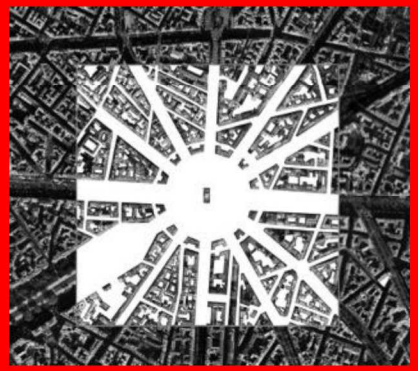
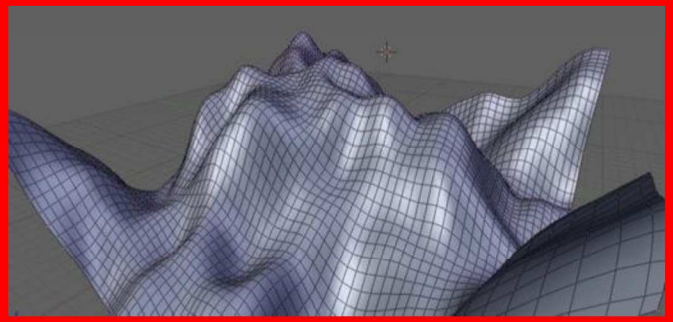



PARIS /NEW YORK

A Morphological Tale of Two Cities



Serge Salat

Urban Morphology and Complex Systems Institute

May 14 - 15, 2014

Politecnico di Torino

Politecnico di Milano

Our cities must become like complex natural systems:

- Scale free:

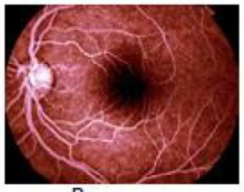
  Fractal

  Pareto distributions for topology and geography (for graphs and maps)

- Small Worlds

- Scale free connected like leaves


A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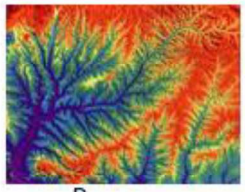
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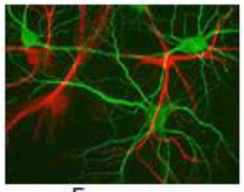
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F

The challenge of a science of cities is to understand the links between urban form (multiscale and evolutionary) and economic, social, environmental (energy, etc.) efficiency and resilience (adaptiveness to progressive or catastrophic change).

The challenge is also to understand the relationships between self organization and planning. The large number and the diversity of agents operating simultaneously in a city suggest that cities are a multifractal emergent phenomenon ruled by self-organization. On the other hand, central planning plays an important role in the city, leaving long standing traces. Indeed central planning could be thought of as an external perturbation, as if it were foreign to the self-organized development of a city.

Mathematical regularities emerge in almost all urban phenomena

Inverse power laws are the « signature » of complexity at all scales.

They derive from historical layering (Paris) or market forces (New York)

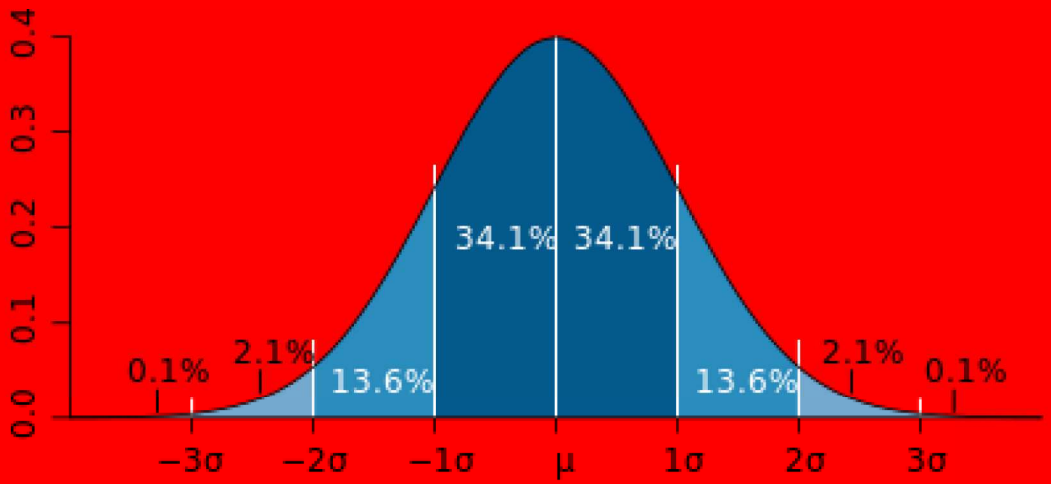
Cities evolving over long periods of time display scale-free structures, multi-connectivity and multifractal structures

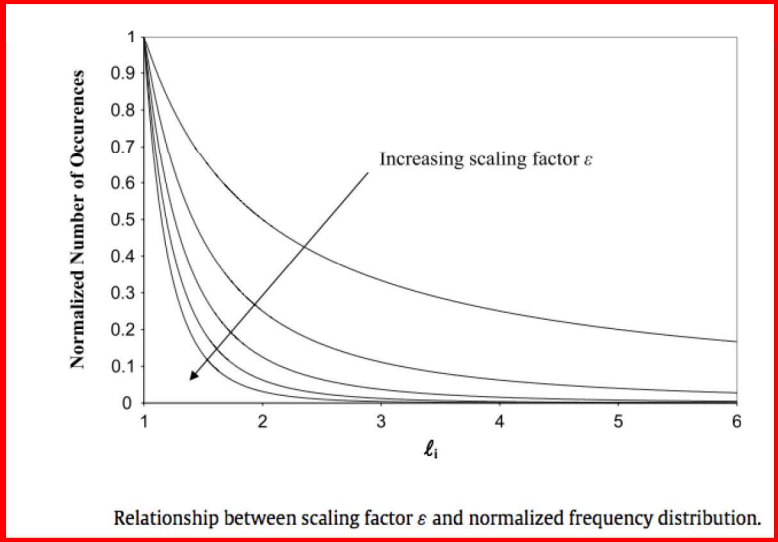
– **Scale-free structure**
  - The urban system is made of many subsystems at different scales
  - The urban system displays a high diversity of sizes and scales
  - The urban system is complex and diversified at every scale; it is scale-free

– **Multi-connectivity**
  - The urban system is highly connected through a variety of short, medium and long range connections
  - No constrained hierarchy: a sub system of a given size/scale can be directly connected to any sub system of any size/scale
  - Connections display mathematical regularities described by graphs theory

- Multifractal structure
  - The urban structure is the layering and interlocking of different fractal structures belonging to different morphological periods
  - The urban structures fractal parameters vary locally

Do average values mean anything in urban studies ?



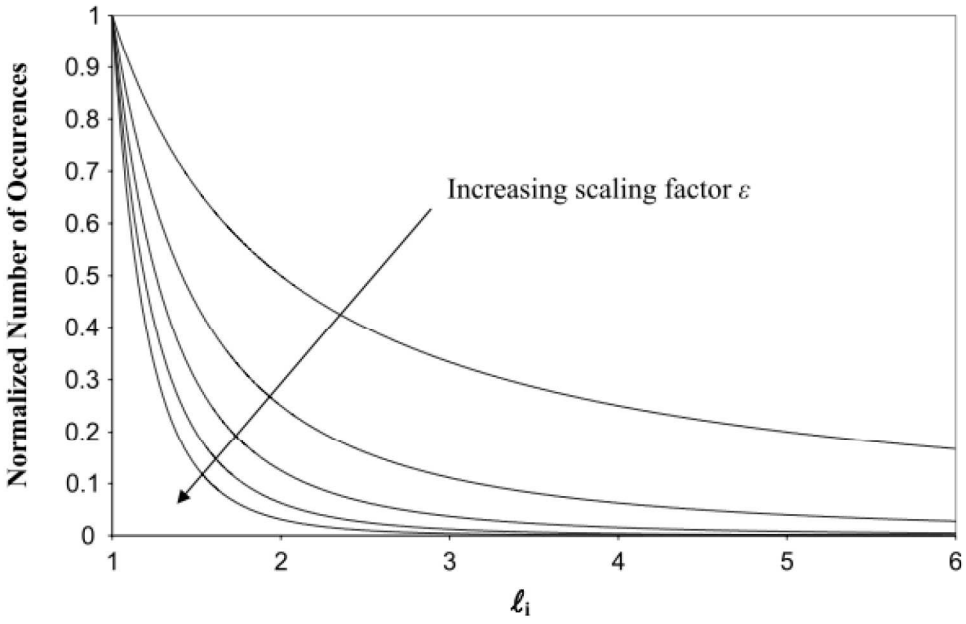


Relationship between scaling factor ε and normalized frequency distribution.

Is the urban world Gaussian or Paretian ?

In a Gaussian world 68% of the values are at one standard deviation from the average. Quite the opposite, a Paretian world is exremely inequal: a few extremely high values are juxtaposed to a “long tail” of very low values.

Key result 1: The urban world is not Gaussian. It follows inverse power laws with extreme inequalities in intensities.



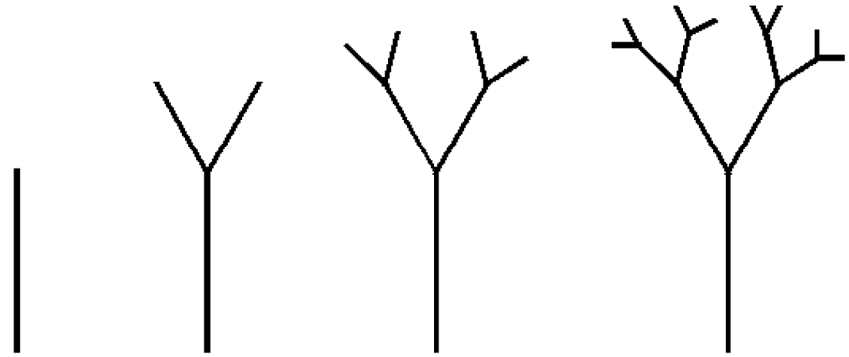
Relationship between scaling factor ε and normalized frequency distribution.

$$freq_i = \frac{A}{I_i^{\square}}$$

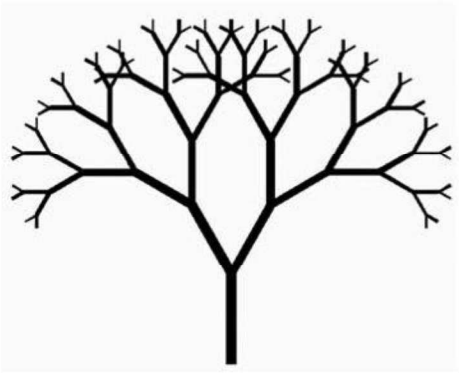
Power law scaling consists of universal properties that characterize collective phenomena that emerge from complex systems composed of many interacting units. Power law scaling has been observed not only in physical systems, but also in economic, financial and urban systems, shedding new light on economics, and, in recent years, has led to the establishment of a new scientific field bridging economics and physics.

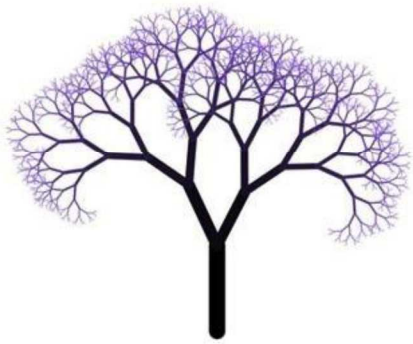
Scaling, fractals and self similarity

Inverse Power laws are a universal rule for the distribution of sizes in complex natural and artificial systems



Generator





Fractal tree

Scaling is a universal property that characterizes collective phenomena that emerge from complex systems composed of many interacting units of different scales

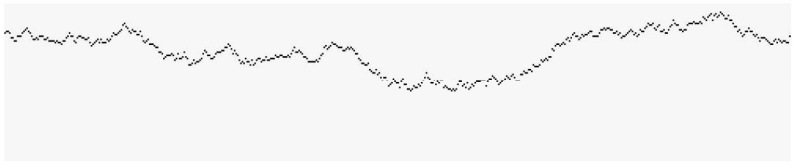
Neuronal networks

River deltas

Trees

Blood systems

What is scaling?



Wiener process

Koch curve

Scale invariance is a feature of objects or laws that does not change if scales of length, energy, or other variables, are multiplied by a common factor.

$$f(\lambda x) = \lambda^{\beta} f(x)$$

Power laws are scale invariant

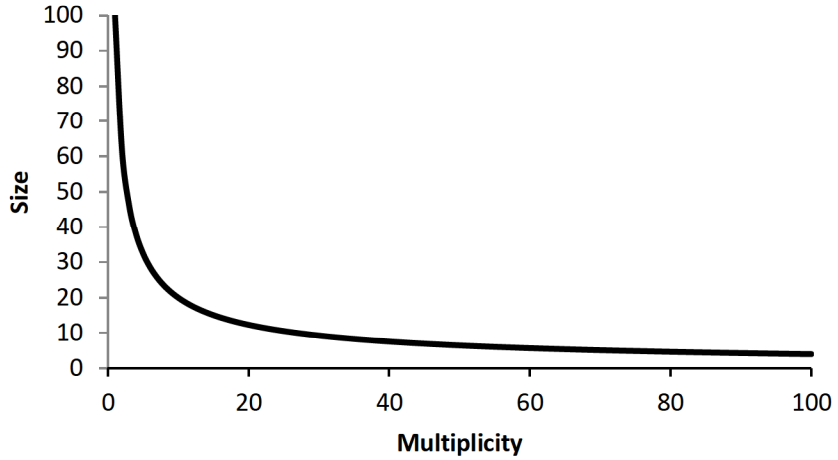
Power laws are described by the following formula:

$$f(x) = ax^{\beta}$$

Power laws are scale invariant as $f(\lambda x) = \lambda^{\beta} f(x)$

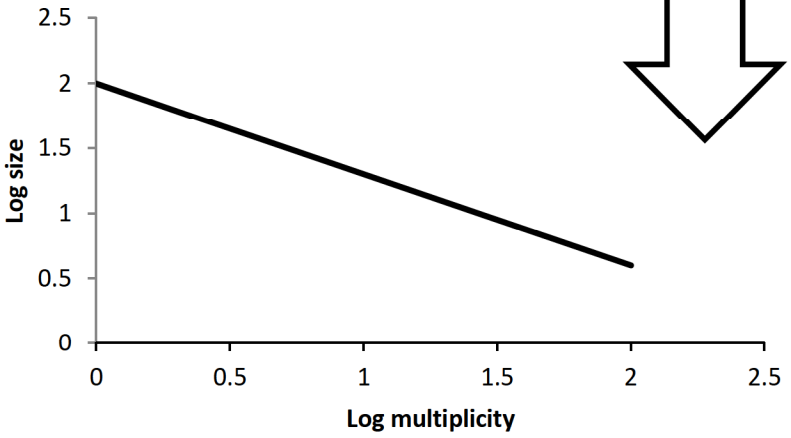
$$\boldsymbol{f(\lambda x)} = a(\lambda x)^{\beta} = \lambda^{\beta} a x^{\beta} = \boldsymbol{\lambda^{\beta} f(x)}$$

Log transformation for power laws



$$multiplicity = \frac{A}{size^{\beta}}$$

Logarithmic transformation



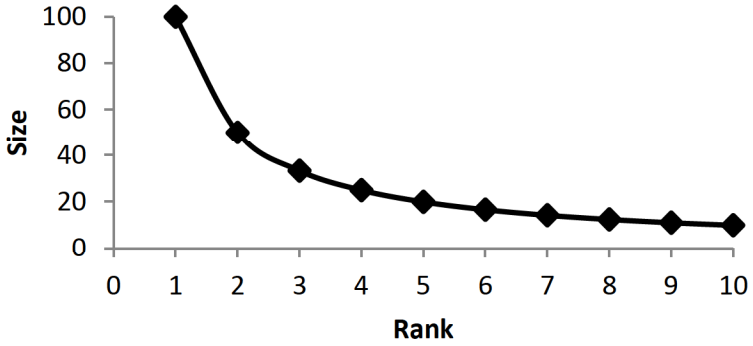
$$\log(multiplicity) = \log\left(\frac{A}{size^{\beta}}\right)$$
$$= \log(A) - \beta\log\,(size)$$

Easy to spot and to test (Ordinary least square linear regression)

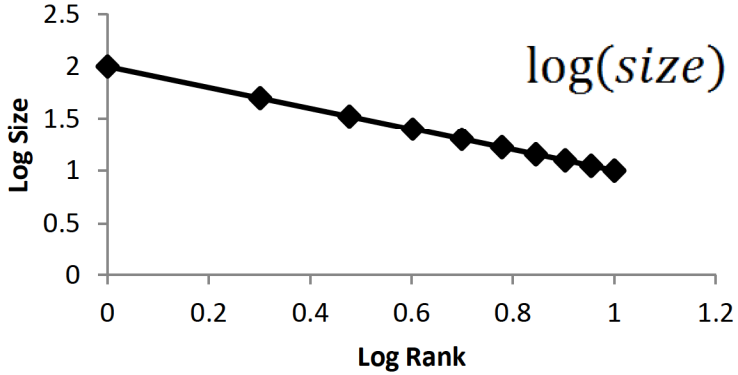
Zipf law | rank-size rule | Power laws

Rank-size distributions describe a mathematical regularity in many phenomena including the distribution of city sizes around the world, the sizes of businesses, the sizes of particles (such as sand), the lengths of rivers, the frequencies of word usage, and wealth among individuals.

Rank	Size
1	100
2	50
3	33
4	25
5	20
6	17
7	14
8	13
9	11
10	10



$$size = \frac{A}{rank}$$

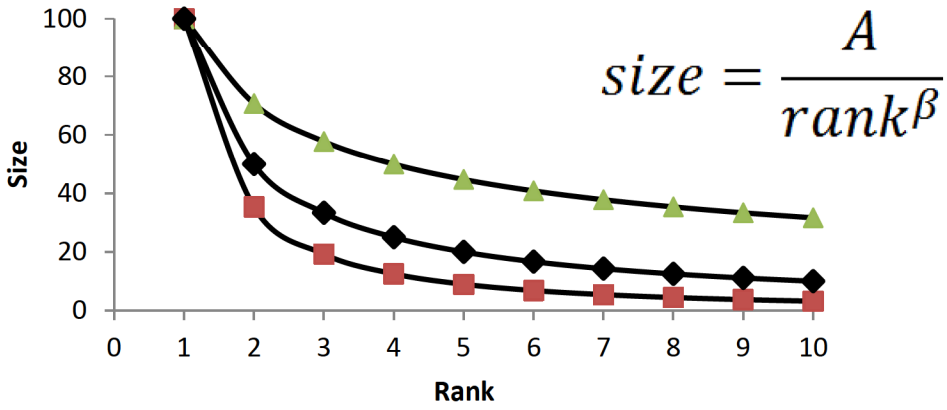


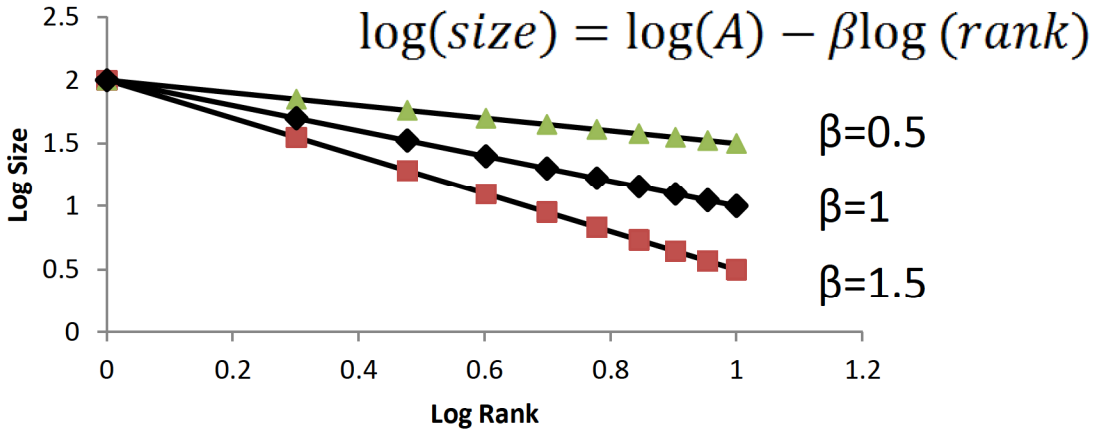
$$\log(size) = \log(A) - \log(rank)$$

Zipf law | rank-size rule | Power laws

Rank size distribution can exhibit a β factor different than 1. The decrease in the inverse power law can be steep or smooth. The distribution can be more (β above 1) or less unequal (β below 1).

	β=1	β=1.5	β=0.5
Rank	Size	Size	Size
1	100	100	100
2	50	35	71
3	33	19	58
4	25	13	50
5	20	9	45
6	17	7	41
7	14	5	38
8	13	4	35
9	11	4	33
10	10	3	32





Urban complexity emerges
from breaks of symmetry

Cities are complex evolutionary systems far away from the equilibrium

1. **Urban systems follow the laws of far away from equilibrium thermodynamics (**Prigogine)

Cities do not automatically return to equilibrium for they are forever changing, indeed they are far-from-equilibrium. Dissipative structures far away from equilibrium increase the complexity of their structures to dissipate efficiently flows of energy.

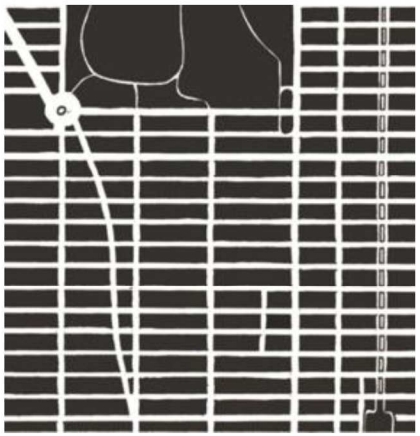
2. **Urban systems display emerging properties**

Dynamic processes build on existing patterns to reinforce size and to generate economies of scale. Patterns are largely built from modules operating from the actions of individuals (or at least individuals acting for groups and institutions) from the bottom up at relatively small scales. They evolve through time in such a manner that any snapshot at any cross section shows an emergent order that is the product of countless decisions.

3. **Urban systems have been selected by evolution**

Resilient cities that have a long history show the characteristics of complexity of evolutionary systems. They are the survivors of a process of creation/elimination analogous to the evolution of life. Paris and New york are extremely resilient survivors of urban evolution.

Urban complexity is an emergent property fostered by breaks of symmetry in the urban fabric

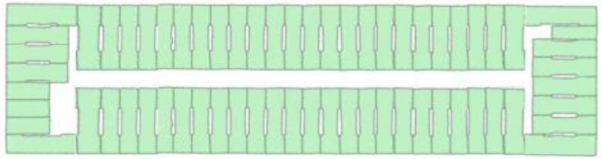


Fine grain

- Fine grain street network
- Fine grain platting
- Fine grain mixed use and diversity

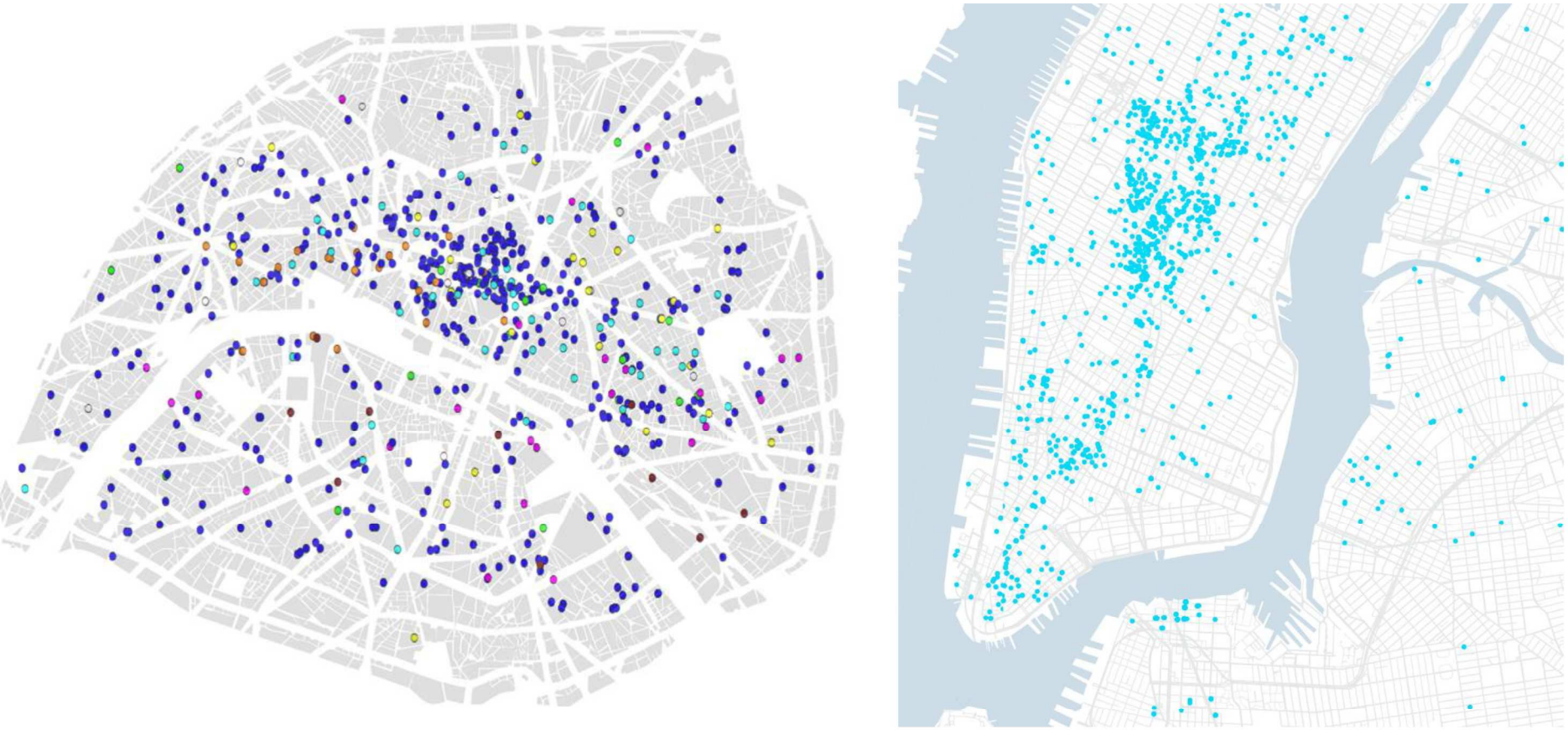
Breaks of symmetry in urban space

- Street width and properties (avenues in Manhattan are 13 times more continuous and connective than streets in terms of graphs theory)
- Elongated block size
- Plot size



Breaks of symmetry and fine grain must be embedded in the master plan to support urban resilience and allow complexity to increase.

