From (Before) Analog to (After) Digital: A Personal Perspective

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Abstract: Where did the ideas that shape the methods that we have been talking about in this conference for the past 20 years come from? And what was the development process? The transformation from analog to digital is only a small part of that development process. My presentation has examples that span 5,000 years. In this presentation, I speculate about the history of the development of the ways in which we look at the landscape and propose to intentionally change it… by design. And I will also offer some speculations about the next years.

Note: This presentation is based on the transcription and images of my unscripted keynote lecture at DLA 2019, which have been lightly edited and added to for this 2020 version. My somewhat informal style has been retained.

Keywords: Design methods, design tools, analog methods, digital methods, history and development

1 Introduction

I have the advantage of having been among the senior colleagues and friends for the twenty years that Erich Buhmann has organized the Digital Landscape Conference and so I get advance notice as one of the people who gets asked about what the next year's theme should be. And when Stephen Ervin developed the 2019 topic there was a subtopic called "Analog to Digital". I immediately said to Eric and Stephen "That's the story of my life. I'm going to give that lecture."

I have been thinking about issues related to this theme for a very long time. I'm interested in the genesis of the ideas that shape the methods that we have been talking about in this conference for the past 20 years (STEINITZ 2009). Where did these ideas come from? And what was the development process? The transformation from analog to digital is only a small part of that development process. My presentation has examples that span 5,000 years. I am going to speculate about the history of the development of the ways in which we look at the landscape and propose to intentionally change it… by design. And I'll also offer some speculations about the next years. It's risky. In my work I like to think two generations ahead, but technically it's not so obvious what will happen in the future. Nonetheless, I'm going to make some speculations in the end of this presentation about the next years and where I think the most important questions for research and development are. And it is a personal perspective. I am not an historian. I'm a collector and an adapter and I sometimes get an idea that may make sense.

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2 Before Analog

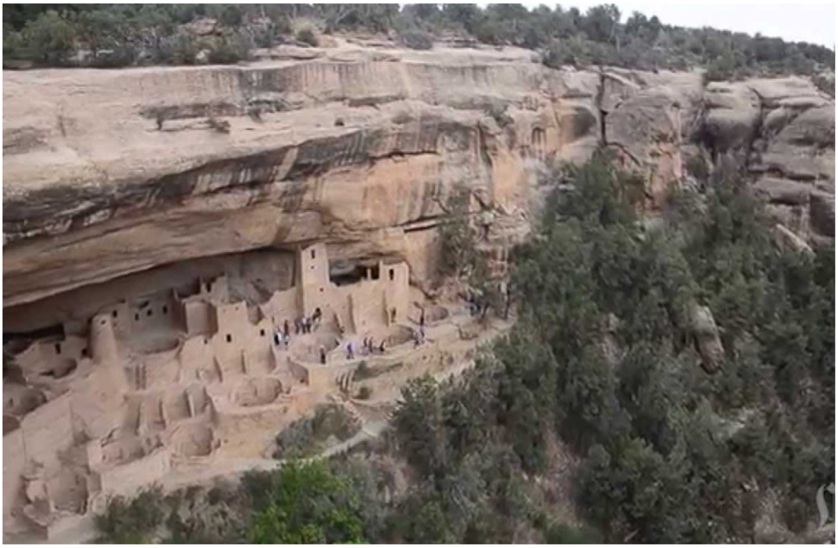
This first image is a settlement in a remote part of the Philippines. It's a settlement that could be a thousand years old. Nobody knows. It's an old photo. It was taken and given to me by Charles Harris who hired me at Harvard in 1964. I have often used this slide in my theories and methods course in my very first lecture. I always asked my students to write down the rules to explain this place. And they think about it for a little while and then we discuss it… and it turns out that there are about five or six rules… and these are the rules more or less, not necessarily in priority… but maybe they are in priority.

Luzon,
The Philippines
Charles Harris
1956

Fig. 1: A settlement in the Philippines

The first one is: don't build in the flood plain… it's hazardous. The second is: protect your agricultural land. The third one is: build where it's sunny. The fourth is: don't build where it's erosion prone. The fifth is: keep some forests for materials to build, for tools, maybe for food and for fire… and maybe that's enough. The resulting pattern is the pattern of life. It's probably family life, and it might be a very traditional process of agriculture… And while you can explain it in greater depth, those five or six basic rules are the important ones. So please remember this image, as I will show it again. It's based on rules. There is nothing special about the rules. They make sense. They produce an aesthetic. But they're basically for day to day life for normal people in their environment. There is nothing special about them.

Another rule might be: protect yourself. Be prepared to defend yourself against enemies. It could also be to stay cool in a hot landscape. This is Mesa Verde, a very old Native American settlement in America.



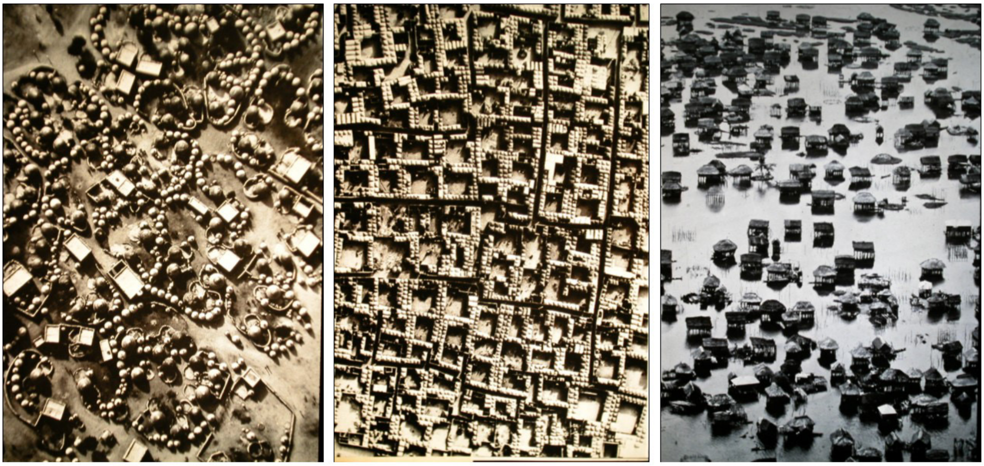
Mesa Verde, USA

Fig. 2: Mesa Verde, USA

Another rule is if you have cattle and are polygamous and you have a Chief, then design your settlement in its landscape to protect your economy and organize your society. This is a polygamous, Chieftain-based society in which cattle are wealth and sustenance.

Fig. 3: A polygamous, Chieftain-based society

And if the climate changes, change the way you live. Some of these images come from a wonderful book by Bernard Rudofsky called *Architecture without Architects,* which was a book that I read in 1964. It was very influential on a generation of architects of which I was one. It had an implicit basic message: People aren't stupid. They learn how to adapt, design and survive.



Bernard Rudofsky, Architecture Without Architects, 1964

Fig. 4: Adaptation to climate

3 Analog

Analog… Most of us use this word wrongly. We use it as representing a set of technologies that aren't digital. But analog really means that it is analogous – something that is comparable to another – an analog of the exterior world. In other worlds, there is an analogy… a larger idea… a construct that determines how we design things.

This is Upper and Lower Ogol, a Dogon settlement in Mali. It is very complicated. It's a highly symbolic pattern of organization. The roof *is* the family. Each family has to make the roof of its house, and then carry and place it on the tall and small building. And there are lots of them.

And the question is: What explains this pattern of settlement? And the answer is: the human body. This is a French priest's interpretation, having lived there (GRIAULE 1965). The altars are at the feet. The altars are masculine. The oil stone is feminine. The women's houses are on the sides, and outside when menstruating. The family houses are the chest and the assembly place is the head. And the council meets in the northern building near the forge, the source of fire, which is the community's enabling power. That is the organization of this place… And you either know it or you don't… and this knowledge is transmitted by oral tradition.

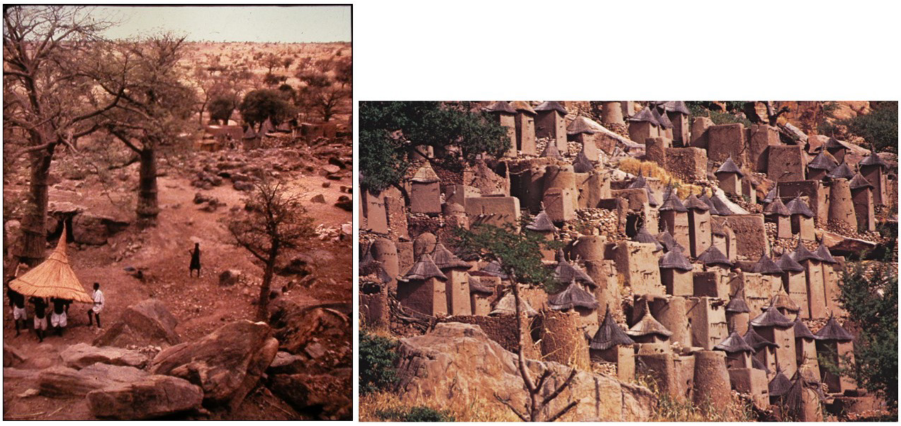
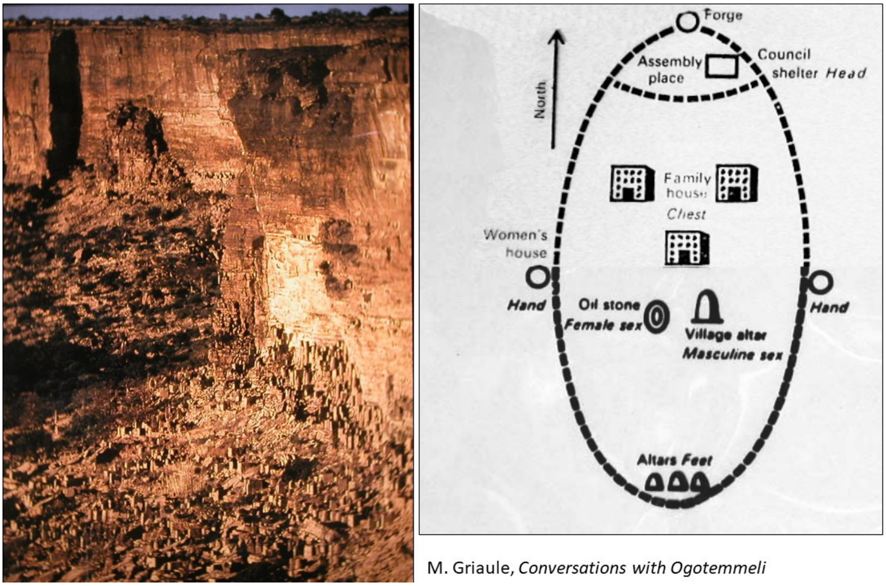


