown, to take a few examples of extreme density increase (see figure 16, left).

---

7 For a simulated animation of the expansion of the built-up area of Manhattan through its 'built-certain' maps from 1800 to 2010, see http://youtu.be/9Snw3Huxm5U

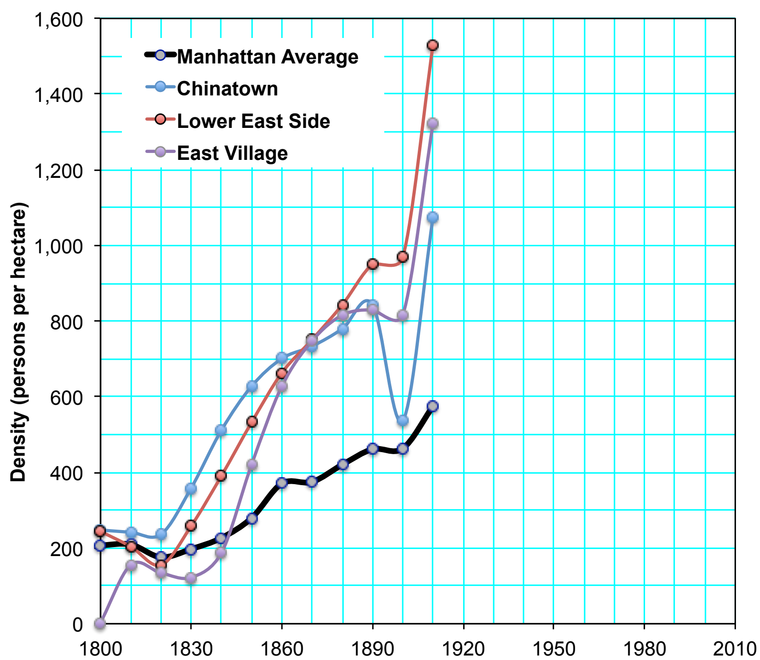


Figure 17: The increase in the average density of the built-up area of Manhattan and in selected neighborhoods, 1800-1910 (For data, see Appendix 1)

The tenements of New York City's 10th Ward, for example, often contained 20 or more 30 m^2 apartments with no indoor plumbing on a 7.5 x 30–meter lot, each containing a household of 3 to 14 persons (Dolkart 2007), and many were used as a workplace as well as a residence (figure 18). Politicians, reformers, and scholars were seriously concerned with living conditions in the city's crowded neighborhoods during this period:

> The Tenth Ward has a population at the rate of 185,513 (708 persons per hectare) to the square mile the Seventeenth 170,006 (657 persons per hectare) and so on with others equally overcrowded. Portions of particular wards are even in worse condition (The New York Times, 3 December 1876).

As figure 16 shows, densities continued to increase for decades after this article was written. Jacob Riis, a reformist journalist and photographer credited with exposing the overcrowding and dire living conditions in the city's tenements in his book, How *the Other Half Lives,* was quite pessimistic about the prospects of ever reducing overcrowding and high densities in the city:

> What then are the bold facts with which we have to deal in New York?
>
> I. That we have a tremendous, ever swelling crowd of wage-earners which it is our business to house decently.
>
> II. That it is not housed decently.
>
> III. That it must be so housed *here* for the present, and for a long time to come, all schemes of suburban relief being at yet utopian, impracticable.
>
> (Riis 1971 (1890), 223)

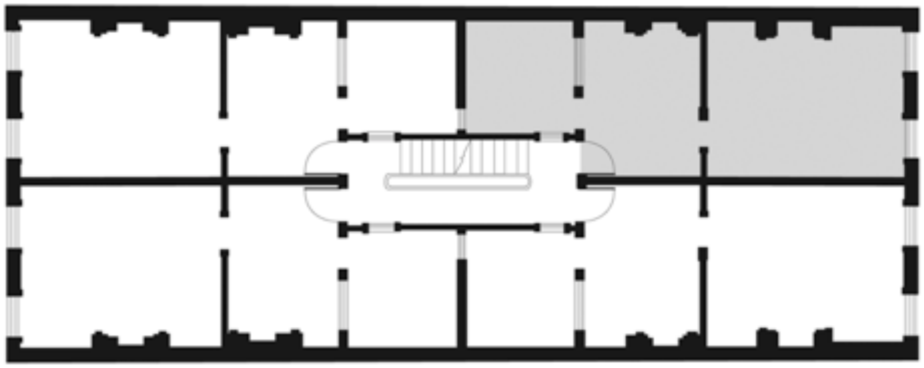


Figure 18: A New York tenement floor plan (1864) showing 4 3-room apartments with no kitchens or bathrooms

By the final quarter of the 19th century, contemporary news reports indicate that those neighborhoods, including the Lower East Side, Chinatown, and the East Village, were extremely overcrowded, with very poor living conditions. The New York Times of Nov. 28th, 1898 speaks of "densely crowded quarters," and "inmates…huddled together in their cramped hutches like rabbits."

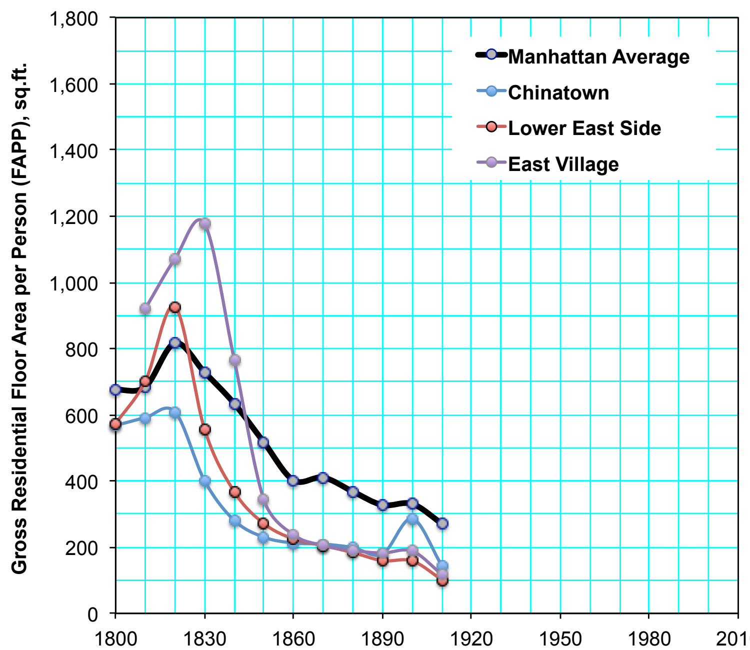


Figure 19: Model estimates of the change in the average gross residential floor area per person (FAPP) in Manhattan and in selected neighborhoods, 1800-1910 (For data, see Appendix 1)

As noted in these reports, density increases were accompanied by an increase in overcrowding, namely by a decrease in the gross residential floor area per person (inclusive of corridors and staircases). Our model estimates, shown in figure 19, confirm these reports. The figure shows that, in the island as a whole the average floor area per person declined from a 19th- century maximum of 817 square feet in 1820 to one-third this value, 272 square feet per person, by 1910. In the three selected neighborhoods it reached considerably lower: In the Lower East Side, the East Village and Chinatown, residential floor area per person declined to 102, 118 and 145 square feet per person respectively. Scenes of overcrowding during this period are shown in figure 20.

Figure 20: Scenes of overcrowdings in 19th century Manhattan: Jacob Riis photos of cigar makers at work in their tenement, Lower East Side, in 1889 (top left) and of the Five Cents Lodging on Bayard Street in Chinatown in 1889 (bottom left); Lower East Side Street in 1898 (top right); and Mulberry Street circa 1900 (bottom right)

How can the decline in built-up area densities and floor area per person in Manhattan during the 19th century be explained? As we noted earlier, densities increase when the rate of population growth is faster than the rate at which built-up area is added. Rapid population growth is typically the result of the availability of employment opportunities: Rapid economic growth propels rapid population growth and is, in turn, propelled by the ready availability of suitable labor. Our comparative studies of average densities in a global sample of cities (Angel, 2012) show, densities increase when average incomes decline, and decline when cheap transportation is available for commuting to work. Densities decline when there is ample area within commuting range for urban expansion and when there are no regulatory restrictions on building on the urban fringe or on floor area ratios. We have also seen that floor area per person increases when densities decline. They also increase when building technology—specifically steel frame construction and passenger elevators—allows for the construction of taller buildings with higher floor area ratios in a given built-up area.

Employment Opportunities in the Port and in the Factories

Three main factors led to the remarkable growth in the demand for labor—and particularly for unskilled labor—in Manhattan in the early decades of the 19th century. The first was the natural advantage afforded by New York Harbor, a deep, ice-free port located midway along the Eastern Seaboard of the United States (see figure 21). The second was the development of a hub-and-spoke transportation system in America, a system augmented by the construction of the Erie Canal connecting the Port of New York to the Great Lakes system. These developments, as we shall explain below, created the "cotton triangle." A third factor—the early advantages offered by the port and the Erie Canal that led to a concentration of skills, capital, and commercial experience in the city—made it possible for New York to retain its competitive advantage long after the development of the railroad reduced the importance of the Erie Canal.

Figure 21: New York Harbor, South Seaport, undated

New York began to rise to prominence with the legislative shift from the Articles of Confederation to the Constitution in 1789. This eliminated the earlier barriers to trade among the colonies, turning the central location of the Port of New York into a major economic advantage. Before 1820, Boston was the premier port in America, with annual exports of around $12 million. In 1821, New York had modestly surpassed Boston, with exports of $13 million, and commanded 9.1% of total U.S. trade. By 1830, the Port of New York was exporting a remarkable $55.3 million a year, and accounted for 36.8% of total U.S. trade, coming "to dominate American shipping and immigration completely" (Glaeser, 2005). This remarkable growth in trade continued, and by 1900, the Port was exporting over $1 billion in goods. Figure 22 shows the absolute growth in trade at New York Harbor and its share of all U.S. trade, from 1790 to 1910[8]. The figure shows a rapid increase in trade from 1820 onwards and, indeed, trade increased at the annual rate of 5.4% until 1910, roughly doubling in value every 13 years. By the 1830s, the share of U.S. trade commanded by New York

[8] Sources: Edward E. Pratt, *Industrial Causes of Congestion in New York City* (New York: Columbia University Press, 1911), p.37; Benjamin Chinitz, *Freight and the Metropolis* (Cambridge: Harvard University Press, 1960), p.19; *Annual Reports* of the Chamber of Commerce of the State of New York; *The Manual of Statistics* (New York, 1910), p. 1015

was already one-third of the total. That share peaked at more than 70% in 1850 and never fell below 45% in the ensuing decades.