Source: Urban Morphology Institute



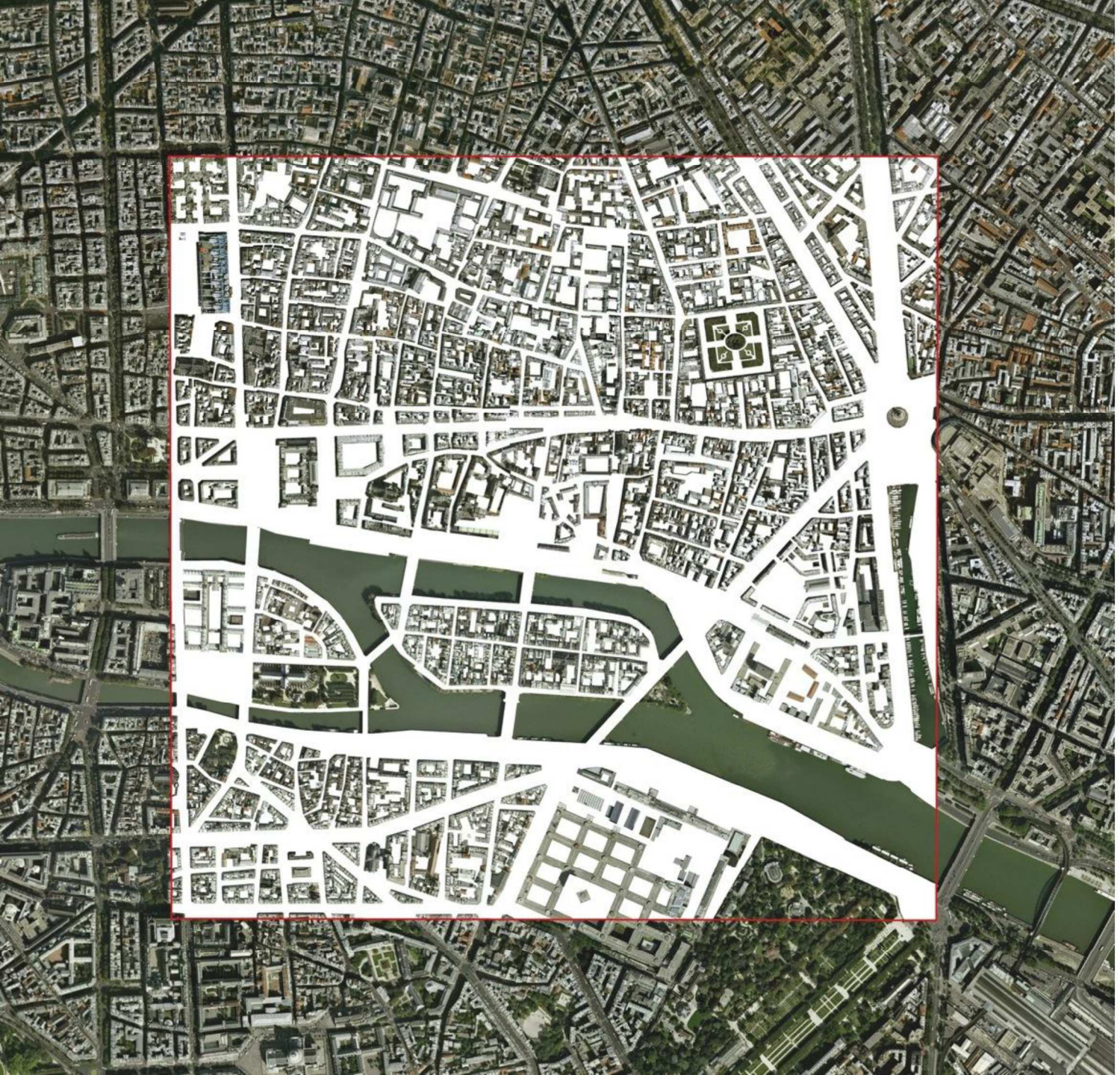
Digital economy in Paris and Manhattan (note the impact of Broadway)

Sources: Left: Urban Morphology Institute / Right: Andrew Laing CURE

Paris

2000 years of urban evolution

have created a multifractal fine grain platting structure embedding the memory of all its history and a scale free street pattern

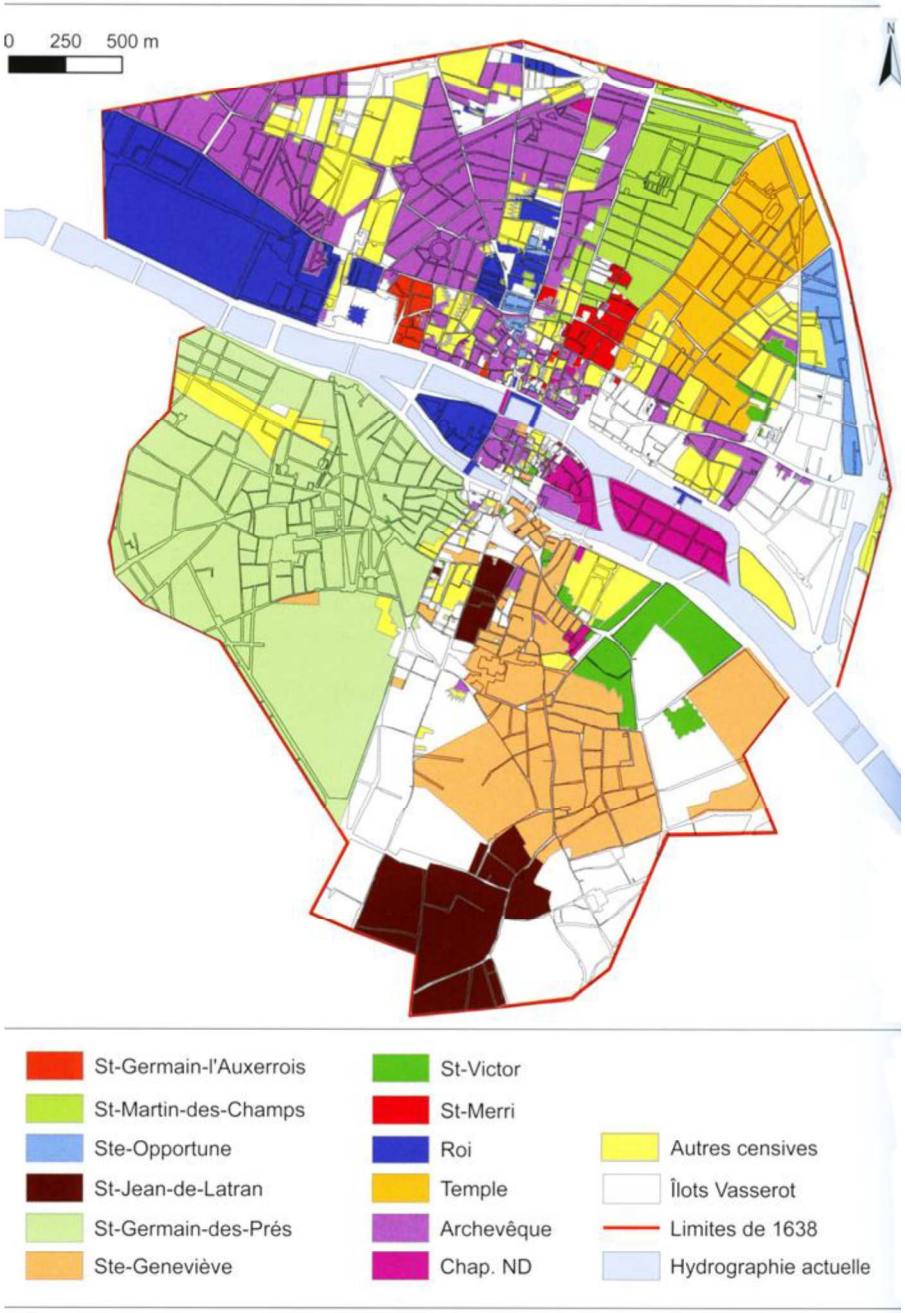


Paris on 1 square mile

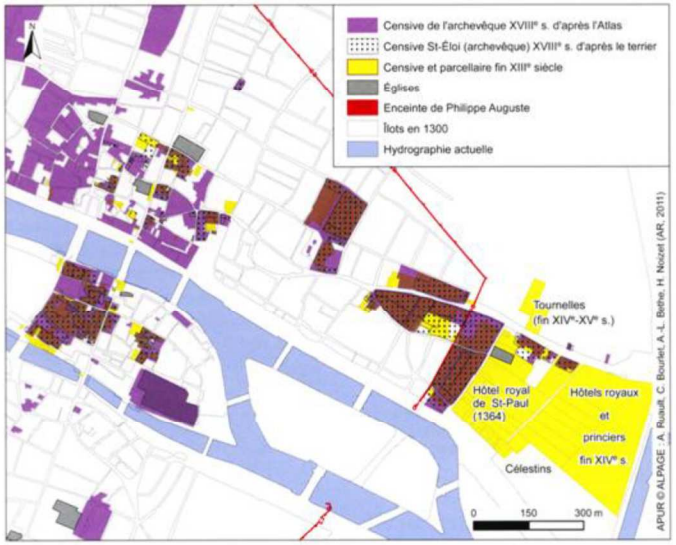
a multifractal structure shaped by 2000 years of urban evolution

Source: Serge Salat, *Cities and Forms*

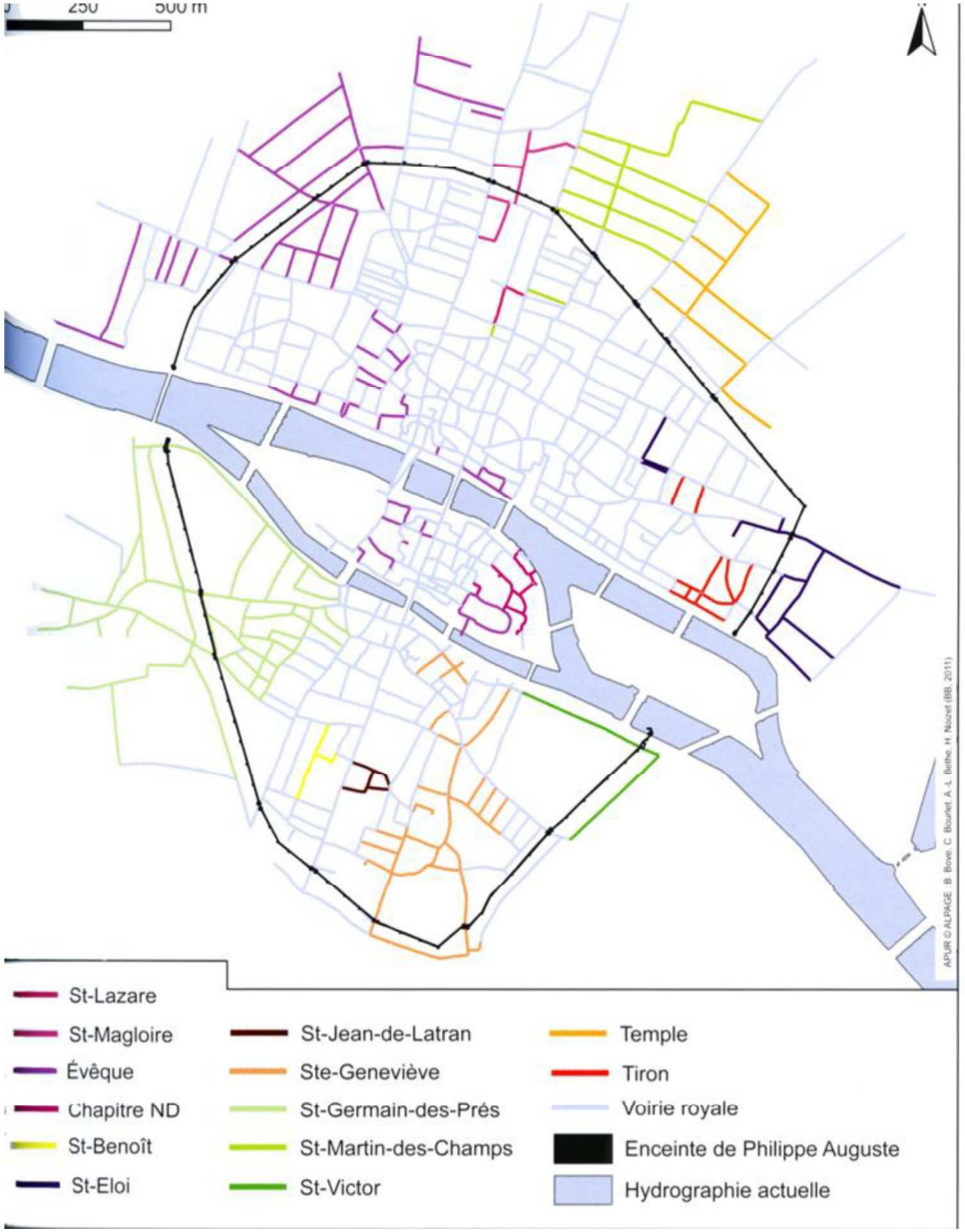
Urban powers fragmentation: “Censives” in Paris XVIIth century



Source: Hélène Noiset, Boris Bove, Laurent Costa (dir), *Paris de parcelles en pixels*



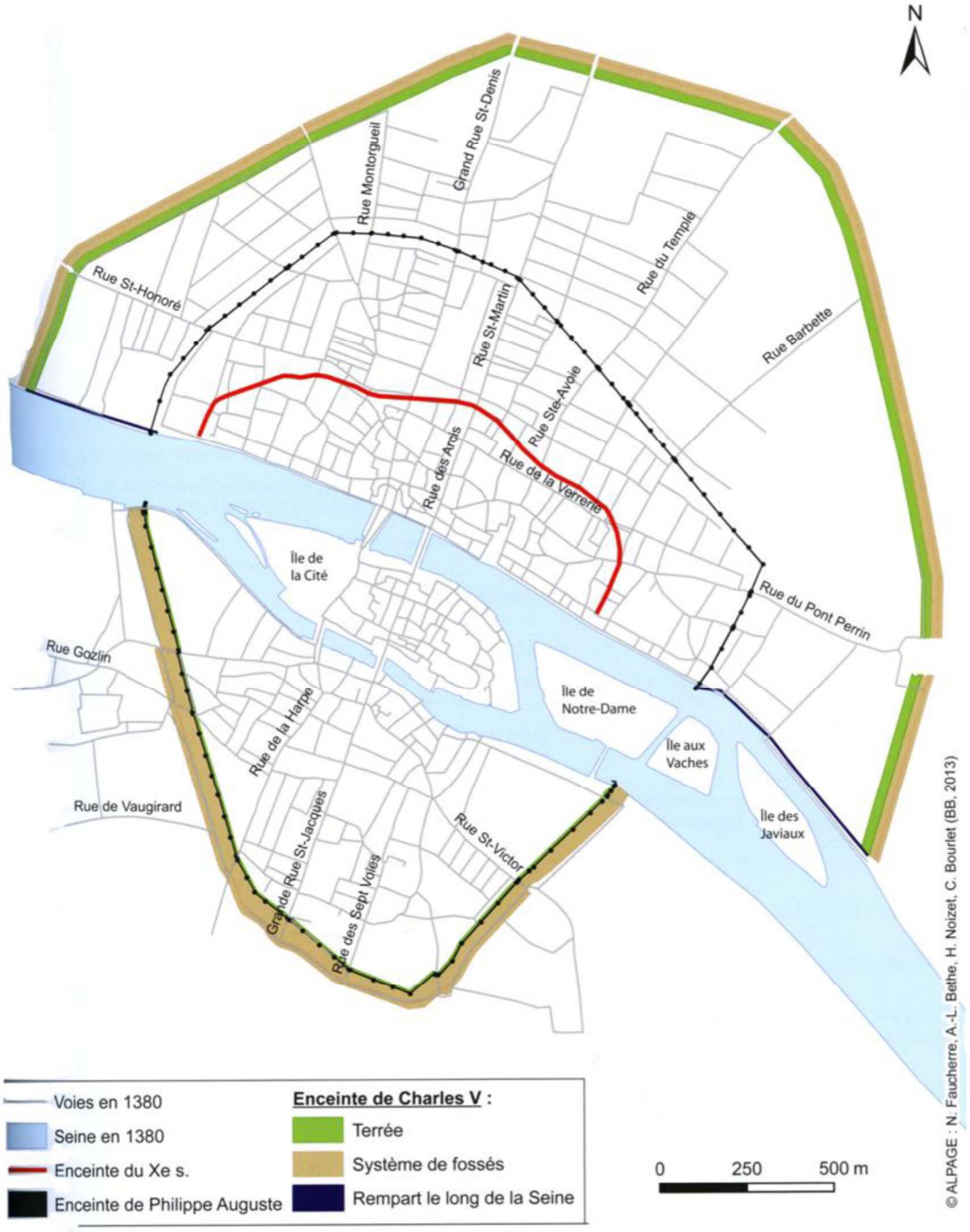
Paris land was, from the early Middle-Ages until the revolution, divided between many Lordships. The lords gradually granted to individuals settled on their land tenures on which they perceived an annual fee, the “cens” - hence the name “censive” for Paris Lordships. This property tax recognized the eminent property of the Lord on the land, the tenant having to settle for the useful property of the plot. This eminent property gave a number of rights to Lords: land rights as the perception of the “cens” or transfer duties, but sometimes political rights such as rights on roads or high, middle and low justice. The Lordship fact was therefore an essential element of the urban life of the Ancient Regime. It gradually became a framework within which social life took place.



Religious and feudal power on streets in 1300 Paris

Compared to the previous map showing the large rural religious lordships and the smaller and more fragmented urban religious lordships, with little control of the king on Paris land, this map shows that the king had acquired in 1300 the lordship of a great part of the streets.

Source: Hélène Noiset, Boris Bove, Laurent Costa (dir), *Paris de parcelles en pixels*



The successive medieval walls of Paris:

- The wall of 10th century
- The wall of Philippe Auguste (1190-1215)
- The wall of Charles V (1356)

The successive walls have had a morphological impact on the fine structure of the city.

Source: Hélène Noiset, Boris Bove, Laurent Costa (dir), *Paris de parcelles en pixels*

Paris extension until the 19th century is not strictly radio-concentric. Since the end of the Middle Ages, the main suburbs (Saint-Honoré, Saint-Denis and Saint-Martin, Saint-Antoine) grow linearly. Source: Hélène Noiset, Boris Bove, Laurent Costa (dir), *Paris de parcelles en pixels*

Paris plot size pattern is a legacy of the medieval period, not Antiquity: while the Roman period city is clearly focused on the left bank, the main urban center has developed on the right bank from the Middle Ages in a tripartition : Université - Cité - Ville.

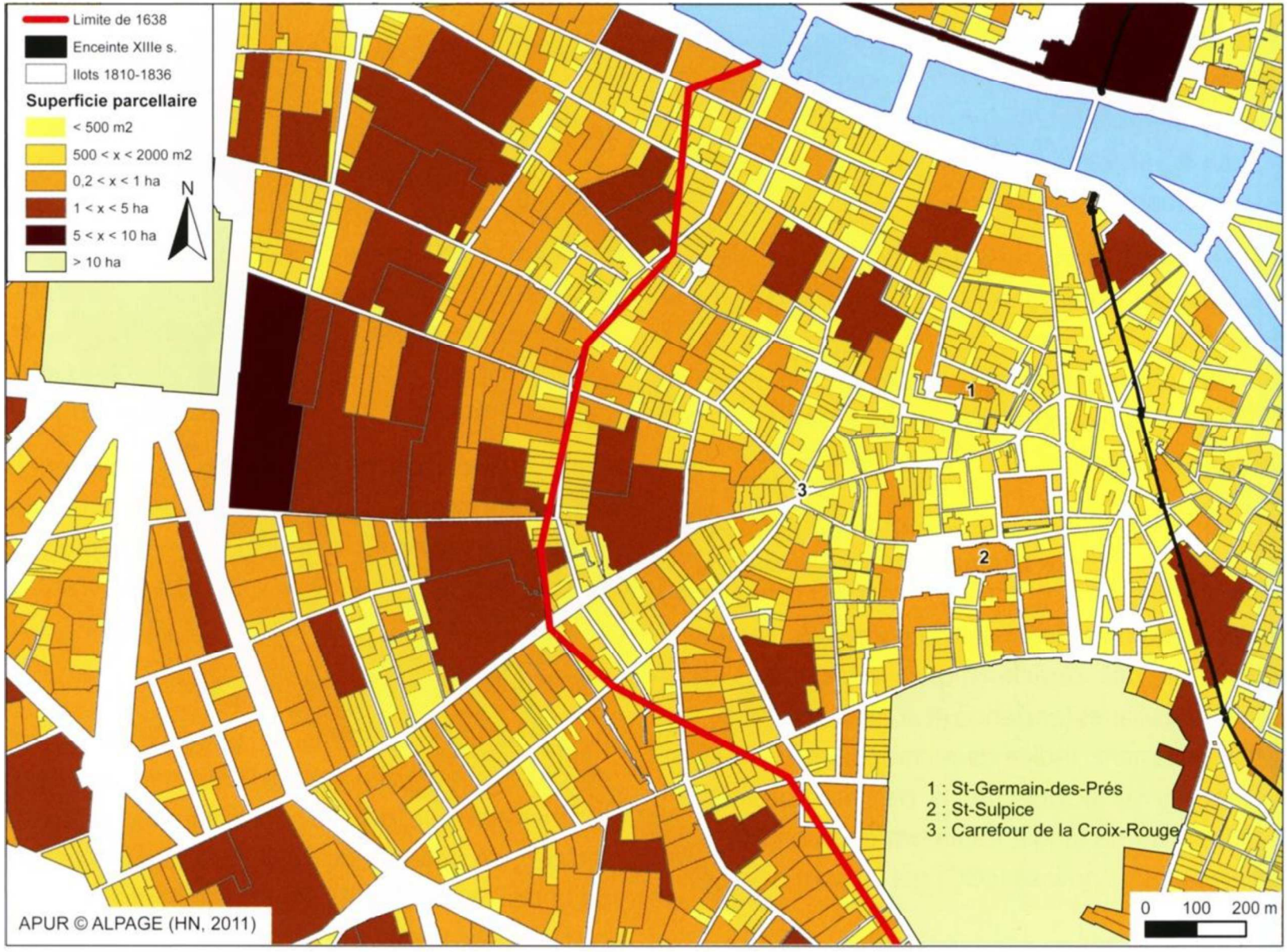
The polygonal characterization of plots involves the exploitation of the geometric characteristics of past and present plot layers:

- surface ,
- elongation index (ratio length/width) ,
- index of rectangularity reflecting the surface of the plot considered in relation to the minimum bounding rectangular box and the convex envelope associated with it.

Overall, the pre-industrial plot characteristic of medieval and modern periods, is in a range between 12 m^2 and 300 m^2 , with plots most often between 50 and 100 m^2 . Highlighting below 300 m^2 plots on the Vasserot plan (1810-1836) confirms the high plot density on the more urbanized right bank compared to the more rural left bank. Per hectare there was on average 11 plots on the right bank against 8 on the left bank.

	Aire totale (ha)	Nb de parcelles	Densité parcellaire (nb parc. /ha)	Aire parcellaire moyenne	Écart-type (aire moyenne)
ive droite	1676	18364	**11**	912.52	**3881**
ve gauche	940	7252	**8**	1296.62	**9118**

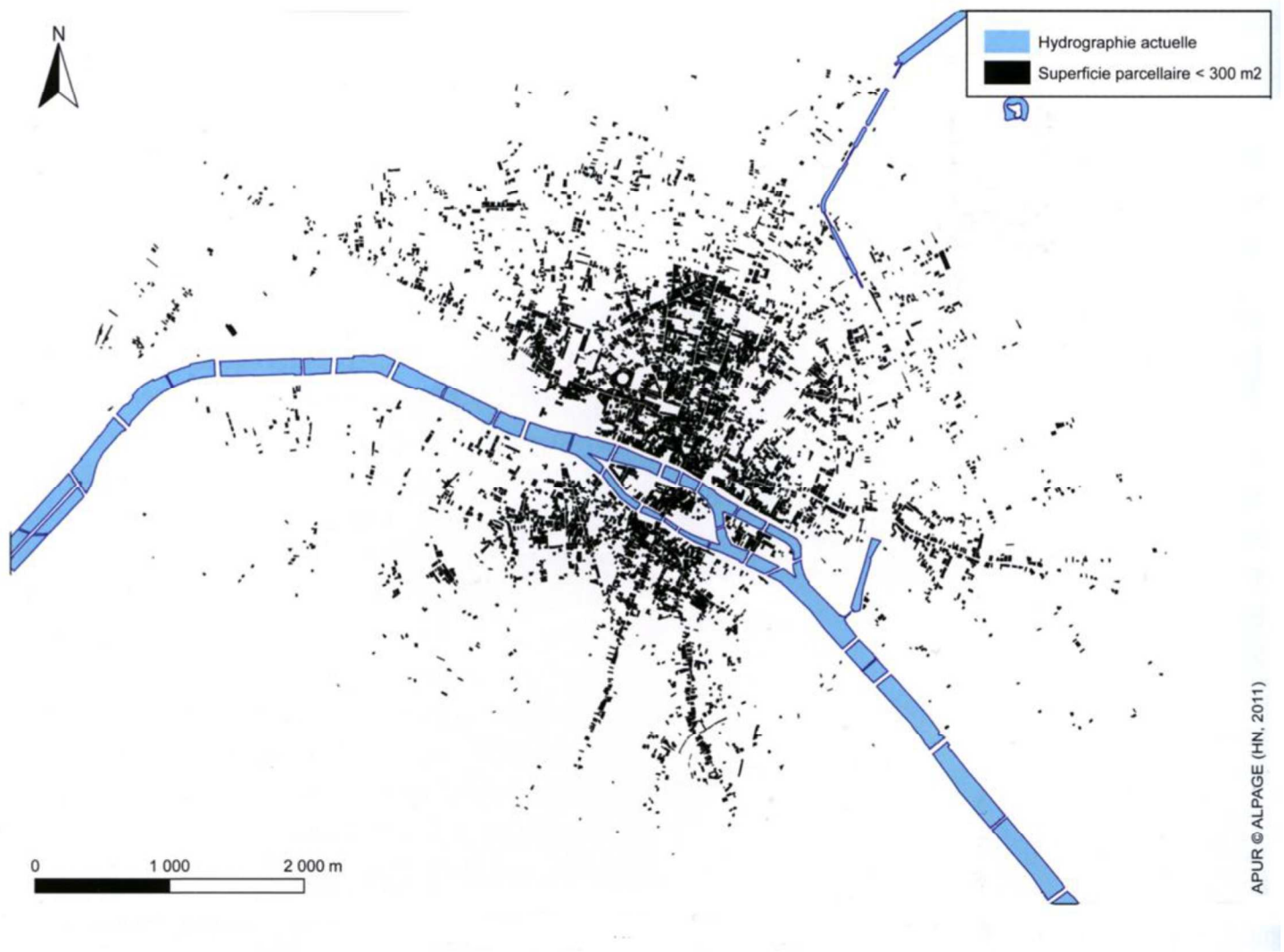
Source: *Paris de parcelles en pixels*



Articulation entre parcellaires rural et urbain vers Sèvres-Babylone.

The limit between urban and rural space on the left bank in the years 1810 - 1836 appears in the morphological difference in the plot patterns.

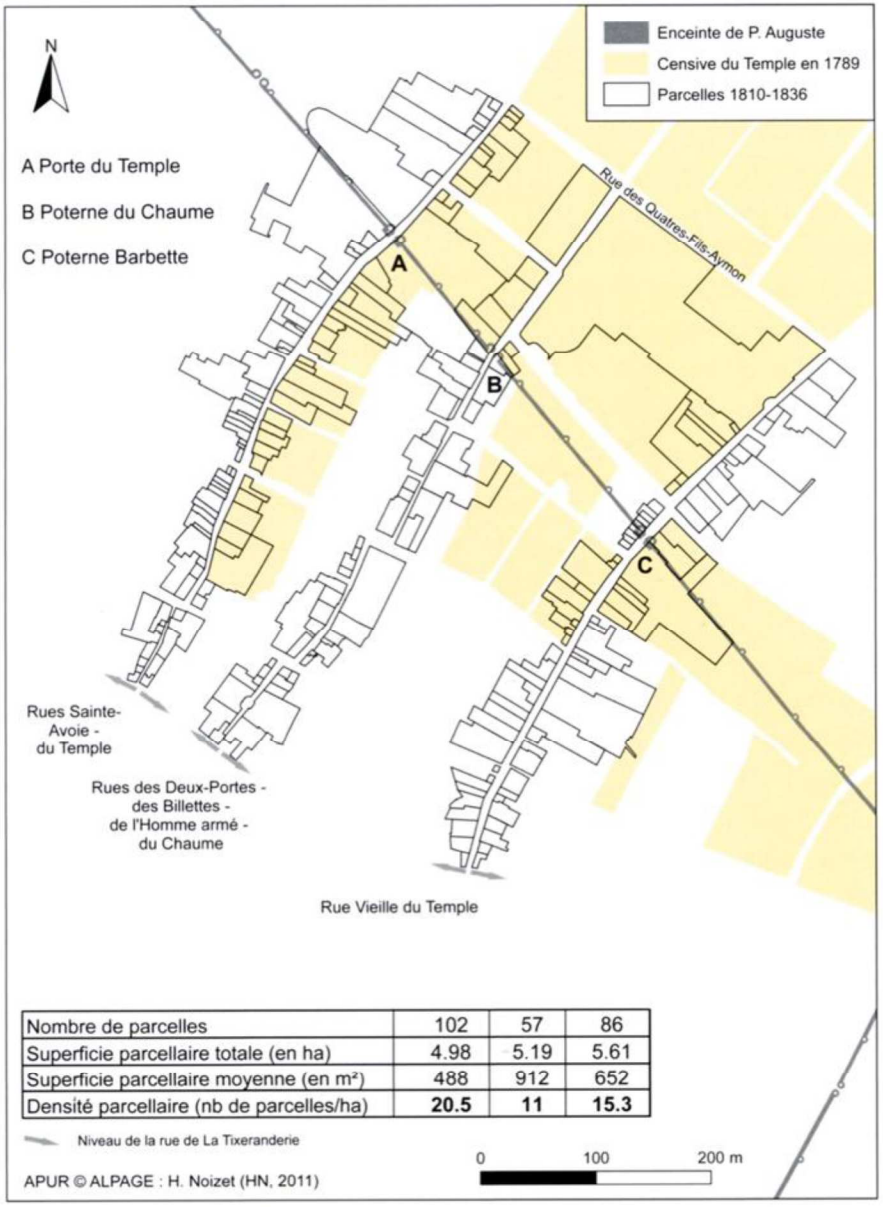
Source: *Paris de parcelles en pixels*



Extracting only the smaller plots corresponding to the most ancient urbanization reveals a fractal pattern oriented according to the 2 morphogenetic axes of Antiquity and the Middle Ages

Source of the map: *Paris de parcelles en pixels*

Platting geometry (size, orientation) is a time travel machine in layered urban strata
It embeds the memory of the city at extreme micro scales



Consequences on the platting geometry of the opening dates of gates in Philippe Auguste wall (1190-1215)

- Rue du Temple crossed the wall through porte du Temple, one of the original gates
- -Rue Vieille-du-Temple was opened very early, before 1203
- - Rue du Chaume was opened only in 1288

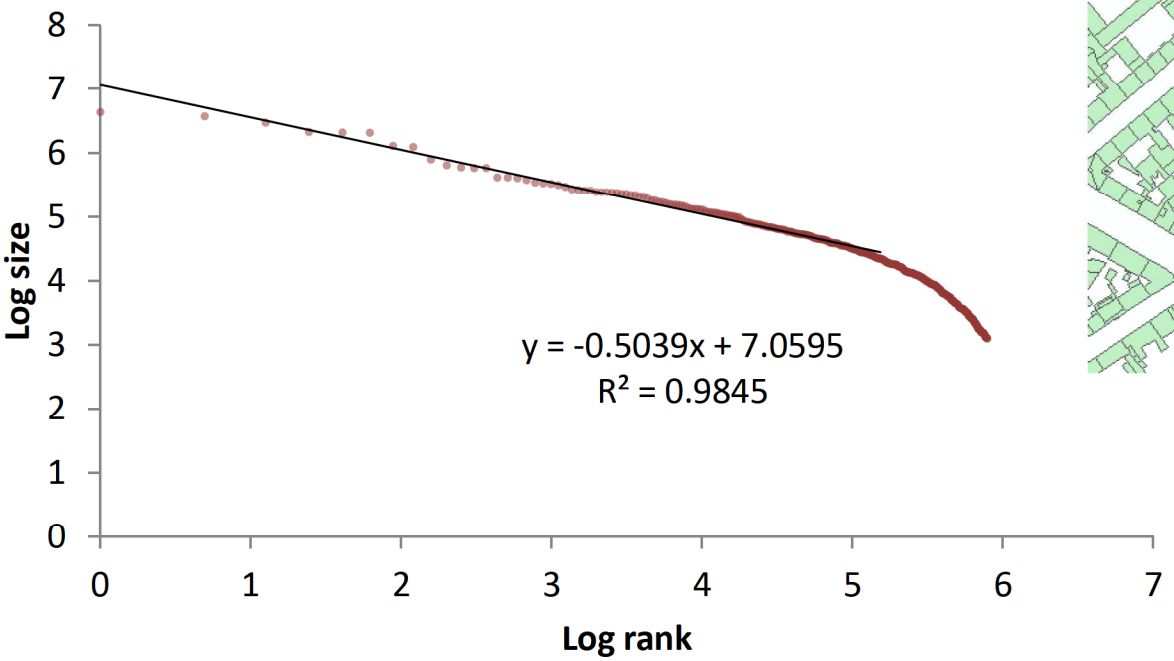
The analysis of plots in Vasserot plan (1810-1836) reveals a morphological hierarchy with 20.3 plots per ha for rue du Temple, 15.5 plots per ha for rue Vieille-du-Temple, 11.3 plots per ha for rue du Chaume.