Fig. 5: Family houses, Upper Ogol and Lower Ogol, Mali



M. Griaule, *Conversations with Ogotemmeli*

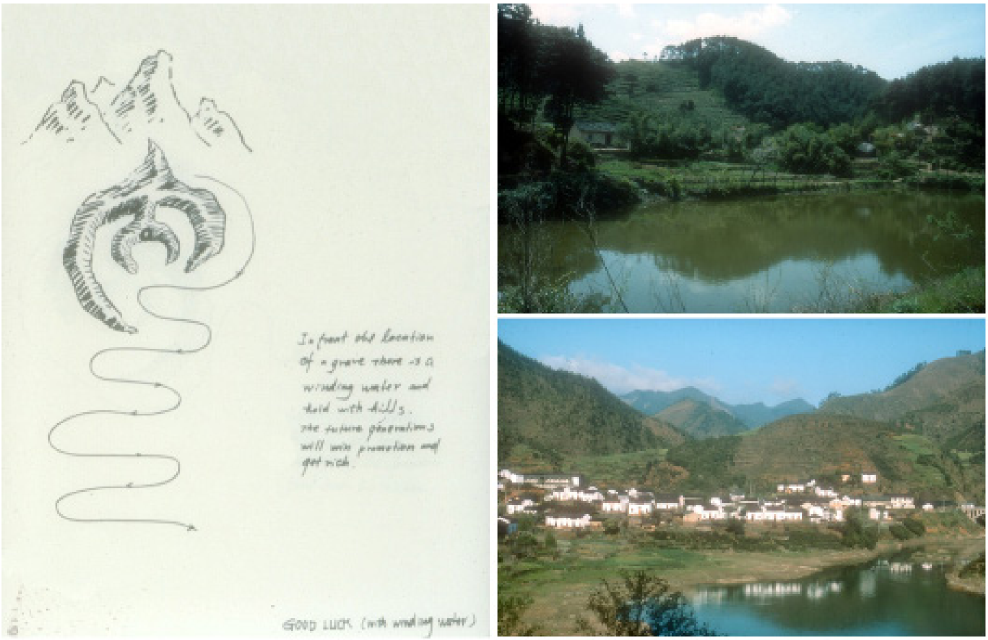
Fig. 6: Upper and Lower Ogol settlement pattern

There are Chinese books in the Harvard Yenching library about Feng Shui from three thousand five hundred BC (XU 1990, 2016). The ideal site in Chinese Feng Shui is for a grave. The grave takes precedence over the house. The house takes precedence over the city. The ideal form to locate a site is surrounded by the tiger and the dragon and has three layers of mountains behind. And there are thousand year old books that interpret these landscapes. There are two schools of interpretation. There is the form school that basically analyzes the physical landform for auspiciousness; you build or can make an site. Or there is the compass school which deals with orientation as the basis for assessment. These are competing schools. They are not compatible… Either you use one or the other.

Xu Ping Feng Shui, est. 3500 B. C. Form School Compass School

Fig. 7: Feng Shui form school and compass school

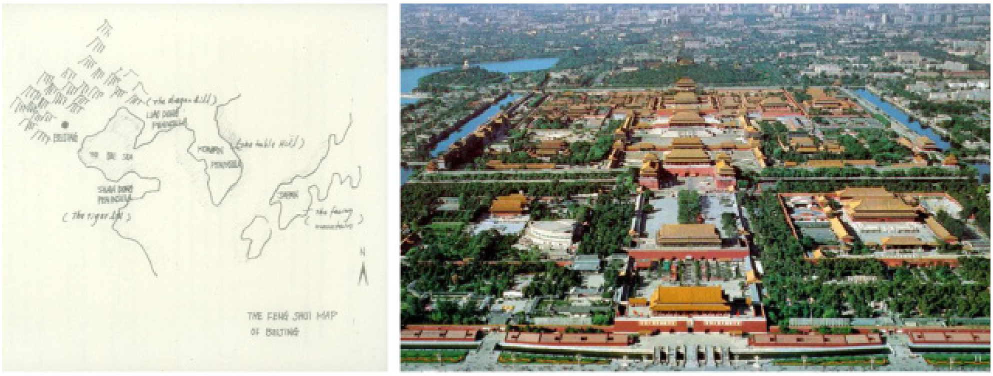
So the ideal site is this, with running water not aiming at you but going away from you. And those are the graves on the right in the best location and that's the house on the left. The graves – the more important ones. And that's a village in an ideal location.



Xu Ping

Fig. 8: Feng Shui form school ideal sites

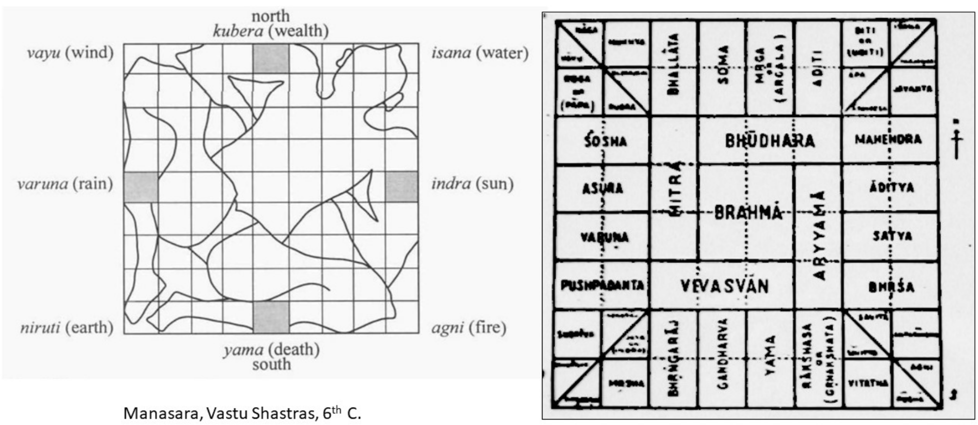
And that is the location of Beijing with the dragon and the tiger and Japan in the distance, and the water follows that principle. The location of the country's Capital city and the seat of the Emperor and a simple farmer's grave… they follow the same analog worldview. Feng Shui was considered superstition and outlawed in recent times… but it is still present.



Xu Ping

Fig. 9: Beijing, an ideal location from Feng Shui form school

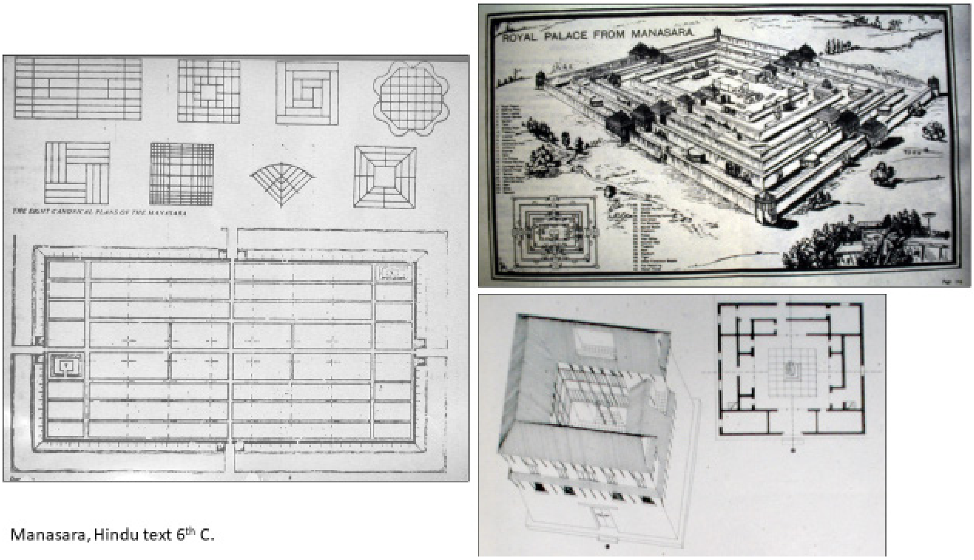
The Manasara [1] is a sixth century Hindu document which identifies the conditions of the ground for a temple or for a town plan. There are instructions and tools. The conditions include smell and taste. You are supposed to taste the ground for acidity, and you are supposed to hit the ground with a hammer and if it's rocky it will make one sound and if it's sandy it will make another sound and if it's wet it will make a third sound. The organization of the community is based on the caste system and the roles they play in society, and the auspicious areas are for the higher castes and the less auspicious are for the lower castes, not unlike social class analyses of modern cities.



