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A SCIENCE OF CITIES

Colloquium April 23, 2013 3:30 PM

A Science of Cities

Michael Batty

m.batty@ucl.ac.uk

<http://www.complexcity.info/>

<http://www.casa.ucl.ac.uk/>

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Centre for Advanced Spatial Analysis



Key Themes

- A Little History and a Puzzle
- Multiple Perspectives on Cities Across the Sciences
- The Fascination with Form
- Attempting to Explain Location, Place and Space
Social Physics, Economics and Transportation
- Systems Models and the Transition to Complexity
- Enter Time: Generic Models, Agents, Cells, and Cities
- More General Theory: Scale, Size & Shape
- Attempting a Synthesis

A Little History and a Puzzle

Cities have been talked about since classical times, since the written record began but only in the last 150 years since the industrial revolution has there been a widespread and sustained effort to intervene in their functioning.

This has largely been through planning which began in the west in the late 19th century.

It now seems strange but there was enormous certainty that the evils of the industrial city were supposedly to be resolved by producing cleaner, greener versions of the same thing, but smaller, and away from the industrial city. A return to the countryside.

The puzzle now is that people thought they could do this with little understanding of the city. In fact they thought it did not need understanding and that all it needed was reorganisation. How can you have prediction or prescription before explanation? I guess in human affairs, it happens all the time.

Cities were physical as was their planning and the prevailing view was based on producing better cities through better physical plans.

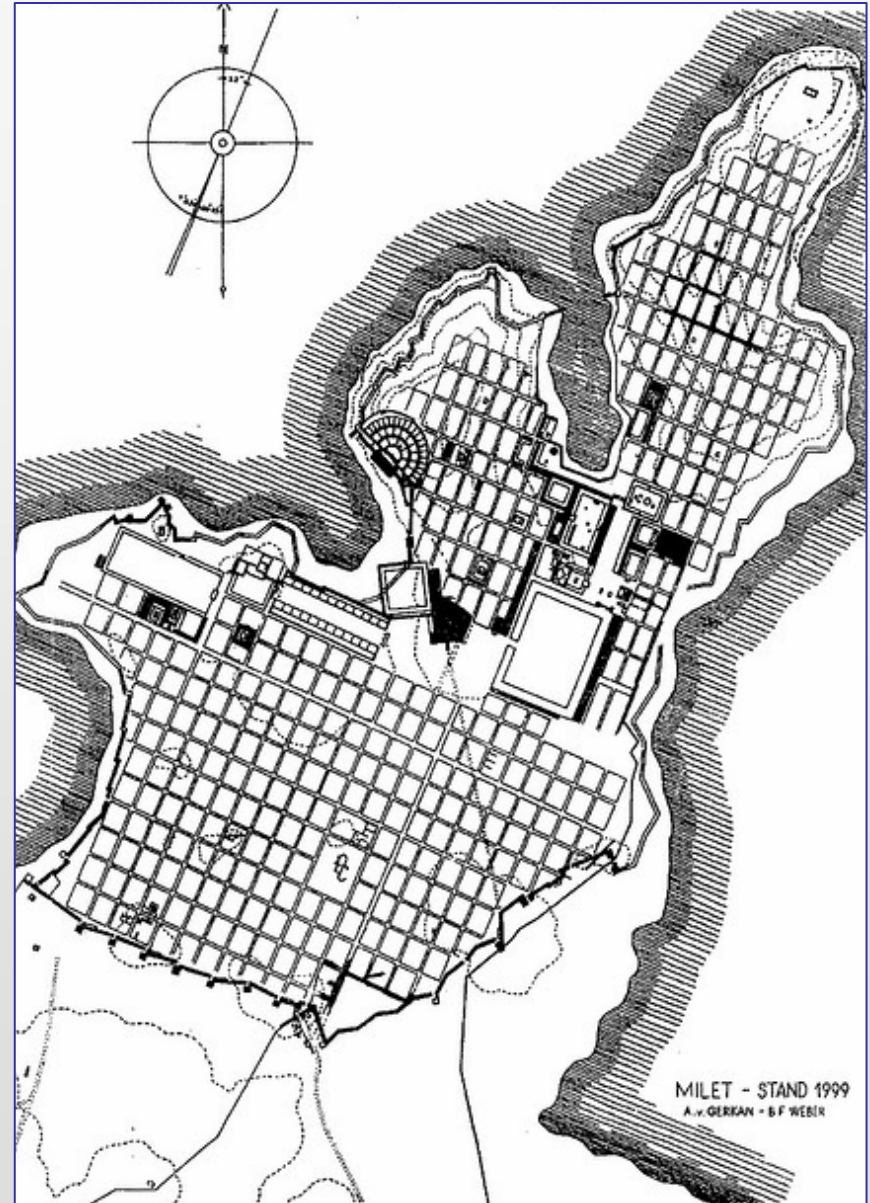
The city was seen as a work of art more than a social mechanism or rather its planning was a work of art embodied in a strong physical order that assumed it would function a little better.

Here are some early – very early – examples



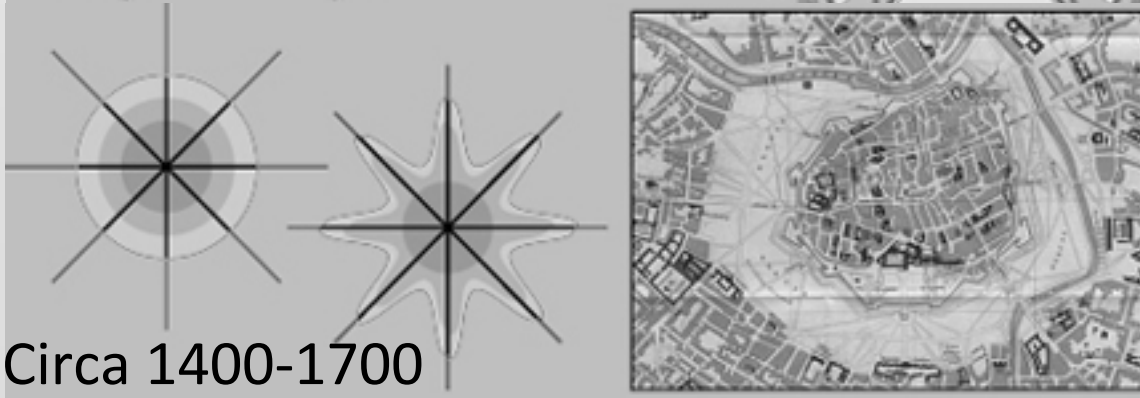
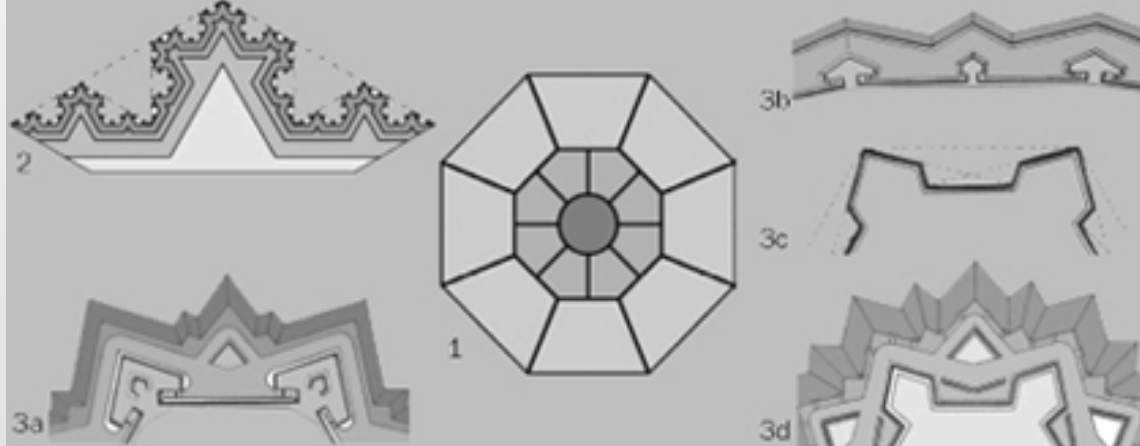
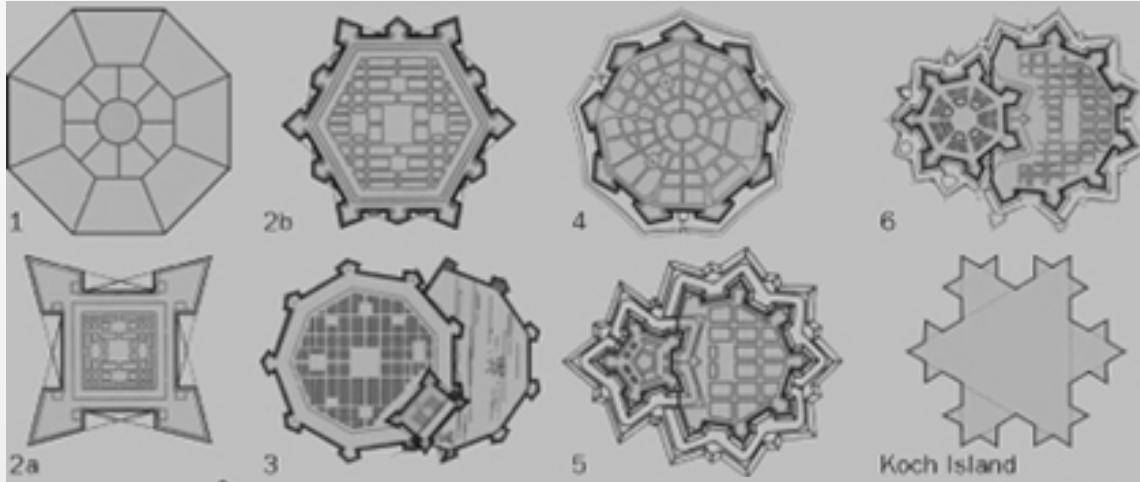
Map of the city of Nippur

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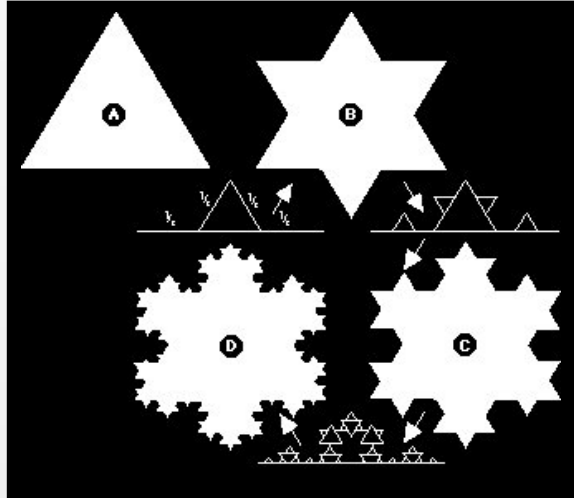


MILET - STAND 1999
A. v. GERMAN - B.F. WEBER

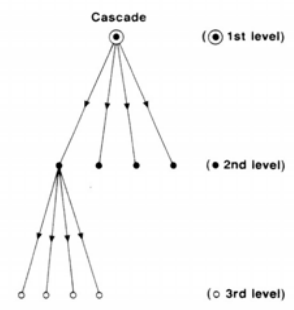
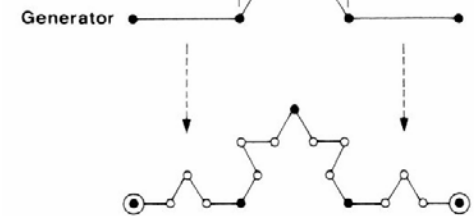
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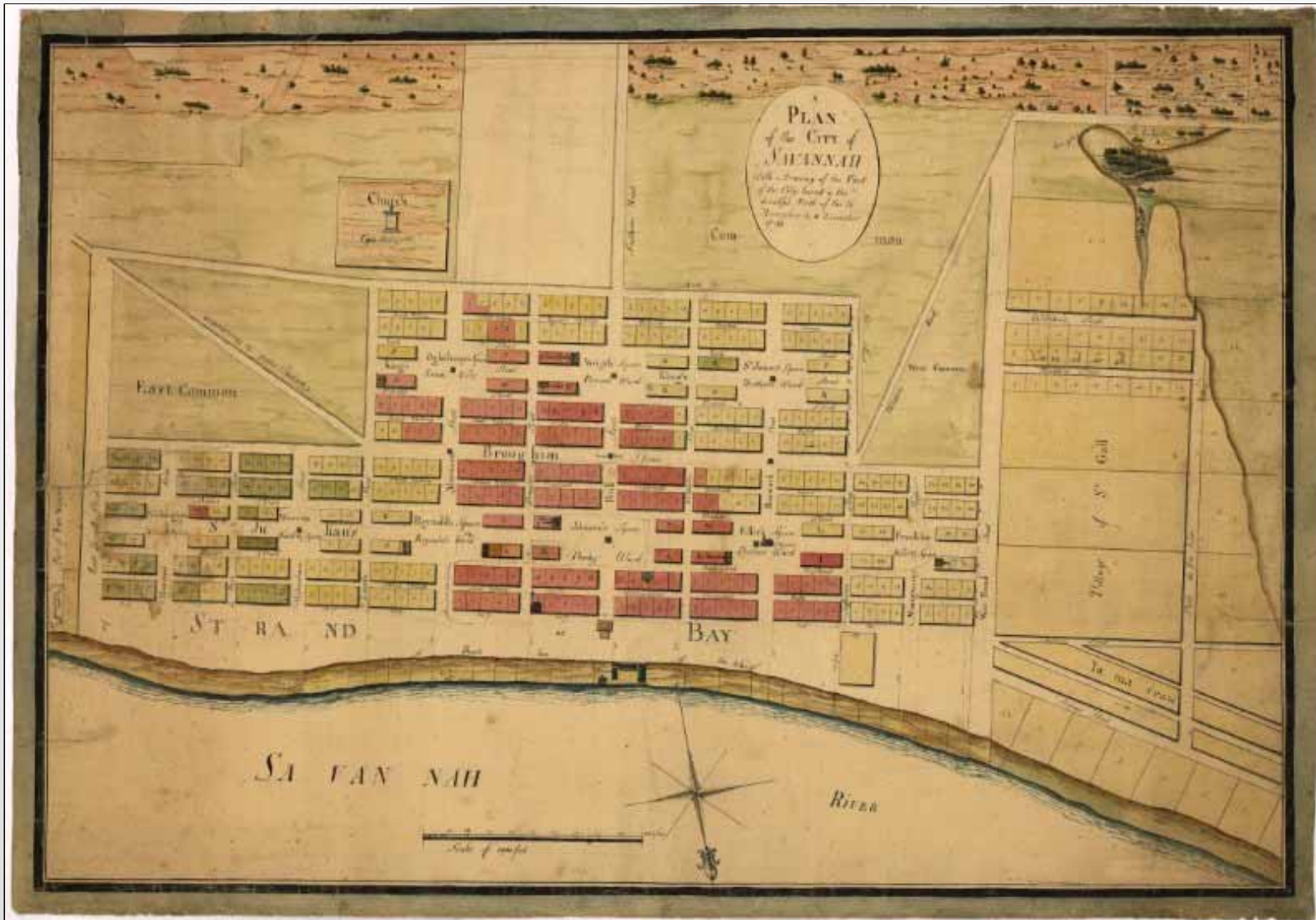


Circa 1400-1700



Initiator \bullet — \bullet
 $N = 4$
 $r(n) = 1/3$
 $D \approx 1.2618$





1. The Houses going up.
2. Mr. Oglethorpe's Fort.
3. The Crane & Bell.
4. The Subaltern's or Capt. House.
5. The publick Mill.
6. The House for Strangers.
7. The publick Oven.