New York also benefited from its location along a deep, navigable river, the Hudson. This locational advantage became an unparalleled economic asset with the completion of the Erie Canal in 1825, which greatly accelerated the growth of the Port by connecting it to the Great Lakes system (see figure 23). The Erie Canal offered unprecedented access to the American interior, and with it's completion, the amount of time needed to ship goods from Buffalo on Lake Erie to New York Harbor fell from 20 days to 8 days, while the price fell from $100 to $15 per ton.

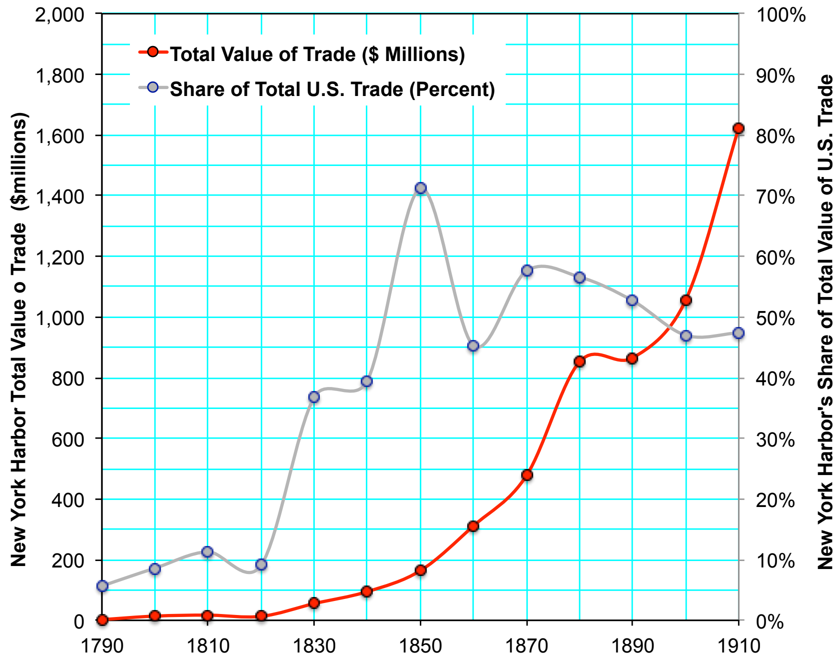


Figure 22: The rapid increase in the value of trade processed in New York Harbor and the share of the harbor in overall U.S. trade, 1790-1910 (For data, see Appendix 1)

New York Harbor's natural advantage was augmented by the innovation of a hub-and-spoke transportation system, the first of its kind in America. The Port of New York's status as a deep-water port made it ideally suited to accommodate a new class of very large clipper and steam ships coming into prominence around that time (Glaeser, 2005). These ships were designed for transatlantic transport. Transport into the American interior on the Hudson River and on the Great Lakes system, as well as transport along the Eastern seaboard, was still conducted using small "packet" ships and barges. This created an enormous opportunity for the Port of New York as a hub for transshipment: Unloading the goods from one class of ship, their temporary storage in warehouses, and the reloading of those goods onto another class of ship.

Figure 23: Along the Erie Canal, Buffalo, New York, undated

Wheat, for example, came down the Hudson from the American interior, via the Erie Canal and Great Lakes, and was unloaded at the Port of New York. It was then stored in granaries before being placed on transatlantic ships bound for the Caribbean. These ships would then sail to the Caribbean, unload the wheat, load a cargo of raw sugar, and bring the sugar back to New York to be processed into refined sugar. The refined sugar was then loaded onto packet ships, bound for the southern United States. These packet ships would unload the sugar and take on a cargo of cotton or tobacco which would then be brought back to New York, unloaded at the port, stored in warehouses, and either sold to local manufacturers (who would then ship manufactured goods back south, to the Caribbean or southern states), or loaded onto transatlantic ships bound for Europe.

During this period, manufacturing in Manhattan was "exploding" as well (Glaeser, 2005). From 1831 to 1855, for example, the number of textile and garment factories rose from 314 to 889 (Historical Statistics of the United States). From 1830 to 1860, the garment industry was the fastest growing industry in New York. In 1858 it employed 58,000 workers, producing $22 million worth of goods (ECNY, 493). From 1860 until a century later, the garment industry was the largest single source of employment in Manhattan (Bradley and Poole, 2010). In many ways, the industry was ideally suited to Manhattan, because of its modest requirements for space and power. After the invention of the foot-treadle sowing machine by Elias Howe in 1847 and its refinement by Eli Singer, all aspects of the trade became open to unskilled workers.

The hub-and-spoke trading system, with New York as the hub, became known as the "cotton triangle." The presence of abundant raw material in New York, in addition to the city's proximity to cheap, regularly scheduled water-borne transportation, created significant competitive advantages for manufacturers. The garment industry in particular benefited from the economies of scale made possible by centralized production, with the invention of ready-to-wear clothing in the 1820s (ECNY, 493). Thus, at each stage in this hub-and-spoke system, demand was created for low-income labor.

Interestingly, New York only retained these initial competitive advantages for some thirty years, until the widespread introduction of railroads sharply reduced the earlier advantages of water-based shipping through the Erie Canal (Glaeser, 2005). However, New York kept its edge over Boston, Philadelphia, Baltimore, and other prominent cities in manufacturing and shipping. This may have been largely the result of the Port having achieved economies of scale, of the concentration and organization of labor and capital that allowed it to remain dominant into the 20th century. There were also economies of scale attained by the agglomeration of manufacturing industries in the city: the sharing of labor, production inputs, markets, and knowledge. These agglomeration economies accelerated the tendency of manufacturing firms to cluster in New York, mostly near the port at the southern tip of the Island.

New York's ability to retain its early competitive advantages over other U.S. cities might be thought of as a form of economic "path dependency," in which a given region continues to perform strongly in a given industry or set of industries simply because it already has the infrastructure (people, machines, relationships, and knowhow) to support these industries. This path dependency allowed Manhattan to remain a major producer in several industries—sugar refining, publishing, and the garment trade in particular—well after most other major cities on the Eastern Seaboard had lost their factories. In conclusion, the growth of the port and the ensuing growth of manufacturing around that port, created a strong demand for labor, much of it unskilled, fuelling the rapid rise in the population that could provide that labor.

Immigration and the Rapid Rise of New York's Population

A substantial share of the growth in Manhattan's population in the 19th Century was due to immigration. Between 1815 and 1915, some 33 million people moved to the United States, and three-quarters of them came through the Port of New York (see figure 24).

Figure 24: Immigrants arriving at Ellis Island, New York, 1892

Most of these immigrants soon travelled to other parts of the country, but many stayed in New York (ECNY, 637). In 1800, the foreign born population of Manhattan was a little less than 1% of the total population. In 1820, it was still only 4.5%, but by 1840 it had risen to 18%. From 1850 onwards, the share of the foreign-born population in Manhattan never declined below 40%. It reached a high of 48% by 1910. By then essentially half the island's population—over 1 million people—had been born outside the United States (see figure 25).

Reports from the time indicate that many of these immigrants settled in the parts of New York that were already the most densely populated. The photographs of Jacob Riis, in particular (see Figure 19 earlier), documented what he termed the "extreme overcrowding" in the Lower East Side. He also observed that the majority of the residents in that area were immigrants and sought to address their plight. Riis was not alone. Many organizations attempted to address the problems facing immigrants living in crowded urban neighborhoods at that time, including the Settlement House Movement, the Children's Aid Society, and the fraternal organizations established by the immigrants themselves. These varied groups were by no means versed in statistics, but their descriptions of the dense and overcrowded areas of Manhattan in the 19th century provide riveting primary source accounts that generally speak with one voice when reporting squalid conditions, low-paid and unskilled labor, and a large population of immigrants.

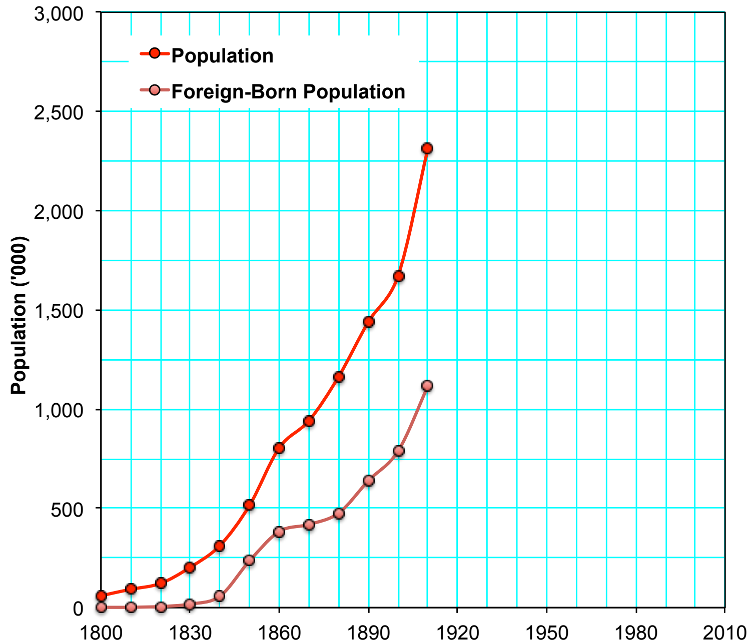


Figure 25: The increasing share of the foreign-born population in the total population of Manhattan, 1800-1910 (For data, see Appendix 1)

When considering why immigrants would choose to settle in New York City in such dire conditions, it may be useful to think about the composition of the immigrant workforce at that time. The Irish are one example of a well-known group that migrated to the United States in large numbers. From 1780 - 1910, an estimated 5 million Irish immigrated to the country. According to the American Immigration Law Foundation, from 1780 to 1820 these immigrants were largely tradespeople, artisans, teachers, or professionals: skilled workers who settled widely throughout the country. After 1820, farming families with very little means began coming. They were often illiterate and many of them lacked the funds to purchase land upon arriving in America. Of those, a great number became employed as urban laborers.

The story of German immigration is similar. The initial wave of German migrants consisted of comparatively skilled and well-off people, who were able to assimilate fairly easily. Later, starting around 1860, immigrants fleeing job scarcity and poor farming conditions began arriving by the millions. Many of these Germans brought money with them and were able to purchase their own farms. Indeed, around three-fifths of German immigrants between 1860 and 1890 settled in rural areas. That said, however, the remaining two-fifths settled in cities, and many of them spent their initial years working in New York's ports and factories before moving on to better paid work elsewhere.