Manasara, Vastu Shastras, 6th C.

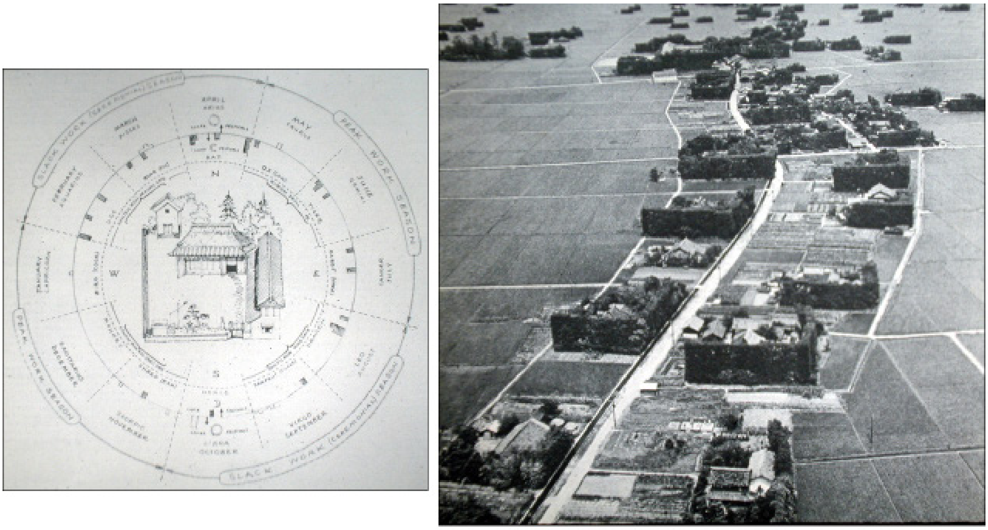
Fig. 10: Manasara, ideal settlement organization

The social organization must be designed in one of eight canonical town plans… and anything else is evil. The concept of evil is a site plan criterion. And this also applies to the house, where different functions are in different locations. There is a best location orientation and there is a worst… auspicious and evil… a worldview analog.



Manasara, Hindu text 6th C.

Fig. 11: Manasara, ideal organization of 8 town plans, temples and houses



Bernard Rudofsky, Architecture Without Architects, 1964

Fig. 12: The zodiac and Japanese farm houses

The zodiac is what determines the shape of rural farm houses in some parts of Japan (RUDOFSKY 1964). There is a reason they all look similar. That's because they're based on the calendar of the zodiac and where the winds come in different directions and where the sun comes in different directions at different periods, and the different seasonal activities of being a farmer. And you see them in Japan today.

Fig. 13: The zodiac and Japanese farm houses

So these are analogs: The central idea is that there are super-ideas that govern what we do technically with our methods and our technologies. And you can fairly ask… it is legitimate to ask the question of us today: "What is your super-idea? What is the analog?"

The most basic tool is really simple. It's a string and a rock. And the characteristic of applying a string and rock to the design for dividing land for tax purposes and ownership leads to a particular kind of orthogonal design with straight lines. It leads to simple geometries because they are easier to measure. Curves are hard to measure. Straight lines are easy to measure.

Fig. 14: Surveying in ancient Egypt to divide land for taxation and for building, 3000 BC +-

You need to make maps to record the landscape. Maps are also old tools. On the left is the earliest scale map according to Wikipedia, and this map is 3500 years old. It’s Nippur, in Sumeria, now mainly Iraq. It’s a carved clay tablet with a map of central Nippur. And on the right is a map of China that is a thousand years ago. China's coastline and river systems are clearly defined and precisely shown on the map. You measure and somehow record the lines in each grid cell, then you put a grid on a large flat stone and redraw your lines on the stone and carve them… and you have a scale map of a huge area.

Fig. 15: Map of central Nippur, 1500 BC +-, Map of China, 1137

This is the region of Angkor Wat in Cambodia. Its development is a thousand years old. It is huge, and it is orthogonal in a jungle. That’s it on Google Earth. That’s the city of Seam Riep. This temple complex is about 30 kilometers by 20 kilometers. And it is fully orthogonal. It was designed and constructed without Google Earth, without satellites, without drones. It was done on the ground, with bamboo sticks, string and stones. In a sense, surveying precedes landscape architecture by a long time… by about 5000 years… and the technologies of terrain analysis precede us by about 4000 years…

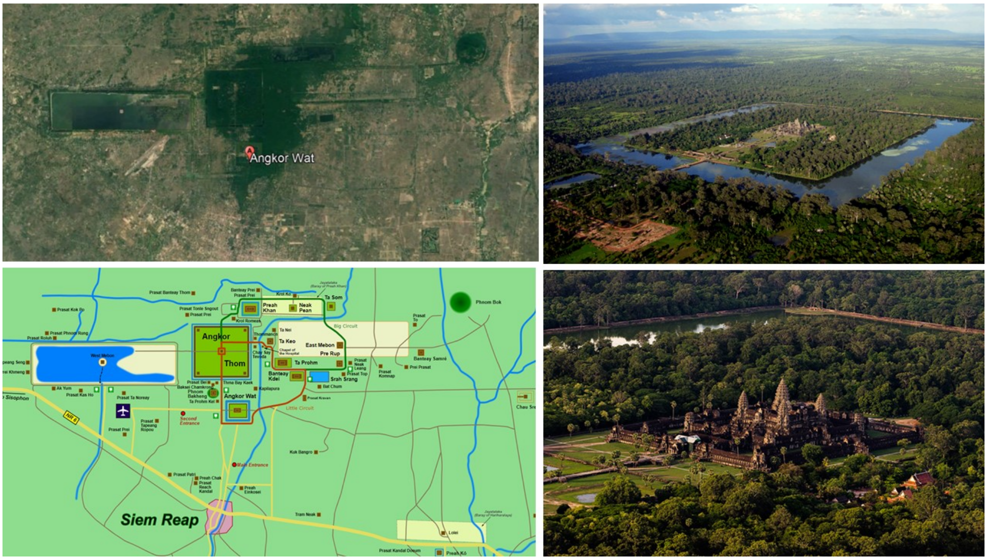


Fig. 16: Angkor Wat region, Cambodia, 12th C

Surveying eventually reshapes the land. That's Thomas Jefferson (1743-1826), third President of the United States of America. When he decided in 1785 to divide what is now the middle of the United States, he sent his surveyors and they changed the landscape. At the time, that one project was one third of the United States of America.

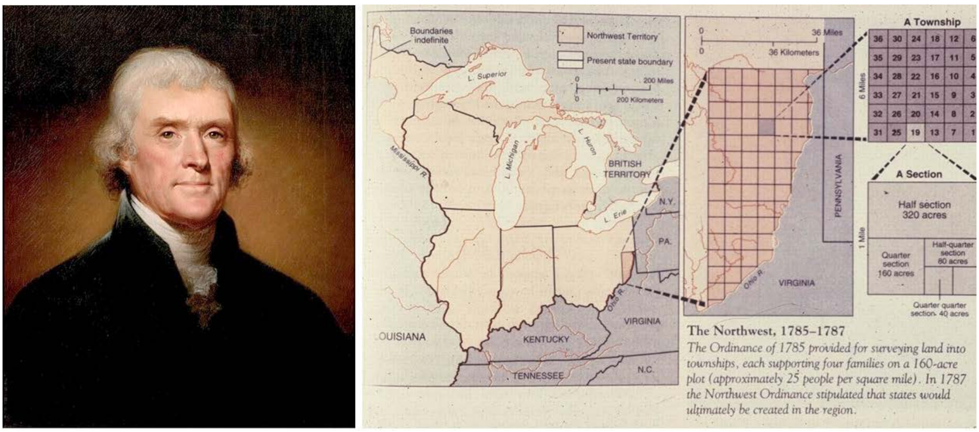


Fig. 17: Thomas Jefferson and the Northwest Ordinance

You can still see those patterns if you fly across the country. They are very powerful and lasting changes based on surveying techniques which are based on very simple measurements. But you have to do them, and now you can do them digitally from satellite-based measurements.

Fig. 18: Current land in the Northwest Ordinance

So the ideas of mapping are old and basic. We tend to consider tangible drawn maps on clay, stone or paper to be an analog representations, because they are symbolic representations of the real world. But we can map the same analogical representation digitally and we would call it a digital representation… how confusing. Surely it is the data which are the analog, and not the representation medium. So when we are working digitally, we're not so different from these earlier people. We're also making spatial analogs and using them. And some of us use them more cleverly than others… but the tool is to organize data as an analog of the real world… and then to represent the study-area.

Before and After

Humphrey Repton (1752 – 1818)
Wentworth, UK, 1790

Fig. 19: Before and After

One of the really important innovations was by Humphrey Repton (1752-1818), the idea that you can make a visualization of a design but that you need two of them, before and after… so I can know what was there before and what the designer changed. I have rarely seen a design presented in two drawings in this conference over the past 20 years, and in 50 years by students that aren't mine. How many of us tell our students it takes two drawings or maps to show a design? Repton was absolutely right! We're usually wrong.

The idea that maps were public as opposed to private is probably 17th century. The English Ordnance survey began in 1801. The Ordnance Survey in England had as its task to produce maps at the level of a house and at the level of at least a group of trees and with roads, streams and terrain, at a national scale. The equivalent still doesn't exist in many parts of the world.