1733

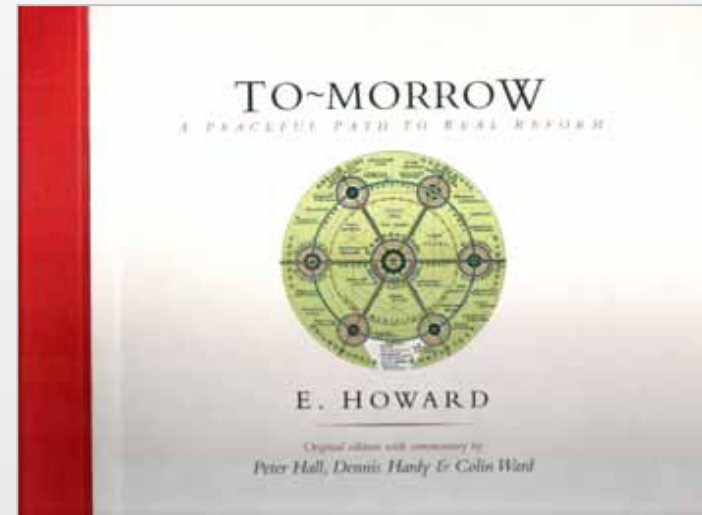
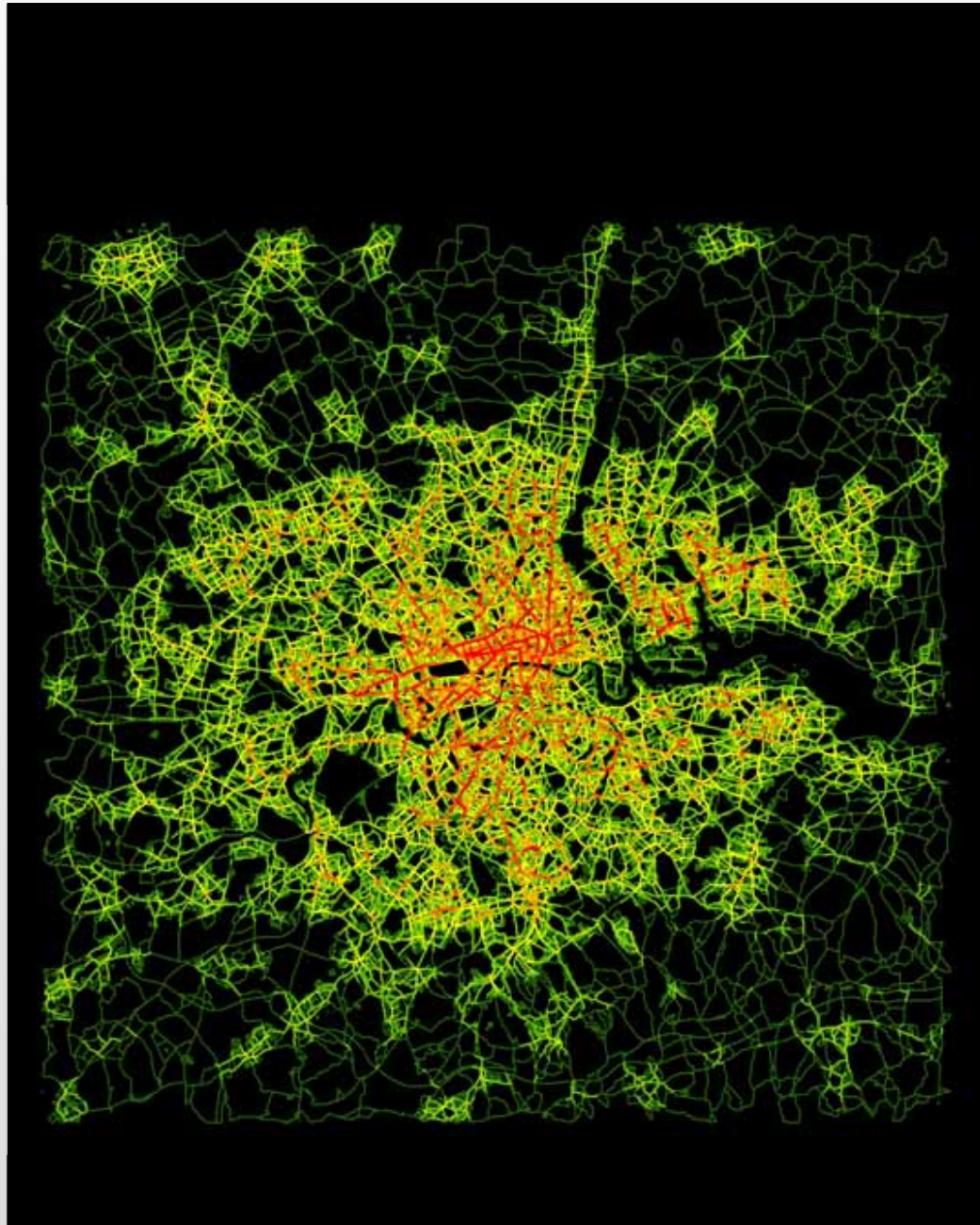
To the Hon.^{ble} the Trustees for establishing the Colony of Georgia in America
 This View of the Town of Savannah is humbly dedicated by their Honours
 Obliged and most Obedient Servant
viz. de Savannah dans la Georgie. Peter Gordon.

8. The Well for the Church.
9. The publick Stone.
10. The Fort.
11. The Barrack.
12. The Barrack House.
13. The Prisoners.
14. The Guard House and Store of Gunpowder.
15. Hutchinsons Island.

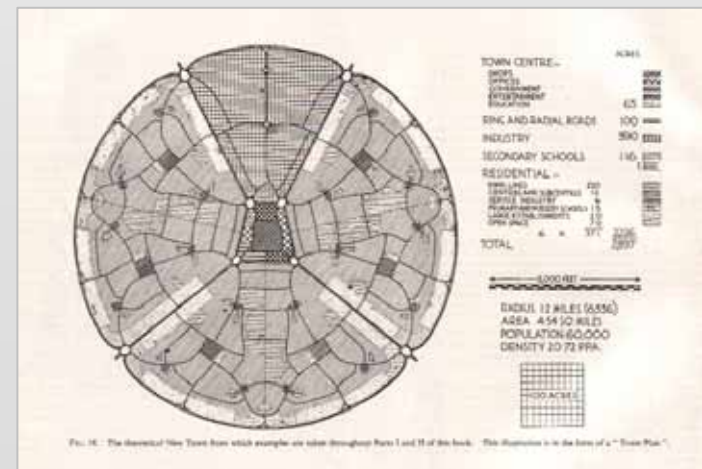
By the middle of the 19th century, the idea that the cities could be improved through top down physical planning gained momentum and by the early 20th century various institutional apparatus had been put in place to do something about it. The key issues were:

- Cities were regarded as something 'evil' to be managed
- The idea that the country should be moved back into the town was important
- Decentralisation, suburbanisation, counter-urbanisation was key to policy
- Managed 'sprawl' implicitly regarded as acceptable

A System of Cities: The Inter-Urban



A City: The Intra-Urban



Multiple Perspectives on Cities Across the Sciences

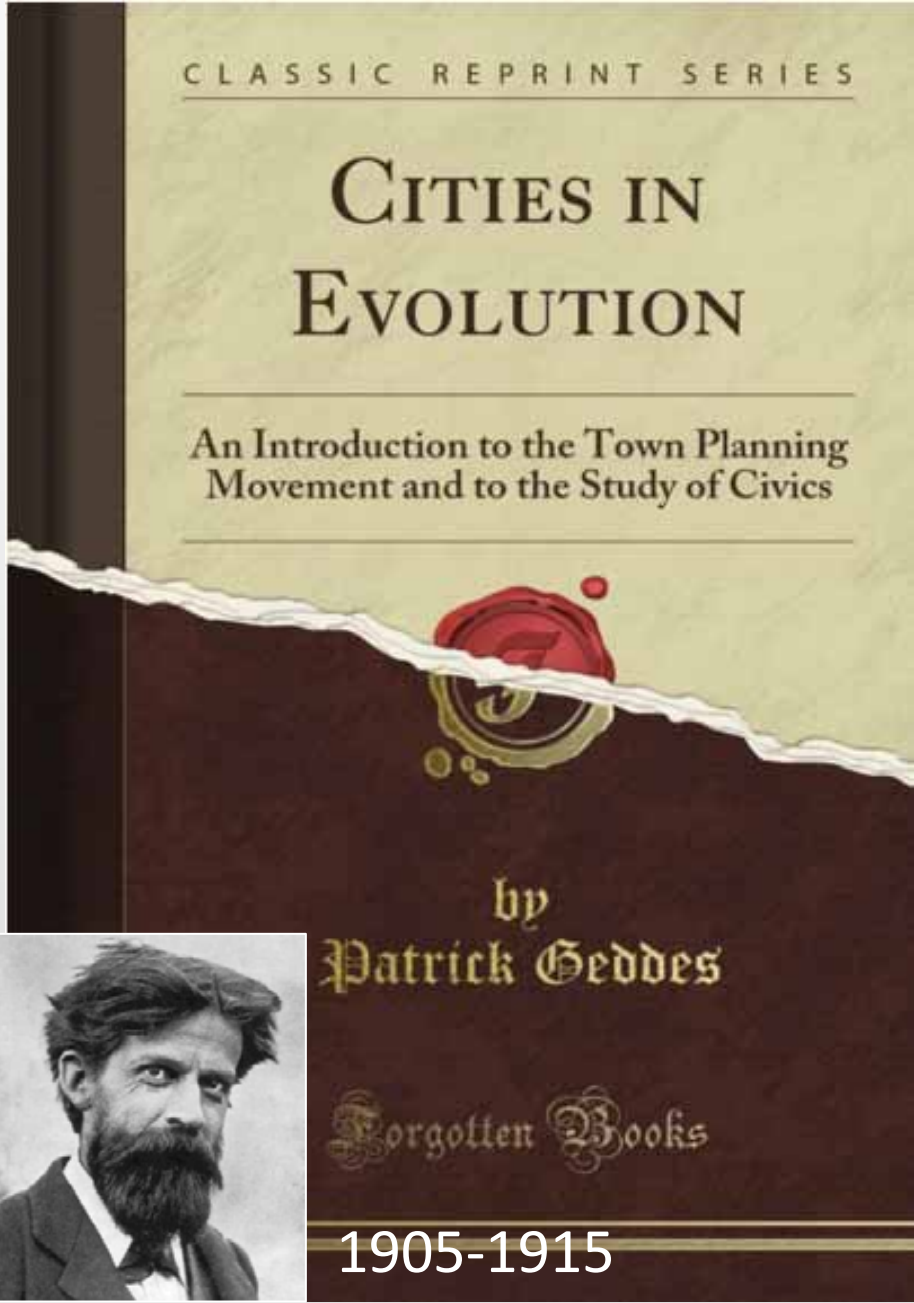
The 20th century saw the proliferation of ideas about the city in many intellectual domains

In the arts and humanities and the social sciences but also in engineering and more recently in physics