Polish immigration followed a similar trajectory. The first wave of Polish immigration, from 1800 to 1860, consisted of intellectuals and impoverished nobles, fleeing the country because of political persecution. It's estimated that fewer than 2,000 Poles immigrated during this time. During the second wave of immigration, from 1860 - 1920, more than 2.5 million Poles entered the United States. Around 95% of these people entered through New York Harbor, and many of them stayed in the New York area. This second wave consisted largely of dispossessed farmers and Jews fleeing persecution, who initially found employment as day laborers and market vendors, and later moved on to the ports and the garment factories (ECNY, 638).

In more general terms, the early waves of immigration (1800-1840) consisted of higher skilled people, with the flexibility to buy land and start farming, or to move from city to city in search of skilled work. A larger second wave of immigrants, from about 1840 to 1920, included large numbers of European peasants, without the means to purchase land and without the skills to seek higher paying urban employment. This labor force entered Manhattan at a time when the demand for unskilled workers was extremely high, and a considerable number of them stayed. Their presence was a major contributing factor to the rise in the island's population, and their particular circumstances—as unskilled and low-paid laborers—left them with meager resources to afford adequate housing or to spend money commuting to work, leaving them with few options other than settling in one of the cities dense and overcrowded neighborhoods.

Making Room for Accommodating Rapid Population Growth

One lesson that can be drawn from the growth of New York concerns the cities that are currently rapidly growing, around the world. In the case of the island of Manhattan, spatial expansion was constrained by geography and transportation technology. In many cities today, spatial expansion is constrained by policy and by lack of planning. The example of New York shows that the expansion of cities that rapid population growth entails cannot and should not be contained. Instead, we must prepare adequate room for this expansion, through the advance layout of streets and public works so that it remains orderly and efficient, and so that the land required to accommodate population growth remains plentiful, accessible, and affordable. The density of cities and the amount of floor area per person are the result of the interplay of supply and demand for space, and more particularly of residential space. When demand for space is high and supply responds with the rapid conversion of land on the urban fringe to urban use and the rapid construction of buildings, density and floor area per person remain the same and sometimes decline as well. Conversely, when, for one reason or another, there are bottlenecks preventing the orderly and timely expansion of the built-up area, or when there are regulatory restrictions that prevent this expansion or limit the amount of floor area that can be built on plots, then land and housing prices increase, resulting in increased densities and reduced floor area per person. The public sector thus plays a crucial role in regulating density and overcrowding; it has an important role in preparing areas for expansion by laying out streets, and it has a crucial role in regulating the amount of building and construction. It also has a key role, as we shall see below, in ensuring that areas on the urban fringe are provided with good access to jobs.

Did the public sector bear a responsibility for the rise in density and the decline in floor area per person in Manhattan in the 19th century? The short answer to this question is no. In 1807, the Common Council of the City of New York appointed three commissioners—Gouverneur Morris, Simeon DeWitt and John Rutherford—to prepare an expansion plan for the island of Manhattan (see figure 26). While it is not clear whether the Council actually sought to attract more people into the city, it certainly made active preparations for a more populous city than any that existed at the time "on this side of China". More specifically, it prepared land for a *sevenfold* expansion of the built-up area of the city at that time. How many cities can claim this audacity of vision?

Wishing to overcome both the resistance to its plans by landowners and the lack of consensus among its own members, the Council sought to tie it hands, so to speak, by empowering the commissioners through an official statute enacted by the State of New York. The Statute, issued on the 3rd of April 1807, applied almost to the entire island, but for its northern tip. It gave the commissioners "exclusive power to lay out streets, roads, and public squares, of such width, extent, and direction, as to them shall seem most conducive to public good, and to shut up, or direct to be shut up, any streets or parts thereof which have been heretofore laid out... [but] not accepted by the Common Council". It was also understood and agreed that the Council could not deviate from the commissioners' plan "without securing specific legislative authorization".

Figure 26: The Commissioners' Plan for Manhattan, completed 1811

The commissioners settled on a simple, rigid, and rather uninspiring orthogonal grid plan because "straight-sided and right-angled houses are the most cheap to build and the most convenient to live in". They also agreed to offer reasonable compensation to landowners whose land was taken for streets once the streets were opened. "Payments could be offset in whole or in part by benefit assessments, and when assessments were approved by the court and the city, payments from the assessment fund were to be made to those whose land had been taken." In an important sense, therefore, the acquisition of the public rights-of-way for streets did not impose a burden on the public coffers. The surveying of the street grid required almost four years and the plan was completed on the 22nd of March 1811.

The grid provided ample area for expansion and there were no restrictions limiting that expansion or limiting the floor areas of buildings in expansion areas. Those limits, in the early decades of the 19th century were largely technological. There was no efficient and affordable transportation technology that could allow people to live beyond walking range from their jobs in lower Manhattan. And there was no efficient and affordable building technology that would allow for the efficient construction of tall buildings. Buildings were largely restricted to six floors—seven at the most in a few cases—allowing people to walk up the stairs to their homes. Elevators were installed in residential building only in the closing decades of the century: the Dakota building on the Upper West Side—the earliest residential building on the island with built-in elevators—was completed in 1884. That is why, as we saw earlier (figure 13) the floor area ratio in Manhattan remained largely the same throughout the 19th century—averaging 3.2±0.3—increased substantially only in the 20th century.

Transportation Technology and Urban Expansion

From its settlement in 1624 and until the early decades of the 19th century, New York, like all cities up to that point in history, was a walking city. Goods were moved by wagon and a few rode horses or moved about by carriage. But the great majority walked. This restricted the extent of the built-up areas of cities, so that one could walk from the urban fringe to one's place of work in a reasonable time period, typically half an hour and rarely more than one hour. The absence of transportation technology in this early period led to the creation of dense concentrations of people near employment concentrations and, in the case of Manhattan as we noted earlier, in neighborhoods like Chinatown, the Lower East Side and the East Village in the southern part of the island.

The commissioner's street grid of 1811 created an efficient network of roads, and a system for parceling and selling land that greatly facilitated urban expansion. It allowed entrepreneurial developers to create upscale row house and brownstone neighborhoods in what was then the northern part of Manhattan: Union Square, Gramercy, and Chelsea. These neighborhoods were made accessible in the early decades of the century with the introduction of a new transportation technology, the Omnibus. Omnibuses, an early form of public transport, began travelling up and down Broadway in 1831 (ECNY, 192). Pulled by a team of horses, the omnibus was capable of carrying 10 to 40 people at speeds of up to 8 miles per hour (see figure 27). Often, and especially in winter, it wheels became bogged down in the mud of the streets, and it speed rarely exceeded a fast walk. Omnibuses were soon put on a system of railroad tracks: The first horsecar line in Manhattan—from Prince Street to 14th Street—was opened in 1832 (Rodriguez). This increased their speed to a fairly consistent 10 miles per hour, and

Figure 27: Manhattan transport before the advent of rapid transit—the omnibus

allowed them operate in most weather conditions (see figure 28).

These vehicles were introduced into Manhattan at a critical time, when much of the land within walking distance of the employment opportunities in lower Manhattan had already been developed. The omnibus and the horsecar expanded the amount of land available for settlement within a tolerable commute of lower Manhattan. However, the expense was nontrivial, and the many poor residents of the city were unable to use the two primary transportation technologies of the era. Access to the nearest developable land between 1790 and 1850 remained the prerogative of the middle and upper classes, with the possible result that those lands developed relatively slowly compared to lands that were within walking distance of lower Manhattan. By mid-century, the limited demand for plots in areas accessible only by omnibuses and horsecars contributed to a slowdown in the rate of growth in built-up area, despite the increase in the rate of population growth at that time.

Figure 28: Manhattan transport before the advent of rapid transit— the horsecar.

Transportation options began to expand in the second part of the 19th century with the advent of urban rail service. In the 1870s, major elevated railroad lines were built on Second, Third, Sixth, and Ninth Avenues, as well as on several streets downtown. These elevated lines initially connected lower Manhattan to Midtown, but by 1878 had made connections to the Bronx via the east and west sides of Central Park.

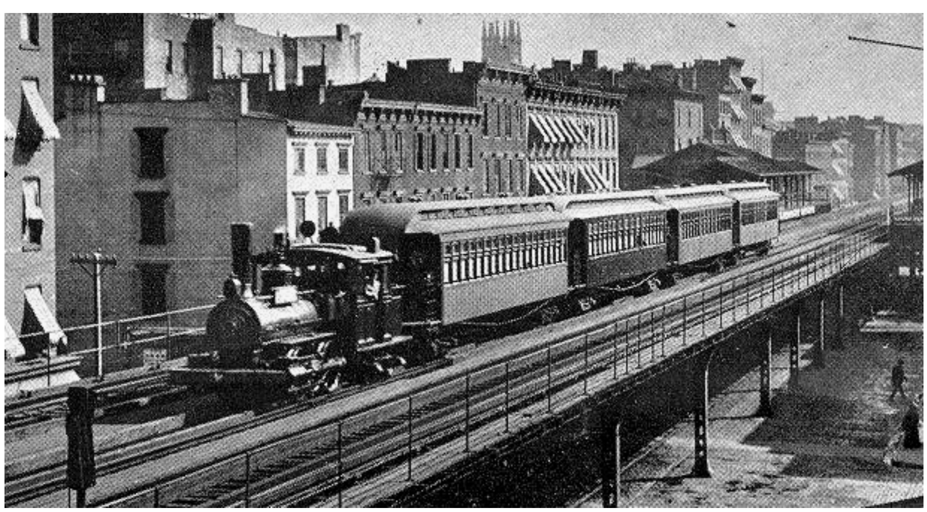


Figure 29: An elevated train on the Sixth Avenue line in Manhattan, 1886

The several-fold increase in speeds, in comparison to the earlier omnibus and horsecar, expanded the amount of land that could be developed within a tolerable commute of the employment centers of lower Manhattan. Reformers were hopeful that these elevated trains would succeed where the horsecars failed, allowing the poor and the working class to move away from the dense neighborhoods of lower Manhattan to the ample lands of Harlem and the Upper West Side. Indeed, those areas had developed quite slowly until the construction of elevated lines. Their development accelerated in the two decades, 1880–1900, following the introduction of the elevated railways, but few if any of the buildings were affordable by the poor, let alone the cost of getting to work from there.

Unfortunately, these elevated trains initially cost ten cents for a one-way ride, with no transfers, putting them beyond the reach of an average working person who generally earned less than $2.00 for a ten-hour day. Instead, the elevated rail lines facilitated the development of the Upper West Side as a stable medium-density neighborhood, and the growth of the Upper East Side as a district of low to mid-density private homes and apartment buildings—housing for the middle and upper middle classes. Densities in Tribeca, Soho, the West Village, and Murray Hill began to fall slightly around this time, but the average density in the city as a whole continued to rise. In the Lower East Side, the East Village, and Chinatown, densities were rising particularly quickly. These neighborhoods housed low-income families, within walking distance of the docks, garment factories, and markets that provided them with employment.