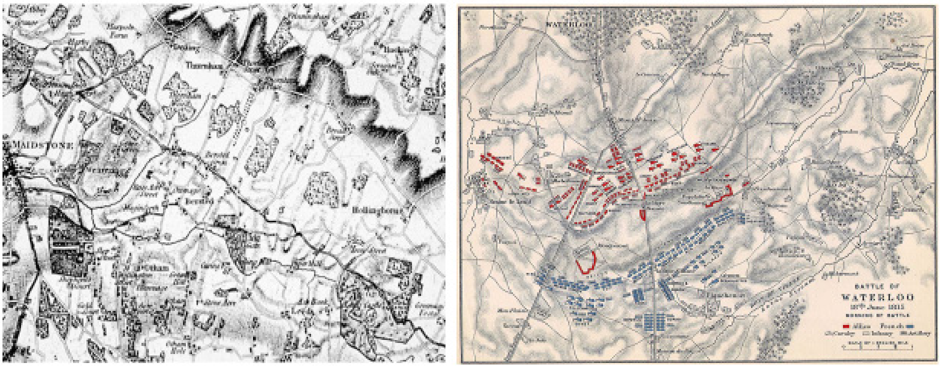
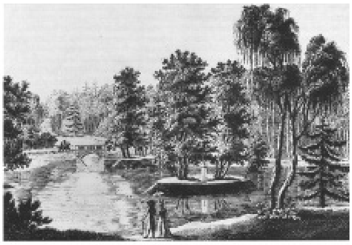


Fig. 20: Ordinance Survey, England, 1801 and map of the Battle of Waterloo

When Peter Joseph Lenné (1789-1866) designed the expansion of Berlin in 1833, you see a drawing made on a map that has every road and every building, and you have to ask where did that map come from? How did that happen? And it's clear that somebody decided… years before… to start making maps of every building in Berlin, and so, when Lenné makes his drawing, it is on a base map and in scale.

Fig. 21: Peter Joseph Lenné, Expansion of Berlin, 1833

And that's his drawing of his remaking of the Tiergarten. It is also a changed drawing based on a drawing.



Großer Tiergarten, early-19th-century engraving

Fig. 22: Lenné, Tiergarten in central Berlin

And that's what the Tiergarten is today.

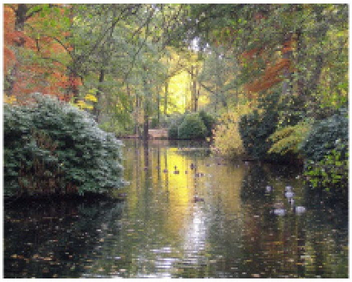


Fig. 23: Tiergarten, Berlin

But consider the time of Lenné. He had no air views. The surveys and assessments in the base map and his design were all from the ground; which is important because that's how the area could be perceived. Basically, Lenné was working in the way most landscape architects still work professionally most of the time. Today, we also have survey-based maps, and we change them by design into other maps. And we draw perspectives (probably only after-views), and we say: "This will be a great place… let's build this place…" In other words we haven't learned so much since the times of Repton and Lenné.

The next example is a methodological breakthrough. Warren Manning (1860-1938) was a landscape architect in America. He was a very important landscape architect. He initially worked for Olmstead and the Olmstead office had its technology at the right time. They had electricity and Charles Elliot wrote that there was a light table in that office. They also had materials to draw on that were translucent. They were not transparent but they let light through. So you could make a drawing, put it on a light table and put another drawing on it, and as long as those drawings were at the same scale and in the same geo-referencing system you could basically make overlays. So Manning made separate maps of different influential data for the town of Billerica Massachusetts… not one analogy-based map for the site analysis like the Chinese would do but separate maps… one of soils, one of roads, one of slopes… not too many, maybe five or six… and he put them all together and he evaluated where the houses should be. The method was published in Landscape Architecture in 1913. This is the first published use of overlay techniques from separate data maps that I'm aware of. I've written a paper on the history of overlay methods (STEINITZ 1976)… Manning's was the earliest published example.

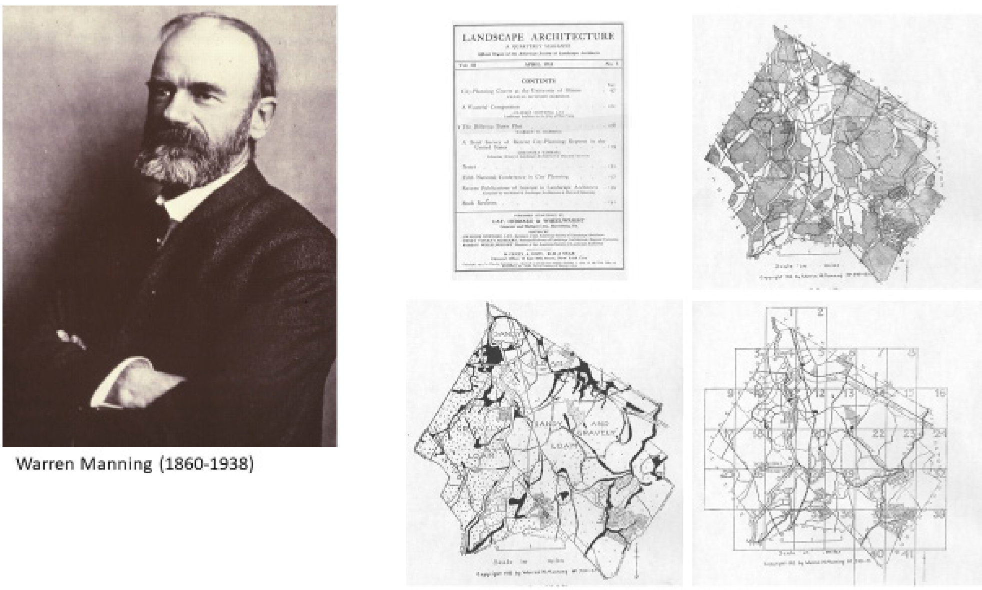


Fig. 24: Warren Manning, Billerica, 2013

The most important early example of overlays is this next one, also Manning's. The early part of the 20th century in America is when the country started producing national maps of its assets. It's a big country and the government wanted to know what we have. About 400 maps were made, and Manning redrew them to one scale in ink on a translucent material. Manning could then overlay these maps on a light table.

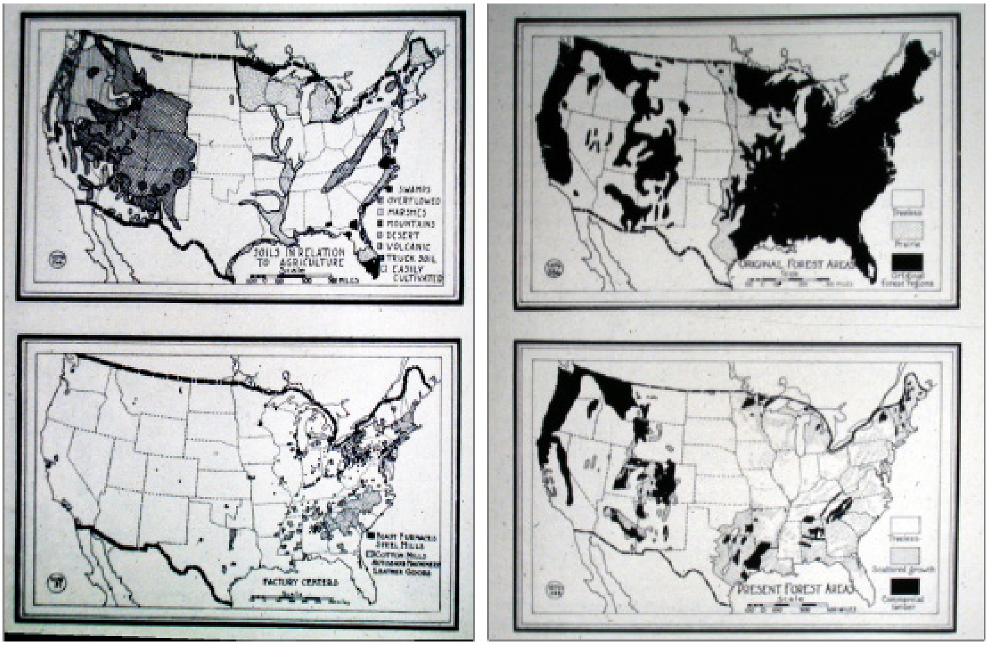


Fig. 25: USA data maps, redrawn by Manning, early 1920s

Manning then made the first design for the whole United States of America. This is one of the most important projects in the history of the profession. It was published in Landscape Architecture in July 1923 and to my knowledge, to this day it's the only physical plan for the United States of America as a whole that was ever made. And what does it have? It has the Interstate Highway Network. It has the national trails along the Atlantic and the Pacific. It has major reserves of National Parks, particularly in the West and the Southeast. It has future urban areas along the coasts and the South, on the West Coast, the Great Lakes region and the Northeast. It was designed with overlays of national data on a light table with pencil and ink and a lot of thought. It's very impressive.