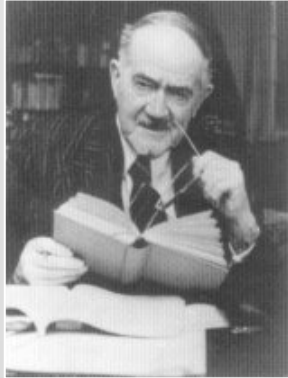
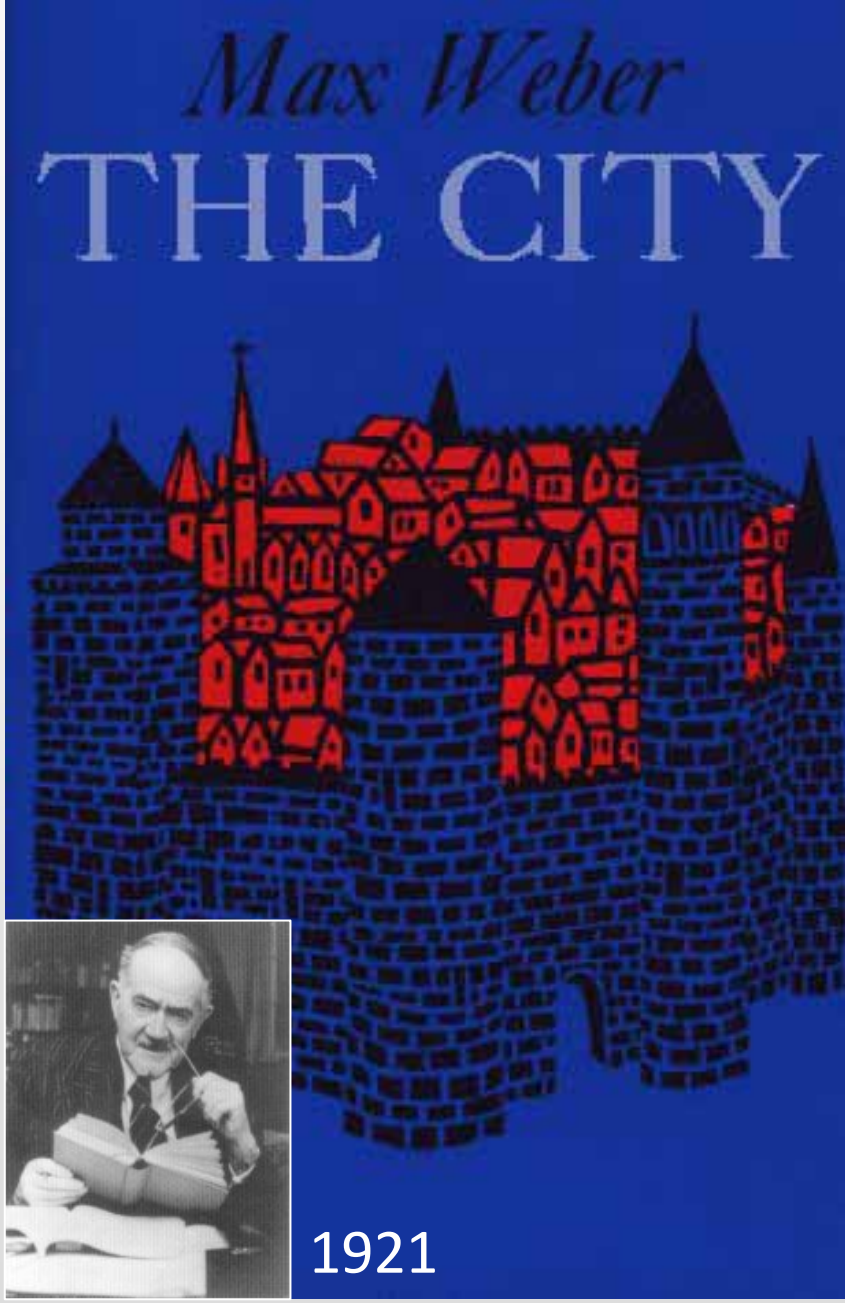
Each professing that they have the kernel of knowledge that will explain the key forces at work in the city

There is an enormous domain of 'urban studies' focusing on cities; and the professional and semi-academic domain of city planning and architecture

Two early books that focus on different perspectives imply a sense that there might be a science of cities



1905-1915



1921

I could show you a 100 books, perhaps a 1000, more,, which profess to explain the city but these two reflect an early concern with science – Geddes – and with politics – Weber.

Although a science of cities was largely not discussed, there were the seeds of a dawning recognition that cities could be understood more systematically

It is one purpose of this talk to try and build a bridge between those currents and what we are thinking about today.

The currents were primarily economic in focus – to explain the city as an economic mechanism although the dominant focus has been physical, and to a lesser extent social

The Fascination with Form

As we have already seen, the city is always articulated in terms of its physical form. I call the quest to explain how cities function through the lens of form *physicalism*

In fact planning cities was almost invariably physical in its manner during most of the 20th century for it was always believed that the efficient and equitable functioning of cities would manifest in urban form

You could see pollution, slums, deprivation, traffic congestion, green space, and so on and a lot was considered to be only surface deep, hence easily solvable.

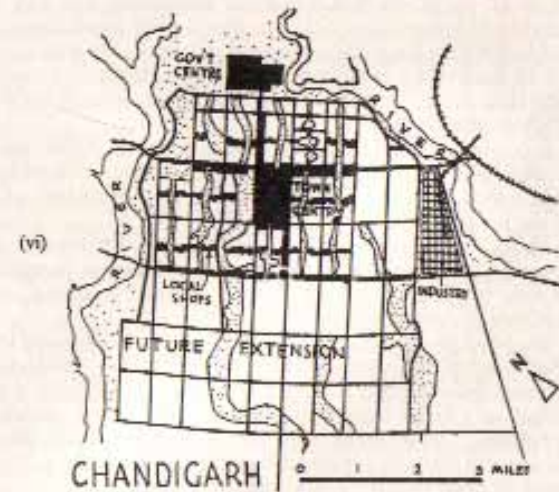
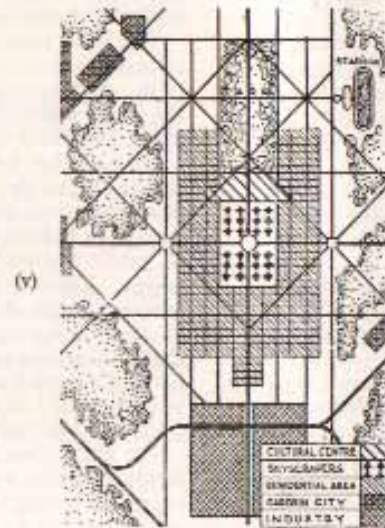
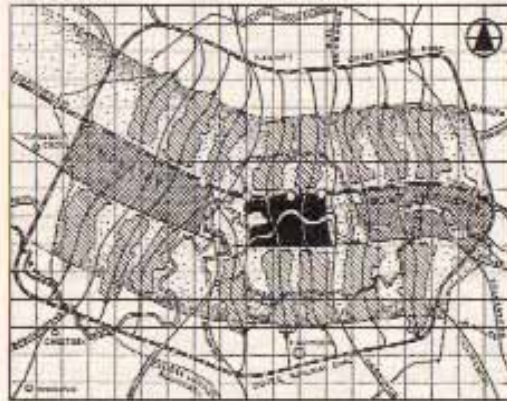
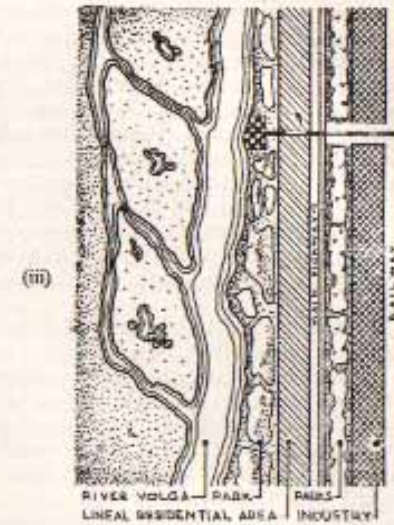
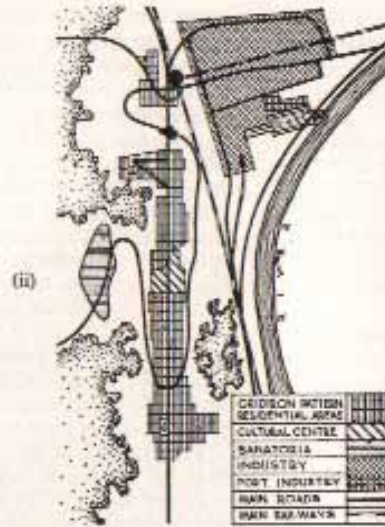
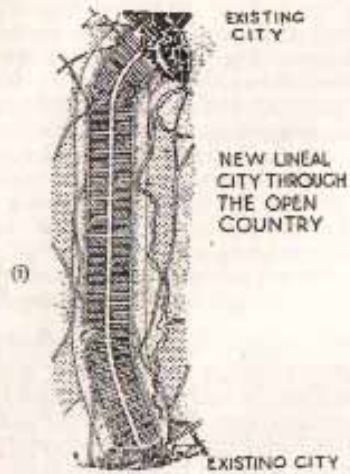
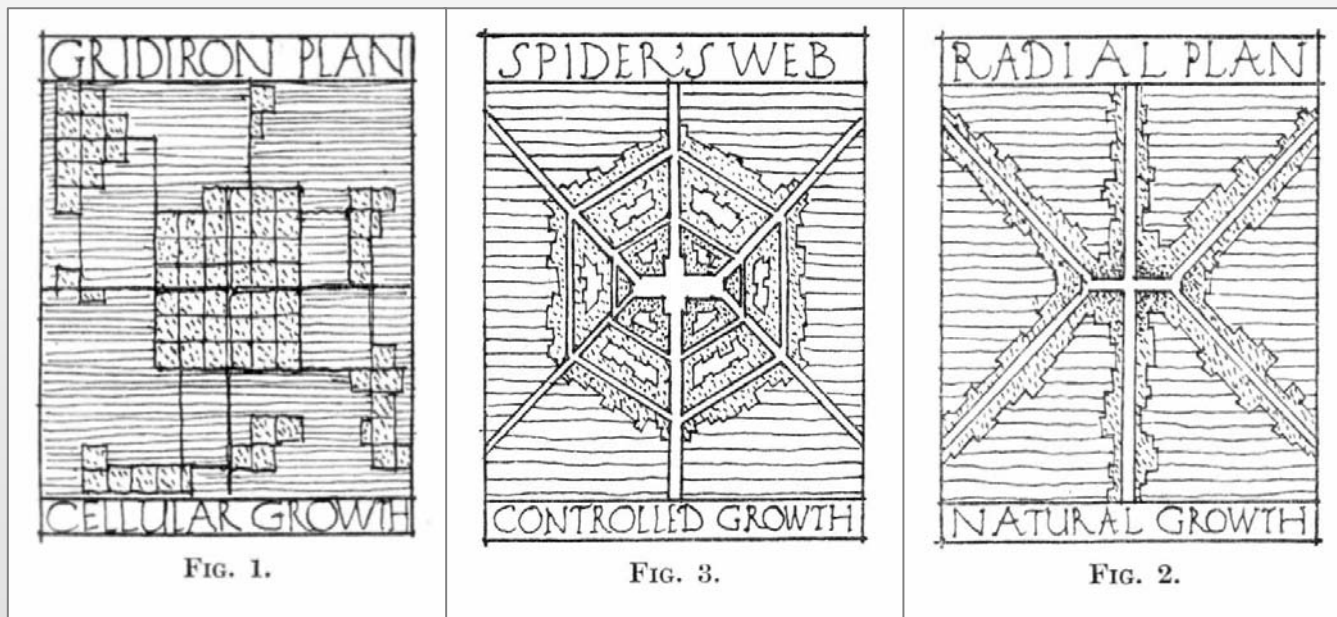


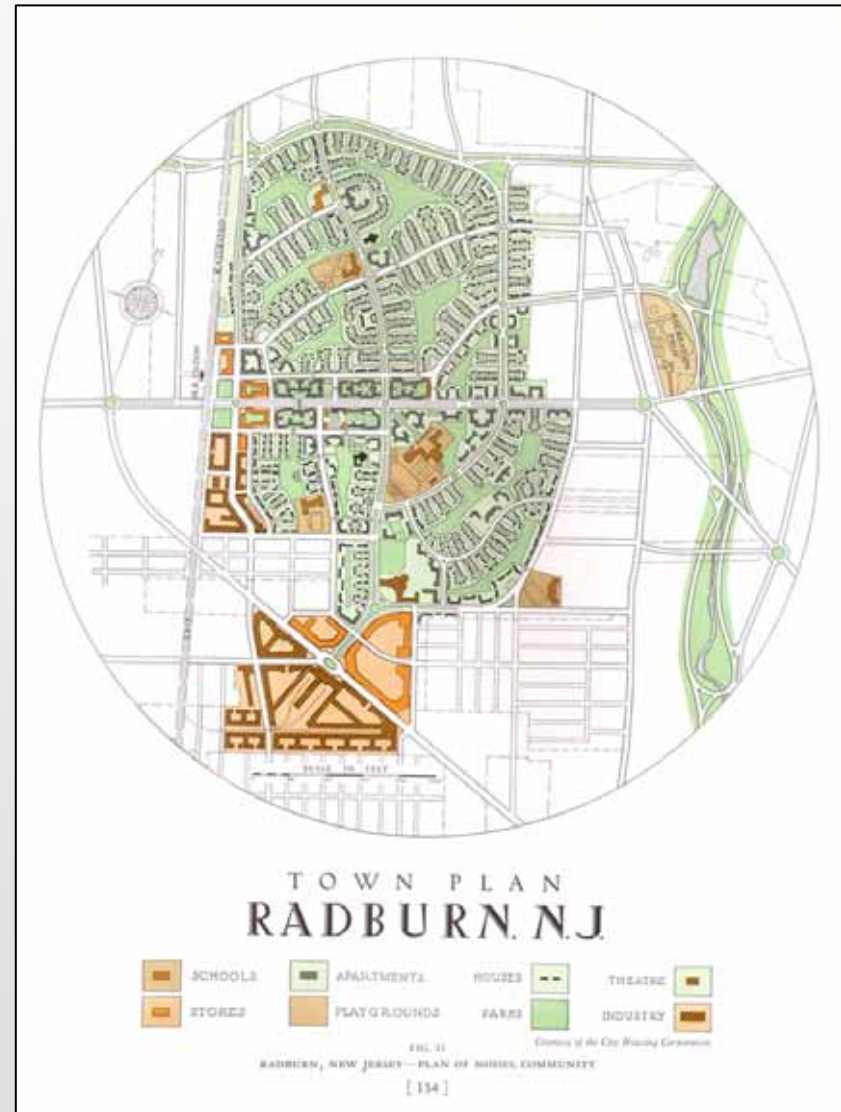
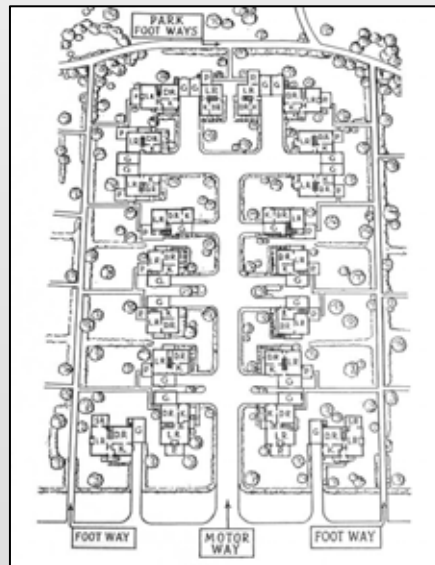
FIG. 17 PLANNING THEORIES

- (i) The original Ciudad Lineal.
- (ii) Garnier's "Cité industrielle".
- (iii) Part of a lineal plan for Stalingrad.
- (iv) M.A.R.S. group Plan for a lineal London.
- (v) Le Corbusier's "City of Tomorrow".
- (vi) Chandigarh.