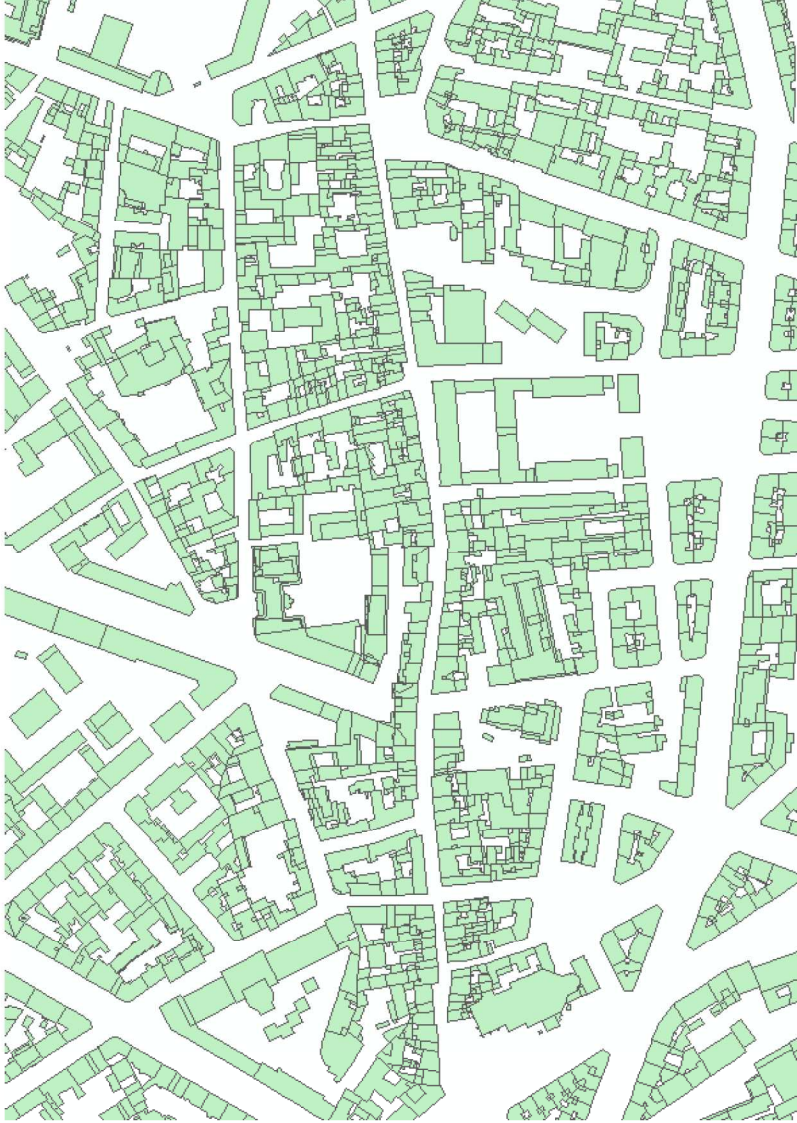
The piercing of wall gates has been so structuring on the micro scale of the urban structure that 5 centuries after, at the beginning of 19th century, the spatial hierarchy of 13th century is still visible.

Source: *Paris de parcelles en pixels*

The scaling hierarchy of plots' area along a structuring axis of Medieval Paris
The largest plot is 760 m^2

Paris
Rue Mouffetard





Source: Urban Morphology Institute

Quartier de l'Etoile

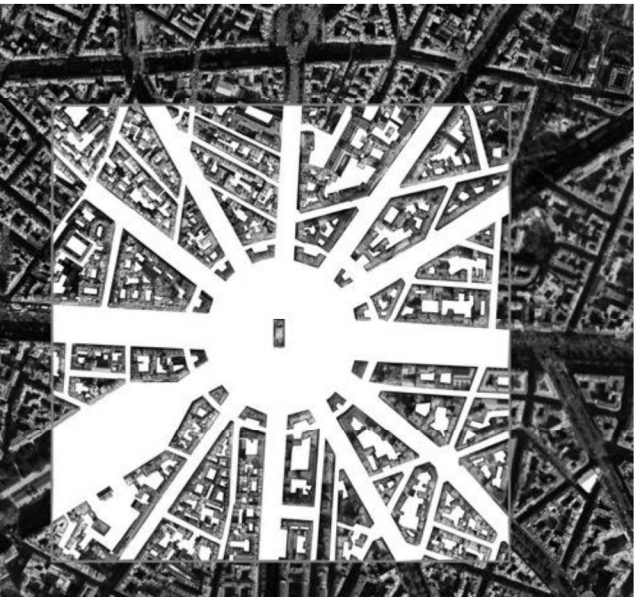
The plot scaling hierarchy in a new Haussmannian development.

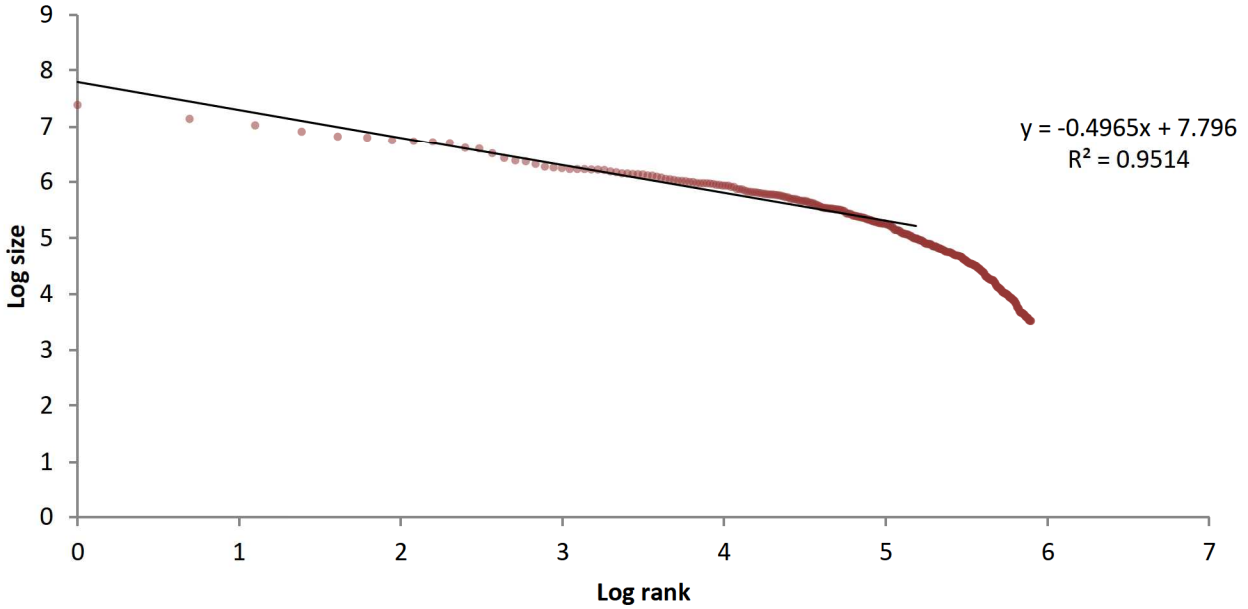
The largest plot is 1600 m^2.

With much larger plots the scaling hierarchy remains similar.

The city dilatation conserves the scaling hierarchy

Source: Urban Morphology Institute

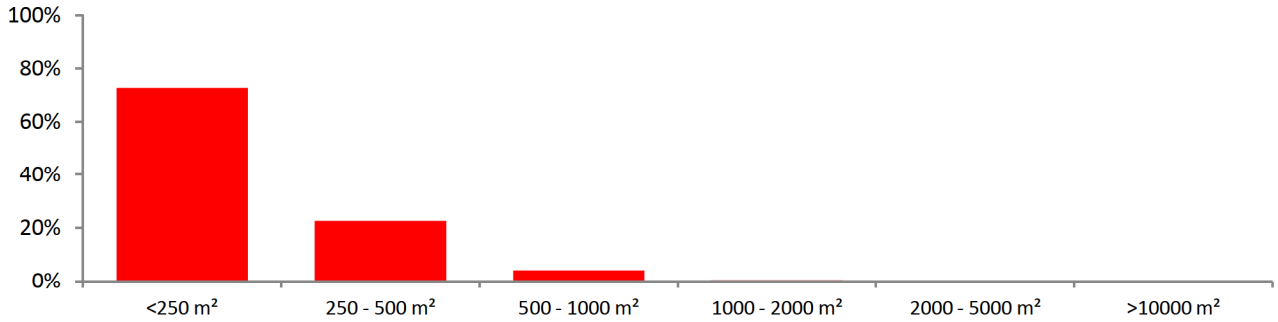




The plot scaling hierarchy in a complex urban fabric near Nation.

Source: Urban Morphology Institute

Paris
Quartier sainte Marguerite

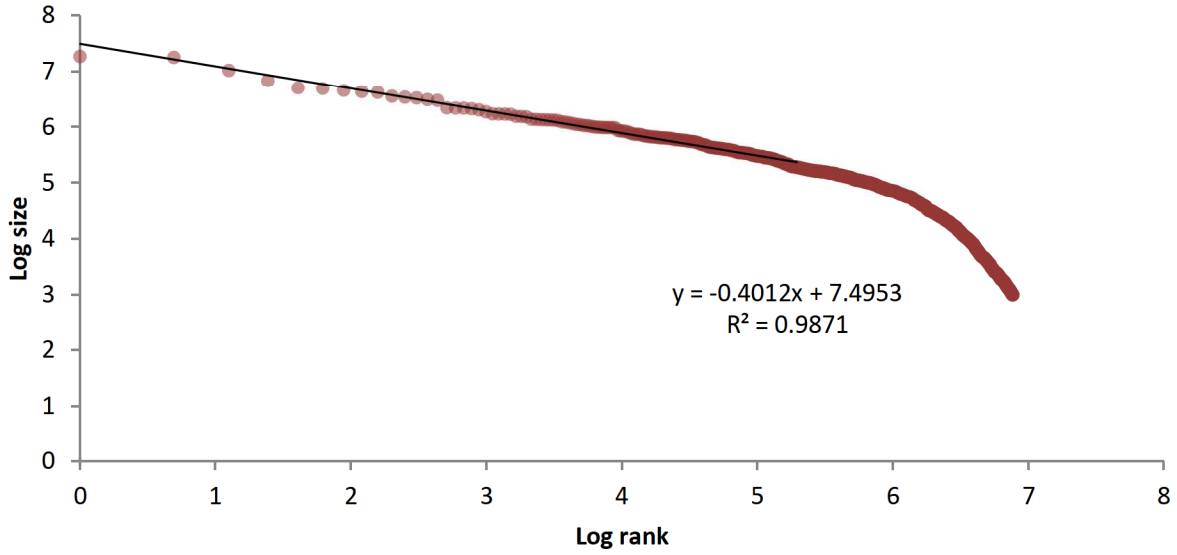


With much larger plots (3300 m2 for the largest) the scaling hierarchy remains similar.

Is this plot scaling exponent a signature of Paris intra-muros?

Source: Urban Morphology Institute

Paris
Quartier sainte Marguerite



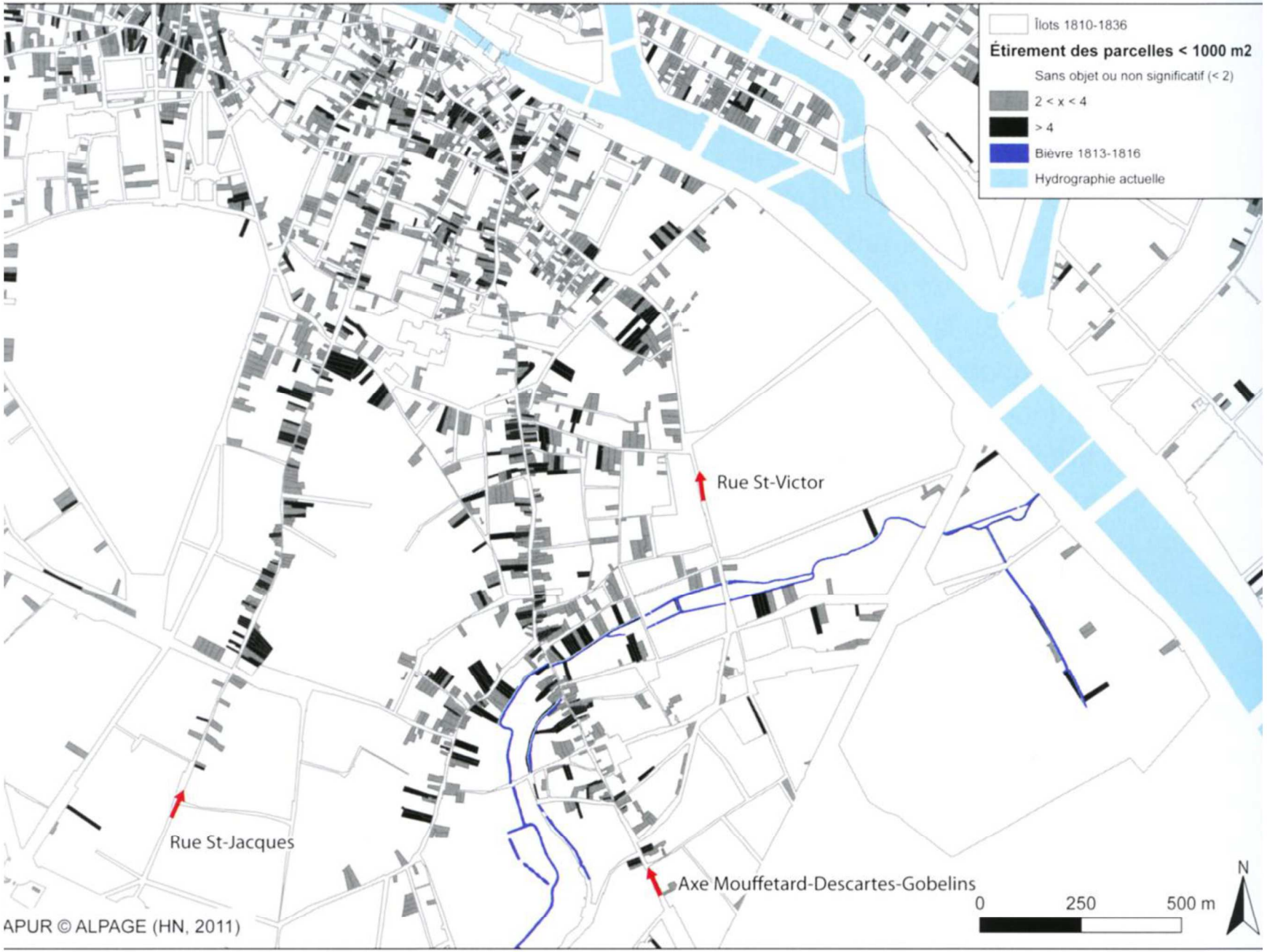
The analysis of the plot elongation index

The elongation index allows to measure the attractiveness of streets.

A strong elongation characterizes a plot on a street along high traffic routes .

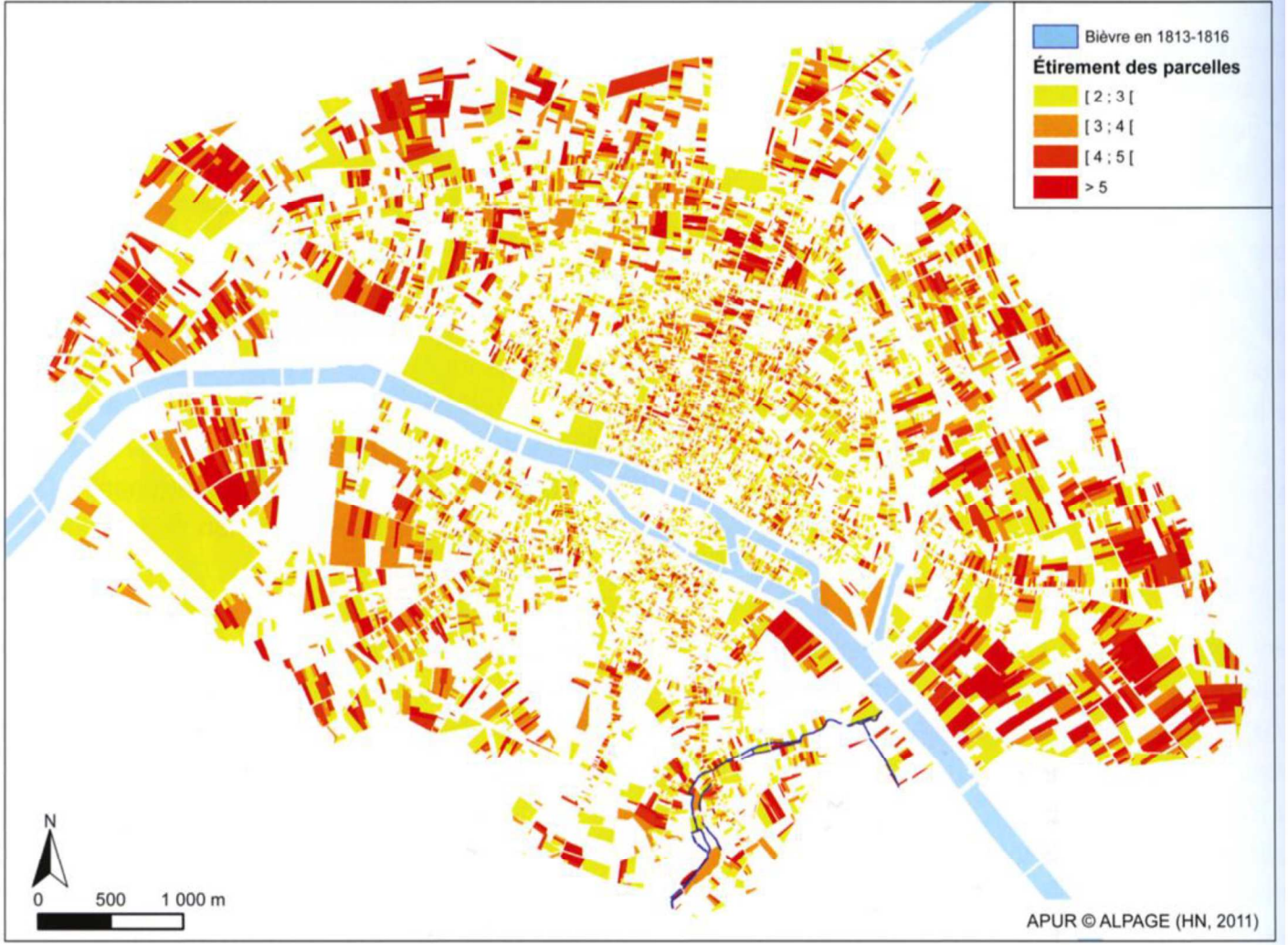
The ability of some streets to capture flows crystallizes in the plot configuration into strips or fringes. The added value of the land bordering these streets, which reflects the competition in order to have access to them, induces a dense, patchy and fragmented plot pattern with short street facade and deployment behind the plot.

This strip plot morphology characterizes rue Saint- Jacques – the former axis linking the North and South – and rue Mouffetard , the former axis that was on the route Paris - Melun. South of the wall of Philippe Auguste , these two axes induced a suburban type configuration with very loose plots articulated around a strong axis where plots were, in contrast, very fragmented.



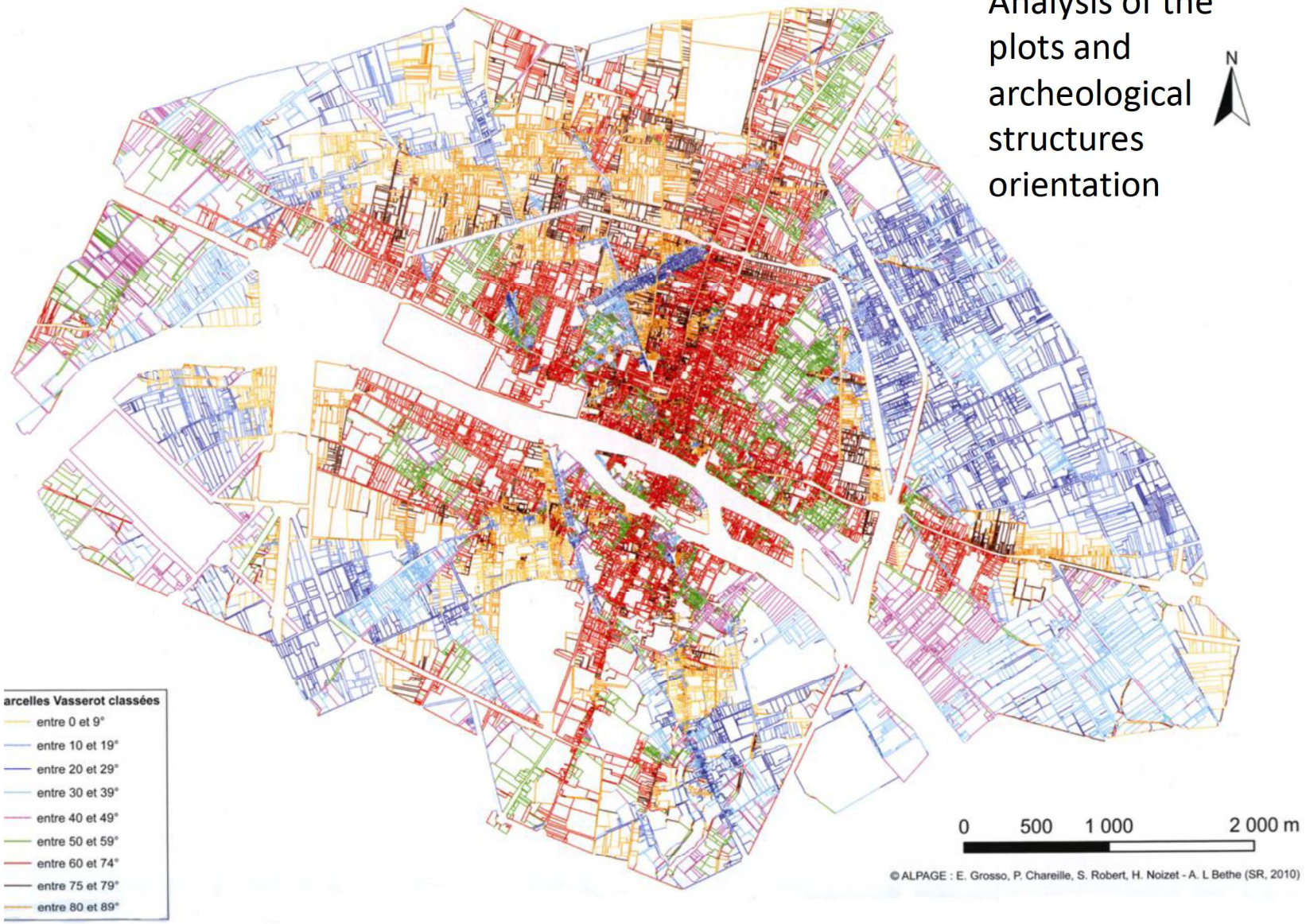
Étirement des parcelles 1810-1836 en rive gauche :
rôle structurant des rues Saint-Jacques et Mouffetard et de la Bièvre.

Source: *Paris de parcelles en pixels*



Étirement des parcelles 1810-1836 : un parcellaire rural en bandes en périphérie.

The elongation index also identifies strip plots of rural origin. This is the type of plot that is located on the outskirts of Paris from before 1860, with a regular arrangement of strip flooring, which corresponds to intermediate forms of agricultural land use. In addition, the elongation index also identifies the mechanisms of plot transmission for earlier periods, such as between rue Saint-Martin and rue Vieille-du-Temple. Source: *Paris de parcelles en pixels*

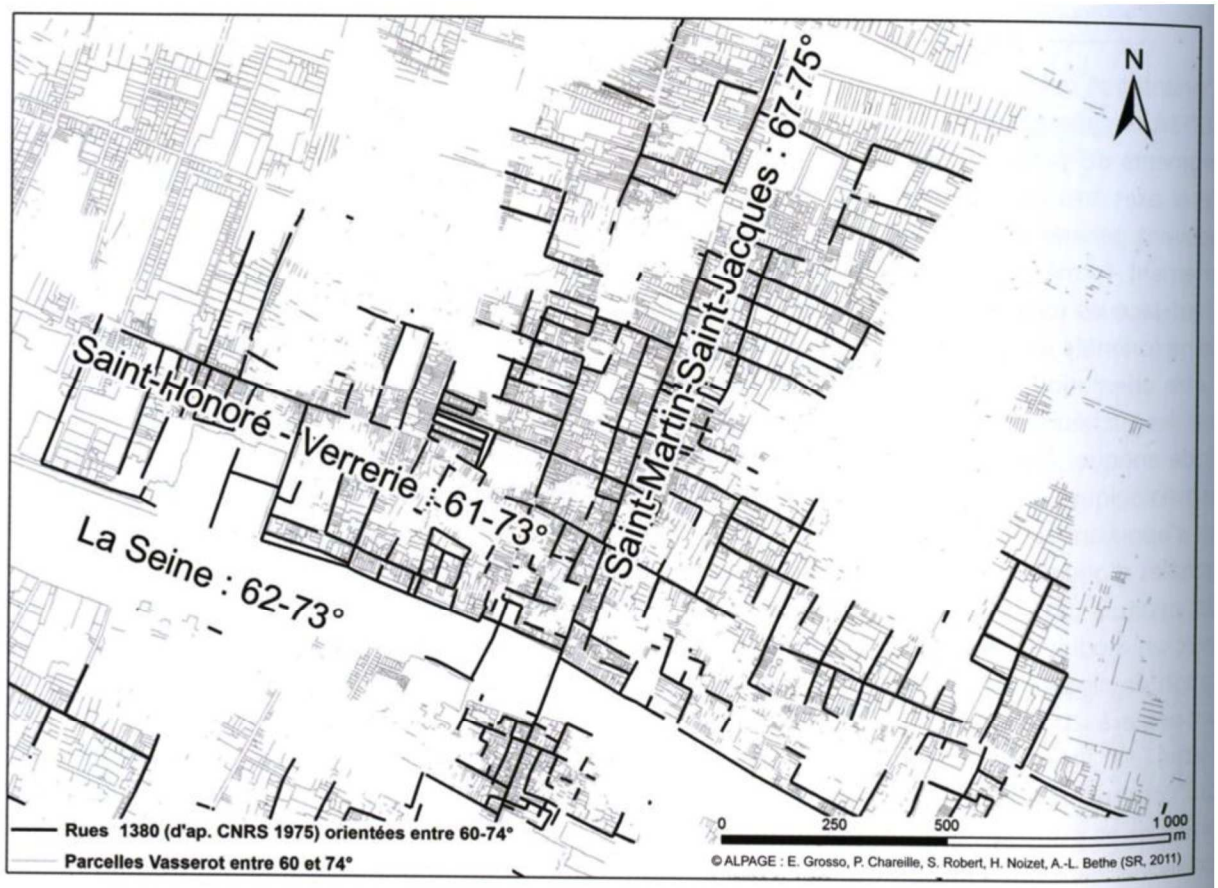


This map shows the orientations of the segments of plots in Vasserot map (1810-1836) as well as of the archaeological structures of Paris .