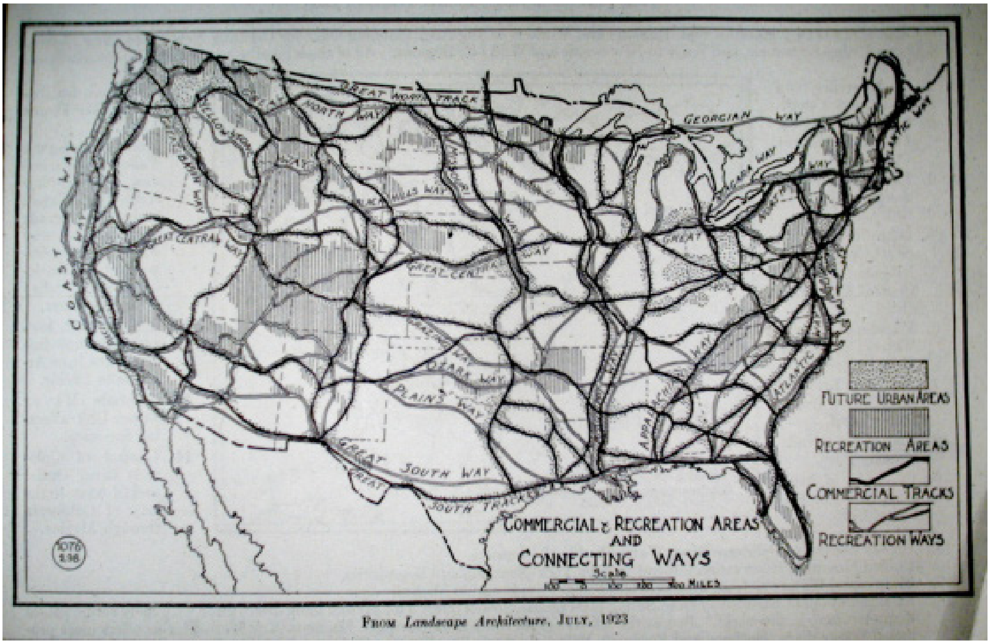


Fig. 26: Manning, Design for the USA, 1923

Patrick Geddes (1854–1932) was a philosopher, a biologist, and a planner… a polymath. As an evolutionist and a global thinker, he was interested in the interrelationships between people, their activities, and their environment. The Valley Section diagram expressed those relationships. The Section begins in the mountains and falls to the coast. At the highest elevations in the mountains, it is natural and usual to find miners; in less high areas to find forests and woodmen; lower to find hunters and shepherds; still lower, peasant farmers and gardeners; and finally, along the shore, fishermen. Failure to respect these human-landscape interrelationships either doesn't work or requires too much energy and too high a risk.

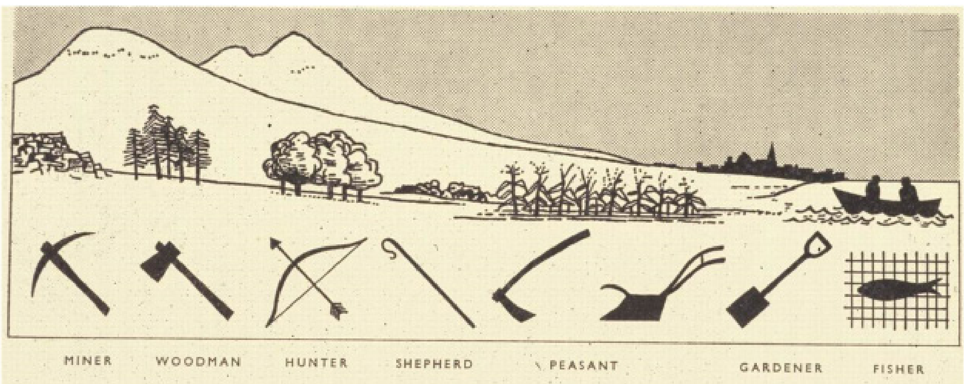
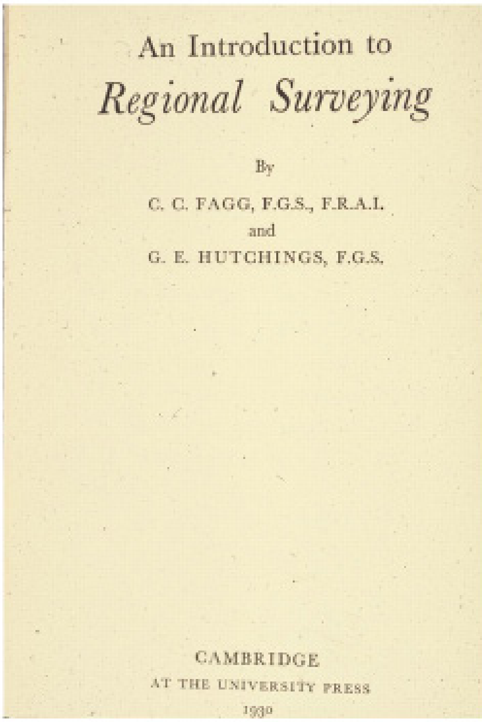


Fig. 27: Patrick Geddes, The Valley Section

This is the earliest diagram of systems interaction that I've ever seen, although there may well be others. It is from Fagg and Hutchings' 1930 book *An Introduction to Regional Surveying.* Fagg and Hutchings were influenced by Patrick Geddes. Human life and Civilization are based on vegetation and animal life which are based on drainage hydrology and the terrain and these are based on the earth's geology and climate. What else do you want to know? And each of these interacting processes implies a model. And when one process changes, that changes the others. That's what Fagg and Hutchings wrote in 1930 and that's exactly the kind of systems thinking that many of us are working in today.



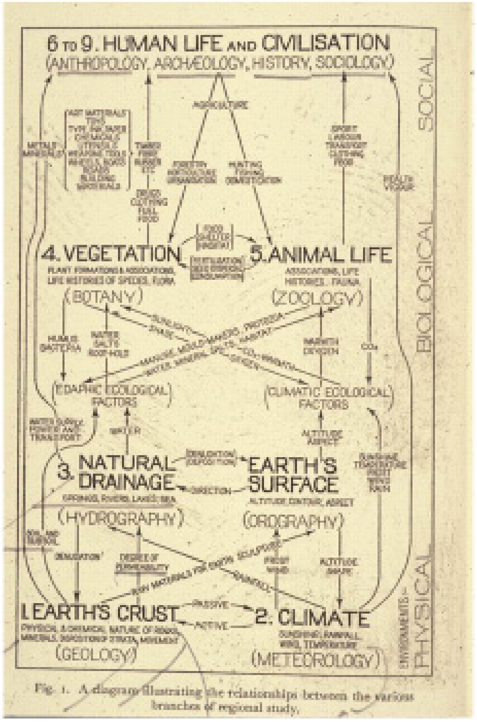


Fig. 28: C. C. Fagg and G. E. Hutchings, 1930, and The Branches of Regional Study

During the Second World War, the British had known that they had a huge rebuilding to make. This was also true in Germany, France, Italy and other countries, but the British were organized about this. "Regional Planning", by L.B. Escritt and published in 1943, is less than one centimeter thick. If my beginning students would read this book, they would know much of what I teach. For example, they would learn how to make overlays, and how to use them to analyze the landscape for particular purposes. The techniques are simple and effective. I want you to look really carefully at this drawn figure based on Boolean logic. There are five data categories, and there could be more. It doesn't matter what their contents are. But each of them is produced as a line drawing in a different orientation (or none). They happen to have different symbols but that's not the important part. It's the varied orientation which is important. Each combination of these is different and each different combination is used for a potential different purpose or constrained for different reasons. The advantage of making overlays in different orientations is that you know what the elements are, not just that there are more of them in any location.

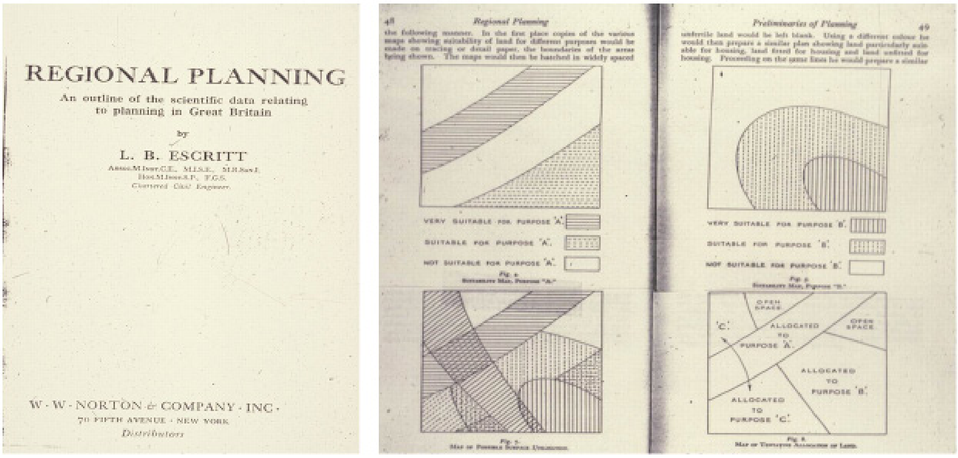


Fig. 29: L. B. Escritt, 1943, and overlays in Boolean Logic

The British produced very good correspondence courses for the military on the theory that the people who were then in the military managing the war would come back and manage the country. The textbook proposed that every place needing physical redesign needed twelve data-based assessment maps… and from those twelve maps they could make a town or/and country plan. They didn't need big data, they needed twelve. And these are how they should be drawn.