Here are some idealised forms, which imply different degrees of planning – from Abercrombie’s little book **Town and Country Planning** (1935)



Note that these forms are highly suggestive of generative models but let me digress briefly about the word 'city' and 'town' for one minute. I should perhaps digress about 'science' but that can wait.



Modular design: an early 'new town' RADBURN, NJ, 1920s

We are still fascinated by form today, as witnessed in more recent examples such as the planned developments in places like Dubai, arguably even more extreme than these more modest layouts of the early and mid 20th century



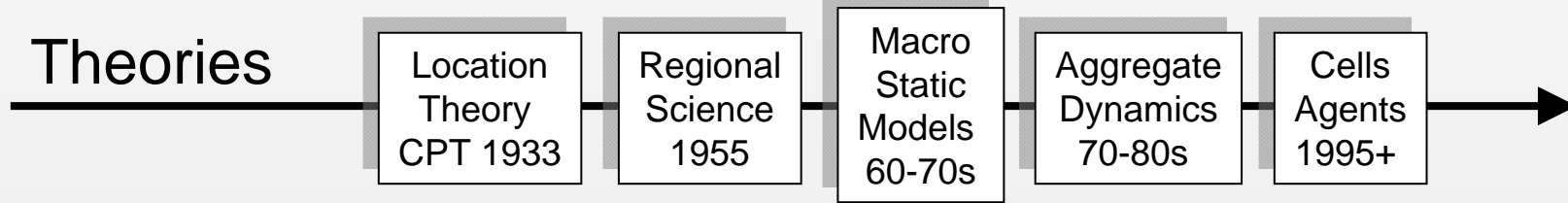
Attempting to Explain Location, Place and Space: *as Social Physics, Economics and Transportation*

Ok let me try to begin by sketching the various currents that began to fashion an understanding of cities as a science during the 20th century

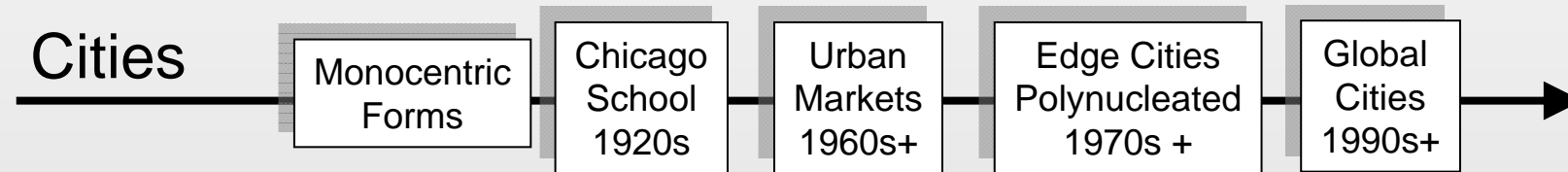
First I will sketch a chronology of ideas and then begin to sample them. It is a tall order to give you anything but a sample on such a wide canvas but I will try.

I will also attempt to see these in terms of ***size, scale, shape of location (actions) and interactions*** - watchwords for what a new science might be about

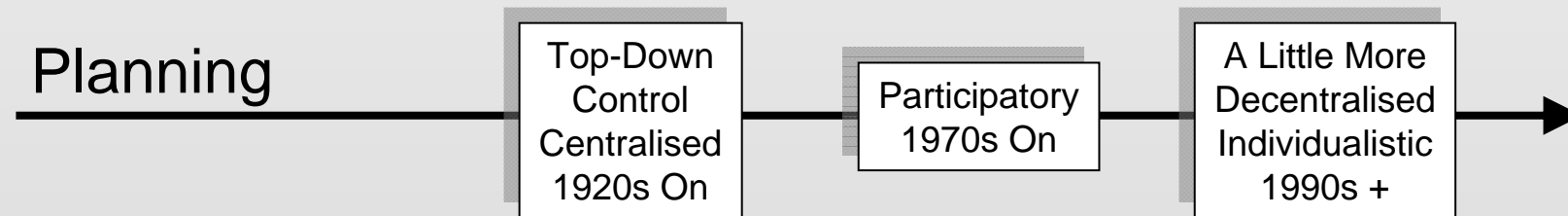
Theories



Cities

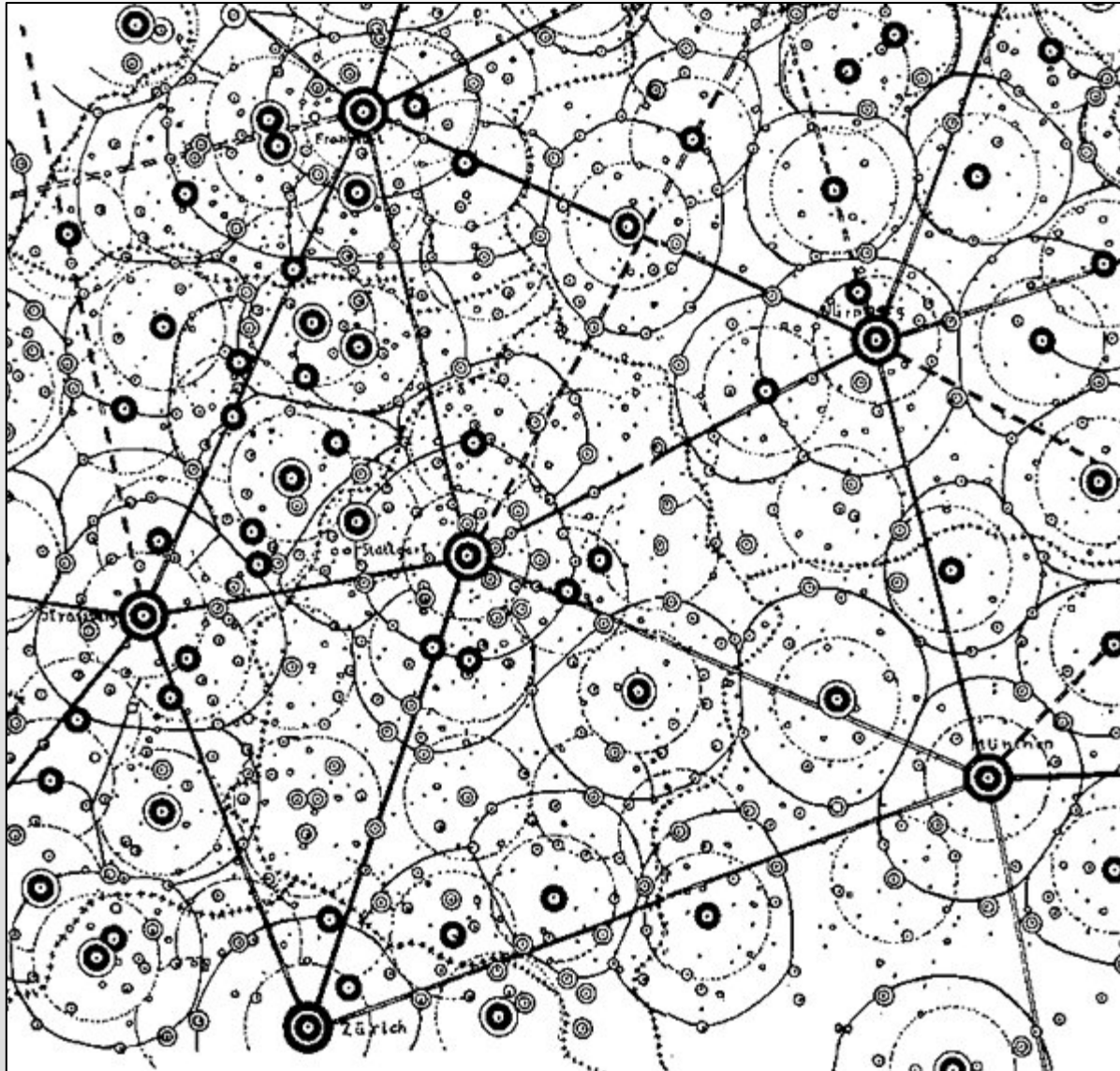


Planning



19th century industrial city 21st century global city

Economics between cities: Hierarchy, Size, Shape & Scale



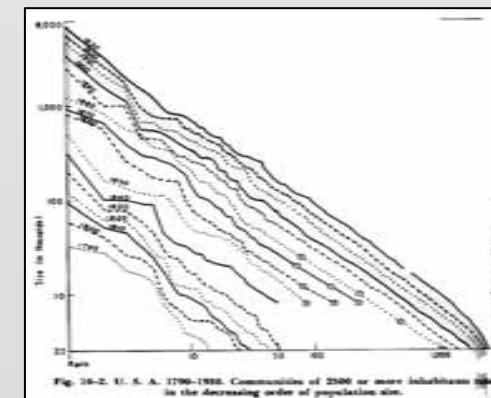
WALTER CHRISTALLER
1893-1969



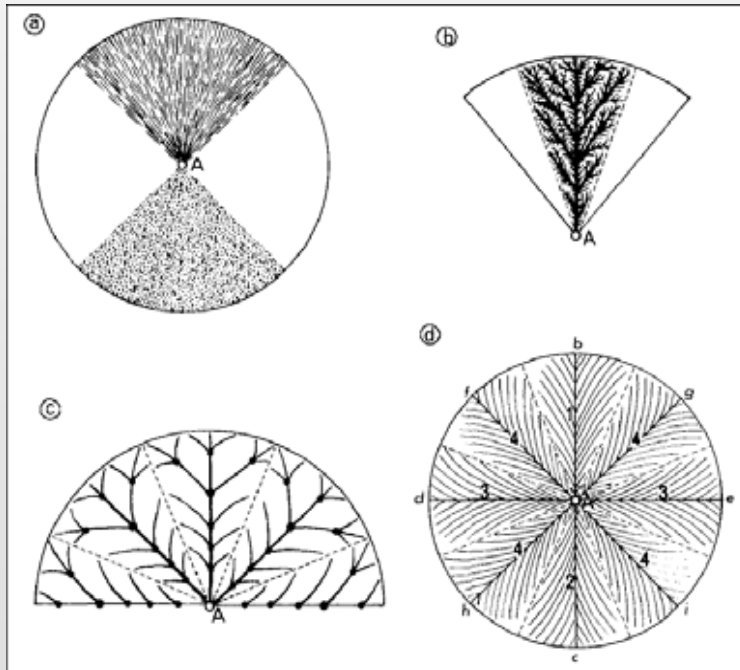
Losch



Zipf



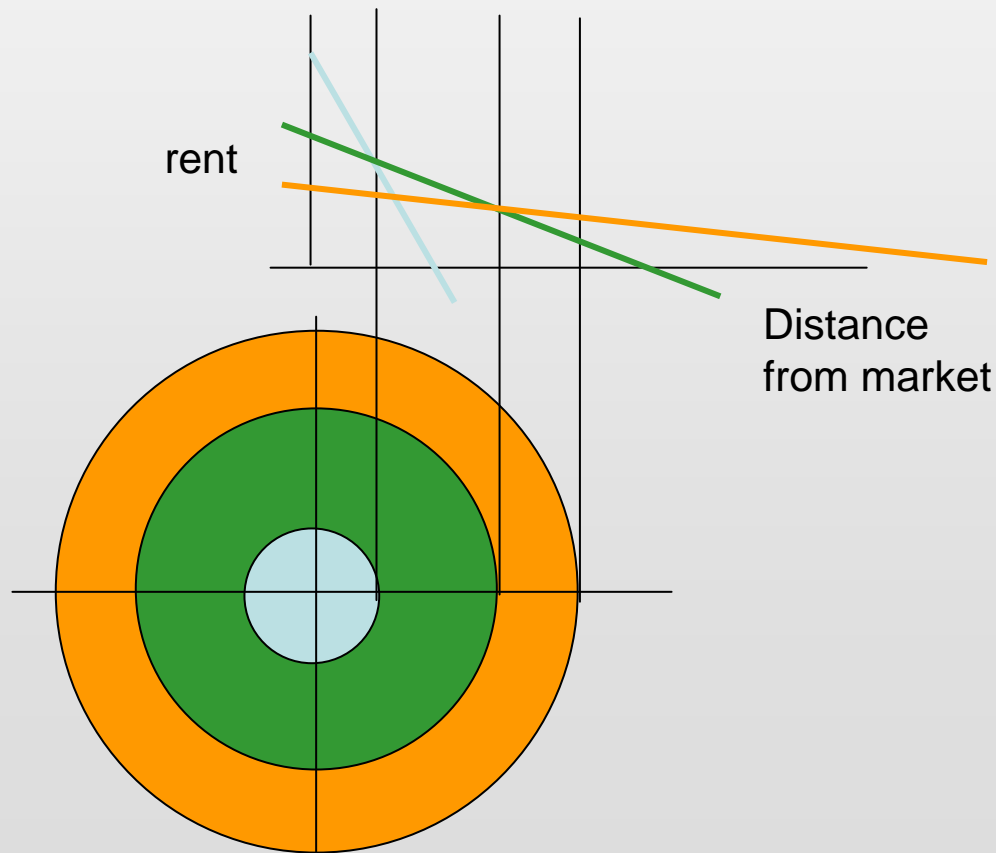
There were several much earlier statements in fact:
Kohl (1841) *Traffic and Settlements of People with
Regard to their Dependence on the Morphology of
the Earth's Surface*



And in 1842 Jean Reynaud produced a version of
Central Place Theory

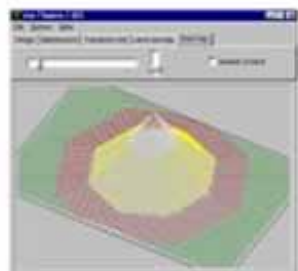
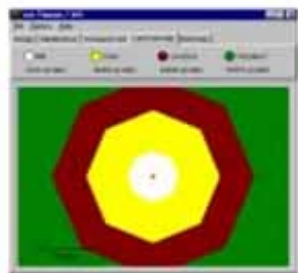
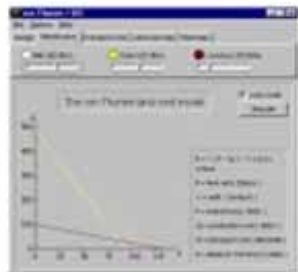
Economics within the cities: Price – Intra-urban, scale and size with shape implicit