Source: *Paris de parcelles en pixels*

The major orientation is between 60 and 74 ° with respect to east. It alone represents 36 % of the total of segments. It relies on two very morphogenetic axes , that is to say, that can generate and transmit forms: the alignment formed by the rue Saint -Martin and Saint- Jacques, and the Seine. **This orientation has been identified by archaeologists as dominant in the Roman period .**

The morphogenetic axis of ancient Lutèce was based on a regular orthogonal grid aligned on rue Saint- Martin – rue Saint- Jacques, which is partly the cardo of the ancient foundation and builds on former islands formerly present in the course of the Seine.



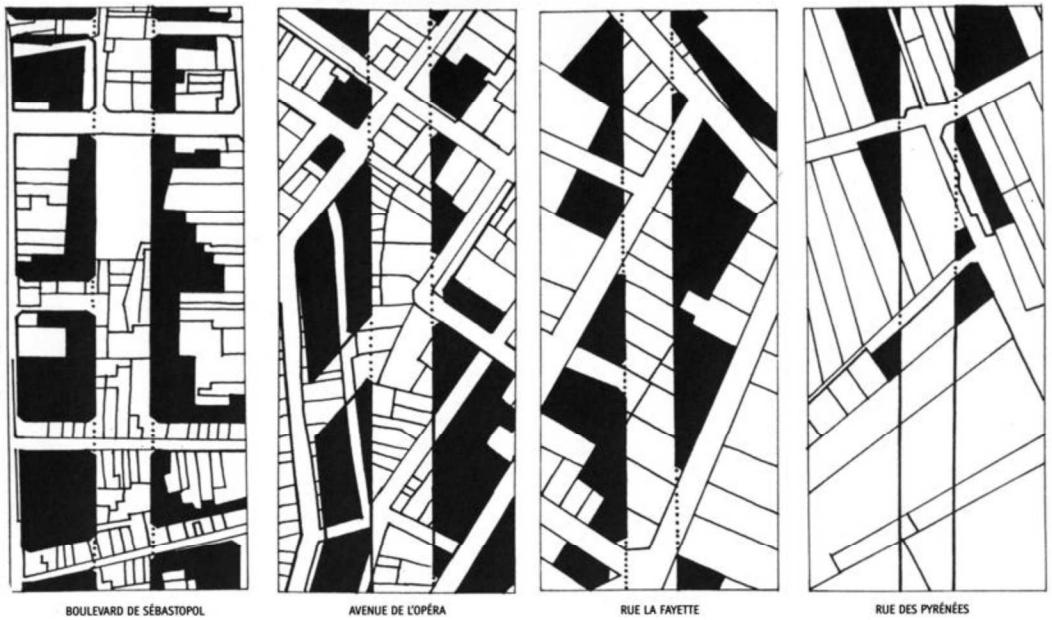
This orientation also dominates the network of streets that existed at the end of the fourteenth century. T**he Middle Ages has played a key role in the resilience of Roman period main orientation and its dissemination on the right bank**.

Source: *Paris de parcelles en pixels*

Percées haussmanniennes et voies anciennes : une organisation différente du parcellaire actuel en front de rue

The rectangular shape is the basic plot module. Thus, the indices measuring greater or lesser compliance with this standard are instructive on the structuring of the urban fabric. Deviations from the standard rectangular plot highlight planning actions that operate cuts in the continuity of the urban fabric, as here Haussmann cuts that have produced a large number of indented plots.

Source: *Paris de parcelles en pixels*



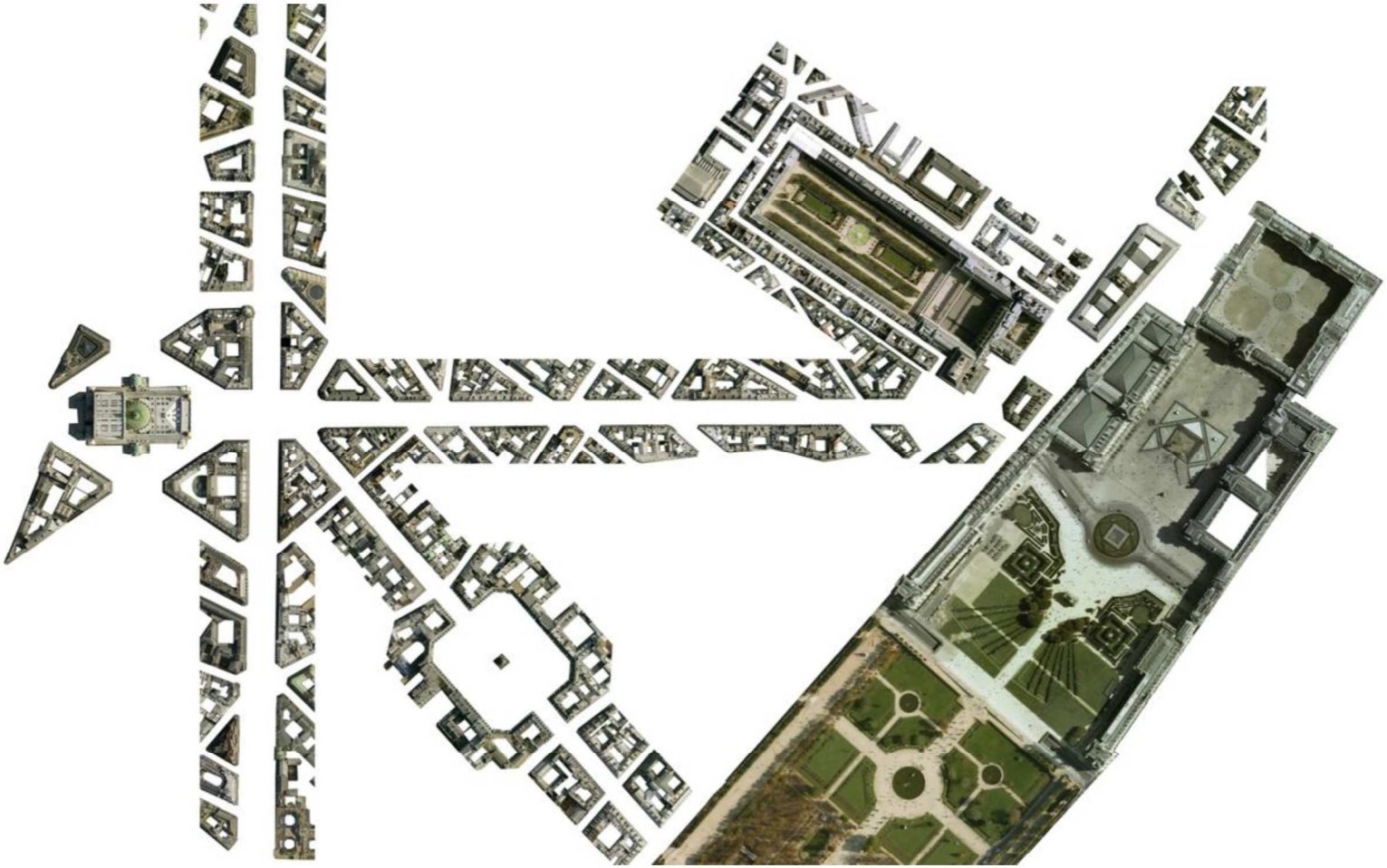
► Plan et vue axonométrique l'immeubles reconstruits l'alignement de l'avenue de Opéra. (Coll. P. Pinon)

The impact of Haussmann intervention on the lot shapes (loss of rectangularity) and the rebuilding of new street frontages (left Avenue de l'Opéra)

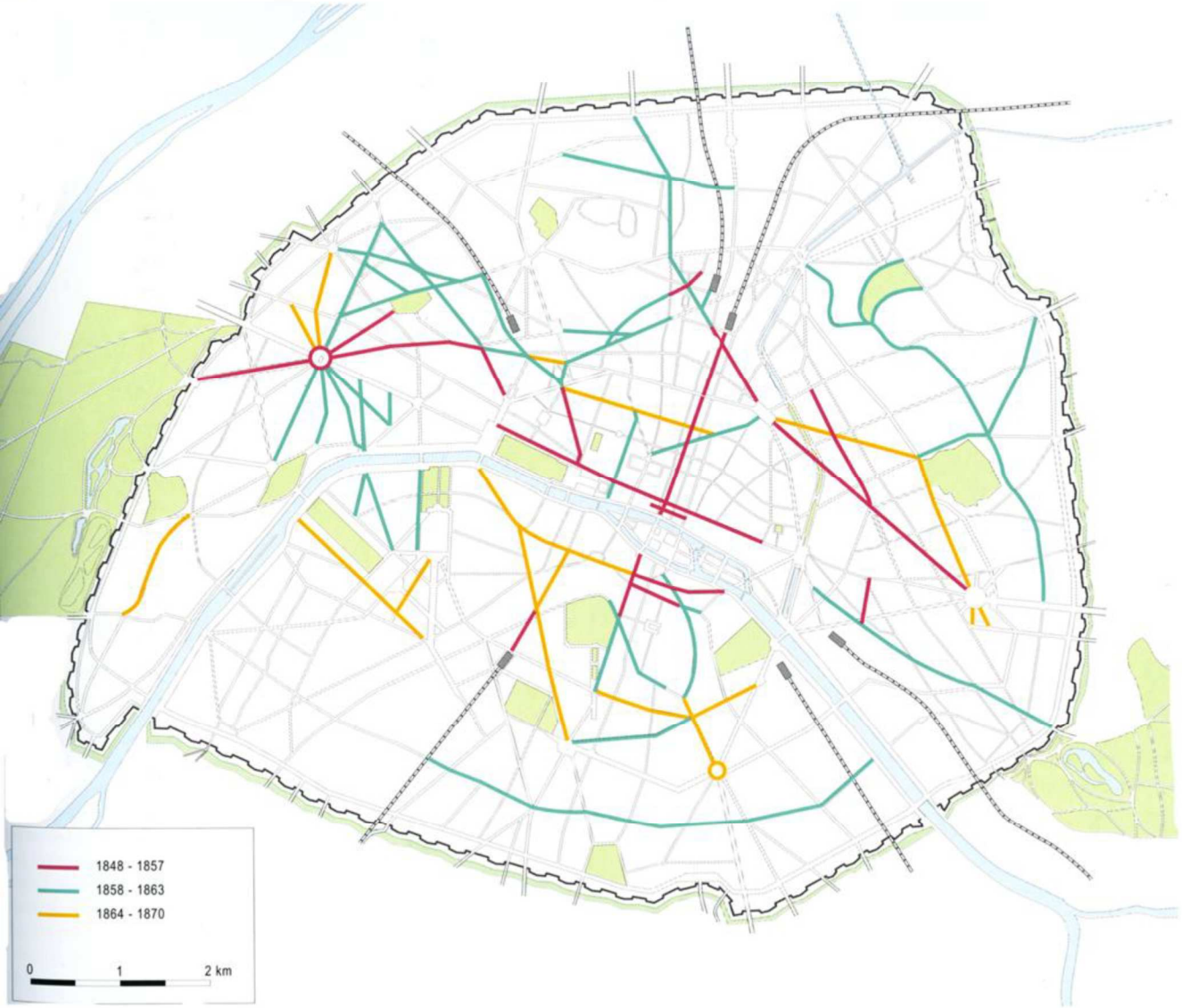
Haussmann's plan implied a large number of destruction and rebuilding: approximately 28, 000 houses were destroyed and 100, 000 were built.

Source: Pierre Pinon, At*las du Paris haussmannien*

Paris: Haussmann cuts into the more than one thousand years old urban fabric. Did it lead to a mathematical order?



Source: Serge Salat, *Cities and Forms*

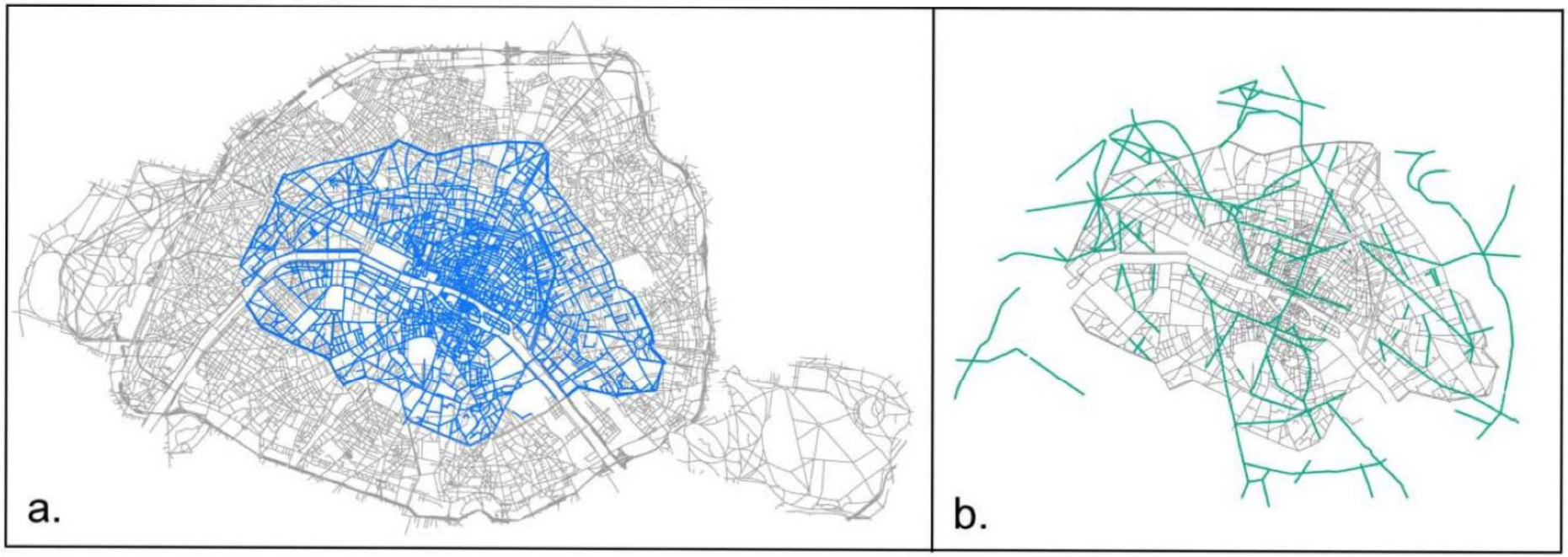


Map of the cuts (« percées) decided between 1848 and 1870

The evolution of Paris results from the superimposition of continuous, local growth processes and punctual changes operating at large spatial scales.
The most important quantitative signatures of Haussmann planning are the spatial reorganization of centrality and the modification of the block shape distribution.

1848-1857:The first reordering of the center.
1858-1863: The conquest of the periphery.
1864-1870: The final integration of the center into a higher scale order.

Source: Pierre Pinon, At*las du Paris haussmannien*

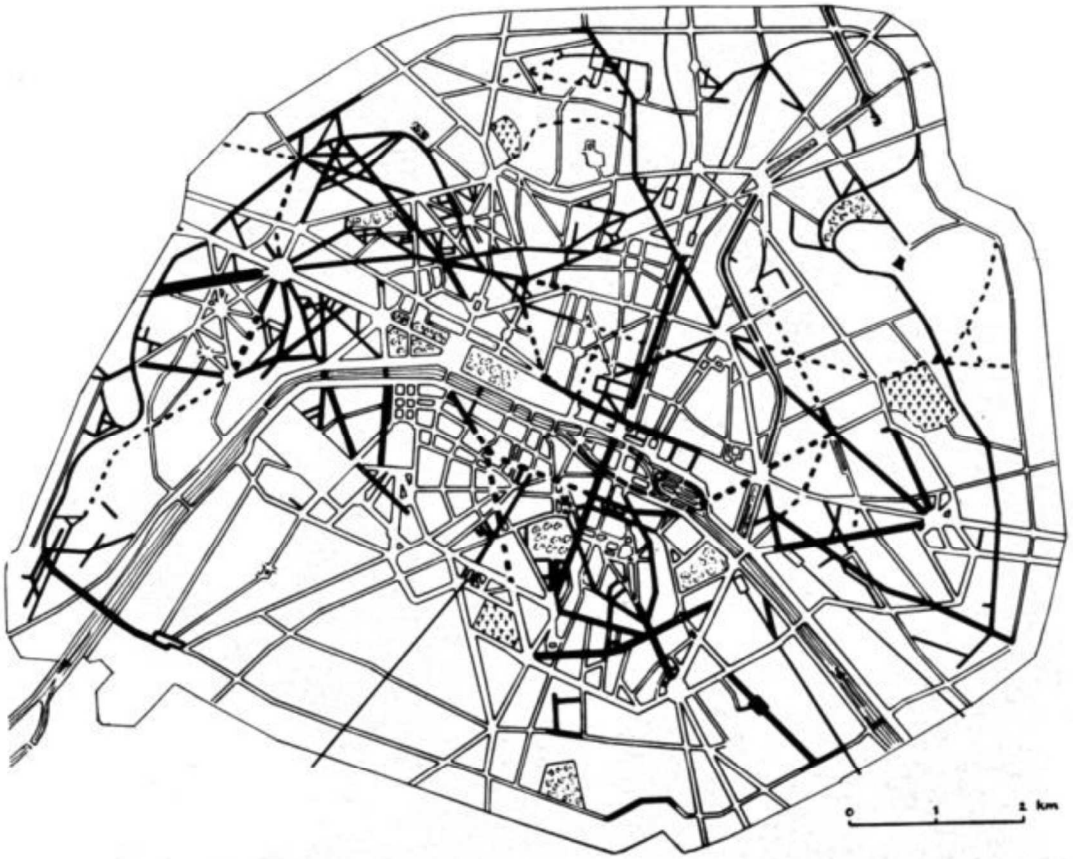


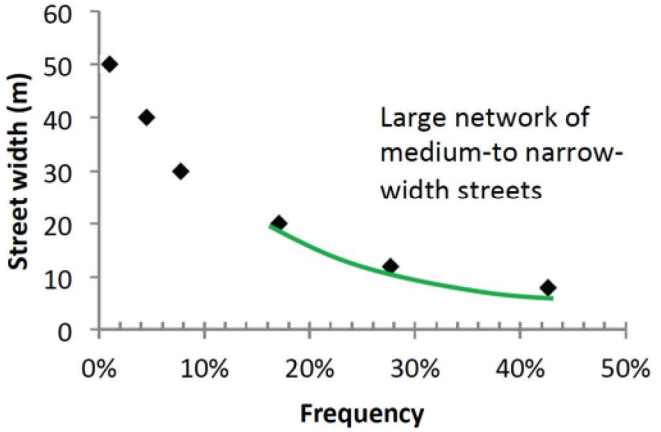
(a) Map of Paris in 1789 superimposed on the map of current 2010 Paris.
(b) Map of Haussmann modifications. The grey lines represent the road network in 1836 (Plan Vasserot), the green lines represent Haussmann modifications.

In the area corresponding to 1789), the number of nodes of the streets graph increased from about 3000 in 1836 to about 6000 in 1888 and the total length increase from about 400 km to almost 700 km, all this in about 50 years.

Source: Barthelemy, Bordin,Beresticky, Gribaudi,
« Self-organization versus top-down planning in the evolution of a city ».

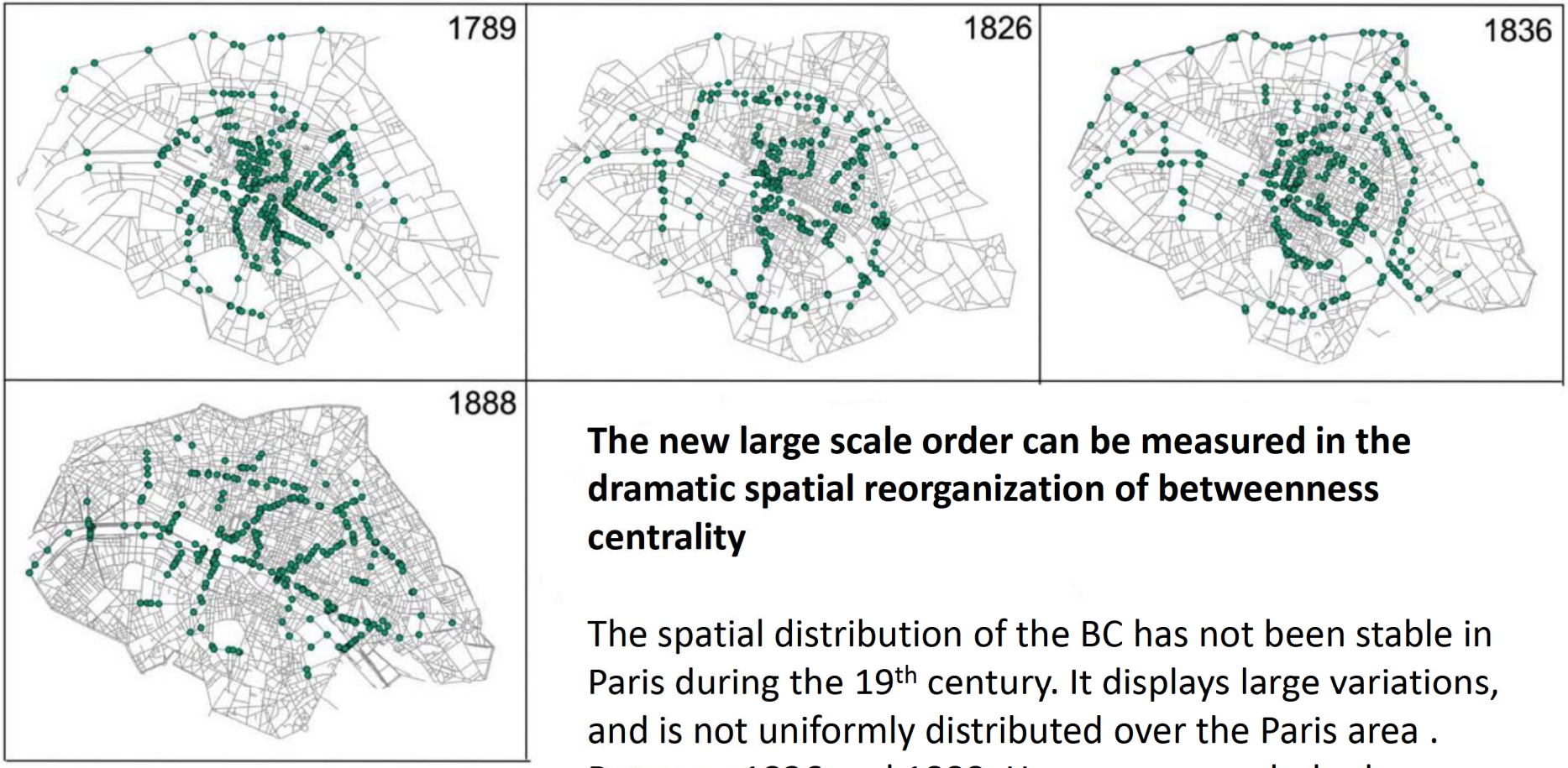
Haussmann reinforced the scaling structure of Paris by integrating the existing city into a larger scale free structure





Scale-free distribution of street widths in Paris

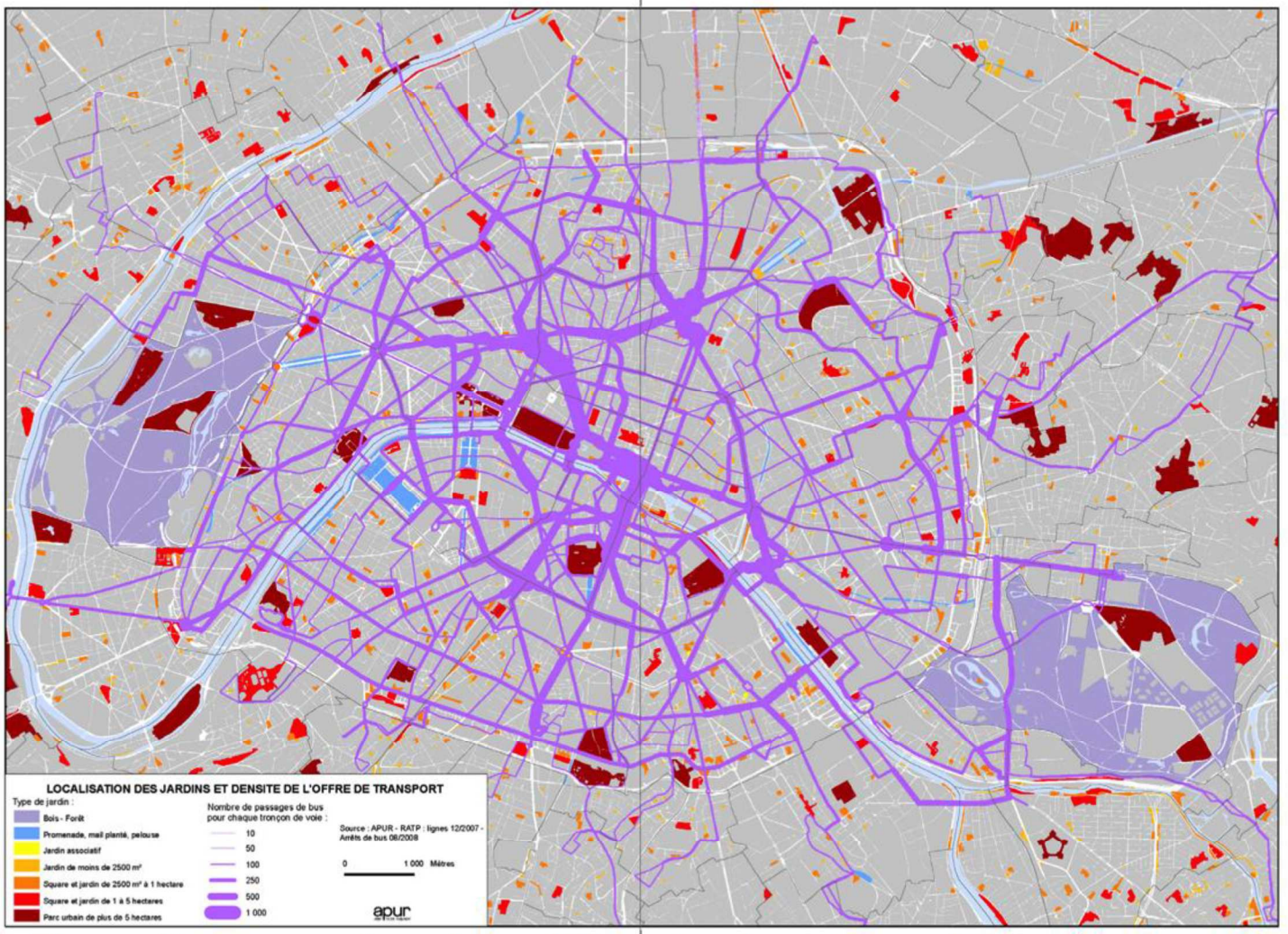
Source: Serge Salat, *Cities and Forms*



Source: Barthelemy, Bordin, Beresticky, Gribaudi, « Self-organization versus top-down planning in the evolution of a city ».

The new large scale order can be measured in the dramatic spatial reorganization of betweenness centrality

The spatial distribution of the BC has not been stable in Paris during the 19th century. It displays large variations, and is not uniformly distributed over the Paris area . Between 1836 and 1888, Haussmann works had a dramatic impact on the spatial structure of the centrality, especially near the heart of Paris. Central roads usually persist in time, but Haussmann reorganization was acting precisely at this level by redistributing the shortest paths.