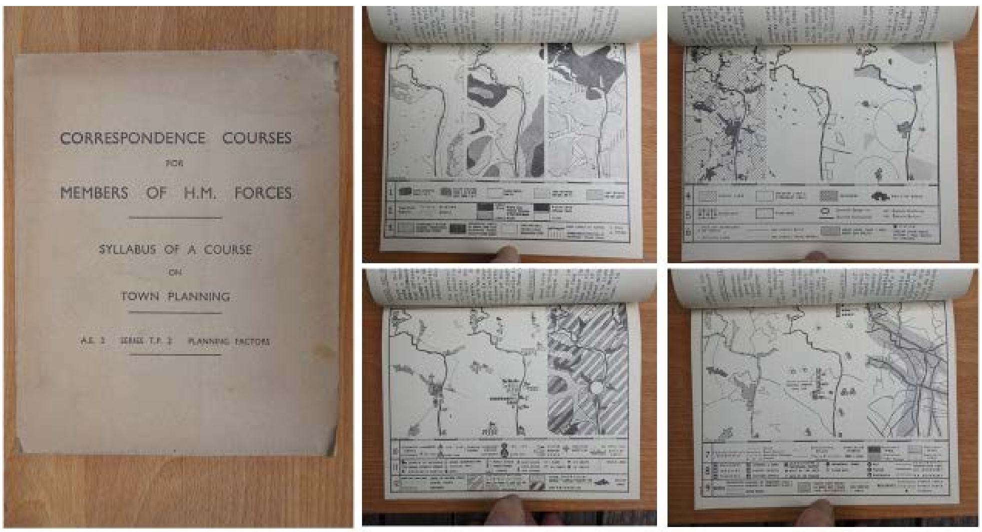


Fig. 30: Syllabus of a course on town planning, UK, and 12 data based assessments, 1945

Look at the postwar application to Exeter, which is the only example that I have found. Exeter was heavily bombed. Black means leave it alone, it's still functioning. White means it's unconstrained, you can expand the city there. And each of these overlain combinations can be read by their orientations as to what's going on there, and the more there are the darker it is and therefore it's more constrained. Almost no current GIS software produces as sophisticated an analysis as these examples then made by hand. These are more easily understood analyses than what we're producing today.

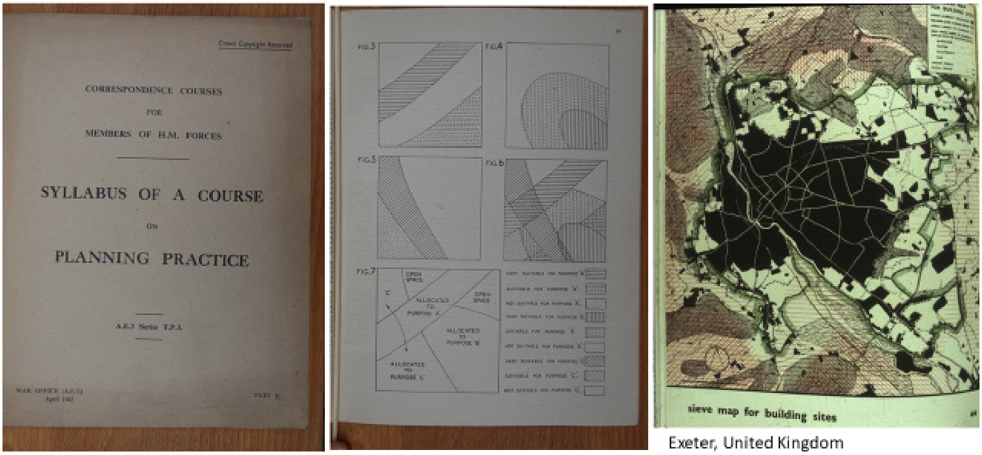


Fig. 31: Boolean logic overlays, and sieve map for the Plan of Exeter, UK, 1945

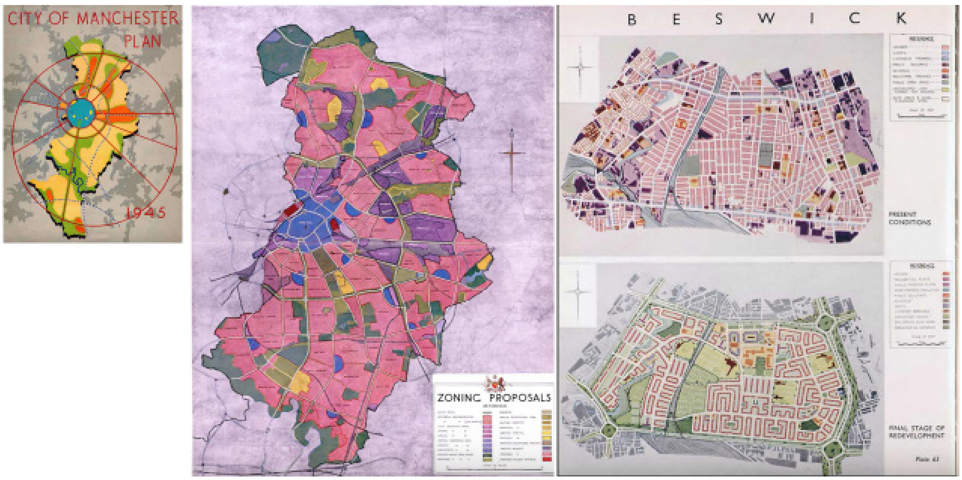


Fig. 32: City of Manchester Plan, UK, 1945

And not only that. Today, almost all digital software uses colors. However, when overlain and combined the summary map normally has changed all the initial colors and nobody can tell what the original elements were. If you were working in the Britain in the postwar period and making a colored plan drawing, these are the national colors that you would have to use, so that the sum of local plans could all be read and coordinated for larger regions. The colors of Windsor and Newton became the official colors of the planners who were educated around that time. After electing a socialist government, in 1947 the British nationalized planning control of all land. They were able to implement a very good planning system very quickly because they had the books to teach the planners and national conventions for analysis and representation. Who has a set of standard colors today? Who even makes a legend on every digital PowerPoint slide?

In 1964, Christopher Alexander and Marvin Mannheim were at MIT. Both were interested in design methods. Earlier, they had started a study of road location. They decided that there were twenty six factors that would influence the location of a highway.

Fig. 33: Christoher Alexander and Marvin Mannheim, 26 highway criteria, 1964

These could be drawn as factor maps in black and white, and overlain and then redrawn in a hierarchical structure. These are the partial analyses and that is the final combined set of criteria. And those are the main choices, and that's a better choice than that, so this highway should probably go there. A similar experiment appears eight years later in Ian McHarg's very influential book *Design with Nature*.

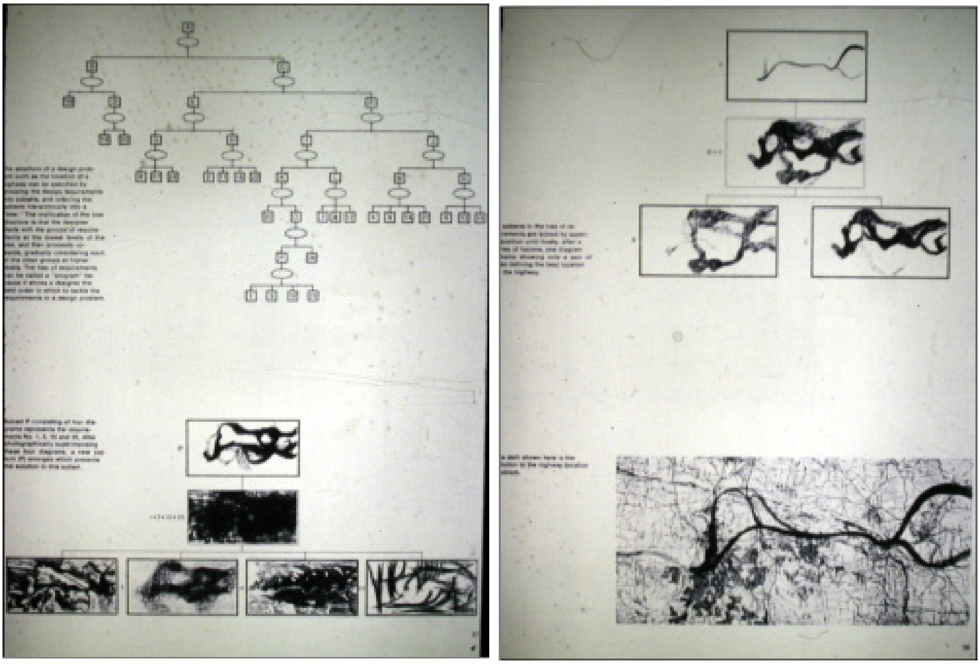


Fig. 34: Alexander and Mannheim, combining 26 highway criteria for the best location, 1964

Buckminster "Bucky" Fuller (1895–1983) was an American architect, systems theorist, author, designer, inventor, and futurist. He believed that the whole world was a design problem. He created the World Game in 1961 to be a comprehensive database and educational simulation tool to create solutions to overpopulation and the uneven distribution of global resources. He wanted to create solutions that shared resources globally in the most equitable fashion possible for what he called the real enemies of humanity: hunger, illiteracy, lack of health care, environmental degradation and selfish national thinking. Participants In the game were required to cooperatively solve global scale solutions to hypothetical scenarios, thus generating a more holistic global perspective. The game remained largely speculative throughout Fuller's life and he claimed that he had been playing it "longhand" since 1927. "Bucky" Fuller was prescient and right: the entire globe now reflects the most important problems requiring design.

Fig. 35: Buckminster Fuller and the World Game

4 The Transition to Digital

The transformation from what we consider analog to digital methods is mainly a transformation of older ideas to digital tools. The basic aims are also very old. We now have digital tools which can enhance our understanding far beyond our personal view, smell, taste and touch, but our ways of applying these digital tools to design today are also not really new ideas.