The best model I can show of urban economics in the mid to late 20th century is von Thunen's – of 1826



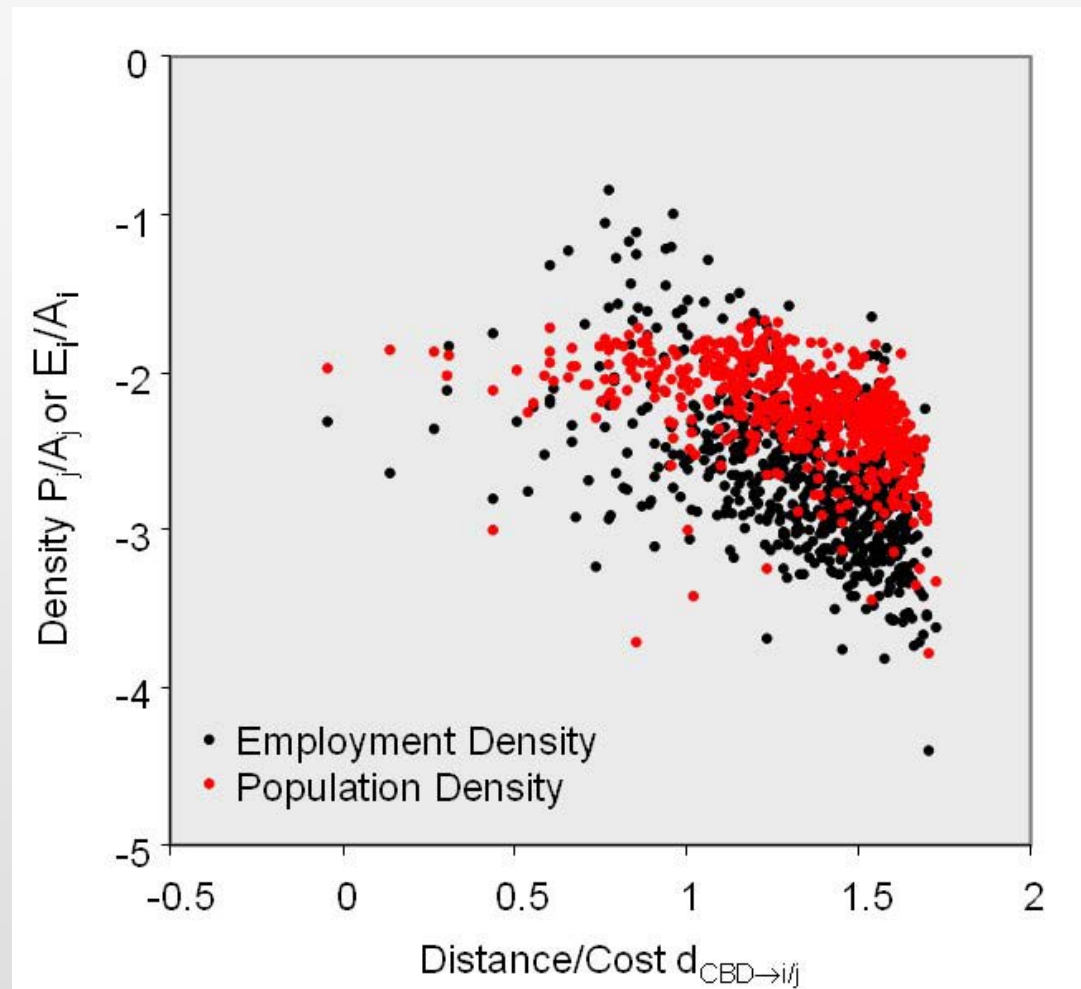
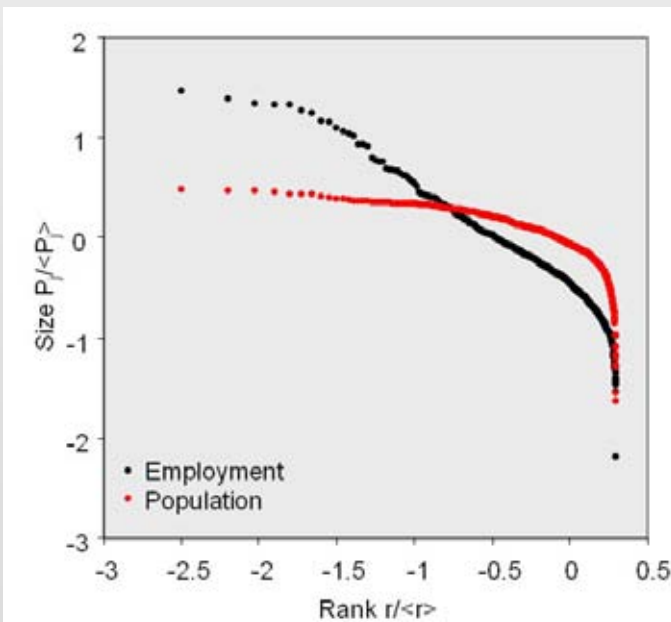
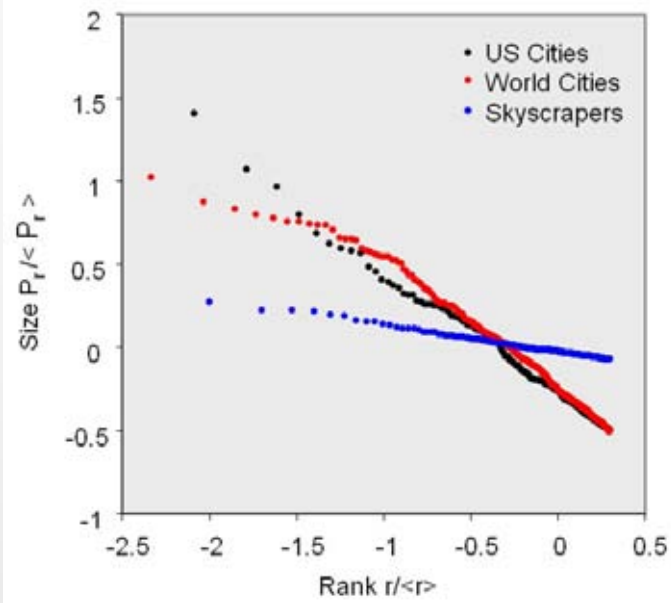
I have a little model to demonstrate this and it really contains everything we know about how accessibility shapes land use and how rent is determined. It relates a little to shape as well

Von Thunen



Spatial Interaction: A long history of application of the gravity model which treats distance as a scaling phenomena. I don't have time to go into this in detail but worth noting that the von Thunen monocentric city rent model is really a one dimensional spatial interaction model

Worth noting too that as yet a complete set of ideas about ***scale, size, shape, hierarchy*** for ***locations and interactions*** defining ***systems of cities*** (inter-urban) and the ***city system*** (intra-urban) has not been assembled but could be. Let me finish this brief section by pointing to the difficulties of fitting these kinds of idea to data and show some of these for London.



Systems Models and the Transition to Complexity

In the 1960s, there was some sense that we needed to underpin cities with comprehensive theory and the systems approach became popular. Systems conceived as being in equilibrium – another massive limitation of the emerging theories but fitting them rather well.

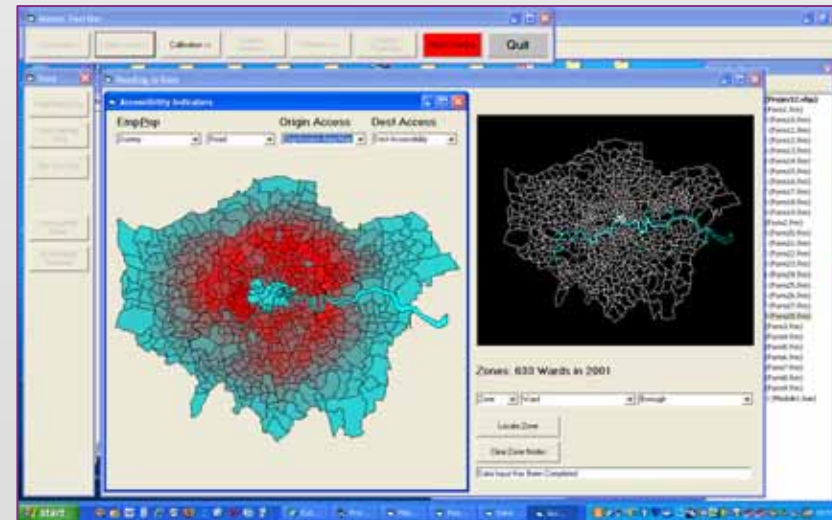
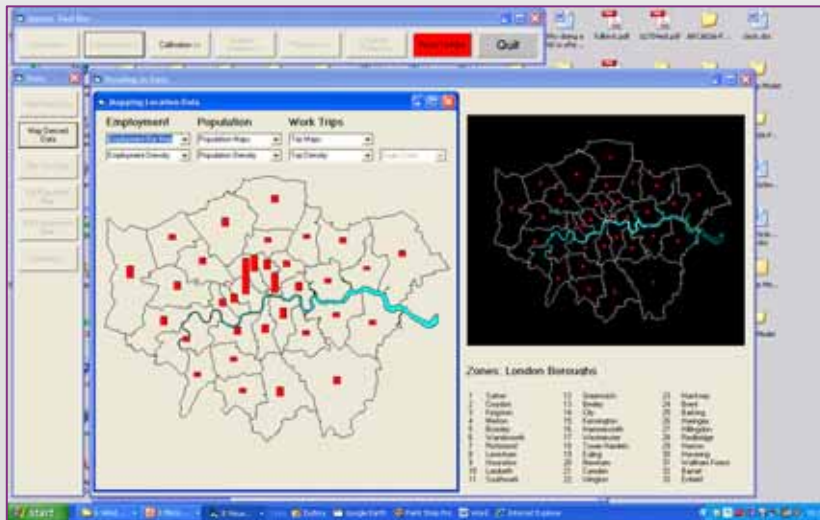
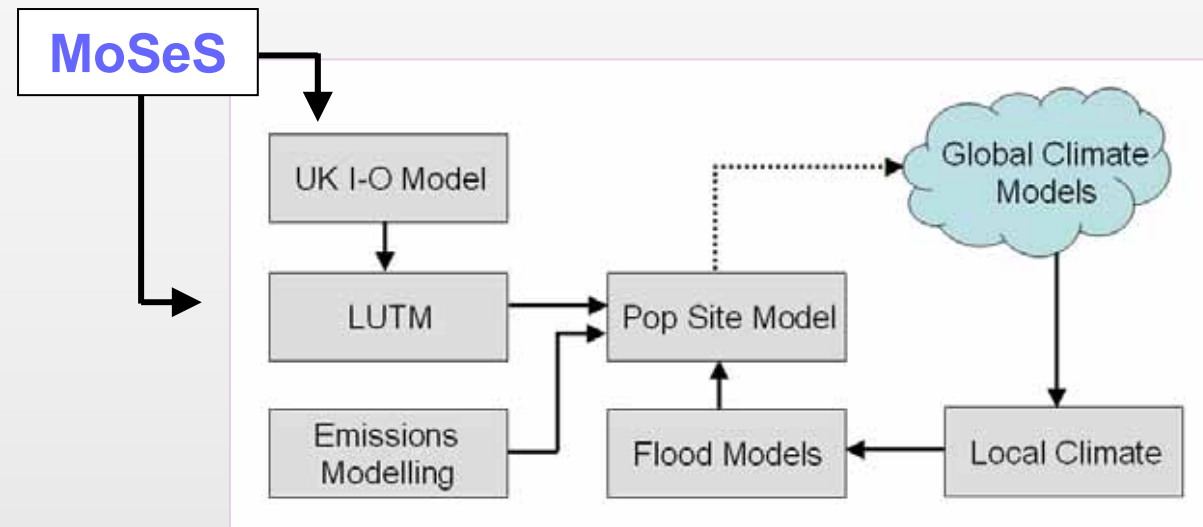
And top down in terms of their organisation – and control – fitting rather well the predominant model of planning that had become widely established since the end of the 19th century.

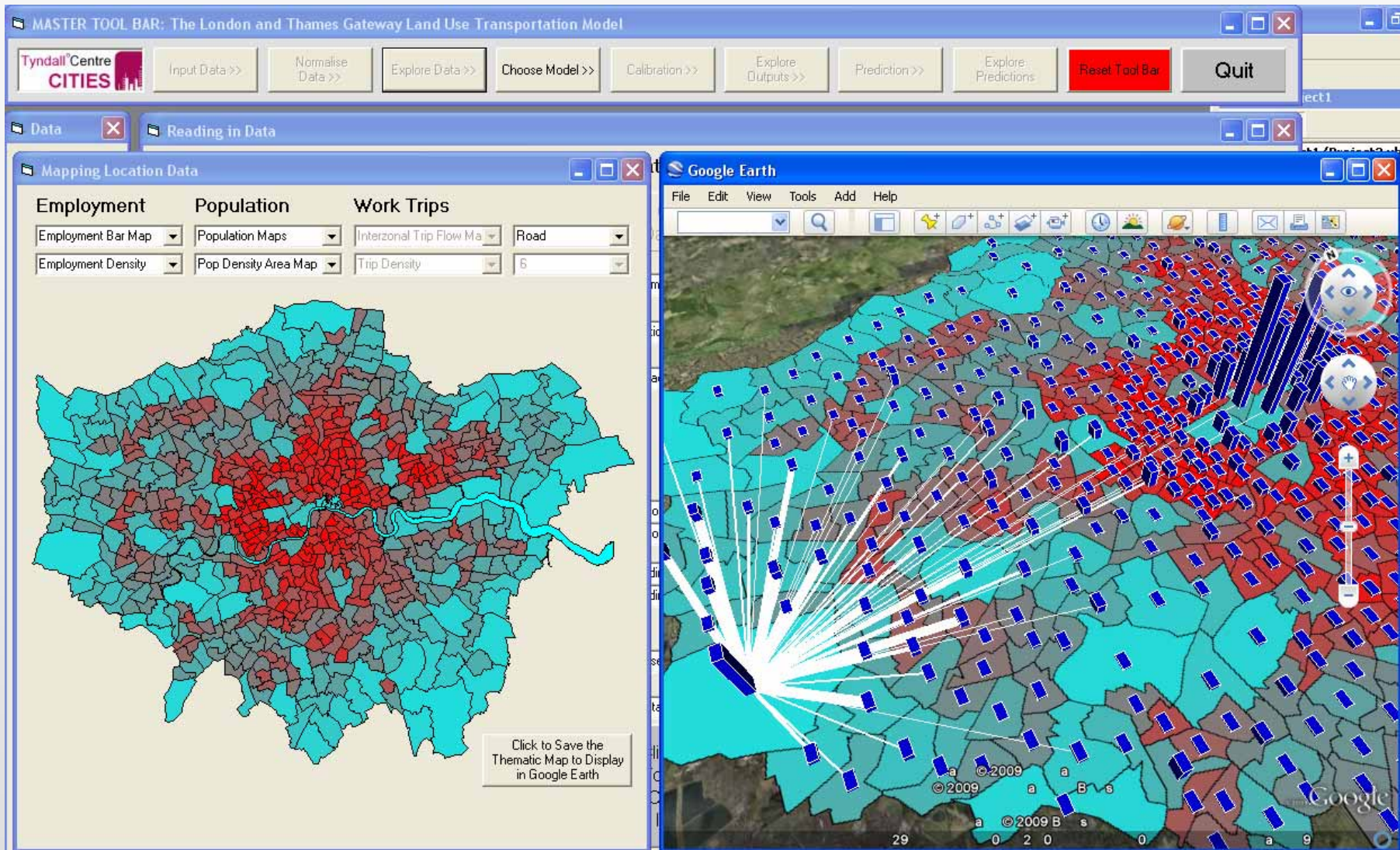
Onto this scene came aggregate, equilibrium, operational meaning empirically grounded in data and applicable for practical prediction, transport then land use-transport models.