Source of the map: APUR

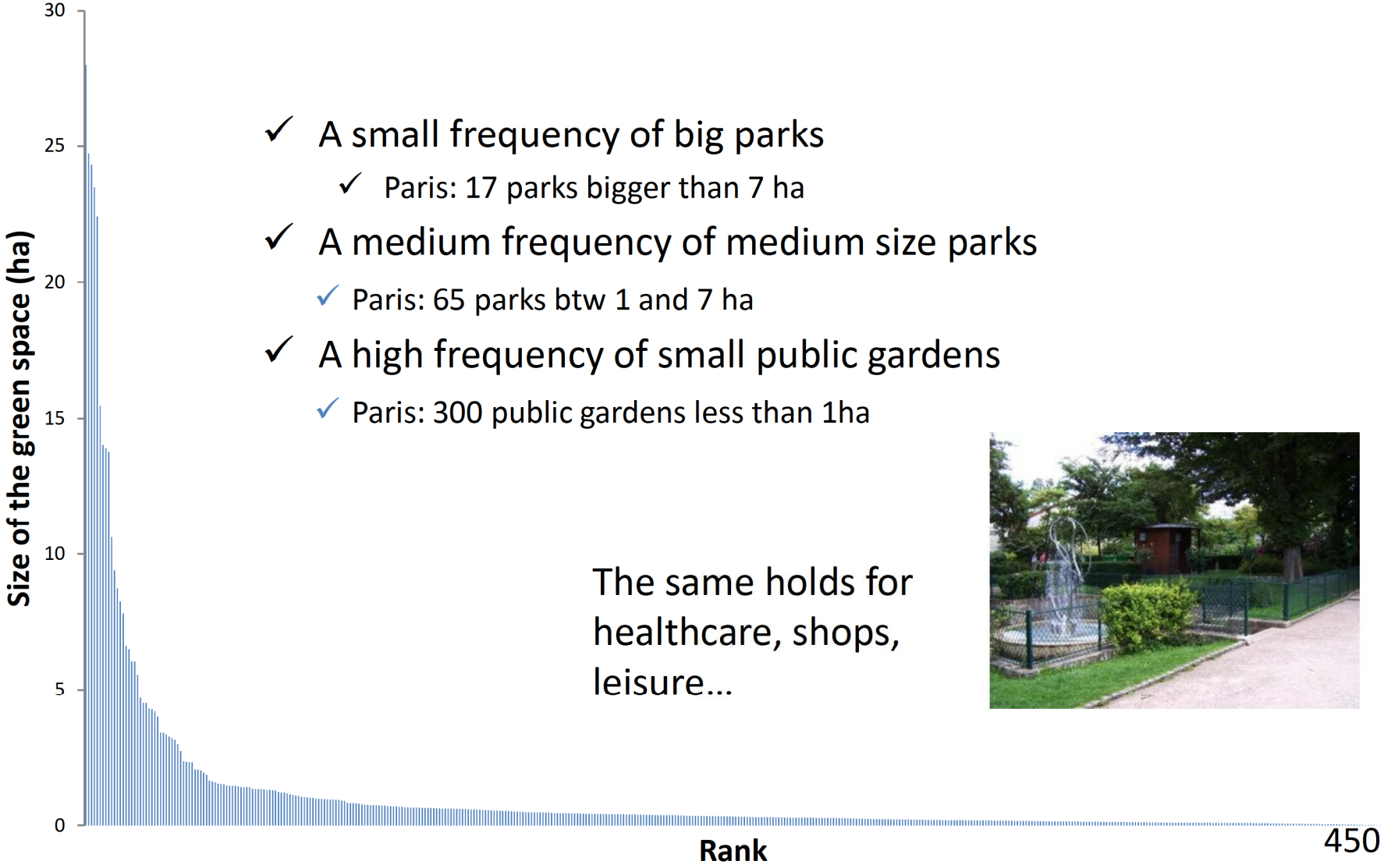
The scaling properties of the different sub-systems of the city are coherent one with the other. This map shows the frequency of buses along main streets over-layered on the map of public gardens. Streets are scaling, frequency of transit is scaling, gardens are scaling. Buses ensure accessibility to the larger amenities along main transit lines while the long tail of smaller streets ensures accessibility to smaller amenities. The different scales are well integrated.

At intra urban scales, accessibility is enhanced by a scale-free distribution of amenities within the urban fabric

APUR

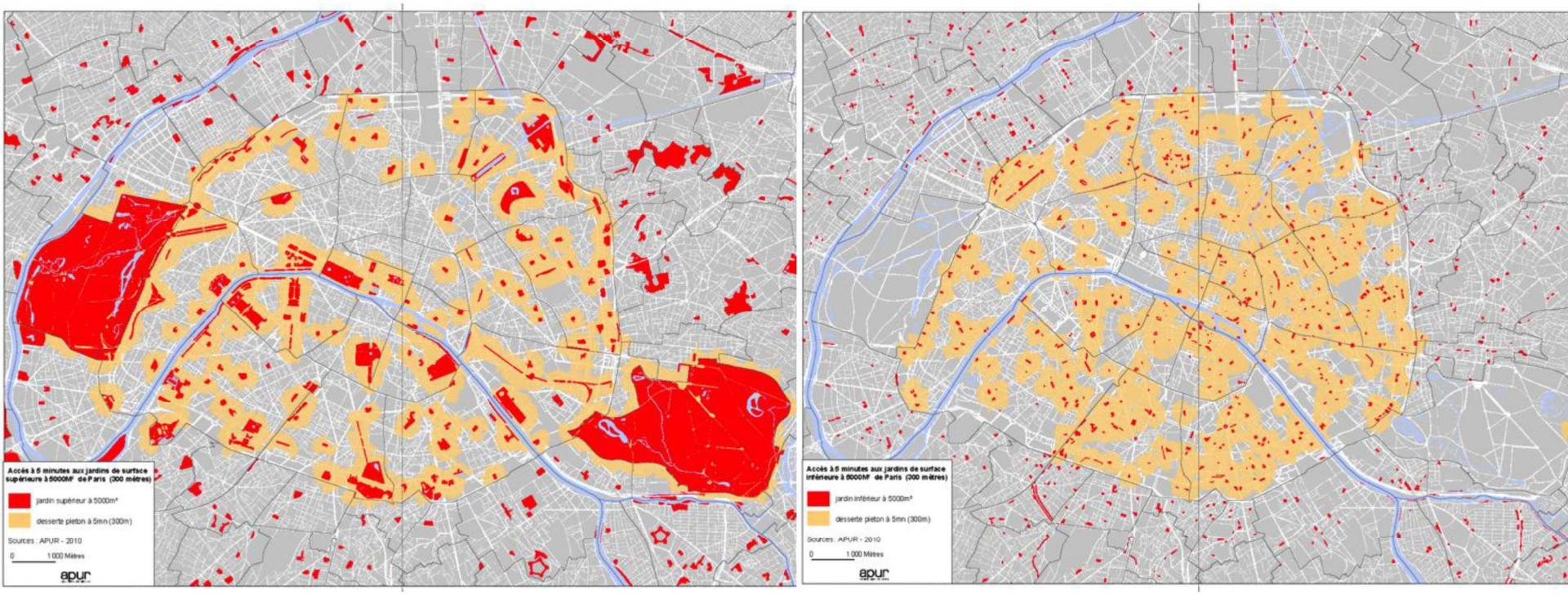
In Paris intra-muros, scale free distributions enhance accessibility with a long tail of small elements

Source: Urban Morphology Institute



- ✓ A small frequency of big parks
  - ✓ Paris: 17 parks bigger than 7 ha
- ✓ A medium frequency of medium size parks
  - ✓ Paris: 65 parks btw 1 and 7 ha
- ✓ A high frequency of small public gardens
  - ✓ Paris: 300 public gardens less than 1ha

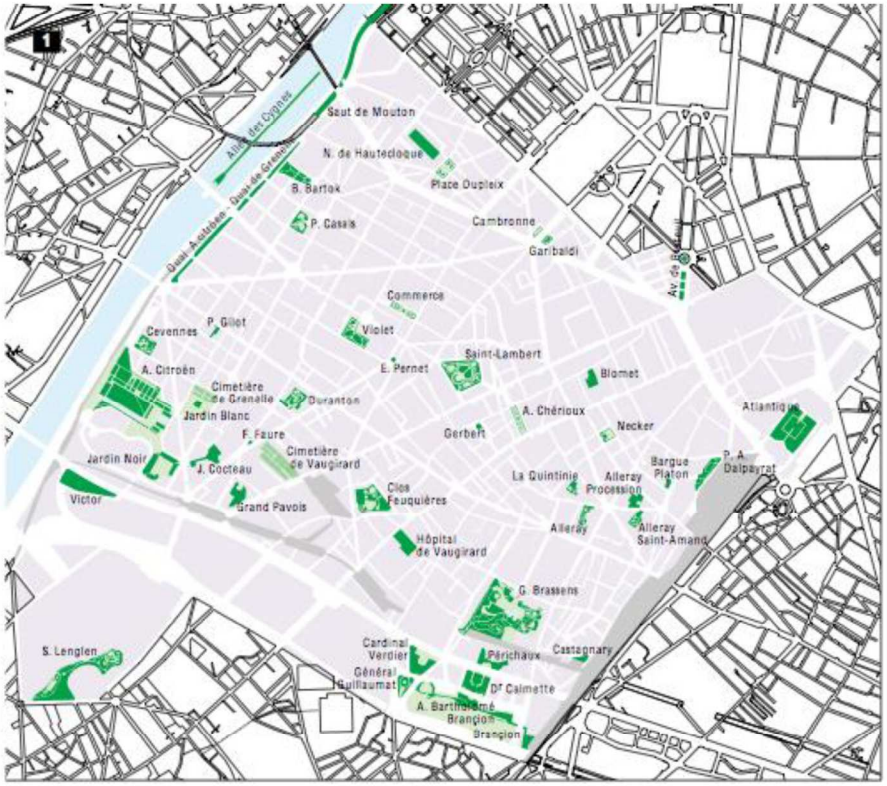
The same holds for healthcare, shops, leisure…



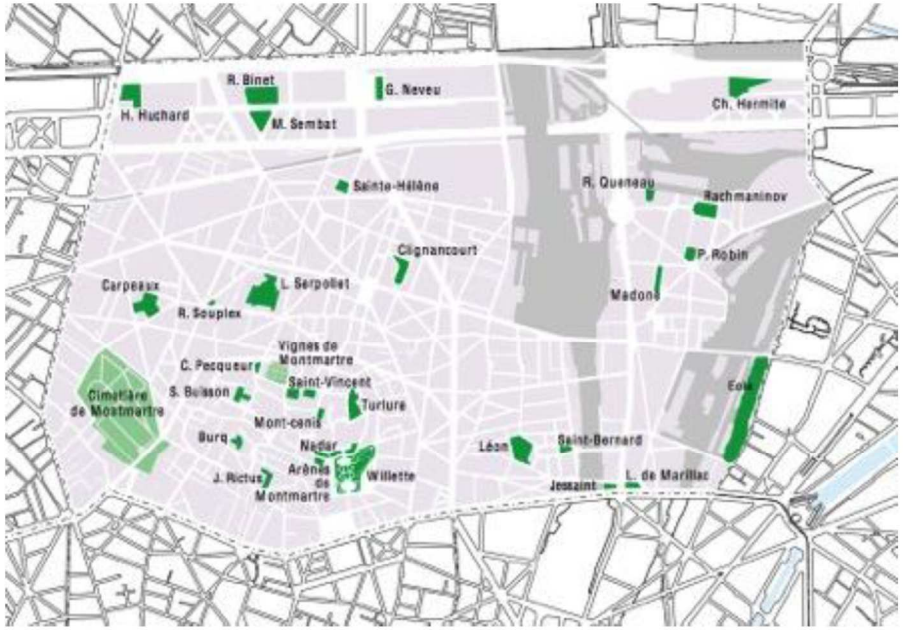
The scaling of public parks ensures a general accessibility at less than 300 m in the whole Paris intra-muros city. On the right, accessibility at less than 300 m of the large public parks (more than 5000 m^2). On the left, accessibility at less than 300 m of the long tail of small public parks (less than 5000 m^2). The long tail of 260 public gardens less than half ha ensure general accessibility. (Source of the maps:APUR)

The inverse power law distribution distribution of sizes is verified at arrondissement scale

15ème arrondissement



18ème arrondissement

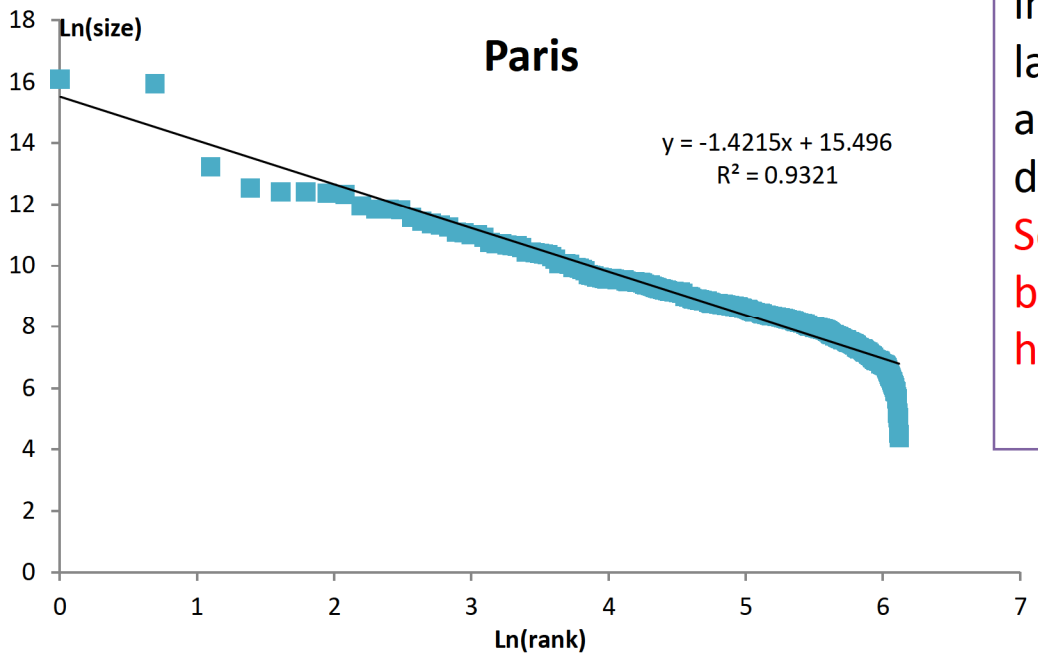


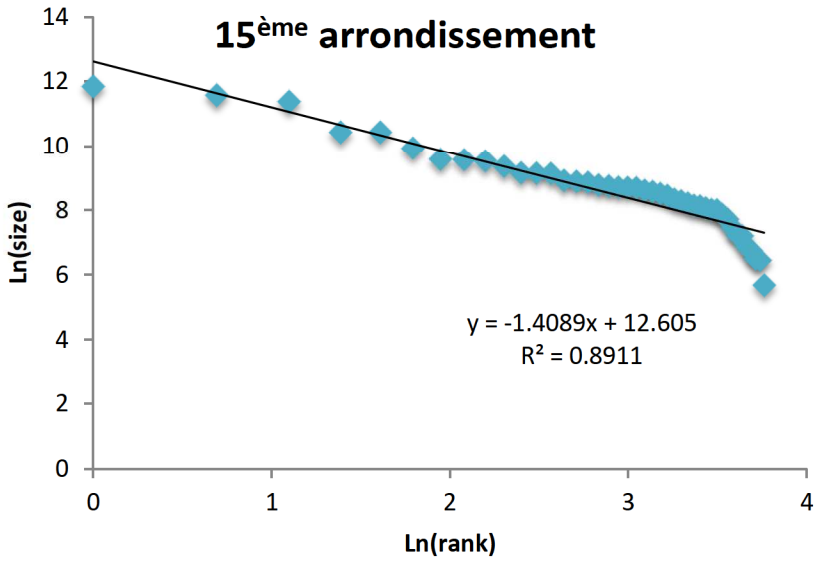
Source : APUR

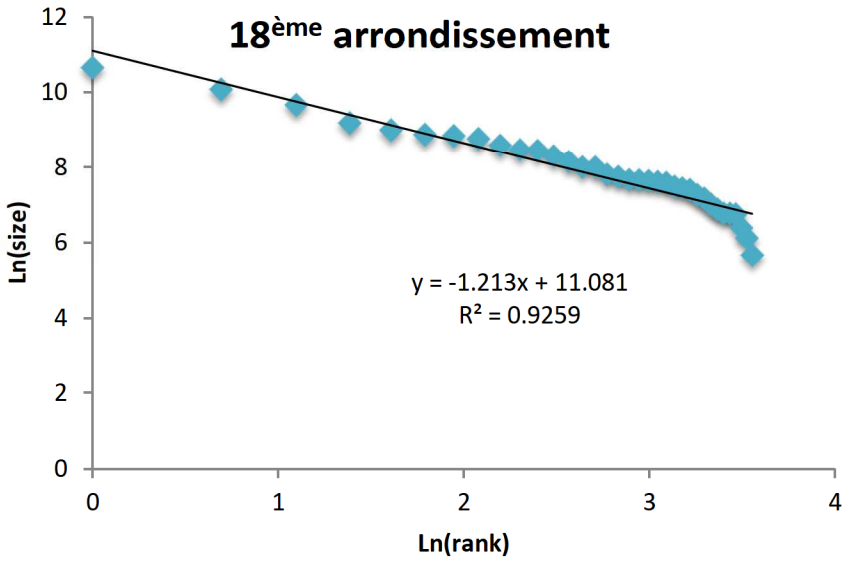
Public parks distribution in Paris intra-muros follows an inverse power law. The same holds at arrondissement scale. The distribution is scale free

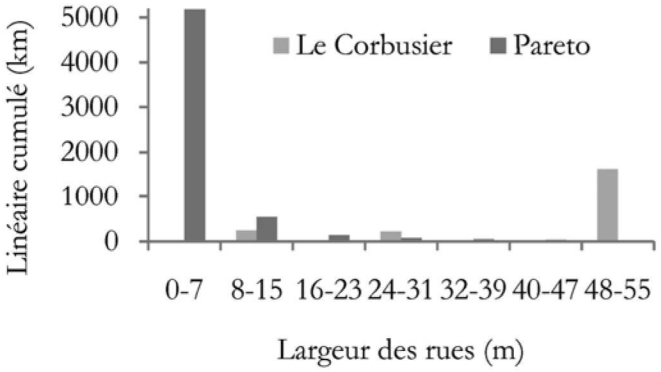
Scale free distributions in Paris have been created by 2000 years of urban history

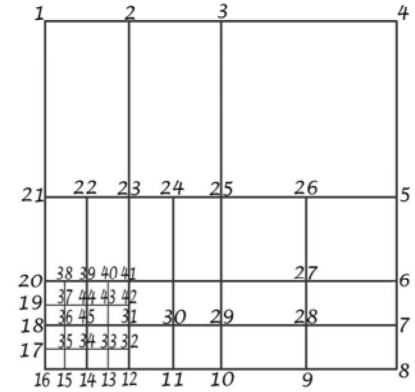
Source: Urban Morphology Institute



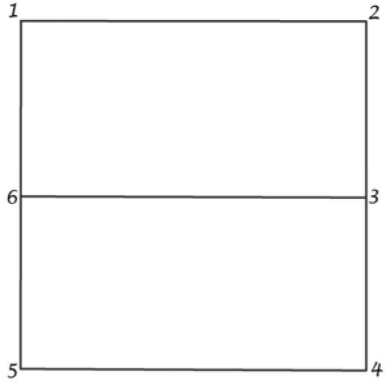






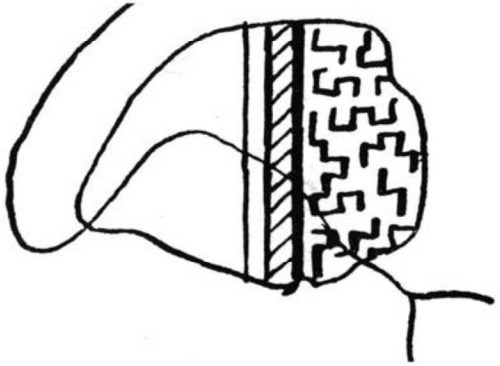


A) Schéma synthétisant le système des rues d'une ville actuelle.



B) Schéma proposant le tracé des rues espacées à 400 m. d'axe en axe.

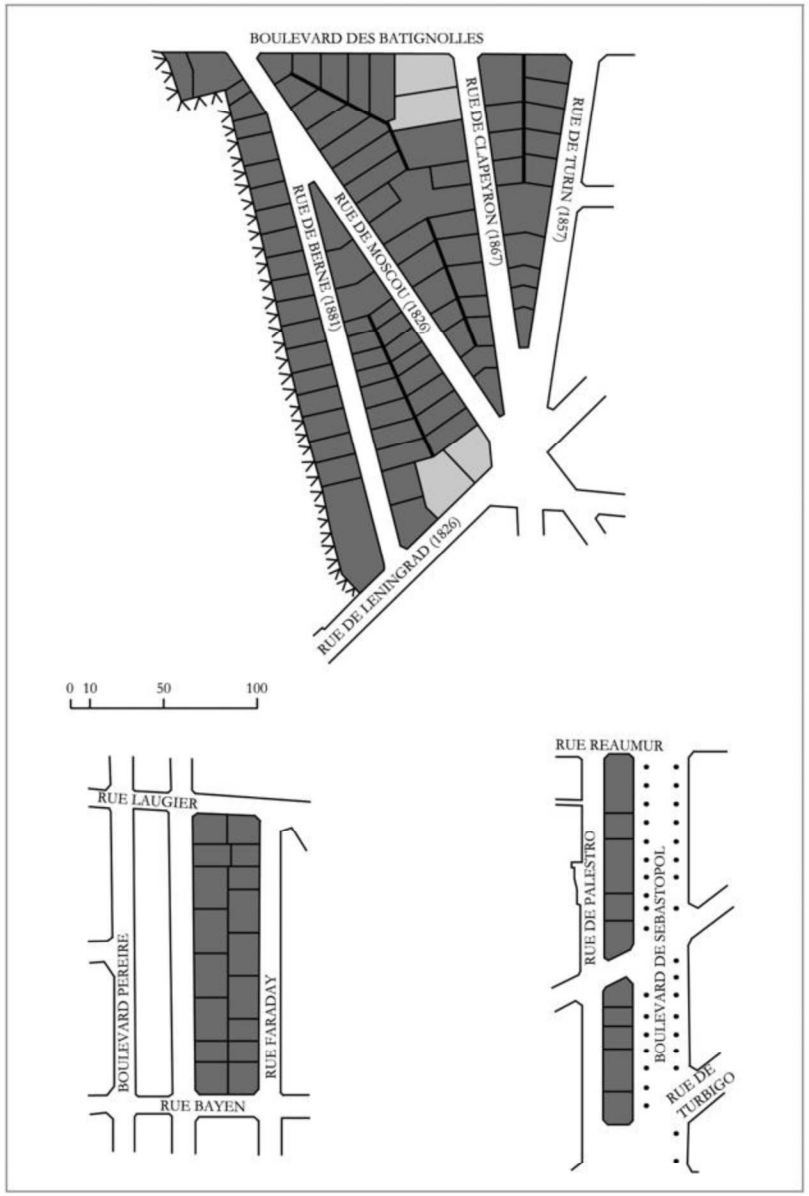
Le schéma A) accuse 46 croisements.
— B) — 6 —

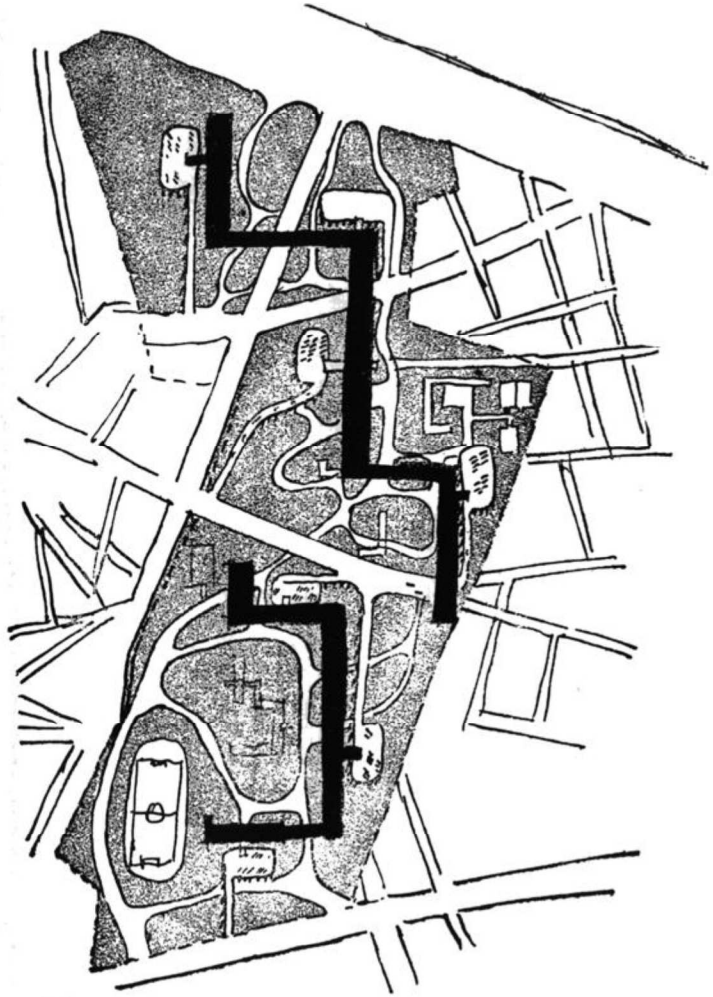


Le Corbusier's schematic drawings for eliminating all the subscales of the urban network in Paris

It ends up in an inverted power law pattern

Source: Serge Salat, *Cities and Forms and* Le Corbusier *Urbanisme*



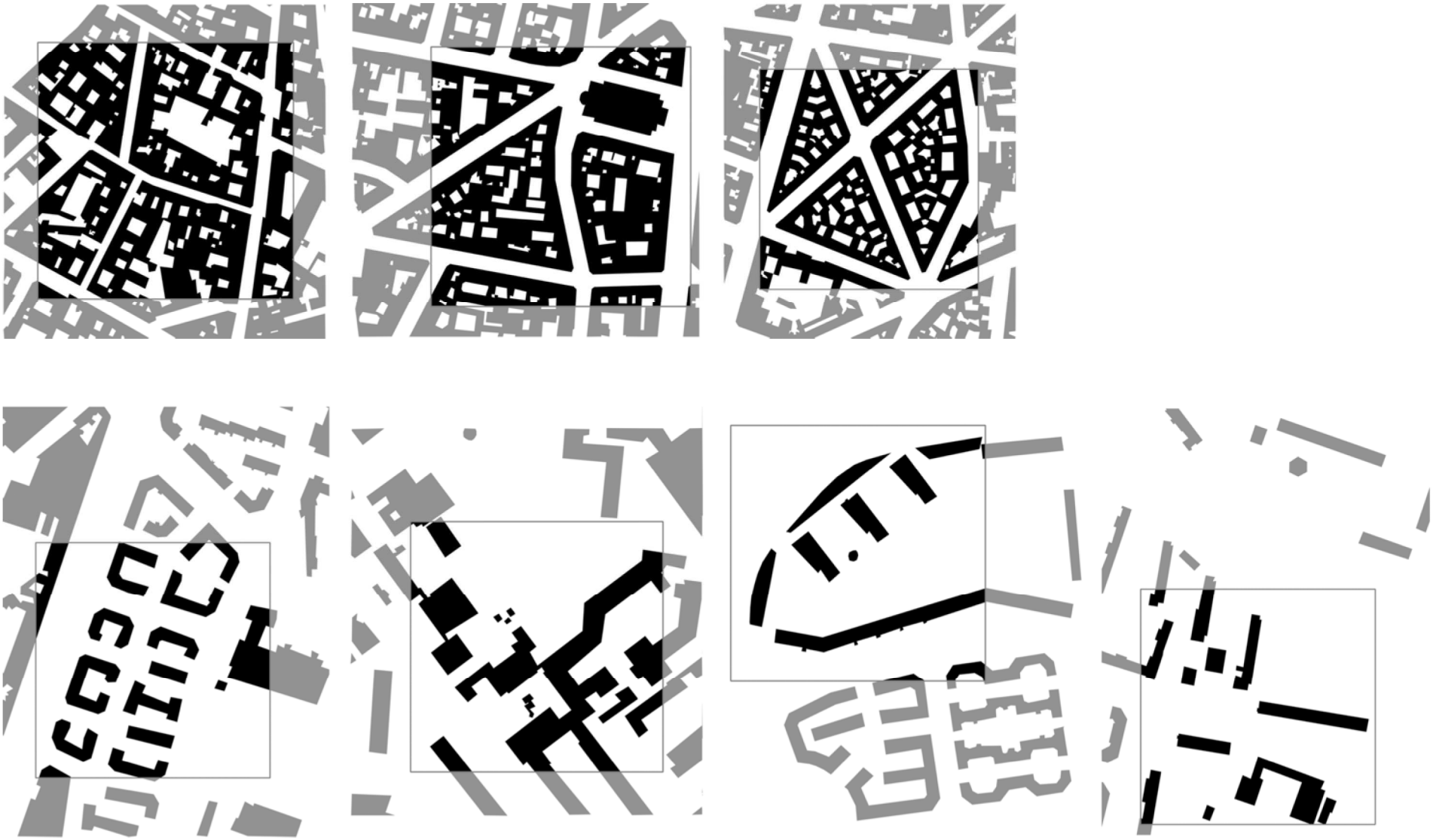


Le Corbusier's vision for Paris

The agony of the urban block and of the urban multifractal struture

« Il faut tuer la rue » (Le Corbusier)