The construction of bridges over the East River—the Brooklyn Bridge in 1883, the Williamsburg Bridge in 1903, and the Manhattan Bridge in 1909 laid the groundwork for the de-concentration of Manhattan and the relief of overcrowding there. The Brooklyn Bridge connected Lower Manhattan to Brooklyn, free of charge. It vastly increased the number of commuters living in Brooklyn and working in Lower Manhattan. Brooklyn's population doubled between 1880 and 1900, from 600,000 to 1.2 million. However, much like the upper west and upper east sides of Manhattan, the housing that was being constructed in Brooklyn was targeted at middle class residents, offering limited relief to the poor. Densities thus continued to rise in the East Village, Chinatown, and the Lower East Side, and continued to decline in all other neighborhoods. Despite these improved connections to other areas containing buildable land, average densities did not begin to decline in Manhattan until after 1910, with the development of cheap high-speed underground rapid transit: the subway.

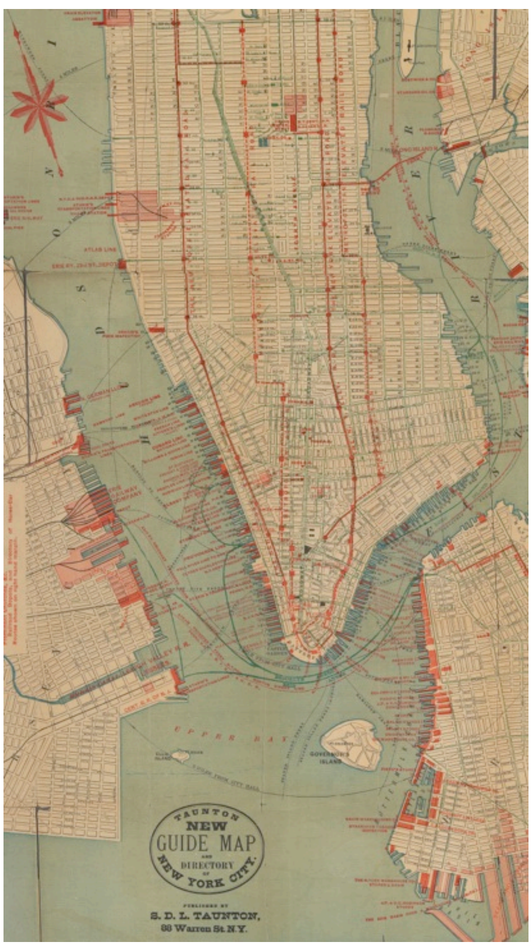


Figure 30: A map of the elevated railway lines in Manhattan, 1899

To conclude, the population and the built-up area of Manhattan grew rapidly in the 19th century. Between 1800 and 1910, the population of the island grew almost 40-fold, from 60,000 to 2.3 million while its built-up area expanded only 14-fold, from 290 to 4,000 hectares. As a result, the average density of the built-up area almost tripled. By 1910, the population of Manhattan reached its historic peak, while 90% of its buildable land was built-up, leaving little room for further expansion. Population densities increased steadily from 1840 onwards, reaching a peak in 1910, while residential floor area per person declined to an all-time low by 1910. While new residential areas housing the middle and upper classes developed rapidly in new neighborhoods to the north of the island, several poor neighborhoods remained congested and overcrowded with no relief in sight.

4 The Fall of Manhattan's Densities in the 20th Century

After 1910, the population of Manhattan, its average population density, and the population density in its overcrowded neighborhoods began to fall while average floor area per person increased steadily. This radical change was largely due to the opening up of the suburbs occasioned by the introduction of the subway system in the early years of the 20th century. The latter was facilitated by the formation of Greater New York in 1898 with the annexation of Brooklyn, Queens, the Bronx and Richmond County (Staten Island) to Manhattan. Annexation and the preparation of large areas outside Manhattan for residential settlement, increased the affordability of housing in the suburbs. Increased housing affordability, augmented by affordable commuting fares, made it possible for large number of people to leave Manhattan for the suburbs while keeping their jobs in Manhattan.

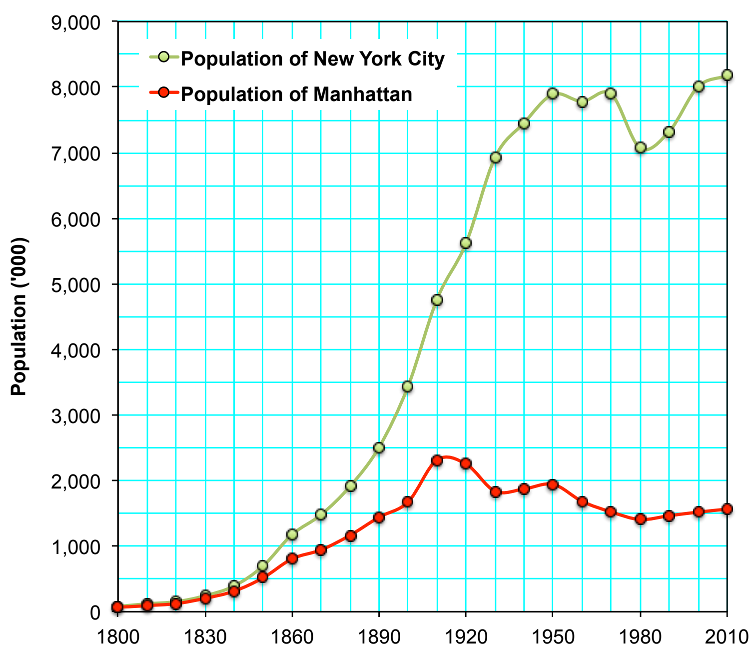


Figure 31: The declining share of Manhattan's population in New York City's overall population, 1800-2010 (For data, see Appendix 1)

This has led to a significant decrease in the share of New York City's population living in Manhattan. In 1800, 80% of New York City's population lived in Manhattan. That share fell steadily to 49% by 1910, falling, on average by 0.5% per year. Between 1910 and 1970, that share fell much more rapidly, at an annual rate of 1.5%—three times faster than in the earlier period, reaching 20% by that year. Since 1970, that share has remained stable at 20% (see figure 31).

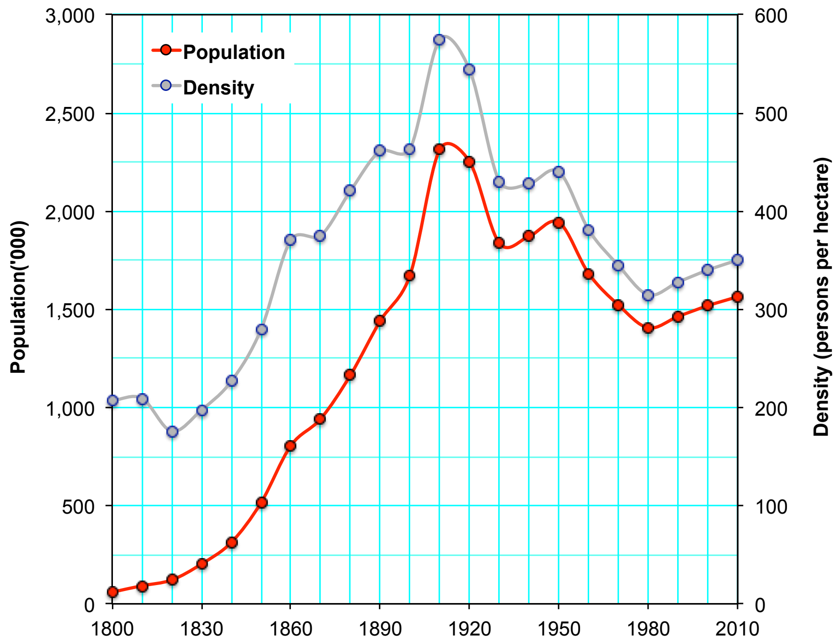


Figure 32: The decline of the population and the density of Manhattan from 1910 onwards (For data, see Appendix 1)

The overall result was a systematic decline in the population of Manhattan from 1910 onwards, accompanied by a systematic decline in the average density of its built-up area. The island was fully built by 1951 and since then, average density change has simply been a function of the island's population. This is clearly observable in figure 32. The figure shows a decline in the population of Manhattan from 2.31 million in 1910 to 1.46 million in 1980—a decline of one-third from peak 1910 population. Average density declined from a peak of 575 persons per hectare in 1910 to 350 persons per hectare in 2010, a 40% decline. From 1980 to 2010, some 158,000 people have been added to the population. An additional 289,000 people are projected to be added by 2030 (U.S. Census) by which time its total population will be 1.85 million, 20% less than its peak population in 1910. In that year, its density will be 415 persons per hectare, still 25% less than its peak density in 1910. In short, the overall trend in the twentieth century was one of decline in both population and density, but more recently we can see a slight upward trend in both the population and the density of the island.

The decline in density from 1910 to 1980 was not only an average decline. It was particularly drastic in the most overcrowded neighborhoods in Manhattan: Chinatown, the Lower East Side, the East Village, as well as East Harlem and Washington Heights, to take a few examples. These neighborhoods, which had resisted decongestion despite the decades-old efforts of reformists, could now become less and less overcrowded as their residents gradually moved to neighborhoods further north or, more commonly, to the suburbs. This can be seen quite vividly in figure 33. In fact, by 2010 densities in most neighborhoods in Manhattan converged to the island's overall average: The average for all 23 Manhattan's neighborhoods in 2010 was 329±23 persons per hectare; there were no neighborhoods with densities higher than 500 persons per hectare; and the densities in the Upper East Side and the Upper West Side were higher than the densities in all the formerly overcrowded neighborhoods. Overcrowding in Manhattan gradually became a thing of the past as these neighborhoods decongested during the early decades of the 20th century.