The heritage of these models largely built around spatial interaction and discrete choice theory in terms of travel demand are still with us today. These models are policy-orientated, large-scale, fit rather badly, and tend to be one-offs. And they persist ...

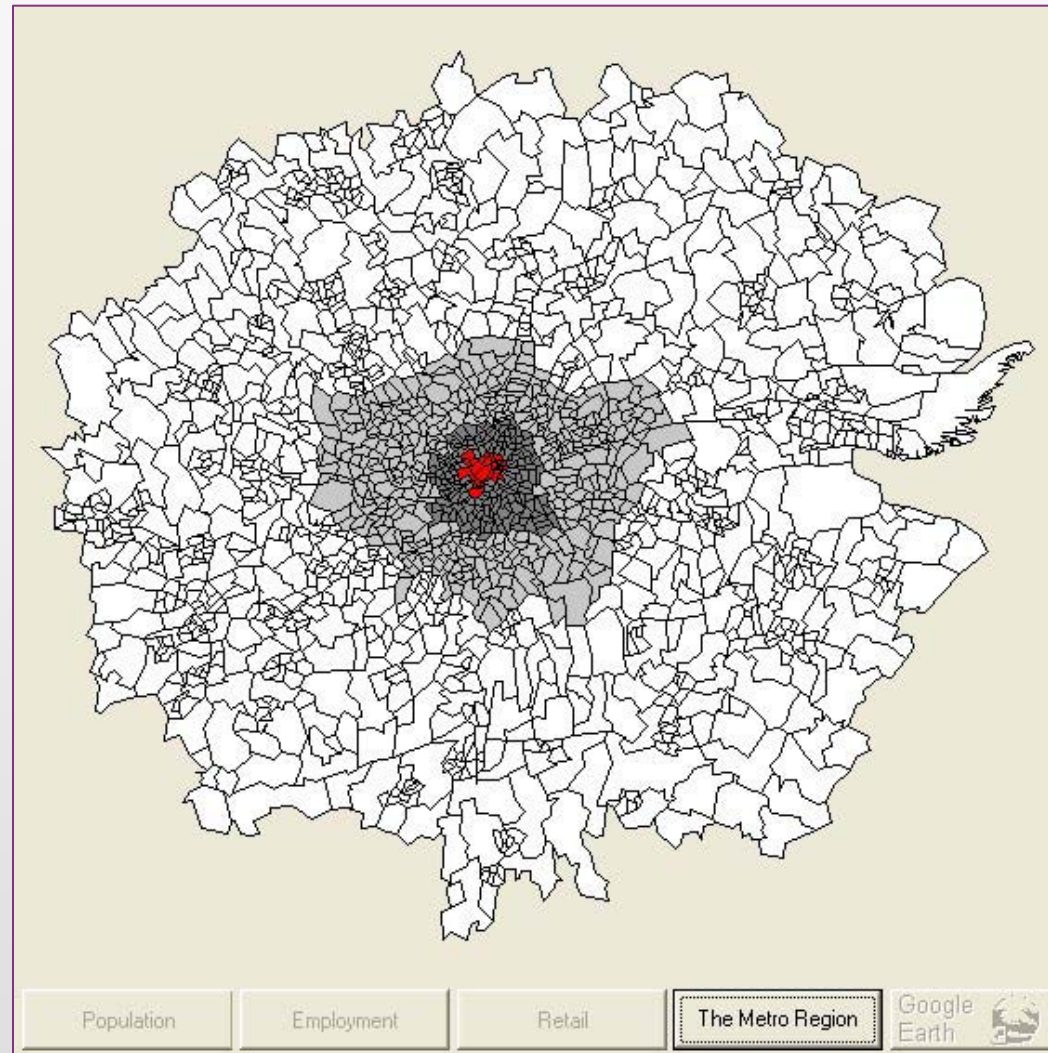
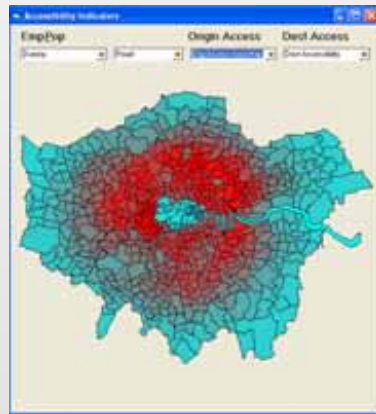
They are now much more disaggregate and some quite interesting developments from the TRANSIMs work at Los Alamos – in particular MATSIM and there are links to UrbanSim. Let me provide a sense of this kind of thinking from our own work in London

Let me first explain the Tyndall Cities Model for London



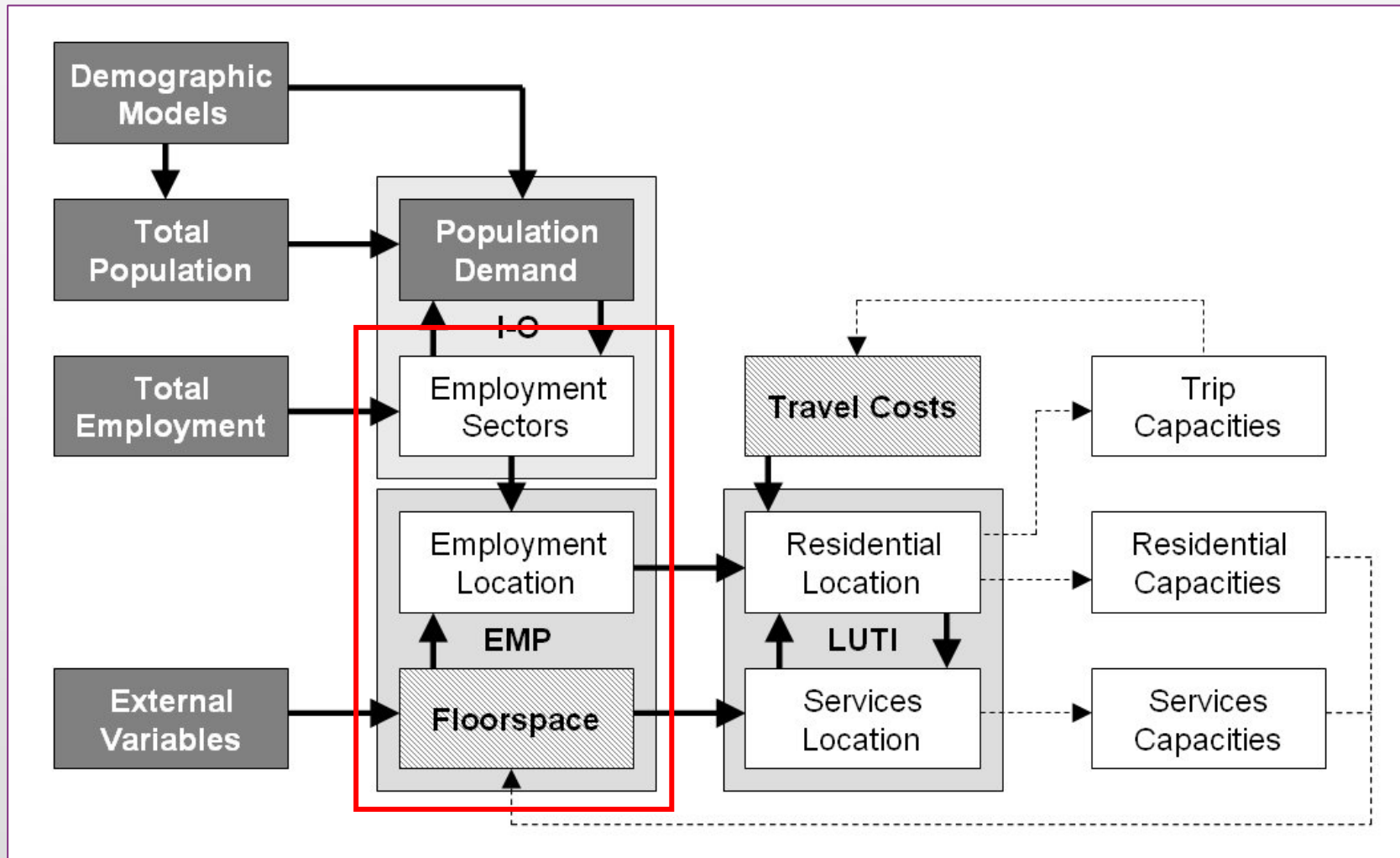


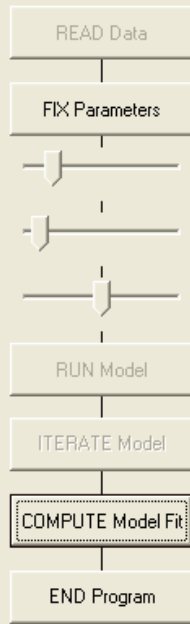
Exporting data and predictions to external software on the fly



Spatial scale is important in this kind of modelling – but the shape of the city is implicit.

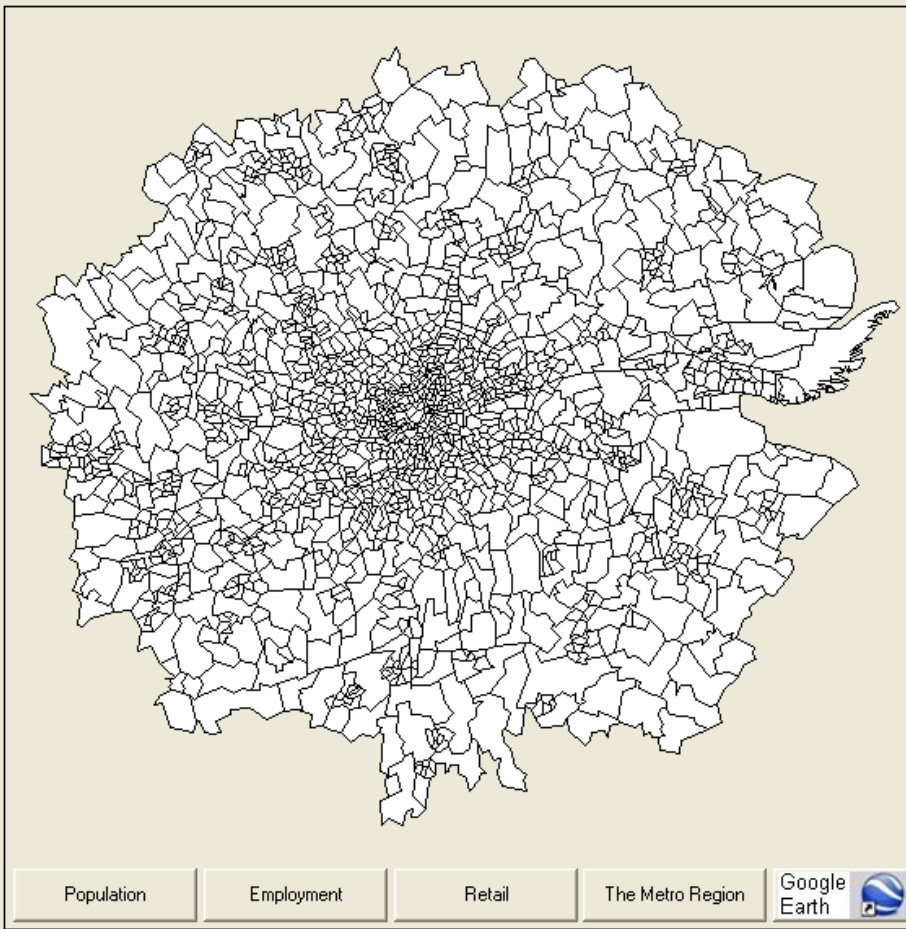
Here are the guts of how these models work and they are a little like input-output structures coupled together with gravity models





ACTIVITY TOTALS

Total Population 13428850.
 Total Employment 6826351
 Retail Employment 1638829
 Internal Employment 2748116
 Exog Employment 2439409
 Activity Rate 1.967208
 Pop-Retail Rate 0.1220379
 Number of Zones 1767
 Area of Metro Region 13238140.
 Obs WorkTrip Mean 19.06106
 Obs ShopTrip Mean 11.1431



Parameterisation

Residential Location
 Trip Length 19 Parameter Value .0789
Retail Location
 Trip Length 11 Parameter Value .1364
Employment Location
 Land-Access 50 Parameter Weigh .5

Calibration: Goodness of Fit

Residential Location
 %Pop Diff 30 Mean 20 R2 84 R2Trip 34
Retail Location
 %Ret-Emp Diff 103 Mean 13 R2 87 R2Retail 17
Employment Location
 %Int-Emp Diff 138 R2 89