Source: Serge Salat, *Cities and Forms* and Le Corbusier *Urbanisme*

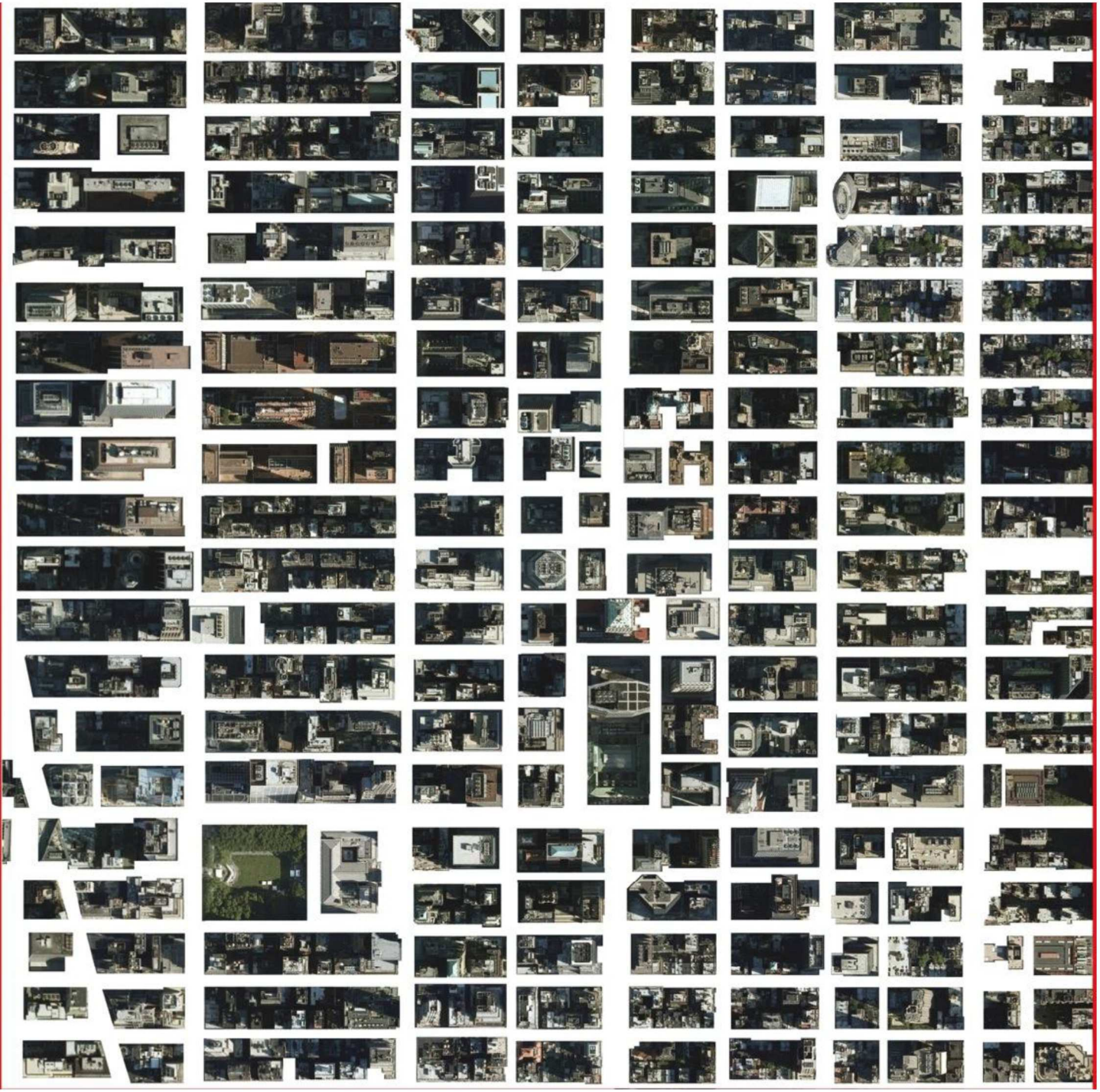


Le Corbusier's modernist vision implemented in Paris intra-muros
Top: urban blocks from 18th century to 19th century (each central square: 200 m side)
Bottom: 20th century, from early century HBM to 1960's near périphérique (each central square: 200 m side) Source: Serge Salat, *Cities and Forms*

New York

Fine grain urban microstructure consolidates overtime in a multifractal structure

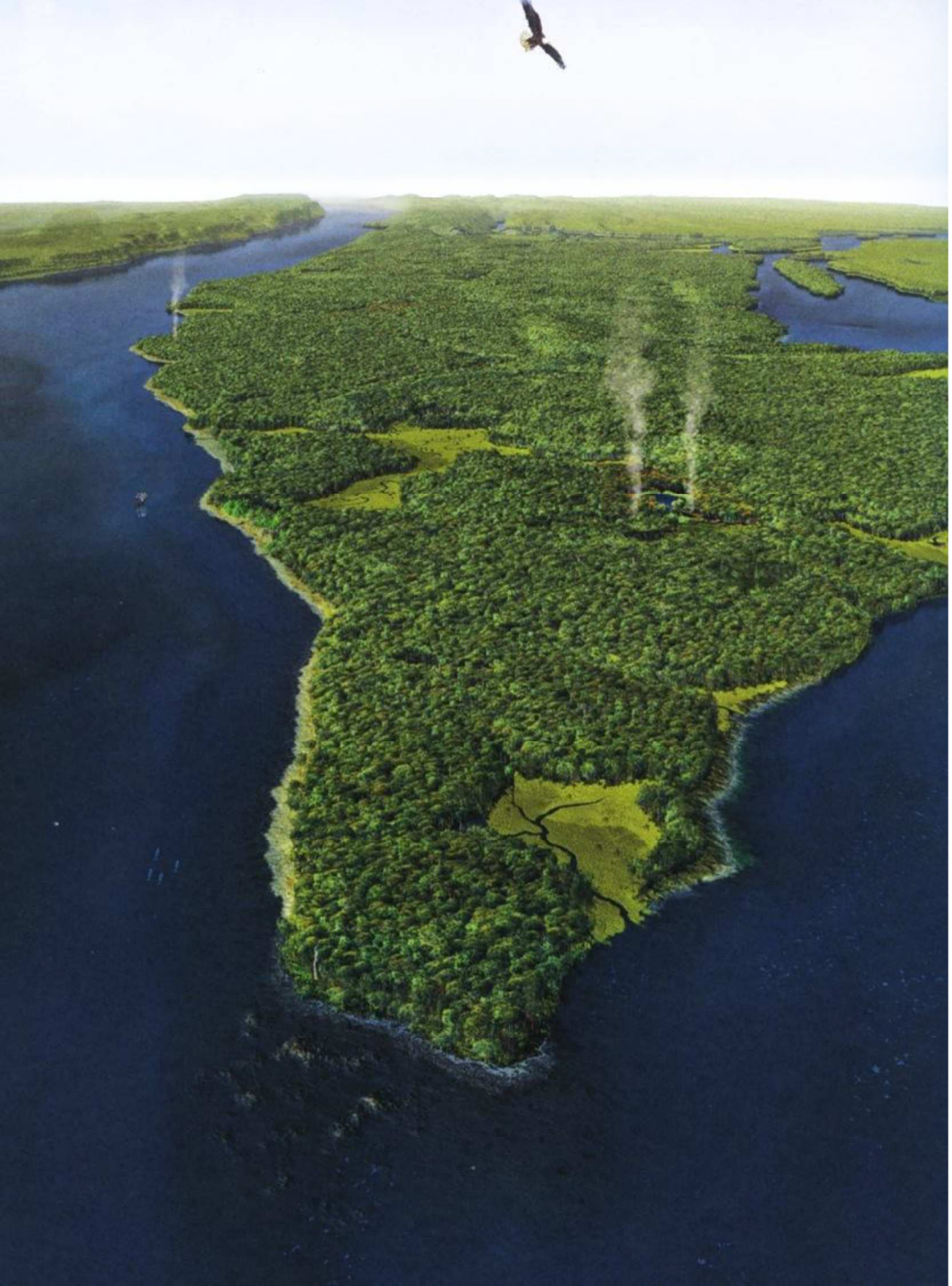
The demography, energy and economic urban landscape is extremely bumpy at all scales even within a regular Euclidean grid



1 square mile of Manhattan

A multifractal structure within an Euclidean grid, shaped by 200 years of market forces

Source: Serge Salat, *Cities and Forms*



Layer 4: The original landscape of Mannahatta when discovered by Hudson in 1609

Mannahatta (« The Island with many hills ») had more ecological communities per acre than Yellowstone, more native plant species than Yosemite, and more birds than the Great Smoky Mountains National Park.

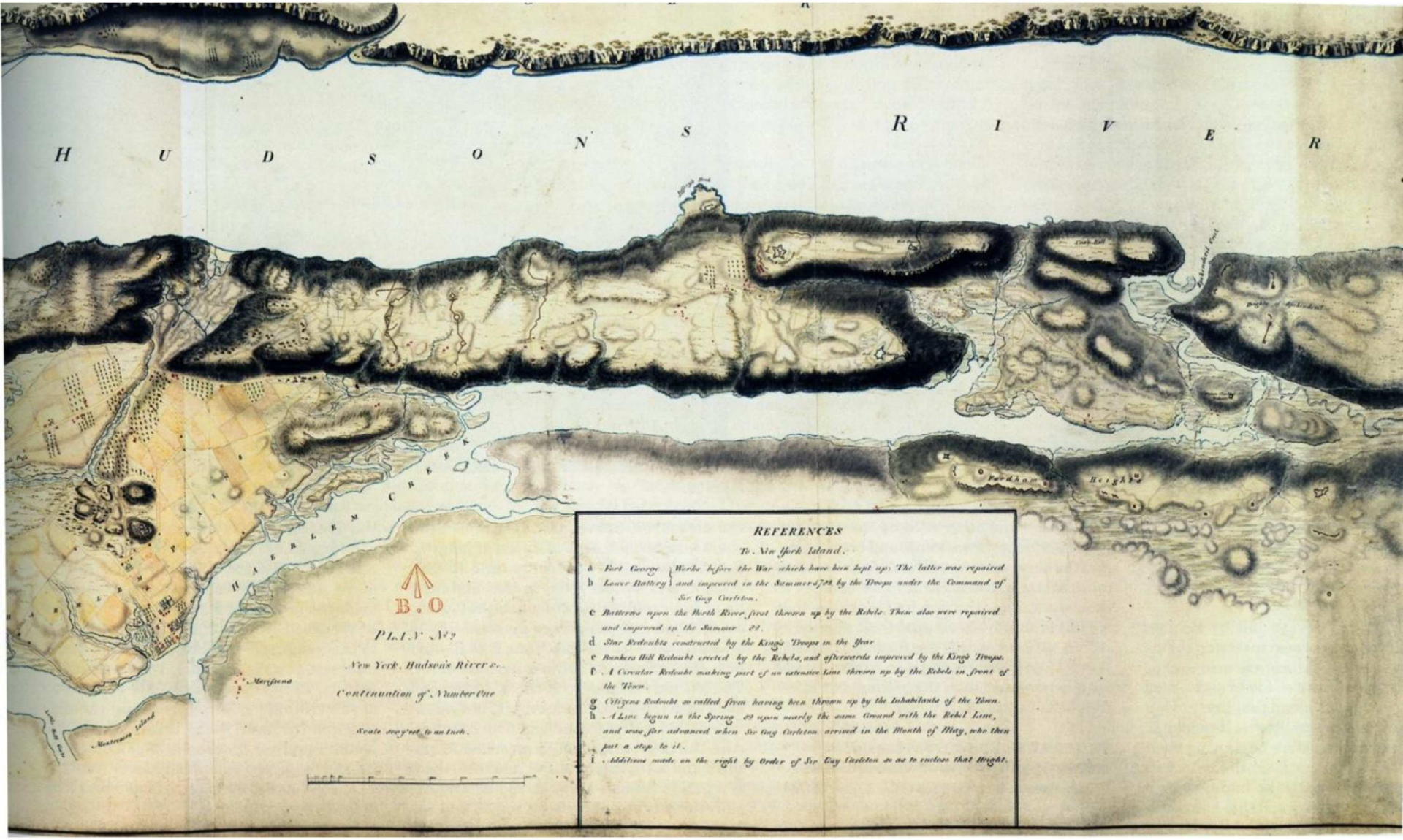
Extreme ecological diversity has been replaced by extreme human diversity.

Source: Eric W. Sanderson, Mannahatta

The British Headquarters map 1776

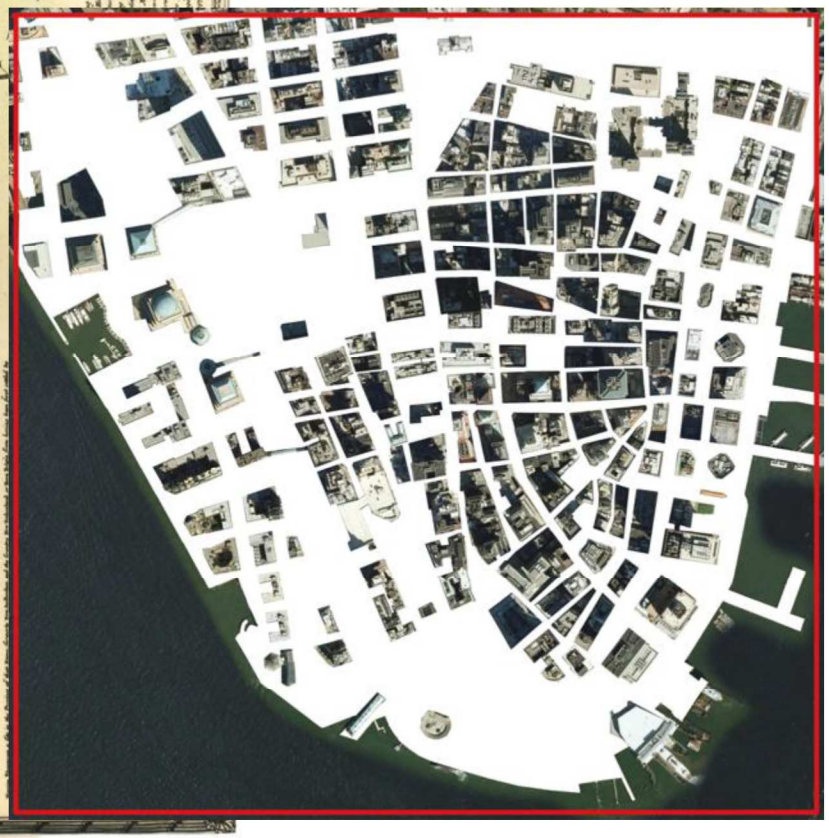
Towards the end of the American Revolution, this British map reveals the fundamentals of Manhattan, almost unchanged since 2 centuries ago, except a town of 32, 000 inhabitants at the bottom of the island (originally New Amsterdam, with its crooked and bent streets, which would eventually become the richest financial district in the world).

North of Manhattan, the low marshlands of Harlem



The resilience of street patterns
1 square mile of Lower Manhattan in 1776 and now

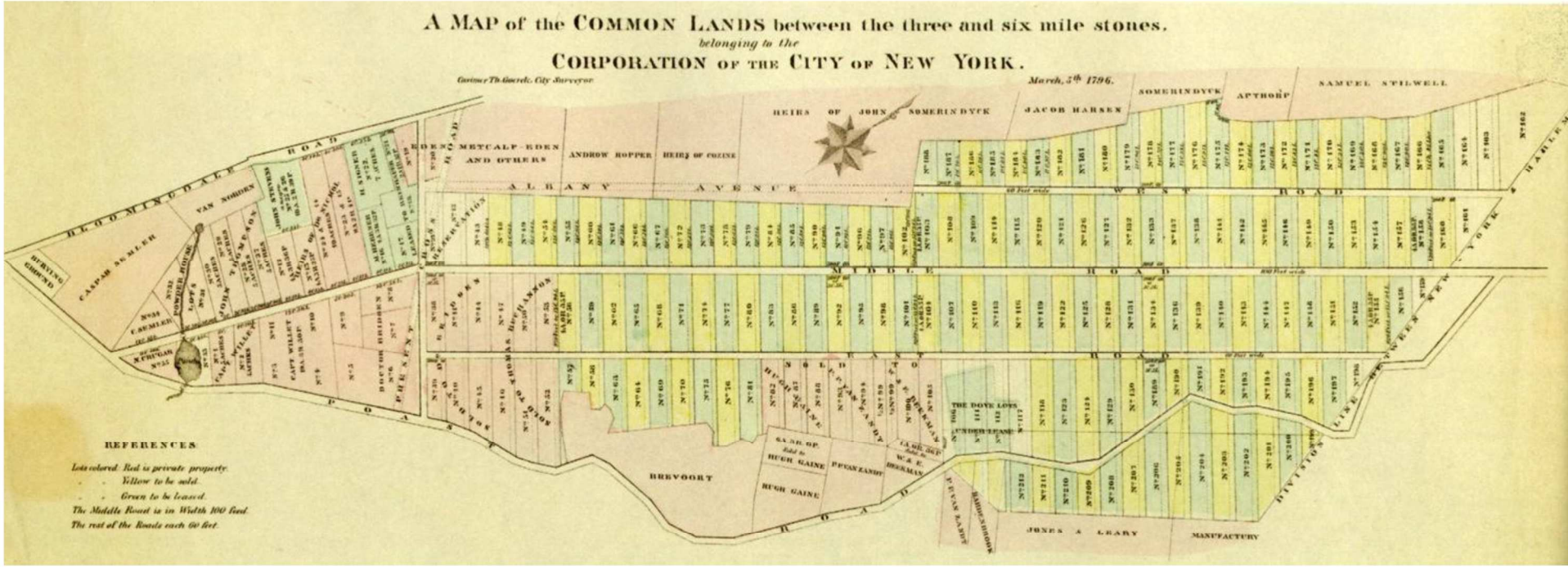
Source: Serge Salat, *Cities and Forms*



The Goerck plan of the Common lands 1796

The Common lands were vacant land first granted by Dutch provincial authority to the government of New Amsterdam in 1658. After the American Revolution, the new and cash-strapped American city government looked to profit from its underperforming domain (about 2 square miles of rocky, hilly undesirable land in the middle of the island.

To facilitate sale of the Common lands, Goerk prepared a subdivision plan with 3 long parallel streets, which would become 4th, 5th and 6th avenues, with an east-west length of blocks identical to the one in Goerck's plan. This plan started the rise of NY real estate market and ascent of land values.

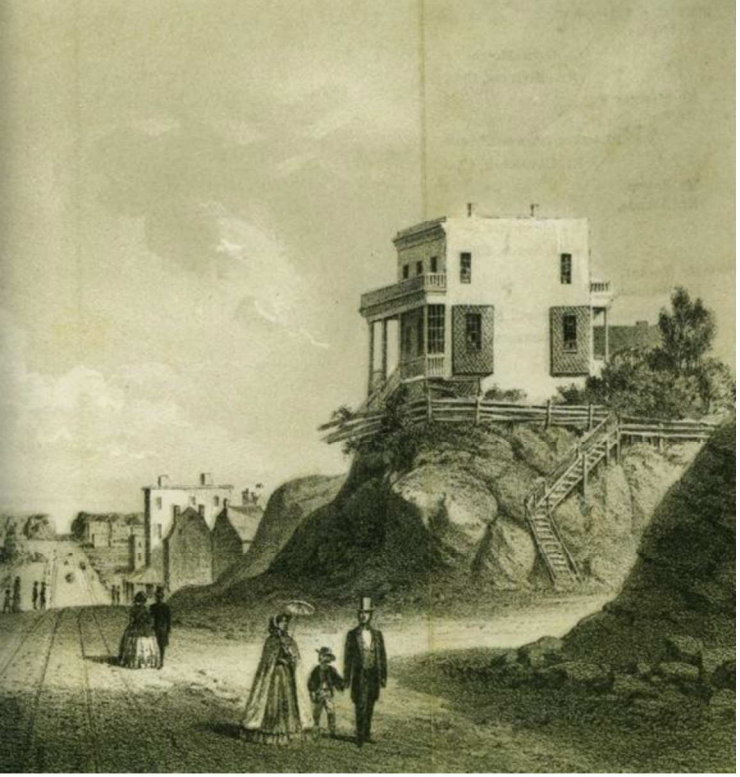


The Commissioners' map of 1807 overlays a seemingly uniform grid of rectangles over the rugged island.

In reality the grid contains **2 patterns** that create variety.

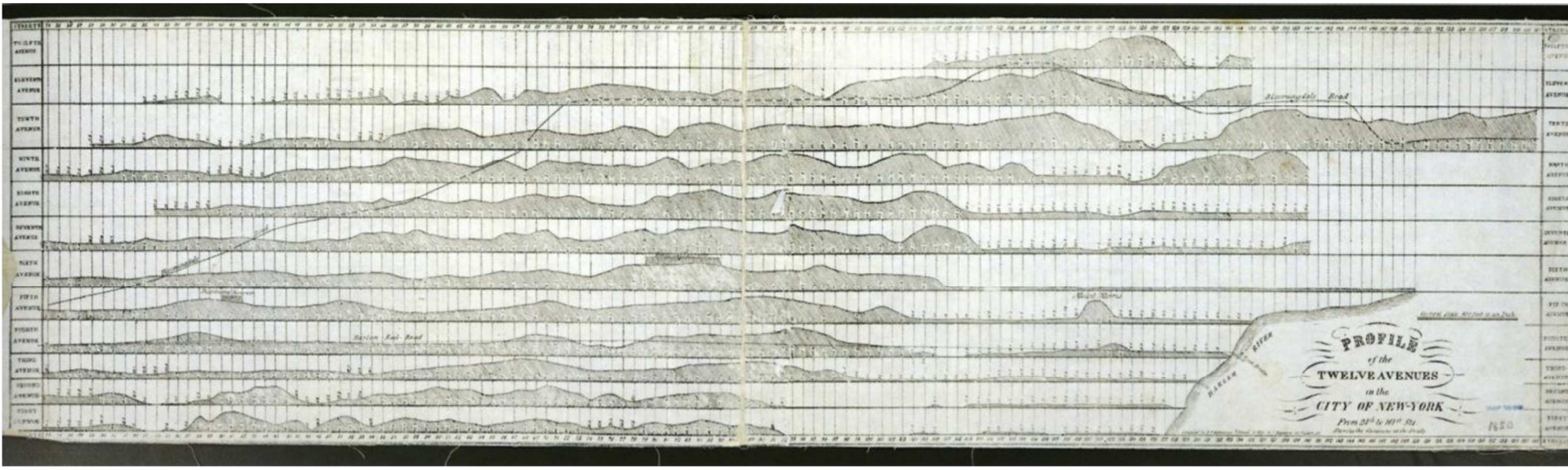
- One pattern is formed by the street widths (100 feet for the avenues, 60 feet for standard cross streets, with 15 major cross streets 100 feet at irregular intervals.
- The second pattern derives from block dimensions. All blocks are 200 feet wide north to south, but their length east to west varies diminishing from the center to the shorelines. From Third to Sixth avenue blocks are 920 feet long. Moving eastward they shrink 620, 650, 640 feet long. Moving westward, they shrink uniformly to 800 feet long

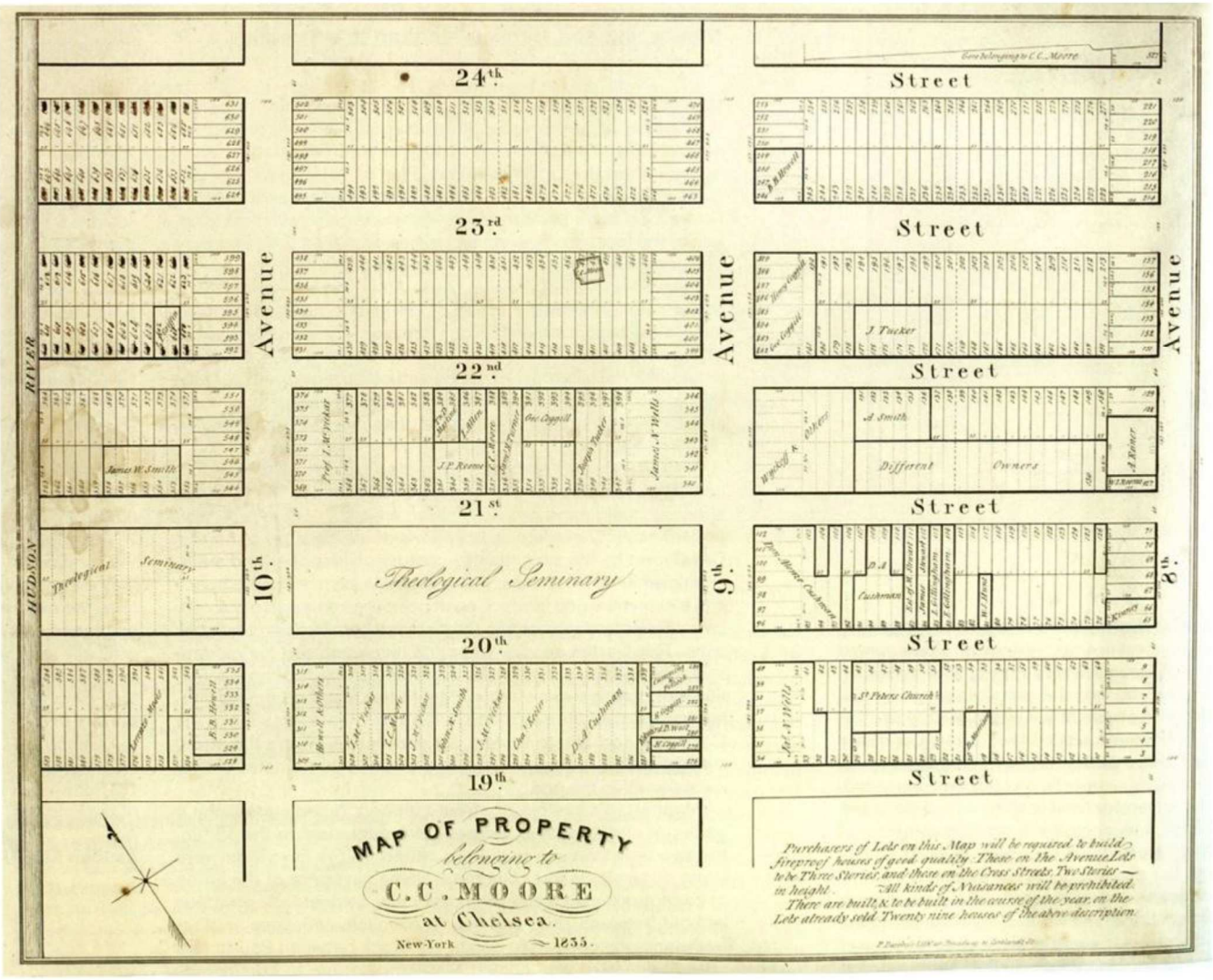
Elgin Garden
Kip's Bay
Bellevue
P A R A D E
Powder House
M A R K E T   P L A C E
Sailors snug harbor
Second Avenue
First Avenue
Brown's Wharf
Townsend
Clinton
Stuyvesant
Bond St
Jones St



Below, Profile of the 12 avenues in 1850. Although the historical elevations along these profiles have been flattened to make way for the grid (see left house in the air in a print of 1861) the difference today is not as dramatic as one might suppose. The elevation profiles of Manhattan's avenues today show a remarkably similar parttern to that depicted in Hayward's map in mid 19th century.

Source: Hilary Ballon, *The Greatest Grid*



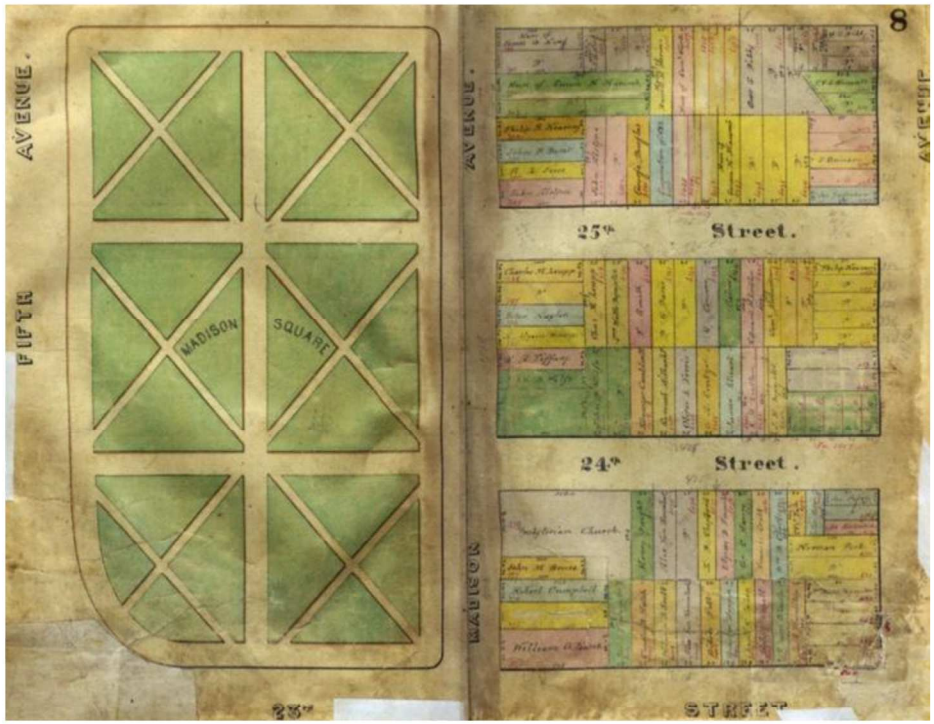


From the property of Clement Clarke Moore to Chelsea neighborhood

Free market is a formidable time accelerator for differentiation and emergence of scale free structures. A early as 1835, this map illustrates the strategies of sellers of vast estates. Moore developed his estate into Chelsea village centered around Chelsea Square he had donated to the episcopal church in 1819. Note the early differentiation of lots

X 35

In 1820 Moore had evaluated his estate at $ 17,000. His wealth was estimated at $ 350,000 in 1845 and $ 600,000 in 1855.