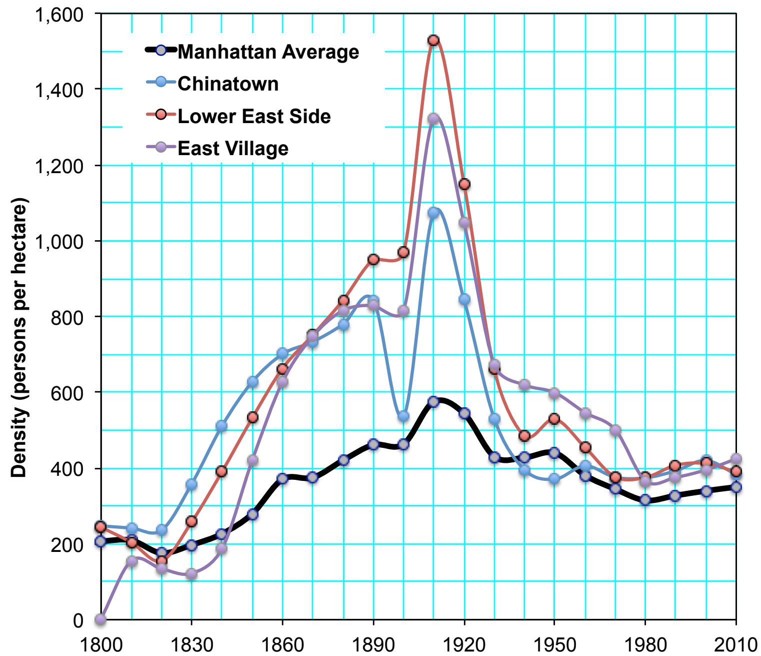


Figure 33: The rapid decline in densities in selected Manhattan's neighborhoods from 1910 onwards (For data, see Appendix 1)

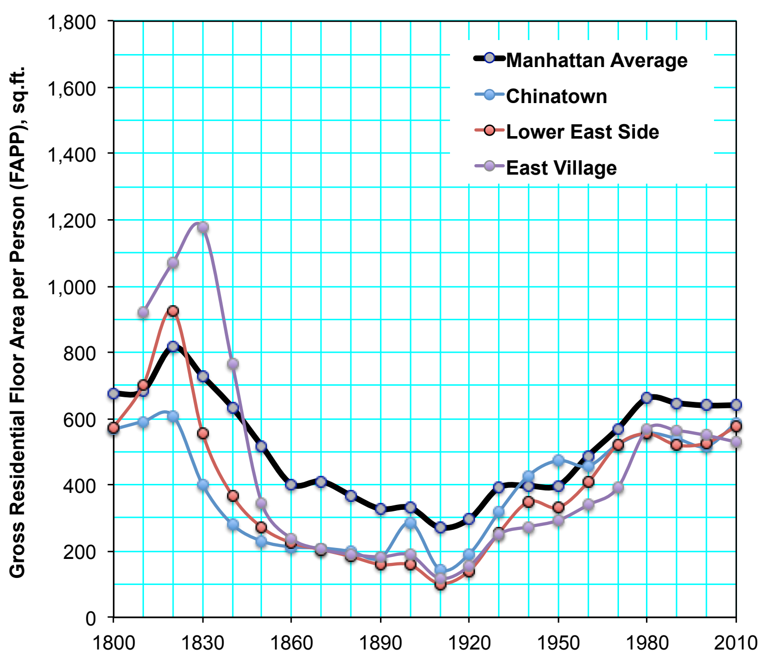


Figure 34: The rapid increase in floor area per person in selected Manhattan's neighborhoods from 1910 onwards (For data, see Appendix 1)

The renowned social reformer Jacob Riis, who declared that "the swelling crowd of wage-earners" must be housed in their existing neighborhoods "and for a long time to come, all schemes of suburban relief being at yet utopian, impracticable" (Riis 1971 (1890, 223), was simply wrong. Other social reformers sought to reduce overcrowding through decongestion policies made possible by the development of new transportation technologies from the early twentieth century onwards. These technologies reduced the cost of movement in cities and made it possible and affordable for large numbers of people to commute over greater distances. Adna Farrin Weber (1899, 475) in his influential *The Growth of Cities in the Nineteenth Century* had it right: "The 'rise of the suburbs' it is, which furnishes the solid basis of a hope that the evils of city life, so far as they result from overcrowding, may be in large part removed."

There is no question that suburbanization did facilitate the decongestion of Manhattan's overcrowded neighborhoods:

> The Lower East Side contained 398,000 people in 1910, 303,000 in 1920, 182,000 in 1930, and 147,000 in 1940. To reformers who had long pressed for the depopulation of the slums, this leveling out of neighborhoods was a welcome and much celebrated relief. (Jackson, 1985, 185)

The depopulation of Manhattan's congested neighborhoods reduced overcrowding, substantially increasing floor area per person in these neighborhoods from their nadir in 1910 as figure 34 clearly shows. While the median floor area per person in the island doubled between 1910 and 2010, from 330 to 660 square feet per person, the minimum more than quadrupled, from 102 to 445 square feet per person. The increase in floor area per person was not only due to the decongestion of crowded neighborhoods and the loss of population on the island. It was also due to the introduction of new building technologies—steel frame construction and the elevator—that gradually increased the average gross Floor Area Ratio in Manhattan, from an average of 3.6 in 1910 to double that value, 7.6, in 2010. In essence, taller buildings allowed for the increase in floor area per person.

Public Actions and the Decongestion of Manhattan

The decongestion of Manhattan in the early decades of the 20th century was largely the result of *public*—rather that private—actions that allowed suburbanization to take place: the creation of Greater New York; the preparation of vast new areas for urban settlement in Greater New York; and the creation of the subway system to provide ready and affordable access to Manhattan's employment centers. It was also facilitated by the introduction of the mass-produced automobile—the Ford Model T—at that time.

Though the 1811 Commissioners' Plan provided enough buildable land for a sevenfold increase in the built-up area of the island at the time of its publication, by 1900 more than 80% of its buildable area was already built-up. Between 1810 and1900 its built-up area expanded more than 8-fold, while its population grew 18-fold, from 92,000 to 1.67 million with a concomitant increase in overcrowding. New York City now needed to make room for its inevitable expansion, both to accommodate its growing population and to relieve the overcrowding in its congested tenements.

This was made possible by an act of the New York State legislature (Chapter 378 of the laws of 1897) that consolidated Manhattan and the Bronx with Kings Country (including Brooklyn), Queens County, and Richmond County (Staten Island) into a single City of Greater New York, later called simply New York City. The administrative area of the city was thus expanded thirteen-fold, from 58.5km^2 in 1810 to 790km^2 in 1897. The Board of Public Improvements, which included all the public works commissioners and the five borough presidents, quickly endorsed a plan for the entire city prepared by Louis Risse, Chief Engineer of the New York City Topographical Bureau. The plan, submitted on the 1st of January 1900, was presented at the Paris Exposition to promote New York as a major world city. It included proposed parks as well as street grids "in those parts of the city consolidated under the above act of the legislature and which had no official street plan prior to 1898" (see figure 35). The city now had vast new lands for expansion: The total built-up area in 1900 in all five boroughs was only 102 km^2 and they had room for multiplying it another 7-fold. Again we must ask ourselves: How many cities can claim this audacity of vision?

Figure 35: Planned street grids and proposed parks on the Western Edge of the Borough of Queens in the Board of Public Improvement's Map of New York City

Given the new breathing room, the city expanded rapidly and by 1930 its entire five-borough administrative area was again largely built-up. It housed 6.9 million people, 87 percent of its population in 2000. It could do so because these areas were made accessible by the subways with affordable fares for low-income commuters as well as by cars, like the mass-produced Ford Model T, for higher-income ones.

The earliest subway system—the London Underground—opened in 1863. In New York, a subway system was considered at that time as well but was never realized. Demand for subway service was high, but no private company was willing to risk constructing a subway system, and the city was neither willing nor able to finance its construction. The unification of Greater New York in 1898 finally provided the necessary catalyst. This merger expanded the city's total area 11-fold, and demanded massive investments in transportation to physically unite the newly politically unified territory. Critically, it also dramatically increased the city's borrowing authority. This allowed the city to finance an arrangement whereby it would lease the rights to the subway system to a private company, which would both build and operate the system. The city would pay the cost of construction, and the private company would make lease payments and share a portion of fare box revenues with the city. For the first time, a viable financing scheme was created.

Figure 36: The City Hall subway station, opened 1904

The first contract for construction of the system was signed in 1900 with Augustus Belmont, a horse racing enthusiast and owner of the Manhattan Elevated lines. Belmont incorporated as the Interborough Rapid Transit Company or IRT. The contract called for the construction of an electrified subway, running north from City Hall to 42nd street and then splitting to run up the east and west sides of central park, before reuniting in the Bronx.

The first phase of the line, from City Hall to 145th street, opened to great praise in 1904. By 1907, Contract 1 was complete and trains were running all the way to 225th street in the Bronx. In 1908, Contract 2 extended the subway system to Atlantic Terminal in Brooklyn. In 1910, when around 270 track miles of rapid transit had been completed (including elevated lines), the subway saw 802 million trips. Contracts 3 and 4 introduced competition into the subway system by allowing the Brooklyn Rapid Transit Company to enter Manhattan. The BRT and the IRT, under the so-called "dual contracts," constructed over 300 track miles between 1911 and 1921. This expansion connected Manhattan to Queens, Brooklyn, and the Bronx, sparking a building boom in the outer boroughs. City dwellers in the dense neighborhoods of lower Manhattan could now move to cheap, spacious apartments and houses, either on open land in the outer boroughs, or in the northern reaches of Manhattan. This trend was facilitated by an increase in average wages in those years, particularly relative to the subway fare, fixed by the subway operating contracts at 5 cents a ride. The most rapid declines in density occurred in the first two decades after the subways connected Manhattan with the Bronx and Brooklyn. From 1910 to 1930, the population of Manhattan fell from 2.3 to 1.8 million (a 20% decline), and average density fell from 575 persons/hectare to 430 persons/hectare (a 25% decline).