Calibration: Graphical Fit

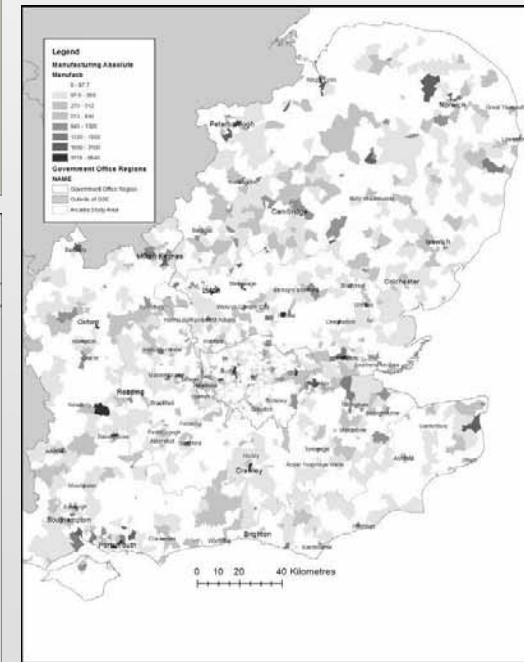
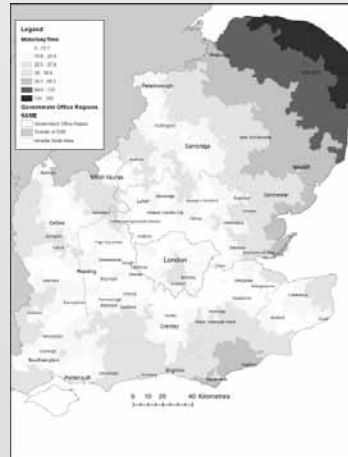
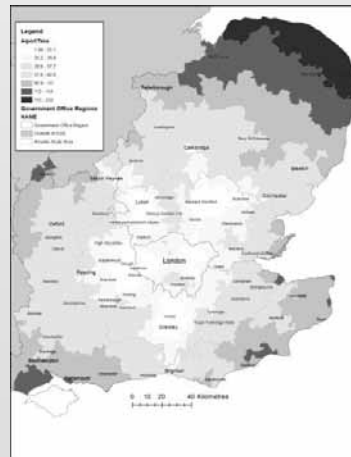
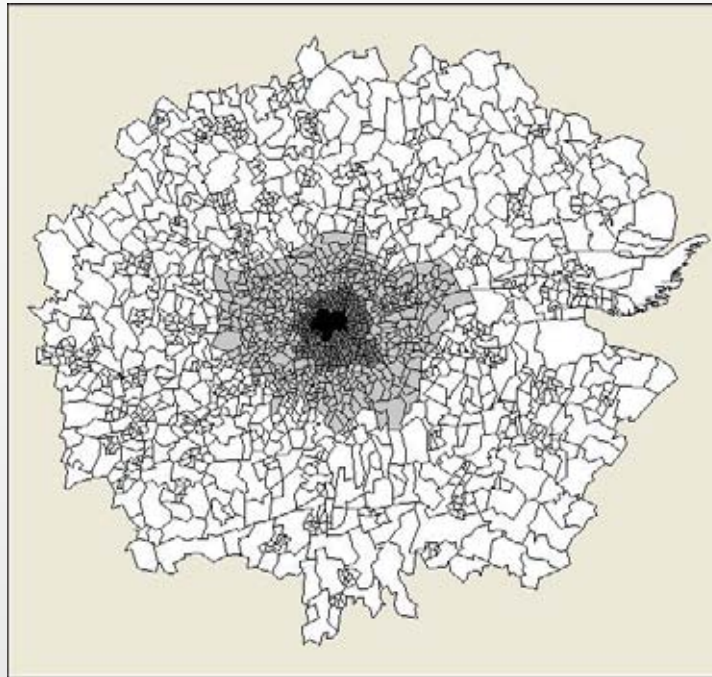
Deviations Histograms Thematic Maps

Count Data
 Density Data
 Observations
 Predictions

arc EPSRC ARCADIA: Adaptation and Resilience in Cities



ARCADIA: Adaptation and Resilience in Cities



Its almost impossible to close the system – in terms of its interactions

Enter Time: Generic Models, Agents, Cells, and Cities

So far most of this science has been a timeless science, a world in equilibrium for obvious reasons. Cities look like they are in equilibrium physically because of the inertia of the built environment, temporal data is inordinately hard to get and so on.

In the 1970s, there were many flirtations with chaos and catastrophe theory, with bifurcation theory and some models were developed theoretically

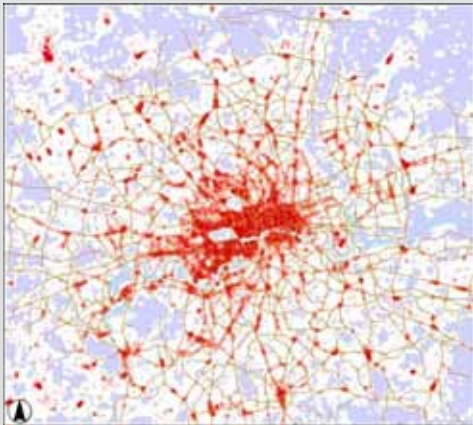
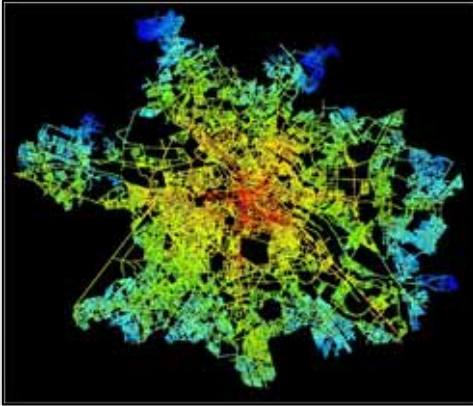
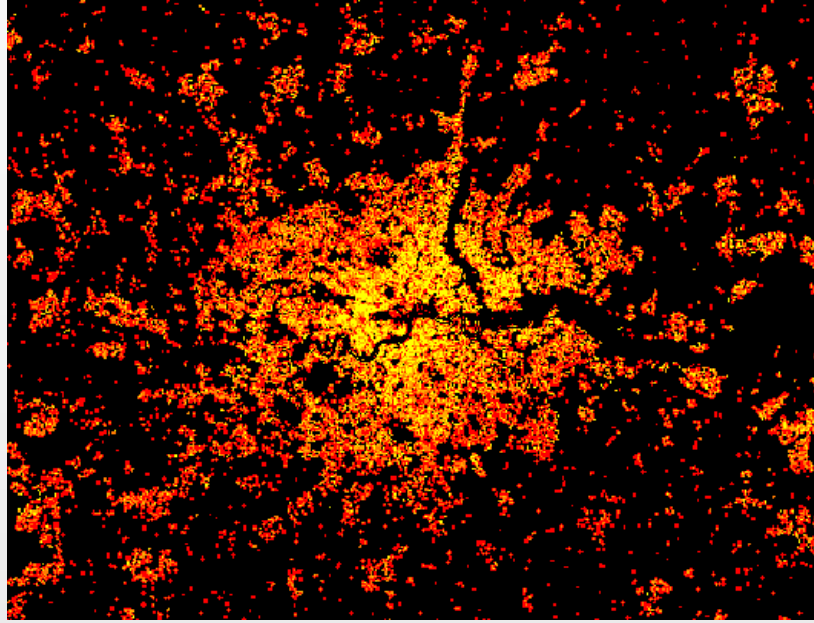
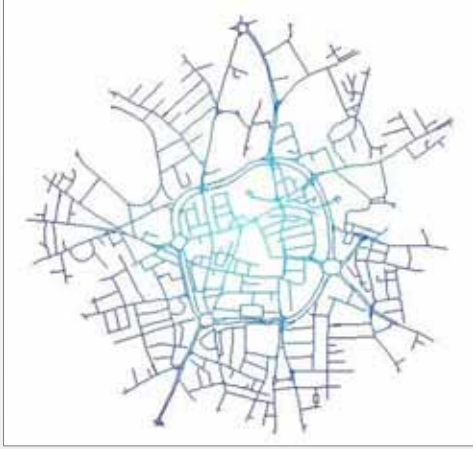
Progress was slow and probably the most significant is the embedding of interaction theory into predator prey models to simulate rapid growth

But by far the most significant were notions about how urban structures might be generated akin to the way fractal structures grow and this meant that the mantle of physicalism continued. Let me show some more pictures of what the focus was – explaining urban growth using fractal models

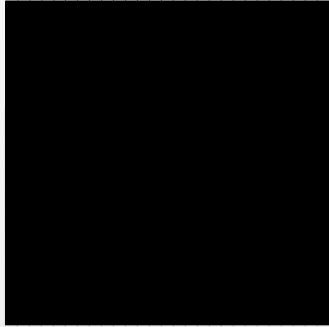
In fact a good deal of this was anticipated in the early quantitative geography movement beginning in the late 1950s where there was a concern for morphology.

And the implementation of these ideas was generally based on cellular automata kinds of algorithm.

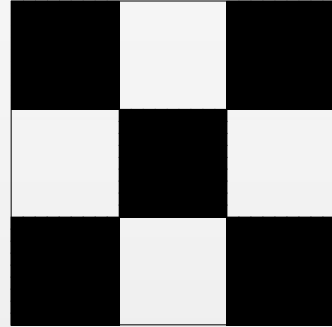
Let me show how these kinds of models might be built.



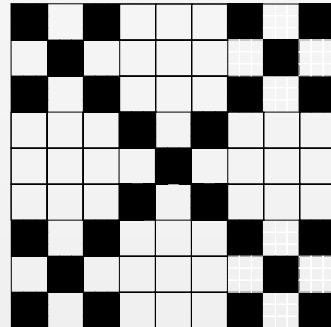
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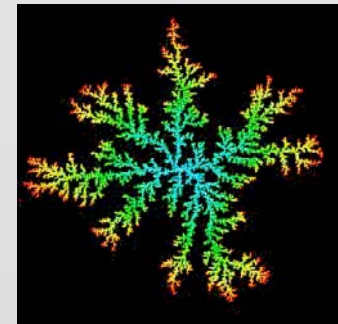
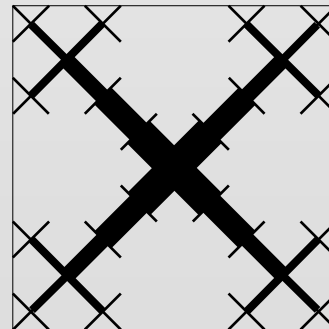
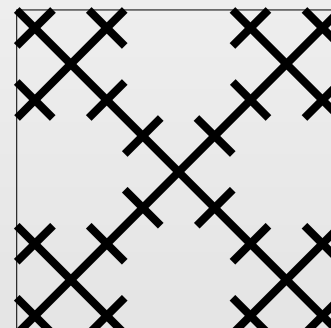
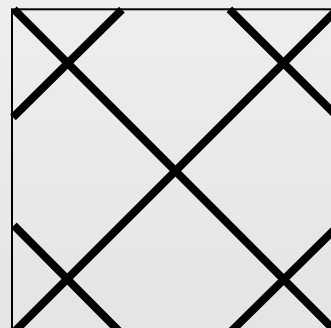
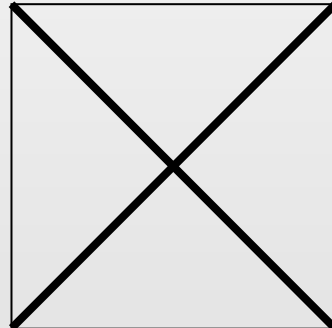
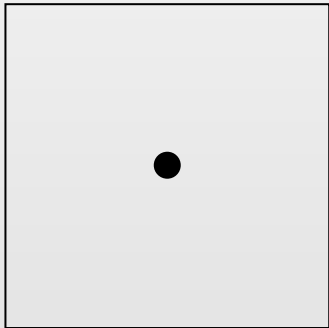
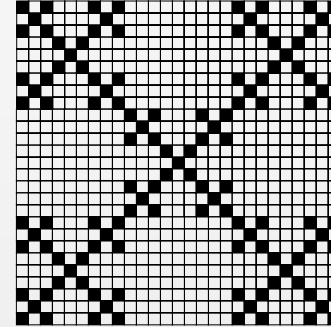
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$k=2$



$k=3$



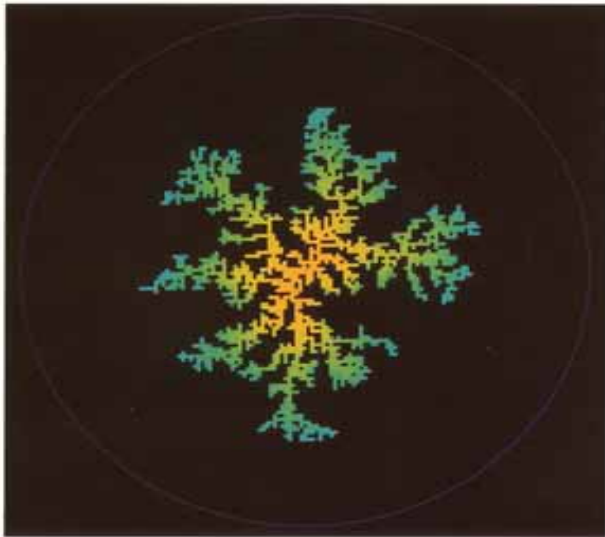


Plate 8.3 (left) The Baseline Simulation $\eta =$

Plate 8.5 (below) The Urban Area of Cardiff.