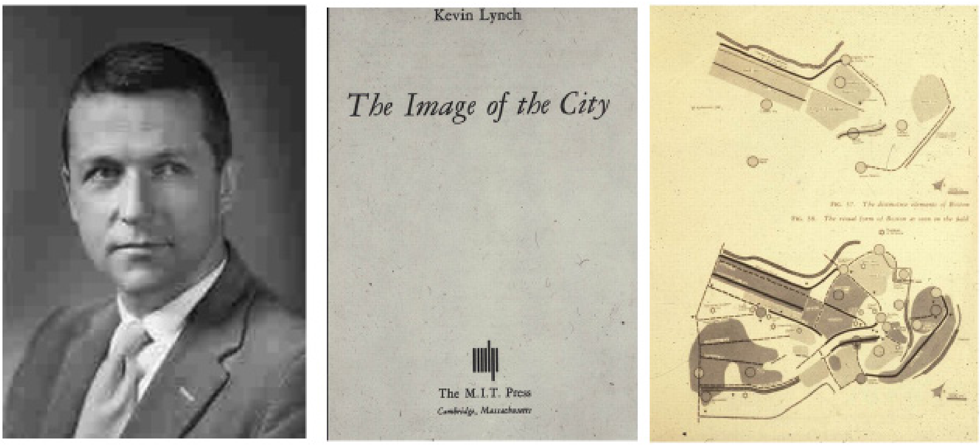


Fig. 36: Kevin Lynch, Image of the City, and the image of Central Boston

For me, 1964 was the transition year to some things being digital. I was then the first doctoral student of Kevin Lynch at the Massachusetts Institute of Technology. Kevin Lynch (1918–1984) considered the region to be a design problem. He was famous for having published the book *Image of the City* in 1961. That book is now in about fifty languages. It was based on interviews, and described how people spatially organized and understood the cities in which they lived. Lynch had studied Jersey City, Los Angeles and Boston. I was in his 1961 seminar in which he gave a lecture about how he did this work and I said to myself "This is a very important study", and it is. But while the book describes, it doesn't explain. It describes and interprets the results of the surveys, but it doesn't explain why some parts of the "image" map of Boston are included and dark, while some parts are excluded and white.

Why is something in or not in the *Image of the City*? I decided that was going to be the question driving my doctoral thesis. Graduate students often take an idea of their professor, thinking maybe that it is not the full answer… and this also was my attitude. So I decided that I would study and try to explain this area of Boston. I made three explanatory hypotheses… that the "image" could be explained by one or more of three different congruence-relationships between urban form and its activity patterns: type, intensity and significance.

I divided the same central part of Boston into hundred meter squares… metric, in 1964. And I walked every square of that part of Boston and took the most public photograph in each from where the most people were looking. In other words I would go to a place and I would say to myself that there are X people and most are looking in that direction… take that photo and make notes. So this is a map… of photographs. There are about a thousand of them in the full version.

Fig. 37: Map of photos, form zones and words, activity zones and words CS

I then interviewed a lot of people in a stratified sample of three variables: young people – old people, black people – white people, northeast people – southeast people – west people – residents. I asked each of them in two randomly ordered sets of questions about the physical shape of the city and its activity patterns… for example, on a base map of central Boston, to map the areas that are of similar physical character, and to write the words that they would use to describe those zones? And I redrew their maps on a single map of zones and words. I also asked them about the activity patterns. Where do things happen in the city and what are the adjectives and nouns that they would use to describe the activities? And I had a huge amount of data.

And it happened that one day in 1964 that I was at weekly lunch at the Harvard-MIT Joint Center for Urban Studies where I was a Fellow. I sat next to Howard Fisher (1903–1979), who I had never met… a total accident of life, one of many that governs one's life… believe me. He turns to me and says "Who are you?" and I say "I'm Carl Steinitz" and he says "What do you do?" And I said "I'm Kevin Lynch's doctoral student." And I said "Who are you?" and he said "I'm Howard Fisher. I'm here because I'm about to join Harvard, the Design school" And I said "Oh, that's very interesting. I'm going to be teaching at the Design school… What are you there for?" And he said, "Well… I've invented a computer program that can draw a map, and I will start the Harvard Laboratory for Computer Graphics." And I said "Well… I've got a lot of data. Maybe that's something I should do." And he said, "Tell me about your data?" And I told him about photographs and that I was going to encode aspects of the photographs. And he said "Oh yes, we could make a map of that." Now please understand that there was only one computer at Harvard at that time. And it was the size of this room. And it was controlled by three people who worked around the clock. And, if you were a faculty member, you had one access every day with a box of Hollerith cards and they would run it for you eventually and you would come the next day and collect your cards and your paper output.

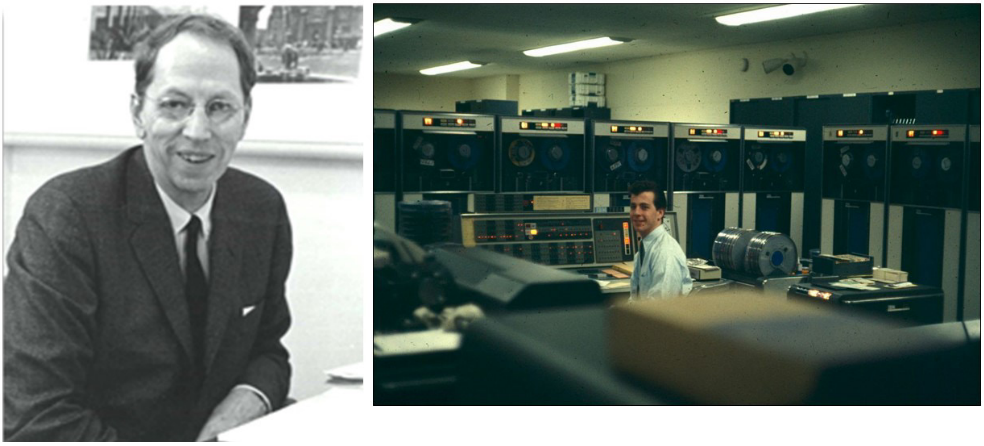
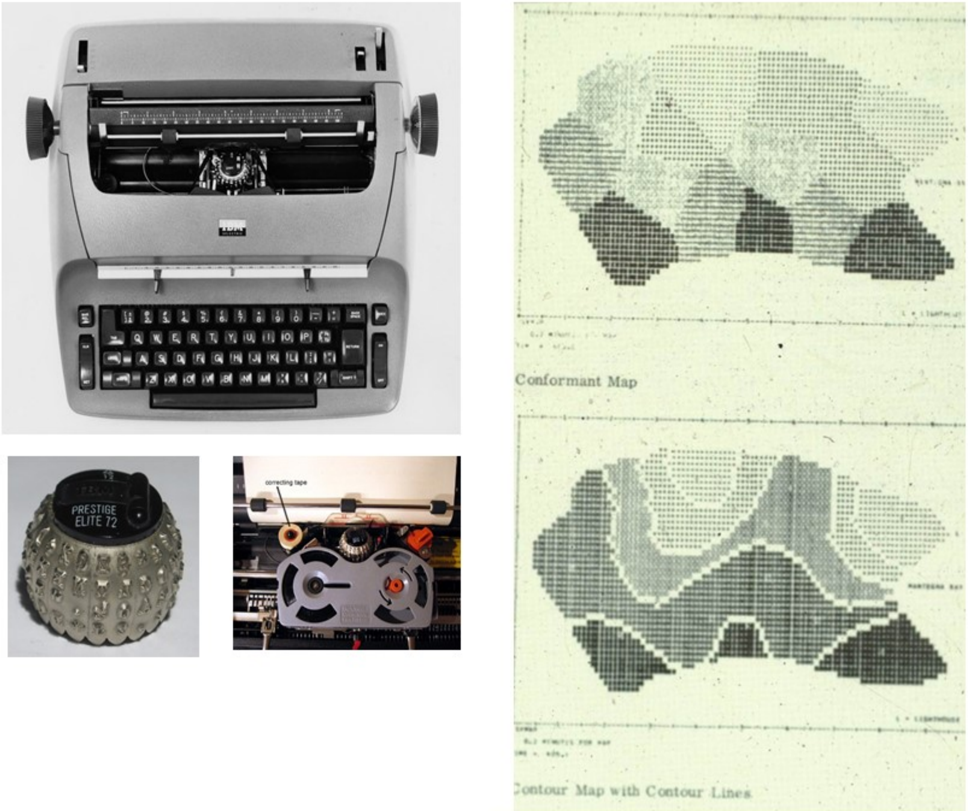


Fig. 38: Howard Fisher, and the Harvard University computer, 1964 +-

Howard Fisher had figured out that the IBM computer made its printing with the same typing ball that was in the IBM electric typewriter. It's a ball that moves and it twists and it prints. He had figured out that you could stop that ball via Fortran program and it would overprint O, X, I, =, and that combination would turn that rectangular letter-position black. And he could make a map from black to white simply by stopping the printer ball and making it overprint. Fisher and his programmer Betty Barnes had made some algorithms that allowed one type of map to be transformed into another type. And I said "I need that thing… will you teach me?” And he did. I spent four weeks learning Fortran and learning how to use this program, SYMAP.



Howard Fisher and the Laboratory for Computer Graphics, Harvard GSD, 1964

Fig. 39: IBM Selectric Typewriter and SYMAP

I then encoded the form and activity characteristics in the photos that I thought people looked at and noticed, and field notes including noise and smell. And I made maps of those characteristics and I made what may be the first urban digital GIS.

I then took the interviews and I encoded them in the same format. I then had to write a program to assess my hypotheses and that showed graphs of the results of my hypotheses. So in the figure from the top row, type congruence was a powerful explanatory hypothesis, intensity congruence was not a powerful hypothesis, and importance congruence was a contributing partial relationship. And I could finish my thesis in 1965 (STEINITZ 1968).