The expansion of the subway continued in the 1920s and 1930s under the auspices of the Independent System, created by Mayor John Hylan to compete with private operators. The subway system as it exists today was completed by 1940. Indeed, the total number of track miles has decreased from

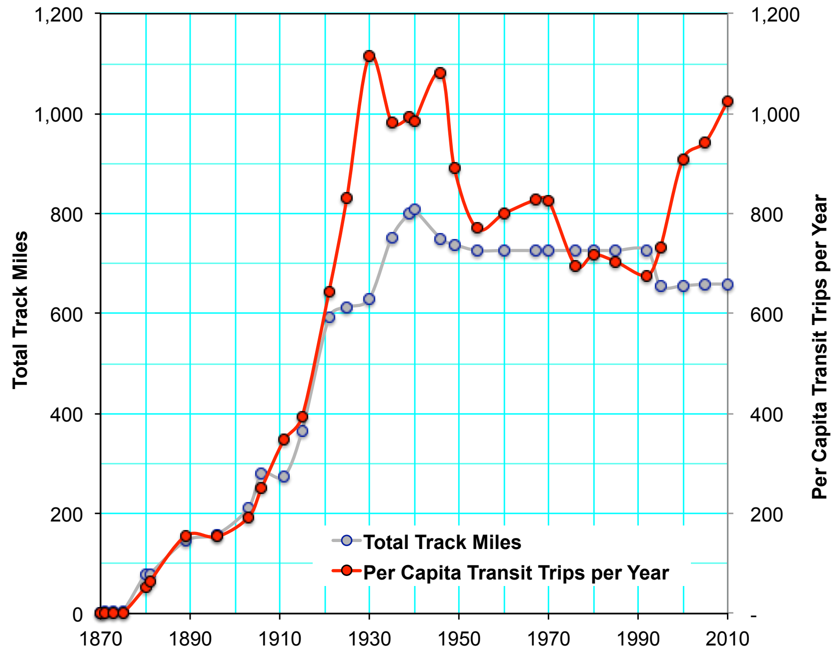


Figure 37: Track miles and per capital transit trips in the New York City rapid transit system, 1870-2010 (For data, see Appendix 1)

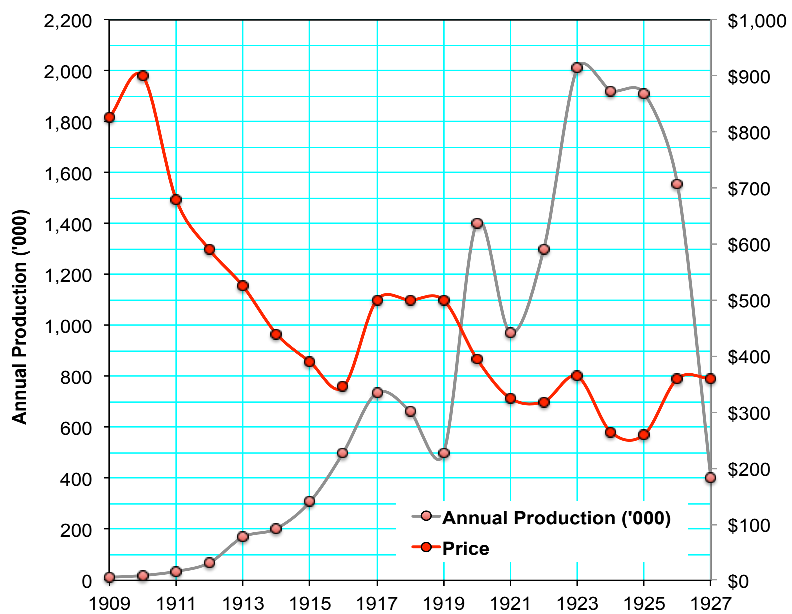


Figure 38: Annual production and price of Ford Model T cars between 1909 and 1927 (For data, see Appendix 1)

the peak that year due to consolidation and to the reorganization of the **s**ubway system under the Metropolitan Transit Authority, which allowed for the elimination of duplicate lines. Figure 37 shows the increase in rapid transit miles and per capita transit trips per year from 1800 to 2010.

The first decades of the 20th century saw a rapid increase in car ownership with the development of the mass-produced and increasingly affordable Ford Model T (see figure 38). Model T cars were initially used for leisure trips but slowly became a new conveyance for commuting to work, initially by the better-off and gradually by large number of middle-class workers who could now afford to move to the suburbs and drive or be driven to work by automobile. Annual production of Model Ts increased from 19,000 in 1910 to 308,000 in 1915, 1.4 million in 1920, and 1.9 million in 1925 (Wikipedia) (see figure 39). The price of these cars declined from $1900 in 1910 to $360 in 1927, a 60% decline. Many of these cars found their way to New York and were in use for commuting by 1930 (see figure 39).

One final note: The increase in the residential floor area per person in recent decades—while densities have been increasing, albeit rather slowly—has much to do with the increasing income of Manhattan's population. The richer people are, the more living area per person they consume. They typically have smaller families and tend to occupy larger apartments, with the consequent increase in floor area per person. Mean household income in Manhattan in 2013 was $121,589, compared with $75,809 in New York City as a whole, and $69,193 in the United States at large.

Figure 39: New York City street scene, 1921

Conclusions and an Outline of a Densification Agenda

To conclude, densities in Manhattan increased in the 19th century, reached a peak in 1910 and declined for most of the remaining decades of the 20th century. They declined most rapidly in the early decades of the 20th century and continued to decline gradually until 1980, before beginning to increase slowly from the 1980s onwards. In parallel, residential floor area per person decreased in the 19th century, reaching a nadir in 1910, and then increased for most of the remaining decades of the 20th century. Variations in the changes in density in different neighborhoods are shown in figure 40.[9] The decline, as we explained earlier, was due to three concerted public actions: The annexation of the outer boroughs, the preparation of large new areas for urban expansion, and the rapid proliferation of subway lines that connected outlying areas to workplaces in Manhattan at affordable fares. This enabled low-income families to purchase or rent decent homes at affordable prices at the urban edge while continuing to work in Manhattan.

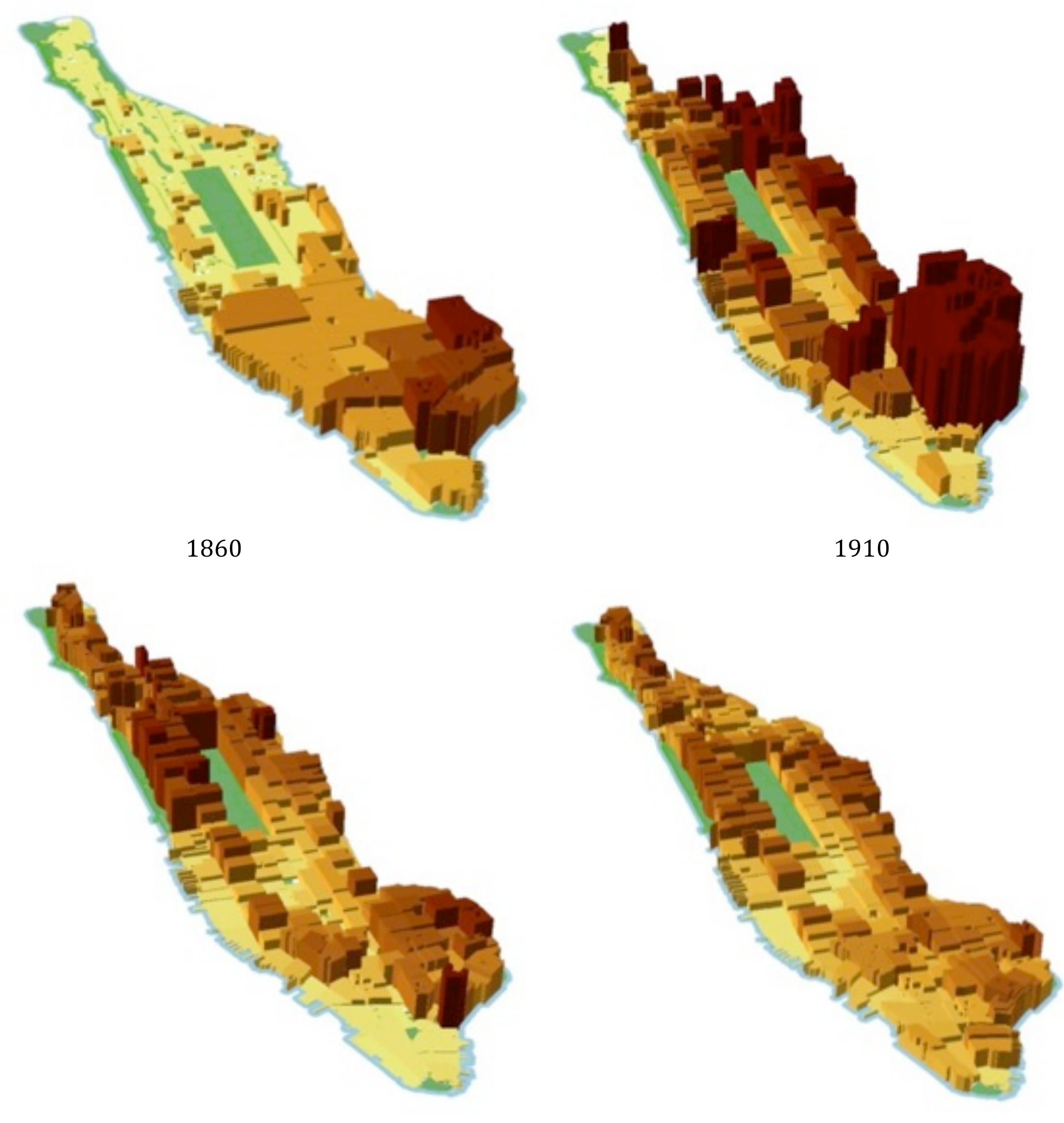


Figure 40: The changing densities in Manhattan neighborhoods, 1860, 1910, 1960, and 2010 (For data, see Appendix 2)

---

[9] A year-by-year animation of this figure can be seen at: http://youtu.be/AGXJTwkc0CA

Given our emerging understanding of the history of densities in Manhattan, we can now shed some light on whether a densification agenda of one type or another—for Manhattan, or for New York City as a whole—can provide pragmatic and politically-acceptable answers to the questions posed at the beginning of this essay: Who would be able to afford, or continue to afford, to live in Manhattan? Who will be pushed out to the outer boroughs or outside New York City altogether? Will Manhattan's colorful neighborhoods and its walkable streets lose their character? Will it continue to attract the most creative and the most productive talent in the world or will it become the playground of the emerging global leisure class?

Densities in Manhattan—and particularly in the neighborhoods closest to the harbor and the industries surrounding it—increased in the second half of the 19th century because low-income workers who were employed there needed to be within walking distance of their workplaces. Housing in lower Manhattan was affordable to these workers because they were allowed to rent the minimum possible amount of floor space—as little as a single bed. These workers could not afford to move further away because the cost of commuting would have been too high in comparison to their meager wages, and their best option was to live in cramped and overcrowded conditions in small apartments or single rooms.

In parallel, densities in today's Manhattan can increase again if we allowed its lower-income residents—and lower-income, given today's housing prices, includes its middle-income residents as well—to live in more cramped quarters and to consume less floor space per person. As long as public authorities can maintain acceptable elementary standards of health and safety—from access to water and sanitation, to proper ventilation and fire protection—there is no reason to restrict the housing options of lower-income residents by mandating a minimum consumption of floor space. A contemporary densification policy may thus entail the removal of zoning and building standards that require minimum apartment sizes, allowing for the construction of micro apartments as well as single rooms sharing common facilities (formerly known as SROs, Single Room Occupancies). It may entail extending legal permission to subdivide larger apartments into smaller ones by furnishing them with additional kitchens and bathrooms. And it may also entail the passage of new regulations that eliminate the exclusionary restrictions now imposed by the boards of cooperatives and condominium associations on the leasing of apartments that are left empty to non-owners, as well as the prohibitions on the rental of rooms on a short- or longer-term basis. The systematic removal of all those prohibitions—through changes in the law and the active enforcement of those changes—will allow more people to occupy the limited floor space now available on the island, and to use the available floor space more efficiently and clearly at a lower cost, without imposing an undue burden on public coffers.