Assessment map of Madison square
1853 - 1879

Differentiation and asymmetry in land prices occurred very quickly in the seemingly uniform Manhattan grid

In 1860, real estate along Fourth Avenue in the section depicted ranged from $ 3,500 to $ 8,000, while lots along Madison avenue were valued between $ 18,000 and 55,000.

X 8 population increase in 50 years

X 80 real estate value in 80 years

Between 1790 and 1810, Manhattan population tripled to 96,000 inhabitants. The Commissioner's plan envisioned a scenario reaching 155th Street with 400,000 in 1860. In 1810, Peking and London each had over one million residents and Paris half million. In 1860, NY population was actually 813,000, doubling the projection.

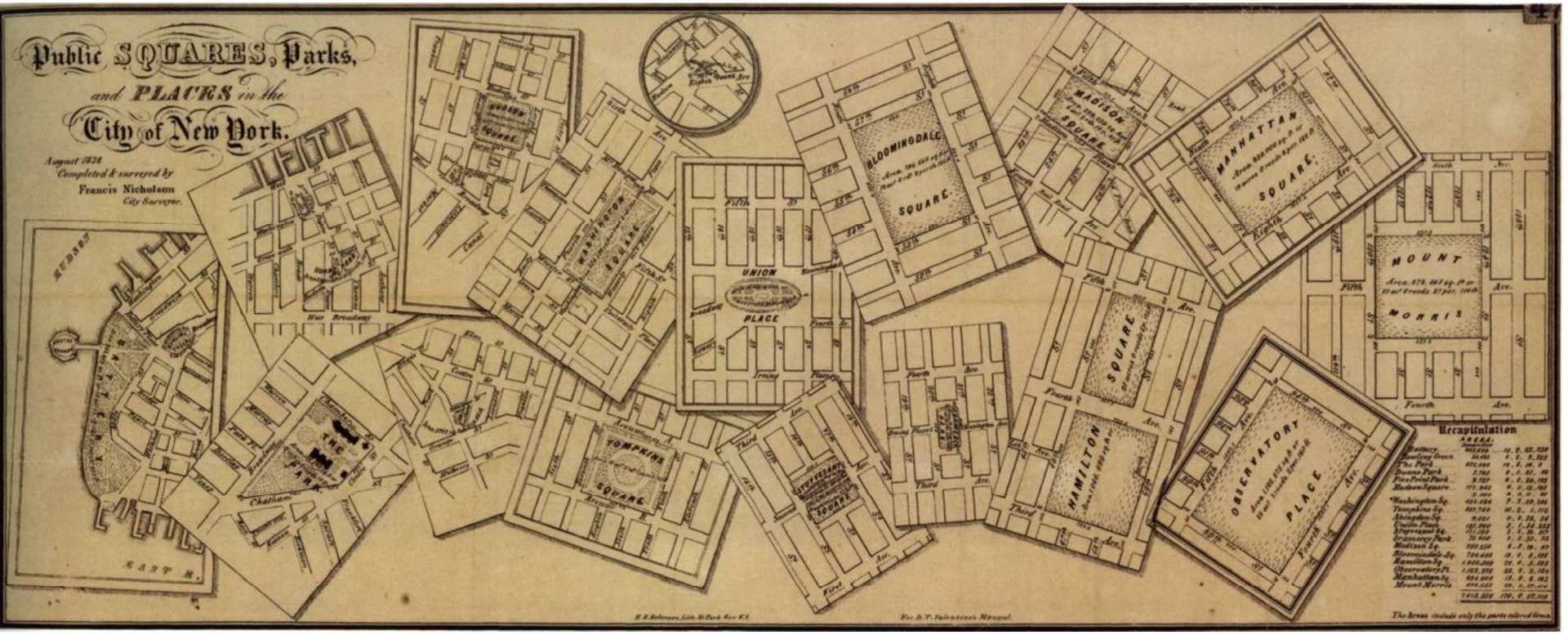
The Grid was above all an easy format for the subdivision and development of land. The grid system stripped the land of topographical markers and specificity, and repackaged it as standardized building lots. The grid re-conceptualized the island in a real estate market. And it worked beyond all expectations. In 1807, the assessed value of New York City real estate was $ 25 million. In 1887 it was $2 billion, a 80-fold increase.

NewYork, The Bridges Map 1811

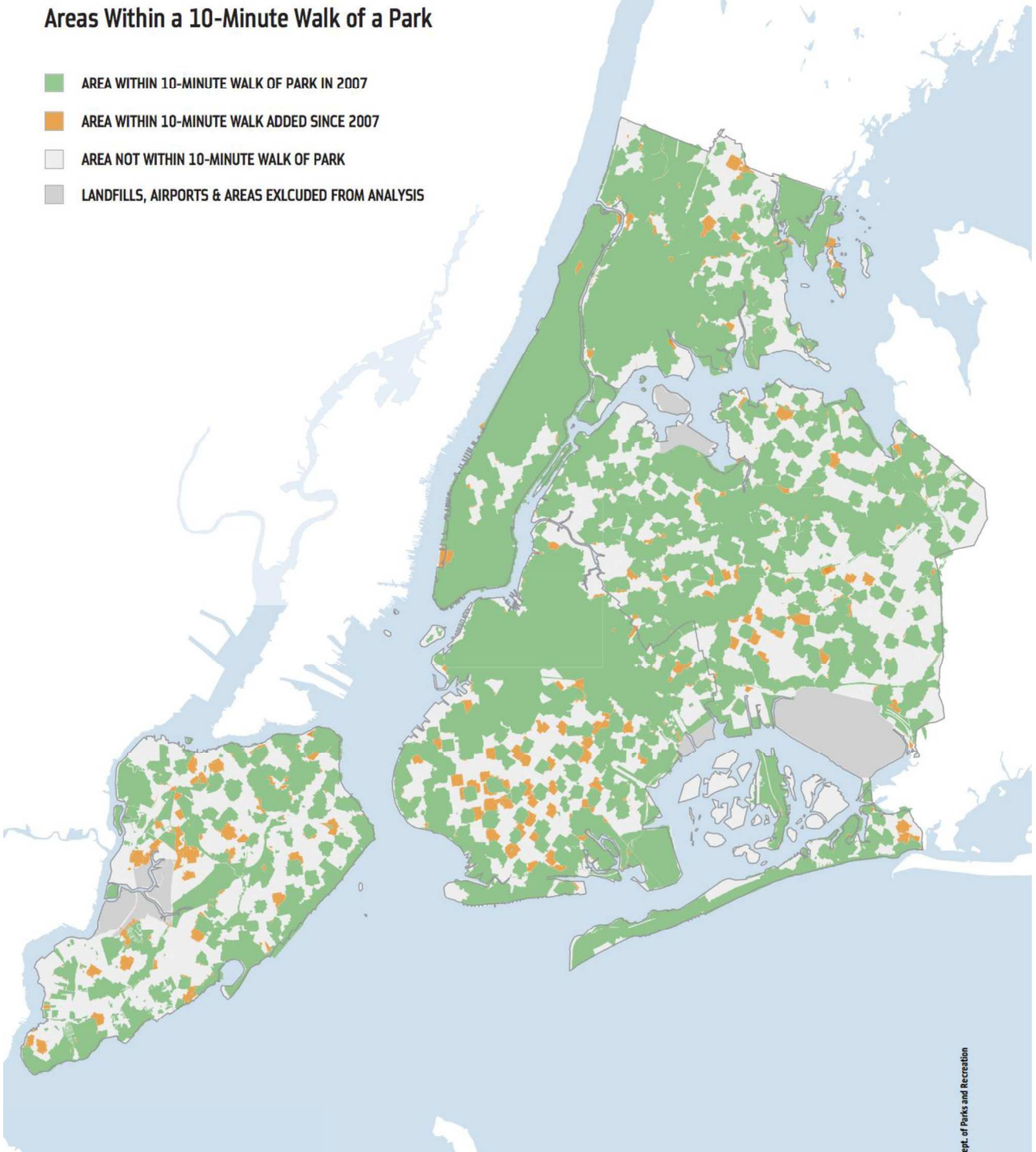
In this pictorial copy of the Commissioners' map of 1811, note the large gardens and the Parade that have been replaced quickly by a policy of more numerous smaller gardens in order to increase land value.

New York Manhattan Collage of public parks 1838

Instead of a few large parks as envisioned in the Commissioners' plan, the city's growing reliance on real estate taxes motivated officials to improve property values by opening parks as a means to collect more money for the municipality.
In 1830, property tax revenue amounted to roughly $200,000, but 7 years later, they totaled $ 1.1 million.

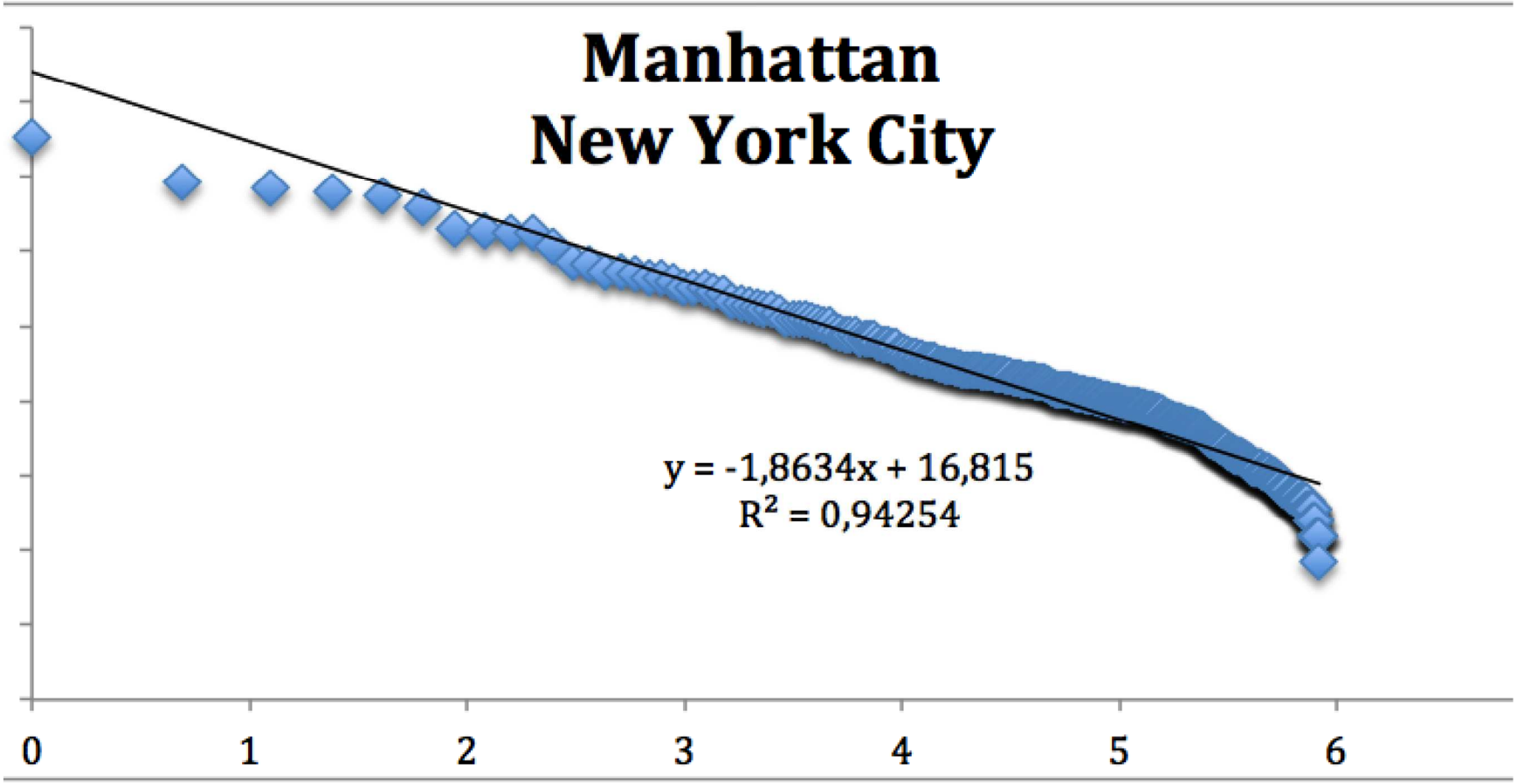


As a result of early 19th century real estate speculation, Manhattan island accessibility to public parks is optimal today



Source: PlaNYC

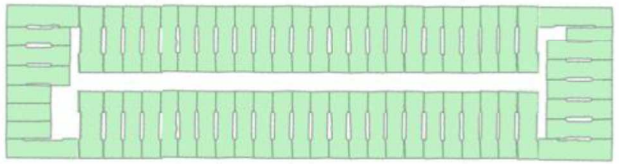
The sizes of Public parks in Manhattan follow an inverse power law with a hierarchy exponent higher than in Paris



Source: Urban Morphology Institute

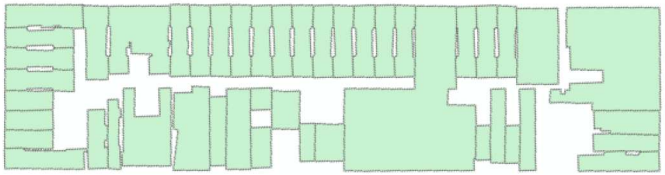
Scaling laws in platting are the result of evolution when the city is shaped by market forces
The scaling coefficient reflects morphological periods

Manhattan
Original plot subdivision in 1811
Average plot size: 205 m²



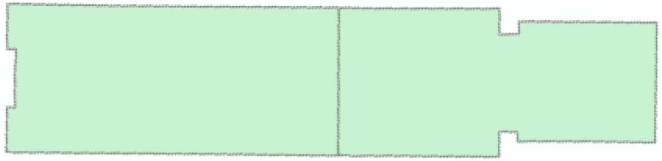
Residential

Manhattan
Intermediary plot consolidation
Average plot size: 255 m²



Mixed use

Manhattan
Extreme plot consolidation
Average plot size: 6,100 m²



Large businesses

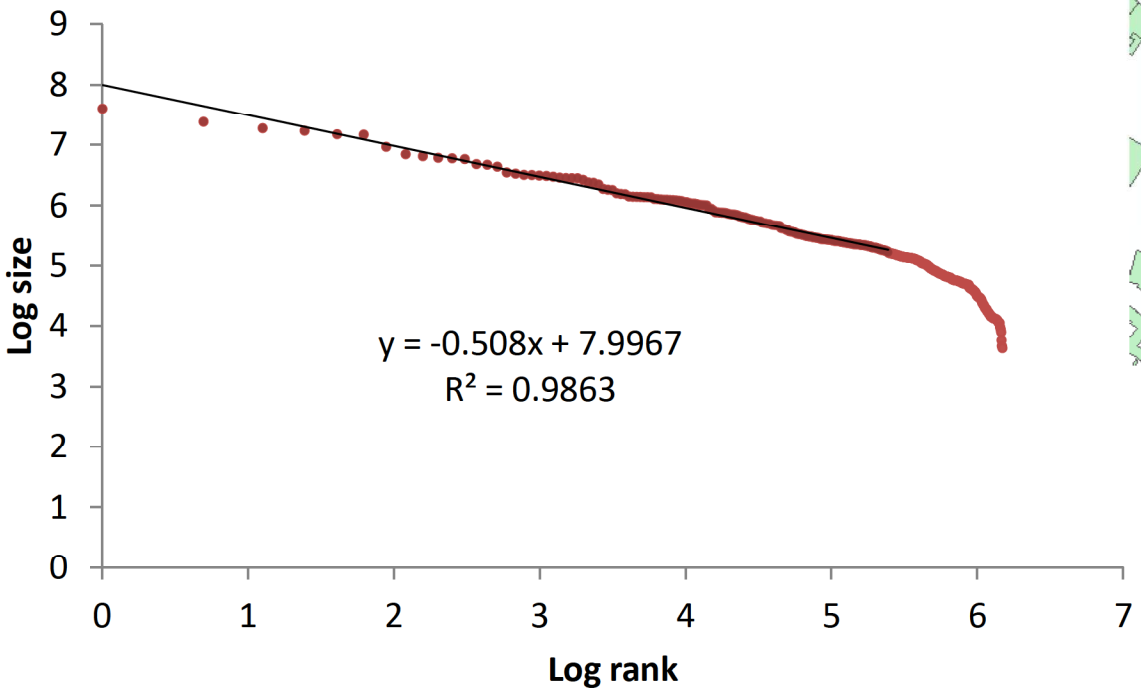
Manhattan original plot subdivision is identical to a 12th century French South West « bastide » (new town). The north-south width of blocks (60 m) is shorter than the Roman empire block size (70 m). Along Fifth Avenue Mahattan street rhythm is Medieval!

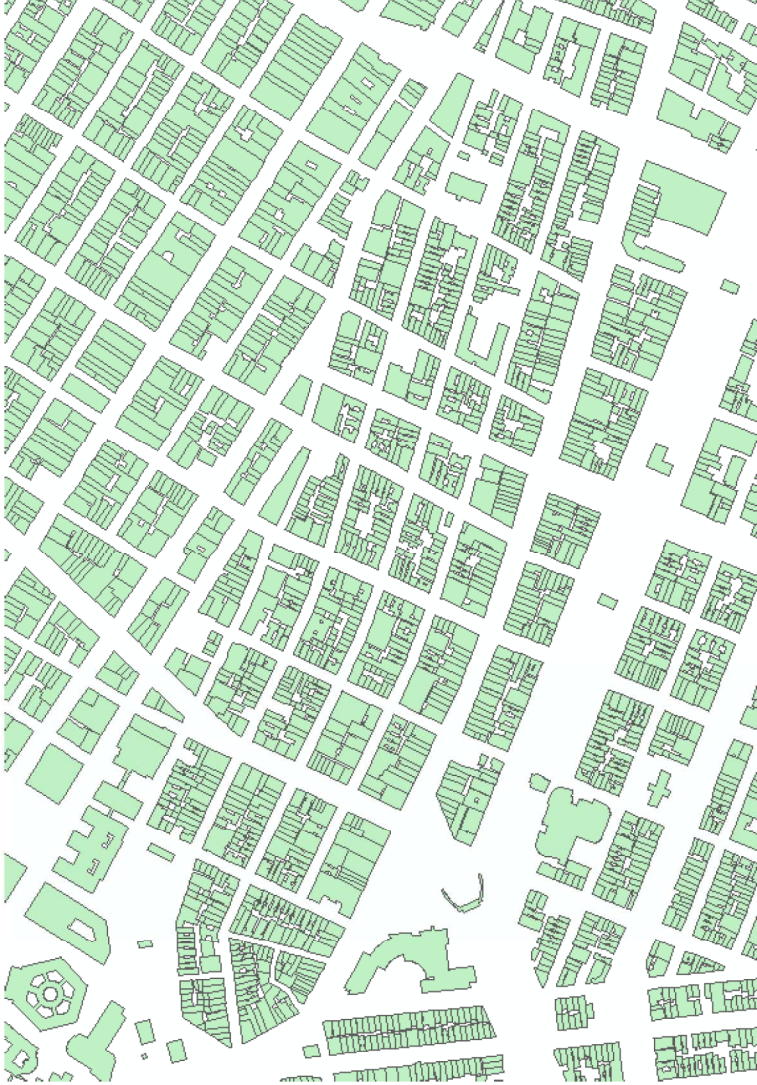
Source: Urban Morphology Institute

Highly adaptive platting follows a mathematical regularity characteristic of scale free complex systems: Frequency of sizes follows an inverse power law

Wall Street's plot area scaling coefficient is similar to Paris reflecting the European origin of this part of the city (New Amsterdam) and its longer evolution The largest plot is 2000 m2.

New York City
Wall Street

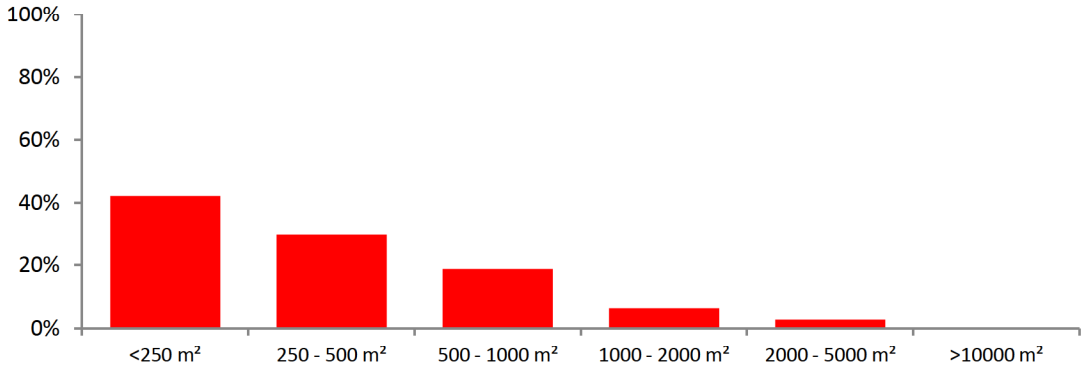




Source: Urban Morphology Institute

Manhattan
Madison square area

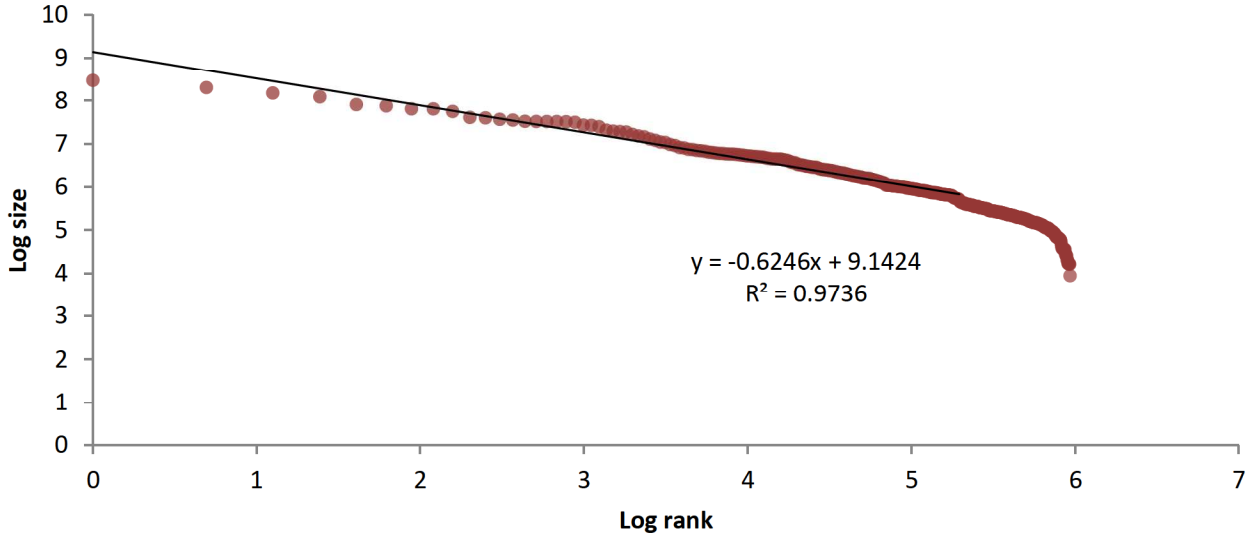
The largest plot is 4,700 m2 reflecting the change of scale in development compared to New Amsterdam.
Only 40% of the plots correspond to the original platting size



Source: Urban Morphology Institute

Madison Square area has a higher scaling coefficient than Paris or Wall Street.

Manhattan
Madison Square area

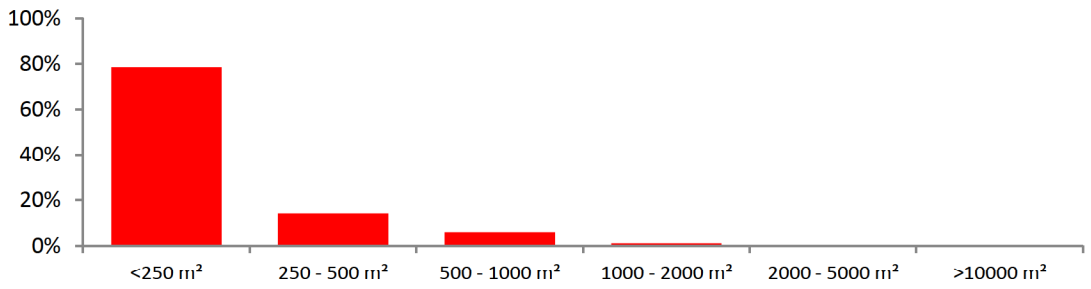


Source: Urban Morphology Institute

New York City
Brooklyn

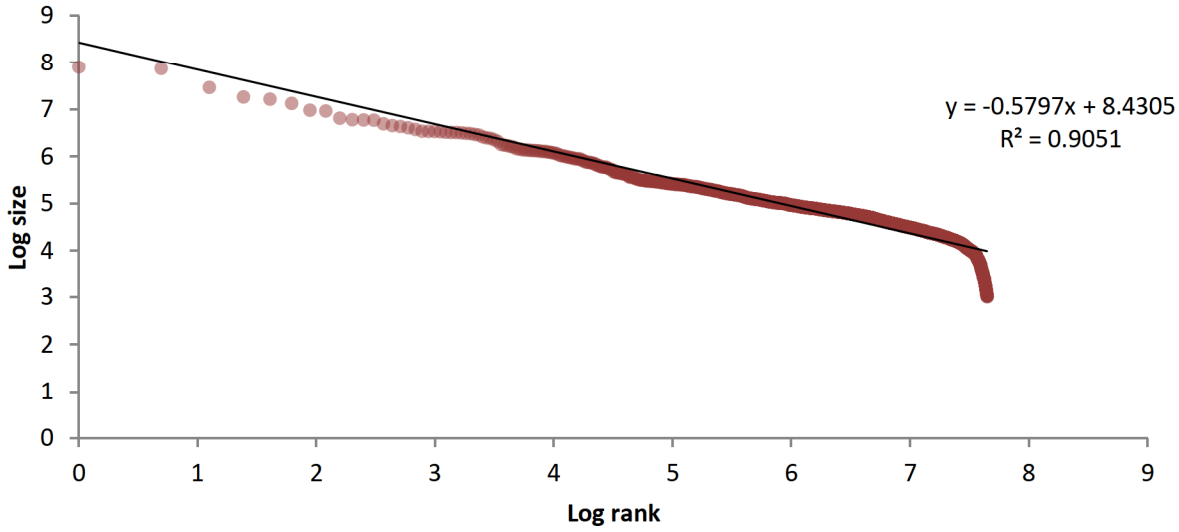
More residential Brooklyn shows more of the original platting (80% of the plots) with a scaling coefficient similar to Madison Square. New York signature ?