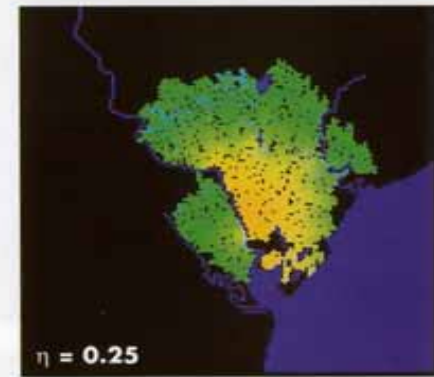
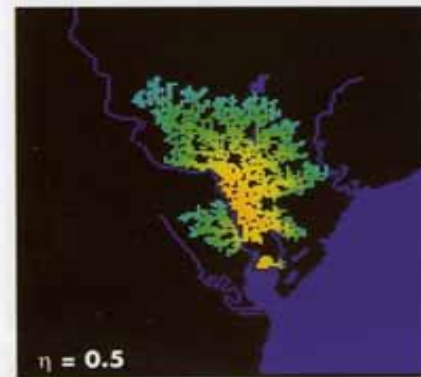
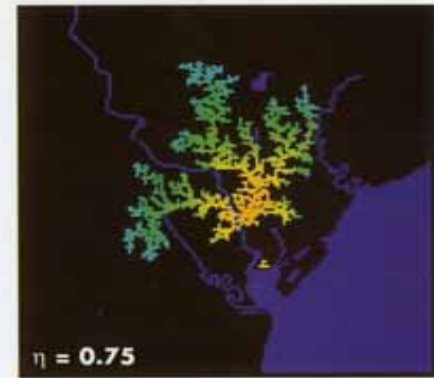
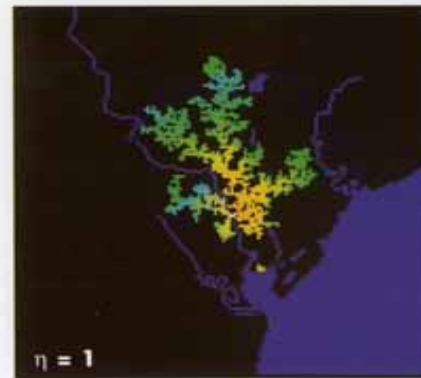
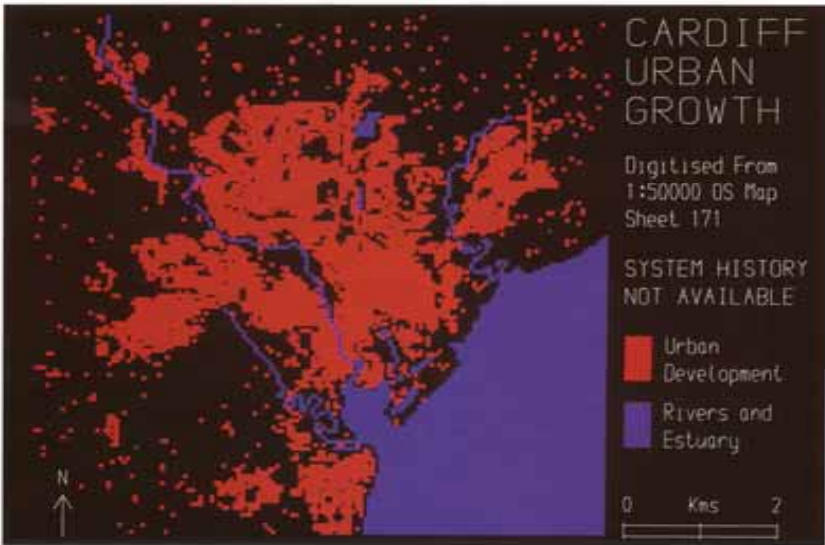
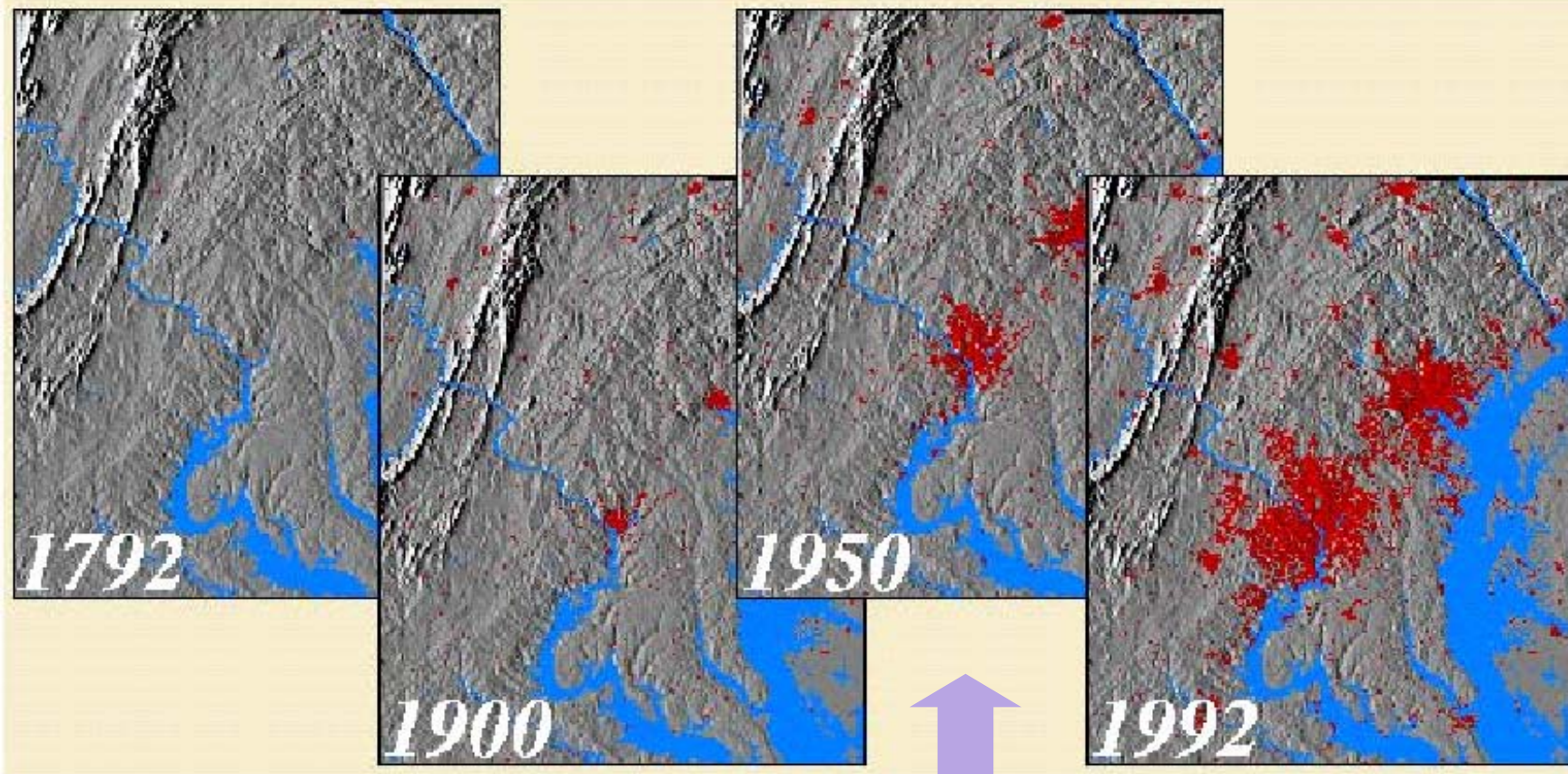
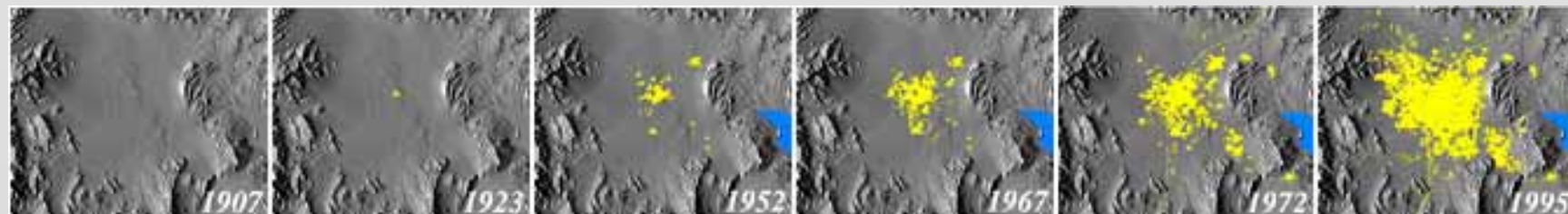
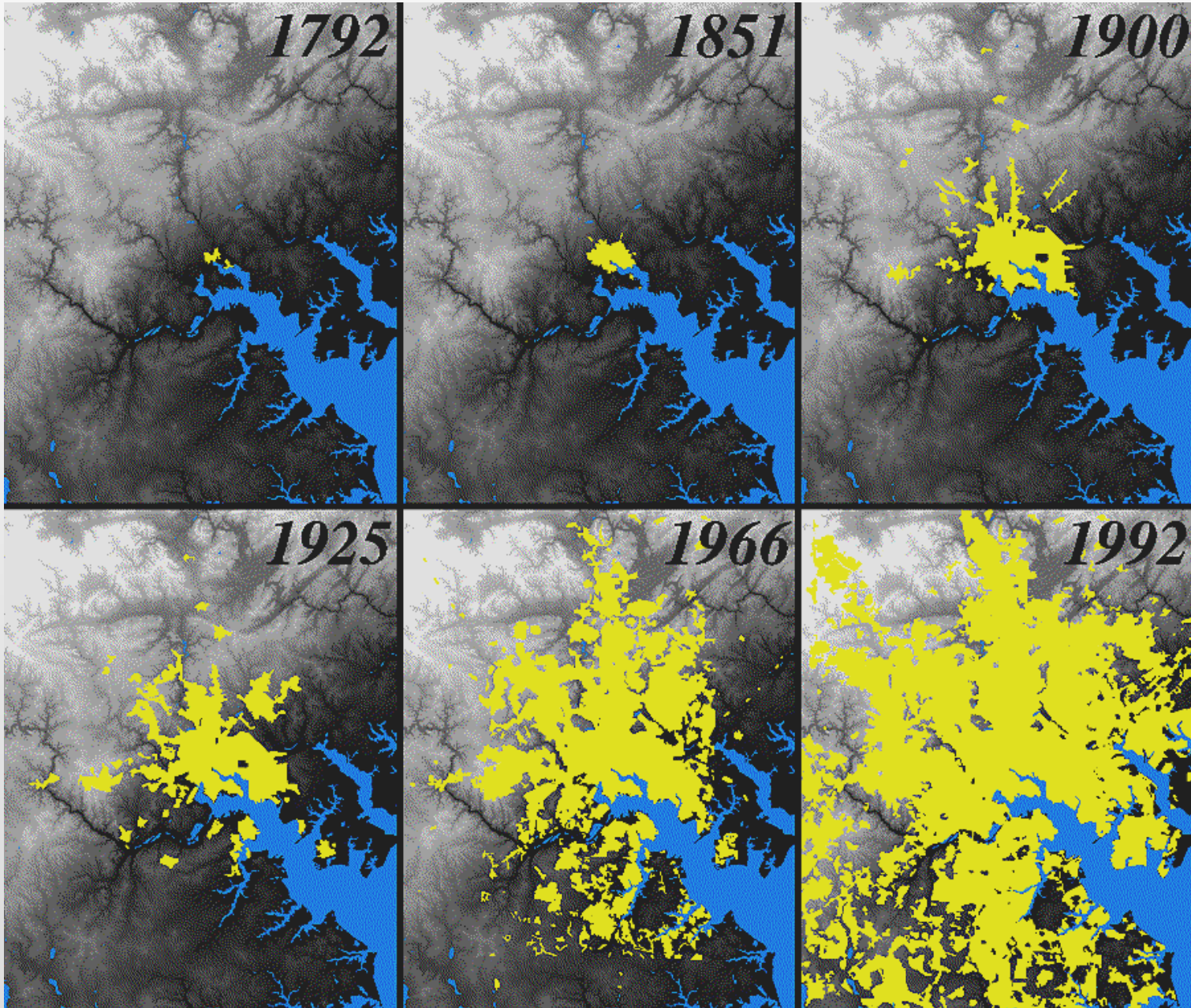


Plate 8.6 Simulating the Urban Growth of Cardiff



Growth through time: Washington DC-Baltimore Las Vegas





More General Theory: Scale, Size and Shape

There are some really key questions that dominate what we have said so far

None of this is integrated any more formally than the way I have sketched it and perhaps there is no need to do this because the focus is on many different aspects of the city and many different problems

There are lots of things that relate to cities and their analysis that I have not talked about – particularly at the fine scales and over short time periods

In so far as the kinds of things I have talked about are tested empirically and there is quite a lot of work on this, their goodness of fit – performance – is poor

In fact many of these models are not tested at all.

These processes are rarely tested, their outcomes might be. But let me list some key problems:

- The level at which the system is considered – aggregation v. the individual – to what extent should we be searching for a theory that embraces both consistently. This has been impossible so far in economics ?
- Dynamics – the time horizons over which we need to observe cities functioning – the smart cities, big data focus is shortening these massively but with consequent changes in what we are interested in
- Equilibrium – do such models that we have seen have any place in a theory of cities?

- The extent to which our models should be tested and validated empirically? A place for models as thought experiments and as simulations of a range of outcomes – exploring the solution space.
- The role of prediction more generally in social systems is key, especially in the context of design and prescription
- To what extent should a science of cities embrace design? This raises the whole question of policy
- The age-old question of organically growing versus planned cities needs extensive scrutiny in the wider context of a science based on the evolution of cities
- I have talked about location but interaction is key

- The key focus to me is on *scale, size* and *shape* applied to *locations* and *interactions* –which means on activities and actions in fixed places, and on interactions between places
- These can be accomplished at *intra-* or *inter-urban* scales and a good question is whether we should expect the same processes and structures and patterns to pertain to both
- I am conscious that my focus on morphology has played down interactions, networks, and although these have entered, all and more of what I have said here about locations apply to interactions that have their own morphology.

Attempting a Synthesis

The biggest question of all is should we attempt a synthesis? Even if not, I am sure we need a big picture in which to anchor our efforts.

I realise this has been a rather general talk but I know that some of my colleagues who study cities would consider it to be rather narrow. And that is a paradox

I would welcome comments and of course discussion because I think there are many aspects of this history that we should be cautious about and we need to identify unproductive lines of inquiry. These as we know do not necessarily die out and good ones do not necessarily prosper.

Questions & Comments

My coordinates again

m.batty@ucl.ac.uk

<http://www.complexcity.info/>

CASA, UCL

<http://blogs.casa.ucl.ac.uk/>

<http://www.casa.ucl.ac.uk/>