That said, the more intensive use of floor space in individual homes will increase the use of common, shared spaces as well: corridors, elevators and staircases, lobbies, sidewalks, street parking spaces, streets, parks, and subways. It will therefore impose some burden on those now enjoying the exclusive use of these common spaces: There will be less of these common spaces per person if more people use them. Moreover, allowing homes to be subdivided, leased or rented more freely may change the human composition of apartment buildings and neighborhoods, allowing more strangers and more transients to use common spaces, people that may not be trusted—as long term neighboring homeowners are likely to be— to keep them clean and safe. Those concerns cannot simply be ignored. They must be addressed and they are best addressed by convincing sitting residents—as individuals, as neighbors, and as residents of Manhattan—that there would be more for them to gain than to lose by densification.

Another option (which may generate similar concerns) is to encourage building owners—be they cooperatives or condominium associations—to add a number of floors to an existing building, or to rebuild it with additional floors on the original plot. This can be done without changing the character of the sidewalk and the streetscape, without changing plot coverage, and without combining plots with other plots to create bigger, alien buildings with larger footprints that are out of character with the rest of the buildings on the street. Instead, this option entails increasing the floor area ratio (FAR) of buildings on existing plots. Homeowners in a residential building in Manhattan could add several stories to their building if it were allowed; if the building could withstand the additional weight; and if it was not a landmark. Alternatively, they may temporarily vacate the building, have a new building constructed in its stead, and then return to their original home address, now enhanced and improved.

This is a densification option that was not available in the dense neighborhoods of Manhattan in the 19th century because of technological limitations: 19th century buildings were restricted to six stories, by and large, because there were no elevators and because steel-frame and reinforced concrete building technology was not yet in common use. If these technologies had been available at the time, densities in these neighborhoods would likely have been even higher. Today, adding a number of floors is particularly relevant in small buildings with, say, 2 to 20 units. There are quite a few of these small buildings: They form over one-half of the total number of buildings in Manhattan, containing some 167,000 units—20 percent of all dwelling units on the island (ACS 2013).

If regulations are reformed to permit it, there are many viable arrangements that may allow for substantial densification of individual buildings in Manhattan. Naturally, these new options would introduce some difficult tradeoffs for homeowners in many Manhattan buildings. They stand to benefit in a substantial way from increasing the occupancy in their building, by adding stories or by subdividing their homes, and by being allowed to lease or rent them more freely. However, they also stand to lose if their neighbors are allowed to exercise the same prerogatives. More generally, the property value of a Manhattan apartment (only 1% of homes in Manhattan are single-family homes) stands to increase if the apartment can generate a higher income stream (including the deferred income of renting to oneself) over time, but the value may decline if the quality of the building or the neighborhood decreases as the result of congestion or a change in the character of the neighborhood. To resolve the possible conflicts this might create, we propose that if a majority—or, for that matter, a super majority—of homeowners in an apartment building in

Manhattan decided that they favor densification in one form or another, then the remaining homeowners in the building should not be allowed to block it and must go along.[10]

There is also the possibility, as in the days of old, of increasing the number of homes—and with it of *affordable* homes—in neighborhoods in the outer boroughs of New York City, neighborhoods that are well connected to the subway system. But since the city is now fully built, this can only be achieved by densification. Again, as we saw in Manhattan, such densification in the outer boroughs can be achieved by the reform of zoning and building standards that require minimum apartment sizes; by allowing for the construction of micro apartments as well as single rooms sharing common facilities; by extending legal permission to subdivide larger apartments into smaller ones; by eliminating the exclusionary restrictions now imposed on the leasing of apartments that are left empty to non-owners as well as the prohibitions on the rental of rooms on a short- or longer-term basis.

Densification in the outer boroughs should be simpler. There are 480,000 dwelling units in the outer boroughs that are single-family homes—23% of all dwelling units and 58% of all buildings there. Homeowners there may gain significant benefits from adding one or two dwelling units to their homes—"granny flats" as they are called—simply by adding a floor or two, by extending their homes outwards, or by building over their garages. Again, this could be done while strictly preserving the character of their block or their street. Indeed, we may imagine the application of a majority or a supermajority rule to a group of buildings sharing a street on two sides of a residential block: If a majority or supermajority agrees, then people can build additions to their homes, provided, of course, that they respect regulations and agreements that ensure that the character of the street is not unduly disturbed. We can imagine that these additional units will be highly affordable, as those homes themselves were a century before, in comparison to small apartments in Manhattan. And, as before, they will have good access to workplaces via the subway system and could afford a commute to Manhattan as well as to other workplaces in the city.

Finally, in addition to single-family homes, there are 328,000 buildings in the outer boroughs of New York City— comprising 40% of all buildings there and containing 46% of all dwelling units—with 2 to 19 dwelling units in the building (ACS, 2013). Again, as in Manhattan, we can envision adding a number of floors to these buildings. And because these buildings are in more outlying locations, additional units in these buildings are likely to be more affordable as well.

In short, there are two principal lessons to be learned from our study of the rise and fall of Manhattan's densities during the last two centuries, lessons that can guide a pragmatic densification strategy today, both in Manhattan and in New York City as a whole. The first is that if more people want to live in Manhattan—either in close proximity to their jobs or in close proximity

---

10 Condominiums and cooperatives have annual shareholders meetings and pass resolutions by simple majority or supermajority vote. Such supermajority voting arrangements in cases of adding stories to existing condominiums or replacing them with higher buildings on the same plot are already in operation in Israeli cities: a majority of 60% of owners in a single building or 80% in a group of buildings (Article 2 of 2006 Law on Clearance and Reconstruction (Compensation).

to its amenities—they can do so, provided they are willing to consume less space or to share space, as they did in days of old. That can indeed happen, but only if regulations are relaxed and rewritten to make it happen and only if these regulations—and they way they are introduced to the city's sophisticated and politically-savvy residents—can be seen as beneficial to those who enjoy the city as it is today and fear that all change would likely be change for the worse.

The second lesson is that—given the access afforded by New York's subway system—the bulk of the needed additional housing units and most of the more affordable ones will need to be provided, as they have been provided in days of old, through similar densification strategies in New York's outer boroughs: Brooklyn, Queens, the Bronx and Staten Island.

Manhattan, New York City and the New York metropolitan area as a whole will most likely increase their population by substantial numbers in the coming decades. The metropolitan area will expand outwards to accommodate more people, typically at low densities, as it has in the past. Workplaces, formerly concentrated in Manhattan, will continue to suburbanize, spreading throughout the metropolitan area. Less than one-fifth of all jobs remain in Manhattan. High land and housing prices in Manhattan will continue to drive out jobs to the suburbs, pulling out workers with them. Unfortunately, the New York Metropolitan area as a whole does not have a well connected and integrated public transport system like the subway system, as well it should. Commuters living on the urban edge must rely on their car for their travel to work, and if they work in Manhattan, for example, they congest its streets and its limited parking areas more than if they lived there.

Public policies in general, and densification policies in particular, cannot ensure that affordable housing is evenly distributed throughout the metropolitan area, any more that they can ensure that everyone can walk or bicycle to work. In fact, there is no obvious reason for insisting that housing in Manhattan should be affordable to one and all or, for that matter, that housing in New York City should be affordable to one and all. There is an obvious reason for ensuring that those who live and work in the New York metropolitan area can make ends meet. And to make ends meet they should be able to find housing they can afford within a tolerable commute range of their jobs. Needless to say, their jobs should pay a living wage, and if they still cannot make ends meet a housing safety net can supplement their incomes with, say, housing vouchers. That said, even housing vouchers will fail when they simply increase housing demand in the face of rigid and inelastic housing supply. A more nimble housing supply, one not bound by restrictive regulations that limit its response to real housing demand, can go a long way towards making housing in the New York metropolitan area, in New York City, and even in Manhattan more affordable. And it can do so, as we suggest, without recourse to heavy-handed land assembly for large and heavily subsidized public housing projects or for large and heavily subsidized luxury housing projects with allotments for affordable housing. We do not believe that the recognizable need to increase the affordable housing stock justifies the destruction of neighborhoods nor compromising their character. We believe that when it comes to the efficient, equitable, sensitive and sustainable densification of New York City, we can achieve more, much more, with small actions on the part of the many than with big actions on the part of the few.

* * *

Appendix Tables

Appendix 1

The tables that contain the data displayed in the figures are available in a permanent archive at the New York University Spatial Data Repository at: http://hdl.handle.net/2451/33846

They are organized as follows:

File Name: Tables for Appendix, 12 Nov 2014

Tab: Figure 5

Figure 5: Increasing and then decreasing built-up area densities in selected cities, 1800-2010

Tab: Figures 13 & 14

Figure 13: The Average Gross Floor Area Ratio (left axis) and the share of Total 2014 Floor Area (right axis) in Buildings Constructed in Different Decades, 1800-2010

Figure 14: Model estimates of the average floor area ratio and the average residential floor area ratio in different decades, 1800-2010

Tab: Figures 15, 25, 31 & 32

Figure 15: The increase in the population (left axis) and in the built-up area (right axis) in Manhattan, 1800-1910

Figure 25: The increasing share of the foreign-born population in the total population of Manhattan, 1800-1910

Figure 31: The declining share of Manhattan's population in New York City's overall population, 1800-2010

Figure 32: The decline of the population and the density of Manhattan from 1910 onwards

Tab: Figures 17 & 33

Figure 17: The increase in the average density of the built-up area of Manhattan and in selected neighborhoods, 1800-1910

Figure 33: The rapid decline in densities in selected Manhattan's neighborhoods from 1910 onwards

Tab: Figures 19 & 34

Figure 19: Model estimates of the change in the average gross residential floor area per person (FAPP) in Manhattan and in selected neighborhoods, 1800-1910

Figure 34: The rapid increase in floor area per person in selected Manhattan's neighborhoods from 1910 onwards

Tab: Figure 22

Figure 22: The rapid increase in the value of trade processed in New York Harbor and the share of the harbor in overall U.S. trade, 1790-1910

Tab: Figure 37

Figure 37: Track miles and per capital transit trips in the New York City rapid transit system, 1870-2010

Tab: Figure 38

Figure 38: Annual production and price of Ford Model T cars between 1909 and 1927