The largest plot is 2,700 m2



Source: Urban Morphology Institute

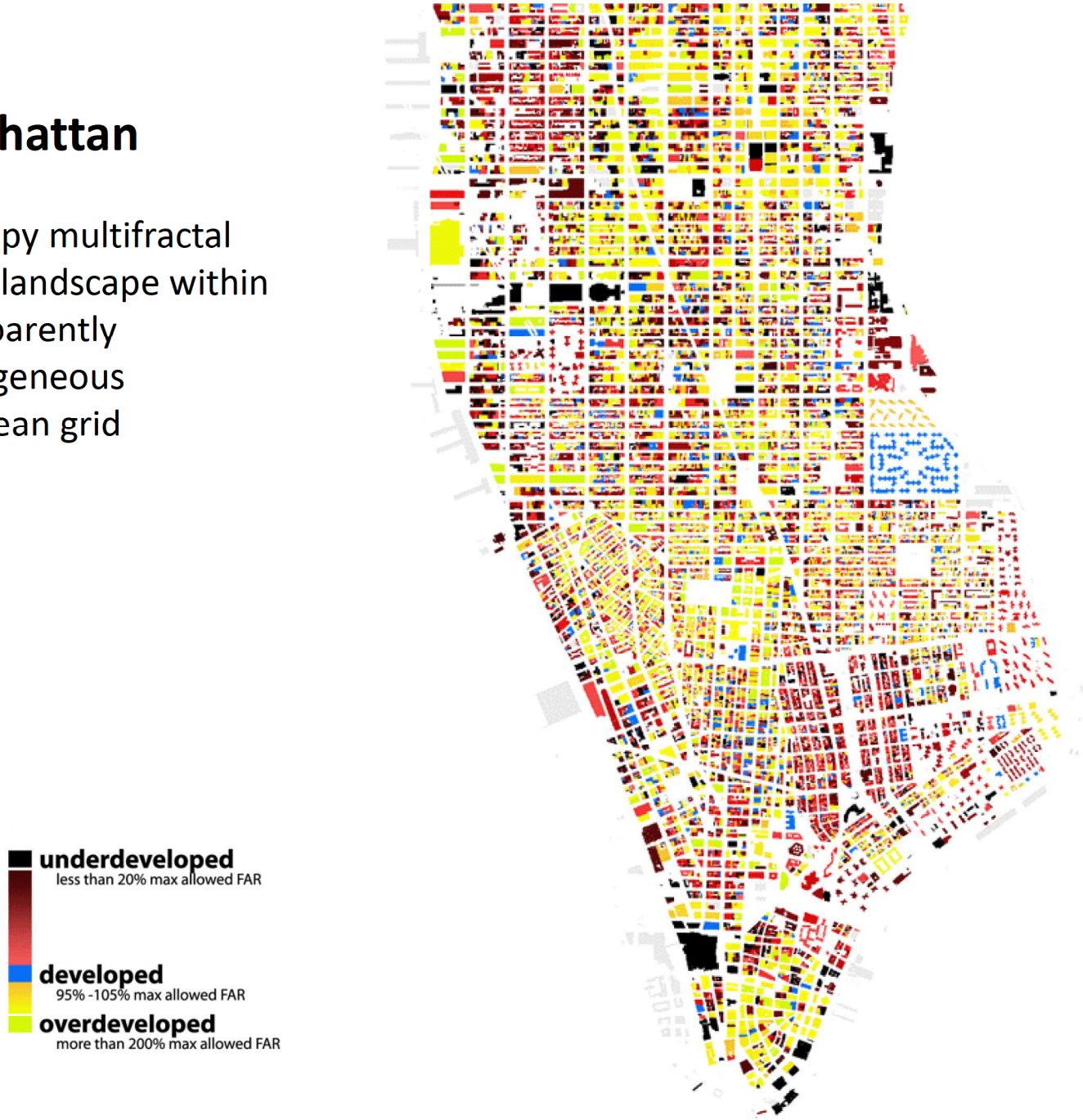
New York City
Brooklyn



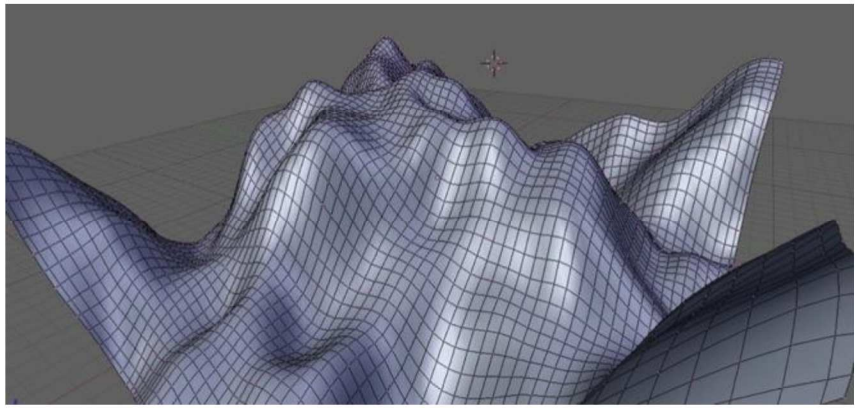
Source: Urban Morphology Institute

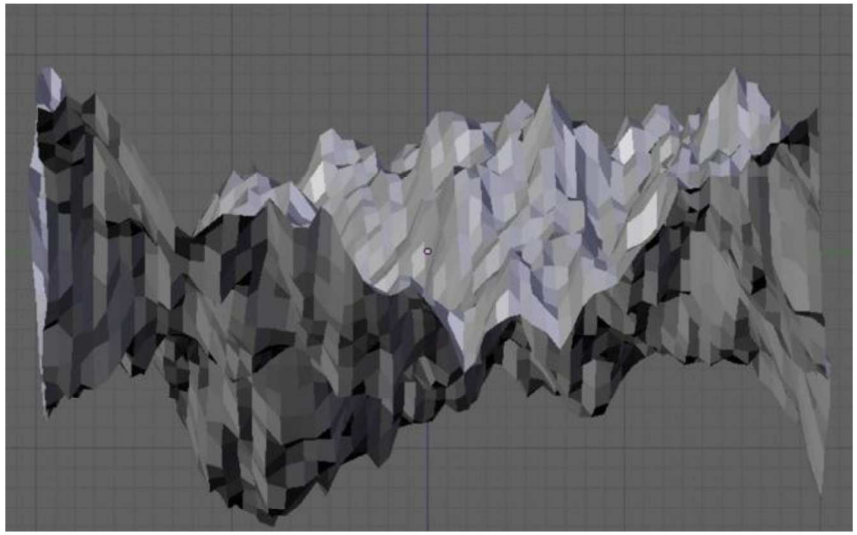
Manhattan

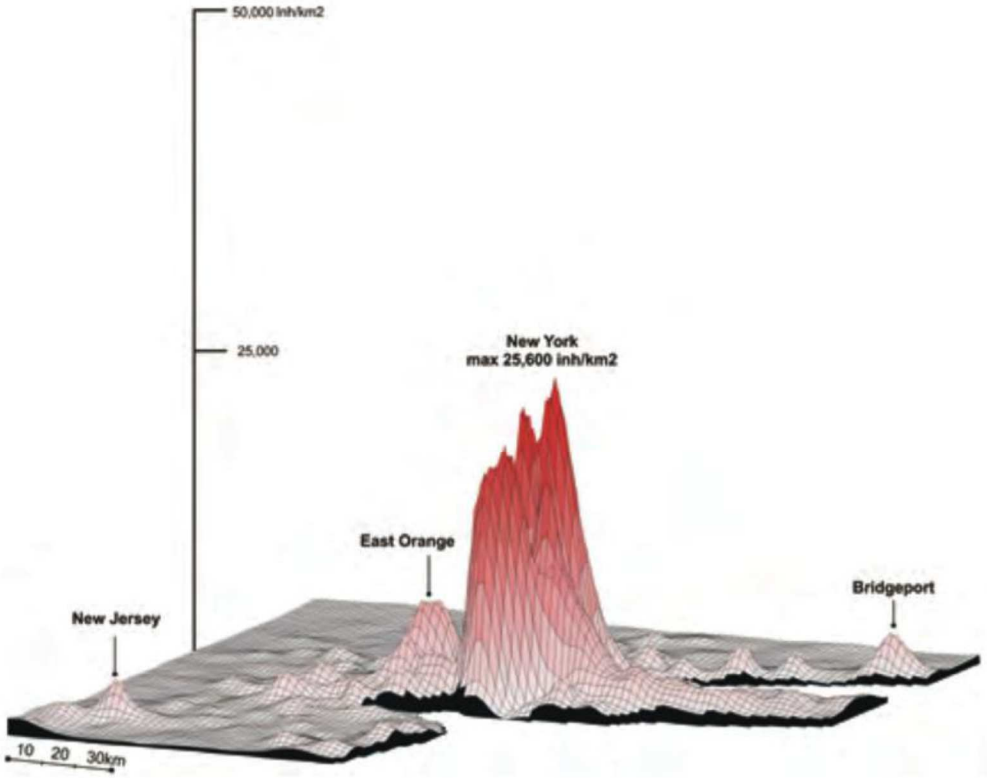
A bumpy multifractal urban landscape within an apparently homogeneous Euclidean grid



Evolution has produced in New York a multifractal urban landscape with a high level of hierarchy







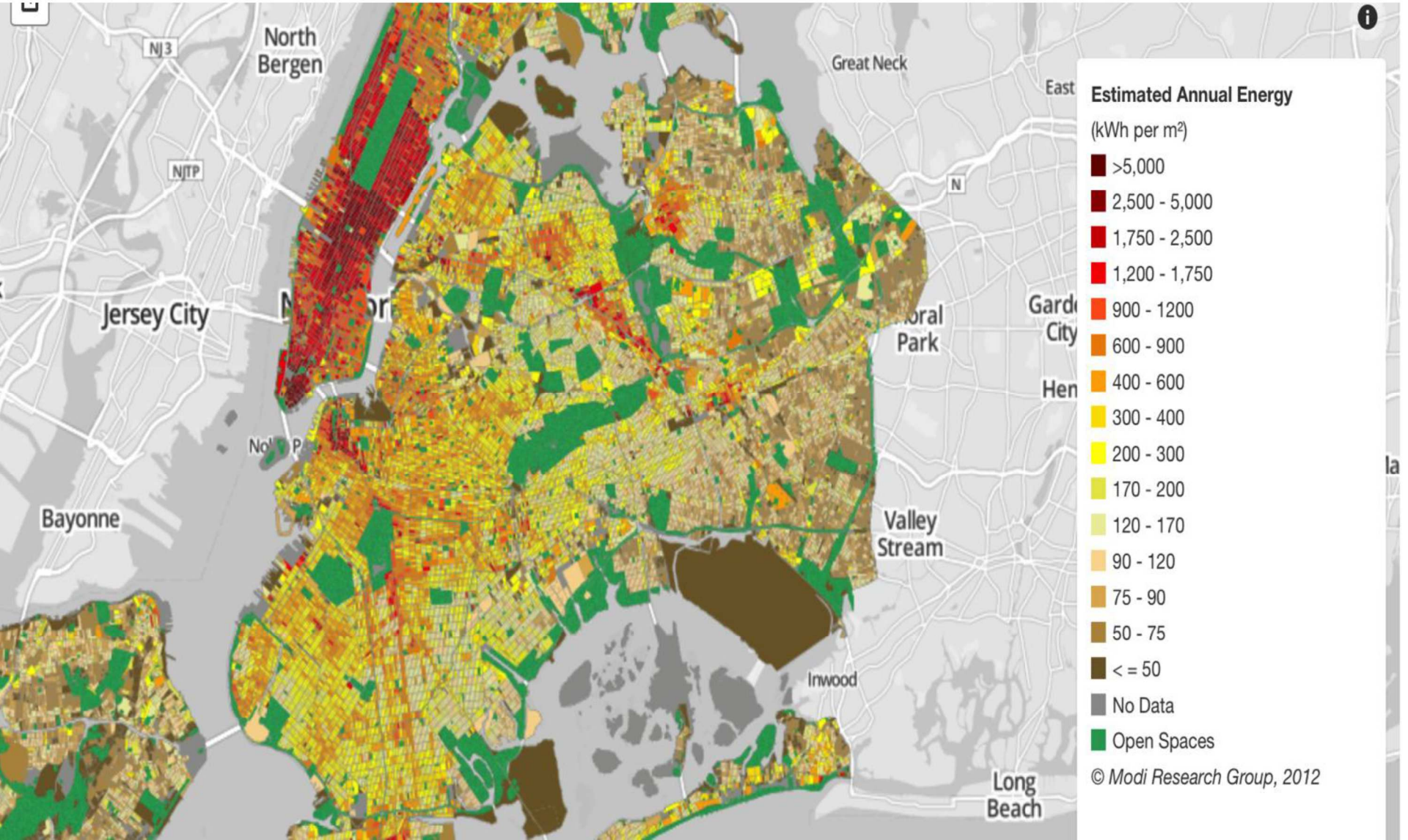
Residential density in New York

Source: The World Bank

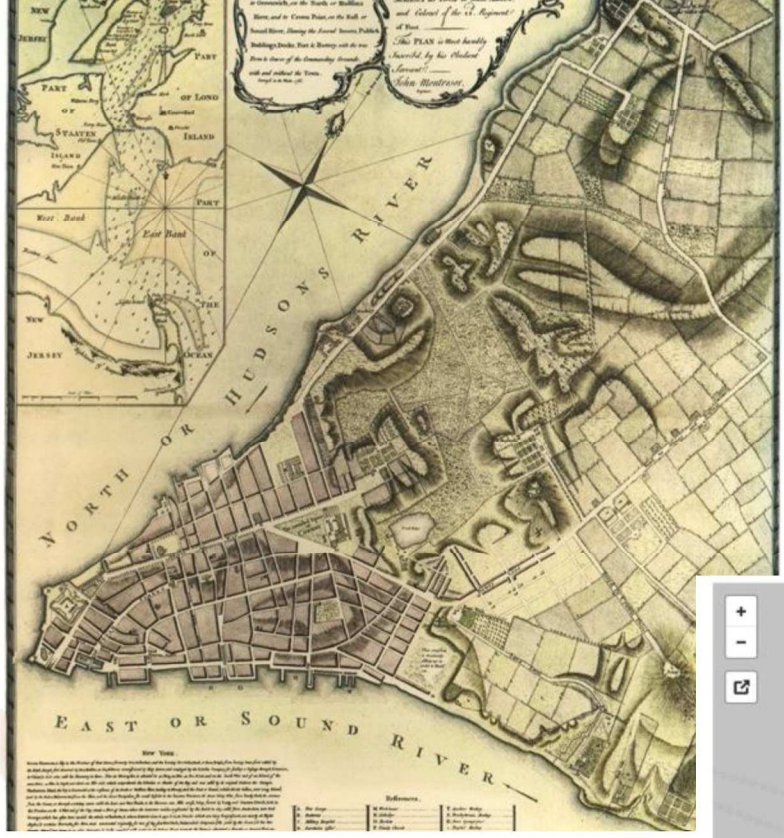
In a "ville pêle-mêle" like New York, the energy density at the tax lot level (in kWh/m²) varies more than 100-fold.

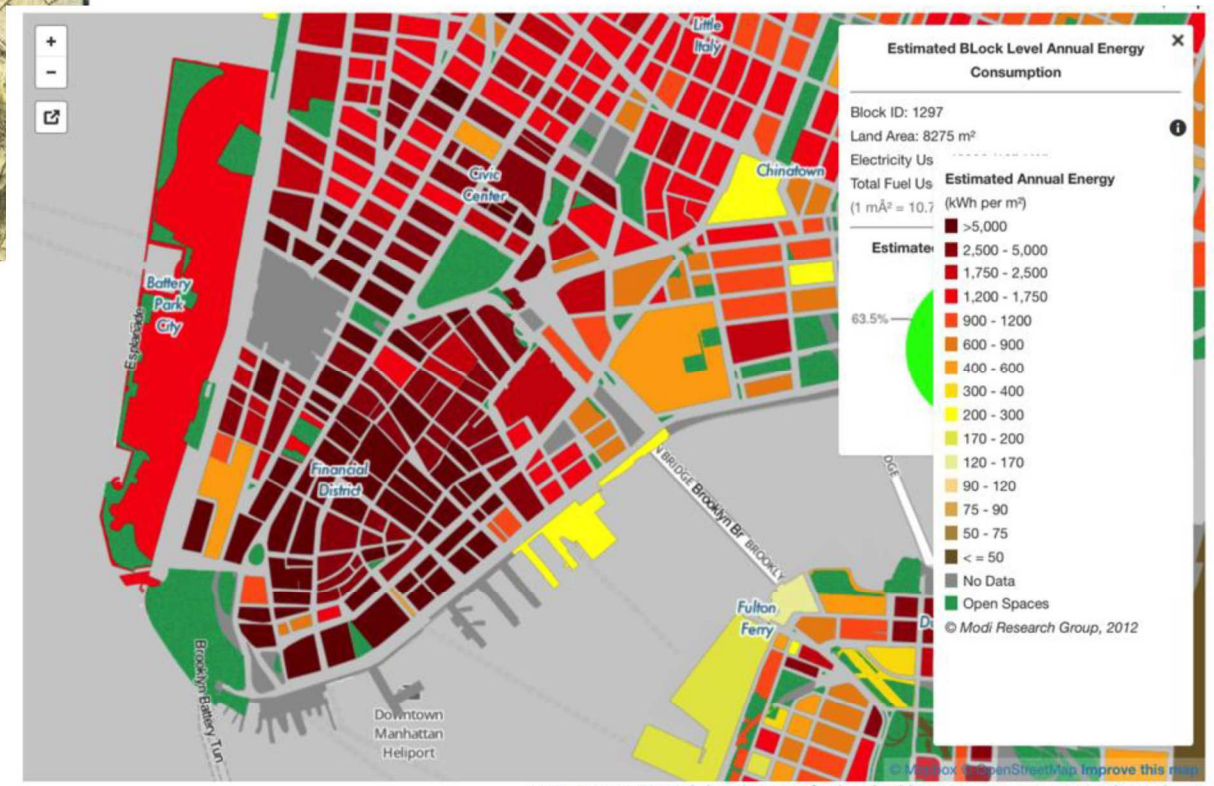
This map and the following

Data Source: [Spatial distribution of urban building energy consumption by end use B. Howard, L. Parshall, J. Thompson, S. Hammer, J. Dickinson, V. Modi]



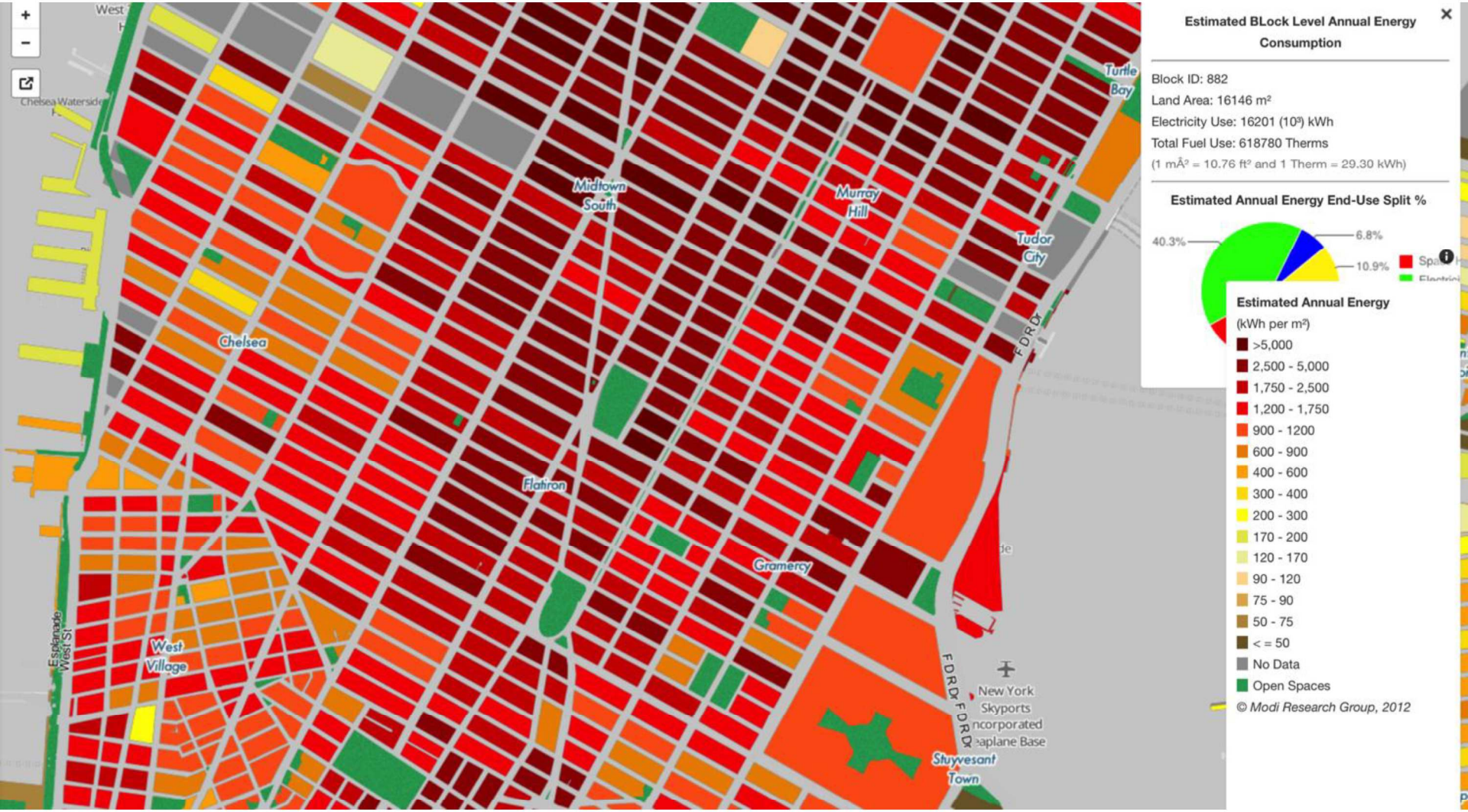
From New Amsterdam to Manhattan Financial district

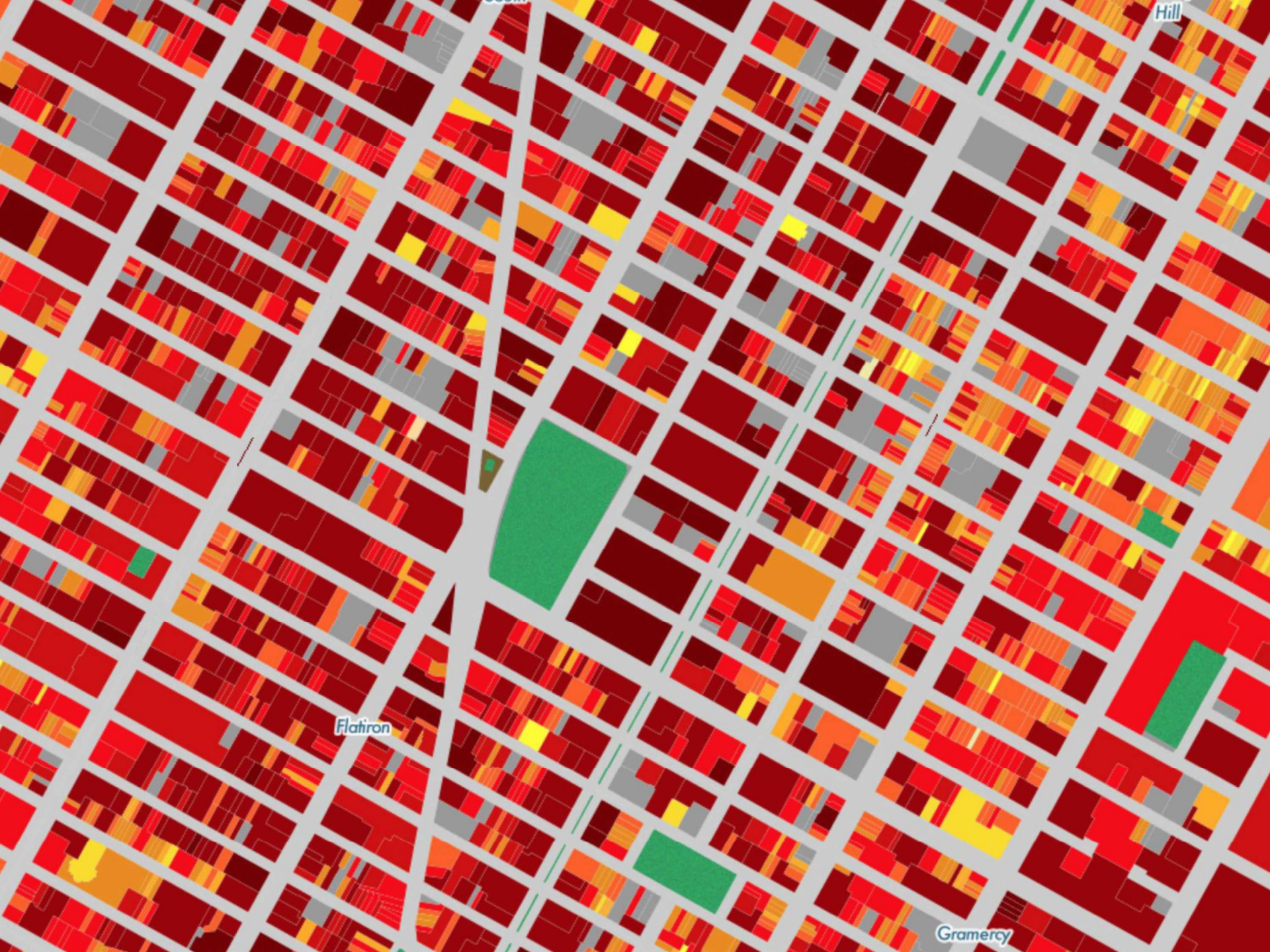




Data Source: Spatial distribution of urban building energy consumption by end use
B. Howard, L. Parshall, J. Thompson, S. Hammer, J. Dickinson, V. Modi

Around Madison square



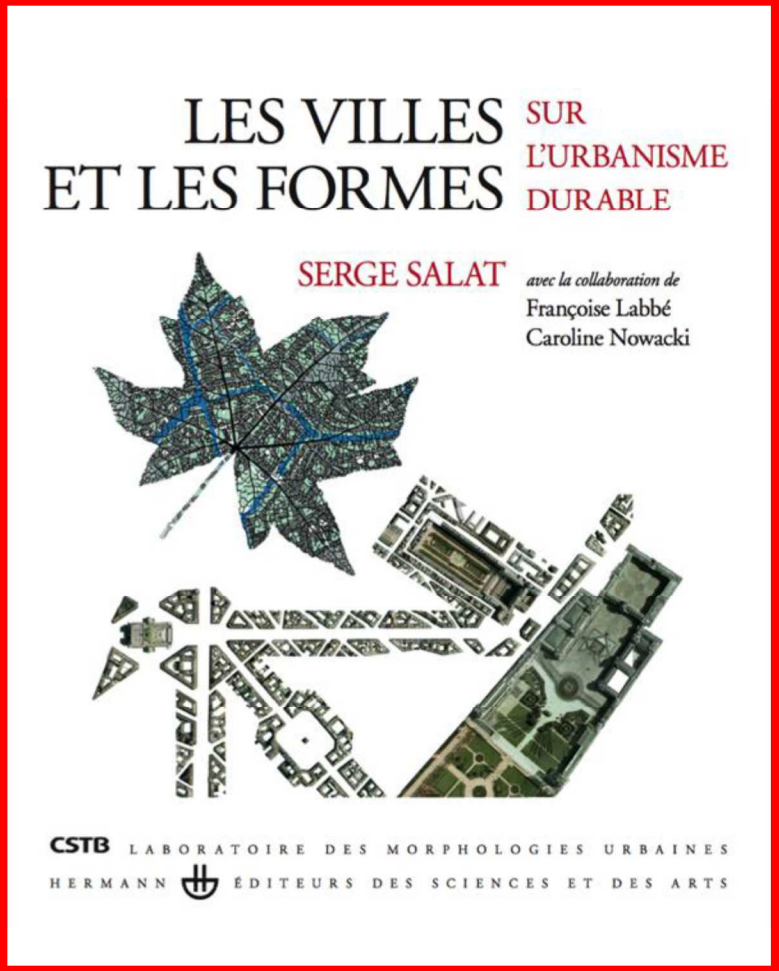

Hill
Flatiron
Gramercy

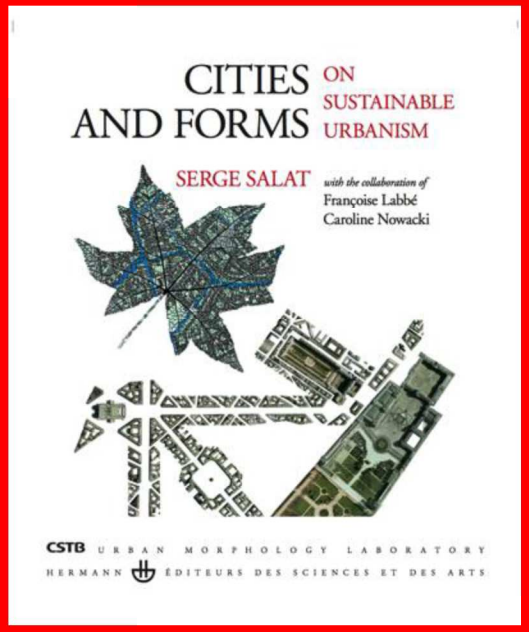
The seemingly homogeneous landscape at block scale reveals high heterogeneity at plot scale

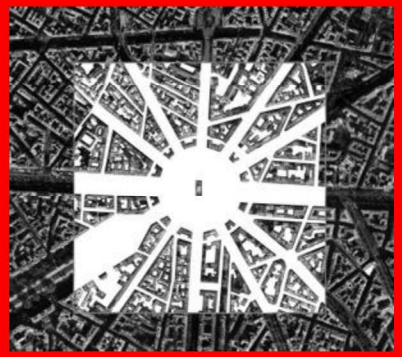
More residential Brooklyn shows less variations in energy intensity.
The fractal landscape is less bumpy


24 St
Crescent St

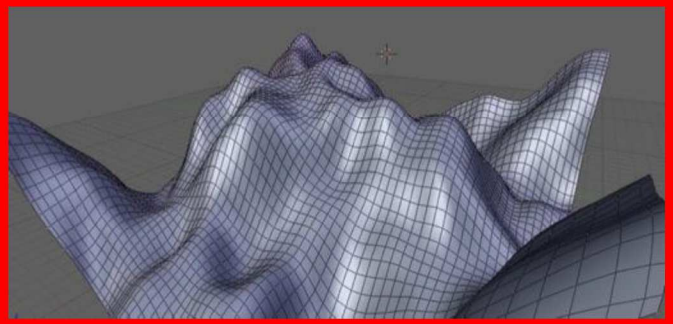
More on Paris and New York Morphology





Thank you for your attention



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