Appendix 2

Geospatial information displayed in images is stored in geodatabases at the New York University Spatial Data Respository and can be accessed at http://hdl.handle.net/2451/33846

File Name: Geodatabase 1: Census Area and Population Layers; Base Layers

Layers:

Blocks

Parks

Neighborhoods

Ward Boundaries and Population 1789 - 1803

Ward Boundaries and Population 1803- 1824

Ward Boundaries and Population 1825 - 1830

Ward Boundaries and Population 1835 – 1845

Ward Boundaries and Population 1850 – 1851

Ward Boundaries and Population 1853 – 1895

Ward Boundaries and Population 1895 – 1900

Ward Boundaries and Population 1900 – 1910

Census Tract and Population 1910

Census Tract and Population 1920

Census Tract and Population 1930

Census Tract and Population 1940

Census Tract and Population 1950

Census Tract and Population 1960

Census Tract and Population 1970

Census Tract and Population 1980

Census Tract and Population 1990

Census Tract and Population 2000

Census Tract and Population 2010

Figures:

Figure 8: Manhattan's 7th Ward in 1800

Figure 12: The changing boundaries, sizes, and number of Manhattan's wards between 1800 (left) and 1890 (middle); and the assignment of blocks to 1890 city wards (right)

File Name: Geodatabase 2: Map Years; Base Layers

Layers:

Blocks

Parks

Neighborhoods

Built-Certain Years 1797 – 1951

Figures:

Figure 16: The neighborhoods of Manhattan and the 'built-certain' map of Manhattan blocks

File Name: Geodatabase 3: Block Density Table 1800 – 2010; Block Population Table 1800 – 2010; Base Layers

Layers:

Blocks

Parks

Tables:

Block Density Table 1800 – 2010

Block Population Table 1800 – 2010

Figures:

Figure 40: The changing densities in Manhattan neighborhoods, 1860, 1910, 1960, and 2010

References

Angel, Shlomo, Parent, Jason, Civco, Daniel, and Blei, Alejandro, 2012. *Atlas of Urban Expansion*. Cambridge MA: Lincoln Institute of Land Policy.

Angel, Shlomo, Sheppard, Steven, Civco, Daniel, et al., 2005. *The Dynamics of Global Urban Expansion.* Transport and Urban Development Department. Washington D.C.: World Bank.

Angel, Shlomo. *Planet of Cities.* Lincoln Institute of Land Policy. Cambridge. 2012.

Bradley, James and Poole, Alex, 2010. "Leading Manufacturing Industries in New York City and King's County in Selected Years, 1800 – 2010," From U.S. Bureau of the Census, Census of Manufacturers.

Clark, Colin, 1951. "Urban Population Densities." *Journal of the Royal Statistical Society. Series A (General)* 114(4), 90-496.

Dolkart, Andrew, 2007. *Biography of a Tenement House in New York City: An Architectural History of 97 Orchard Street*, New York: Center Books.

Glaeser Edward L., 2005. "Urban Colossus: Why is New York America's Largest City?", Working Paper 11398, Cambridge MA: National Bureau of Economic Research. Web. Accessed 14 October 2014. http://www.nber.org/papers/w11398.pdf.

Historical Statistics of the United States. Cambridge University Press, 2014. Web. Accessed 13 October 2014. http://hsus.cambridge.org

National Historical Geographic Information System (NHGIS), 2010. Minnesota Population Center. University of Minnesota.

New York Times, 1876."Overcrowding in Tenement Houses," 3 December 3rd, 1876. Web. Accessed 13 October 2014: http://timesmachine.nytimes.com/timesmachine/1876/12/03/80636955.html?pageNumber=6

New York Times, 1898."Overcrowding in New York City," *New York Times*. 19 June. Web. Accessed 13 October 2014. http://timesmachine.nytimes.com/timesmachine/1898/06/19/102073973.html?pageNumber=17

Riis, Jacob, 1971 (originally published 1890). *How the Other Half Lives: Studies Among the Tenements of New York,* New York: Dover Publications.

Rodrigue, Jean Paul, 2014. "Omnibus, London, Late 19th Century." Department of Global Studies and Geography, Hofstra University. Accessed October 13, 2014. https://people.hofstra.edu/geotrans/eng/ch6en/conc6en/omni.html

The Encyclopedia of the City of New York (ECNY), 2010.. New Haven: Yale University Press.

United States Bureau of the Census. 2013. "Dwellings by unit size," American Community Survey (ACS). Web. www.americanfactfinder.gov. Accessed October 31, 2014.

Williams, Keith, 2012. "Fulton Ferry: a brief history". *The Weekly Nabe*. 15 March. Accessed October 13, 2014.

Additional References:

Atack, Jeremy, and Robert A. Margo, 1998. "Location, location, location!: The price gradient for vacant urban land: New York, 1835 to 1900." *The Journal of Real Estate Finance and Economics* 16(2), 151-172.

Laidlaw, Walter, 1931. *Statistical Sources for Demographic Study of Greater New York, 1900 – 1930*. New York: Cities Census Committee Inc.

New York City Department of City Planning, 2011. *MapPLUTO* (Edition 11v2). New York City: NYC Department of City Planning.

U.S. Census, 2014. *American Fact Finder*. Washington: U.S. Census. 2014. Web.

Maps:

Bromley, George W. and Bromley, Walter S, 1911. "Atlas of the City of New York, borough of Manhattan." *NYPL Digital Gallery*. New York: New York Public Library. Web. Accessed 13 Oct 2014.

Bromley, George Washington, 1897. "Atlas of the City of New York: Manhattan Island." *NYPL Digital Gallery*. New York: New York Public Library. Web. Accessed 13 Oct 2014.

Bromley, Walter, 1934. "Manhattan land book." New York: Columbia University Libraries.

City of New York, 1951. "NYC City Map," (1951 Aerial Layer Enabled). NYC.gov. Web. Accessed 13 Oct 2014.

City of New York. "NYC City Map," (1924 Aerial Layer Enabled). NYC.gov. Web. Accessed 13 Oct 2014.

Colton, J.H., 2005. "City and County of New York." 1836. Rumsey Collection. Cartography Associates. 2005. Web. Accessed 13 Oct 2014.

Dripps, Matthew, 1852. "City of New York Extending Northward to Fiftieth St." Rumsey Collection. Cartography Associates. 2003. Web. Accessed 13 Oct 2014.

Drips, Matthew, 1867. "Plan of New York City, from the Battery to Spuyten Duyvil Creek." *NYPL Digital Gallery*. New York: New York Public Library. Web. Accessed 13 Oct 2014.

Hooker, William, 1824. "Hooker's new pocket plan of the city of New York." 1*NYPL Digital Gallery*. New York: New York Public Library. Web. Accessed 13 Oct 2014.

Maverick, Peter, 1808."Plan of the city of New York." *NYPL Digital Gallery*. New York: New York Public Library. Web. Accessed 13 Oct 2014.

Robison, Elisha, 1885. "Atlas of the City of New York." *NYPL Digital Gallery*. New York: New York Public Library. Web. Accessed 13 Oct 2014.

Taylor, Benjamin, 1797. "A new & accurate plan of the city of New York in the state of New York in North America." *NYPL Digital Gallery*. New York: New York Public Library. Web. Accessed 13 Oct 2014.

Taylor, Will, 1879. "The City of New York." Wikimedia Commons. Web. Accessed 13 Oct 2014.

Unknown, 1842. "New York." University of Texas Libraries Map Collection. 2011. Web. Accessed 13 Oct 2014.

Illustration and Photo Credits

Credits for Images are Pending

Cover Photo. "View of Second Avenue." 1861. Graduate Center of New York. https://dspace.cuny.edu/handle/11049/6754?show=full.

Figure 1. Jakarta. Bertaud, Alain, "Metropolis: The Spatial Organization of Seven Large Cities",2003 in "Time-Saver Standards for Urban Design" edited by Watson, Plattus and Shibley, 2003, McGraw-Hill

Figure 2, 3, 4, 6, 7. Angel, Solly. Planet of Cities. 2013. Lincoln Institute of Land Policy.

Figure 18. A New York Tenement Floor Plan - Redrawn from Dolkart (2007, figure 18, 39); original drawing courtesy of Li-Saltzman Architects.

Figure 20. Scenes of overcrowding in Manhattan.

20a. "Mulberry Street, New York City," 1898. Library of Congress Prints and Photographs Division Washington, D.C. http://www.loc.gov/pictures/resource/det.4a31829/?co=det

20b. "Hester Street Pushcarts," 1898. Tenement Museum. New York, NY. http://www.neh.gov/news/press-release/2012-05-09

20c. "Lodgers in Bayard Street Tenement, Five Cents a Spot," 1889. Jacob Riis. Museum of Modern Art. New York, NY.

20d. "Cigar makers at work in their tenement," 1889. Jacob Riis. Museum of Modern Art. New York, NY.

Figure 21. "New York Harbor, South Seaport," Undated. South Street Seaport Museum

Figure 23. "Along the Erie Canal, Buffalo, NY, " 1908. No. M 71, Buffalo News Co., Buffalo, N.Y. Postcard.

Figure 24. "Immigrants on line at Ellis island," 1900. Corbis Images. New York, NY. Web. http://www.corbisimages.com/stock-photo/rights-managed/BE024038/immigrants-on-line-on-ellis-island

Figure 26. "Commissioners Plan of Manhattan 1811," 1811. Wikimedia Commons. http://commons.wikimedia.org/wiki/File:NYC-GRID-1811.png

Figure 27. "A Fifth Avenue Stage, new York," ca 1900. Detroit Publishing Co. Library of Congress. Washington D.C. Web. http://www.loc.gov/pictures/item/det1994009335/PP/

Figure 28. "The Terminal," 1893. Alfred Steiglitz. The J. Paul Getty Museum. Los Angeles, California. Web. http://www.getty.edu/art/gettyguide/artObjectDetails?artobj=69300

Figure 29. "The 6th Avenue El," 1886. Tenement Museum. New York, NY.

Figure 30. "Taunton's pocket edition of the merchant's and shipper's guide map to the port of New York," 1882. Taunton, SDL. New York Public Library Digital Gallery. New York, NY.

Figure 35. "General Map of the City of New York," 1900. Louis Aloys Risse. Board of Public Improvements, Topographical Bureau. New York, NY.

Figure 36. "City Hall Subway Station," 1904. Wikimedia commons. Web. http://commons.wikimedia.org/wiki/File:City_Hall_Subway_station.jpg

Figure 39. "Fifth Avenue," 1921. New York World. New York Public Library Mid-Manhattan Picture Collection. New York, NY.