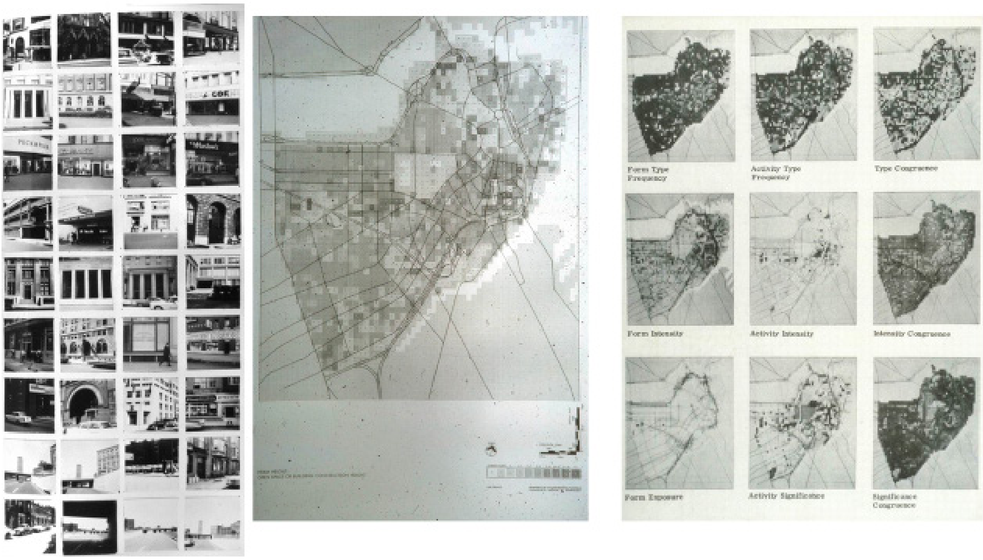


Fig. 40: A visual and GIS assessment of Boston, MA, USA

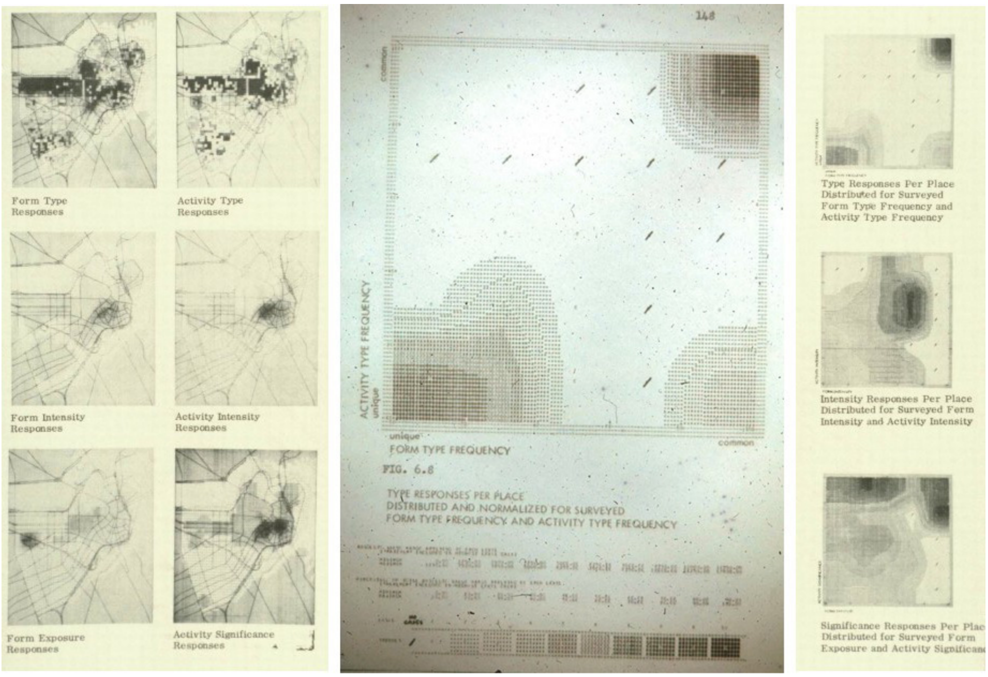


Fig. 41: Data, GIS and the congruence of form – activity type, intensity and significance CS

In 1965 I taught my first collaborative studio (STEINITZ 2014). That handsome young man is me. This base map is of the entire state of Delaware and parts of Virginia and Maryland, USA. The studio was funded by The Conservation Foundation and the central problem for design was the conservation strategy for this peninsula just south of Washington DC which was under pressures of rapid suburbanization and a growing chicken industry. This was a joint studio between the Landscape Architecture and the Planning departments. The visiting critics included Ian McHarg (1920–2001) and Phil Lewis (1925–2017), who were very important landscape architecture professors.

I told the faculty that I wanted to do this study with students who were prepared to do it by computer… and the faculty in Planning said "No". Chuck Harris, who was my chairman and co-teacher said "Yes". And so I took the four landscape architecture students who volunteered to work with me and this is what we did.

It took a month to make the base map. This base map took thirty tries and thirty days to make, and the grid of the data is one square kilometer. It took a month to organize data, much by air photo interpretation by eye and hand guided by Don Belcher who was expert in this.

Meanwhile, students guided by Ian McHarg and Phil Lewis in the first few weeks had filled the walls full of colored data maps made on paper with magic marker. Huge maps… but not overlaying them… just making them.

Fig. 42: Carl Steinitz, 1966 and the DELMARVA base map

The students then learned Fortran, and wrote algorithms to do spatial analysis operations that geographers like Waldo Tobler (1930–2018) were already thinking about. And in the second month we could run a Gaussian plume. We could make a linear traffic map. We could make a gravity model.

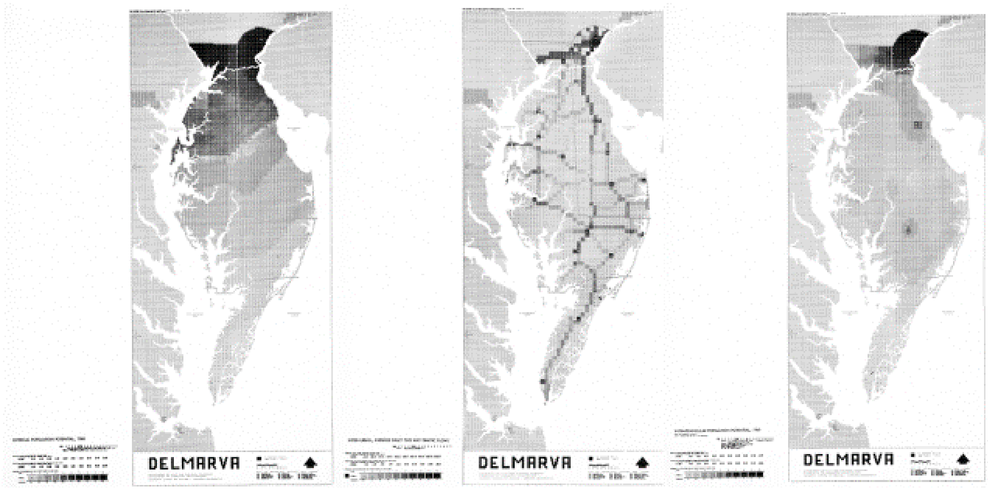


Fig. 43: DELMARVA: time to Washington DC as a Gaussian plume, daytime traffic and population gravity model

We then made… and remade… our three main synthesis analyses, all of which are weighted indices: Capability for Agriculture, a weighted index for conserving the most economically productive land, Capability for Forestry and Capability for Conservation of Biodiversity. So we had our analyses and we had three weeks to the final review.

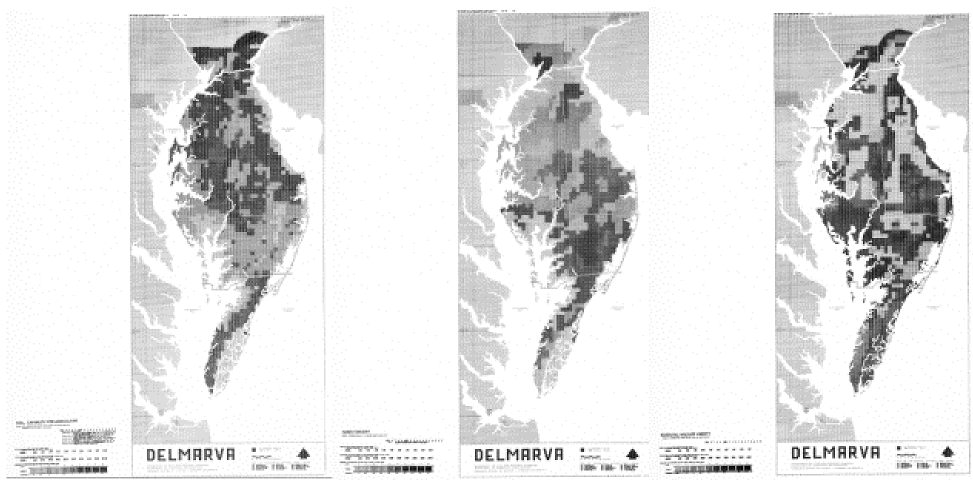


Fig. 44: DELMARVA: Capability for Agriculture, Forestry and Conservation of Biodiversity

And it took us two weeks to make two designs. One design mainly protects the agricultural interests and the other mainly protects the ecological interests. The students presented the two designs in our black and white maps, in a large jury room otherwise filled with colored maps. At the end, my students said: "…since no one told us who public clients are and what they want we can't tell you what the final design should be". And the reviewing-faculty and visiting critics refused to discuss my students' work, probably in part because our maps were made "by computer" and weren't colorful. That's a true story, and a common "computer" response in the early digital years. Chuck Harris came to me immediately afterwards and said "That was very interesting."

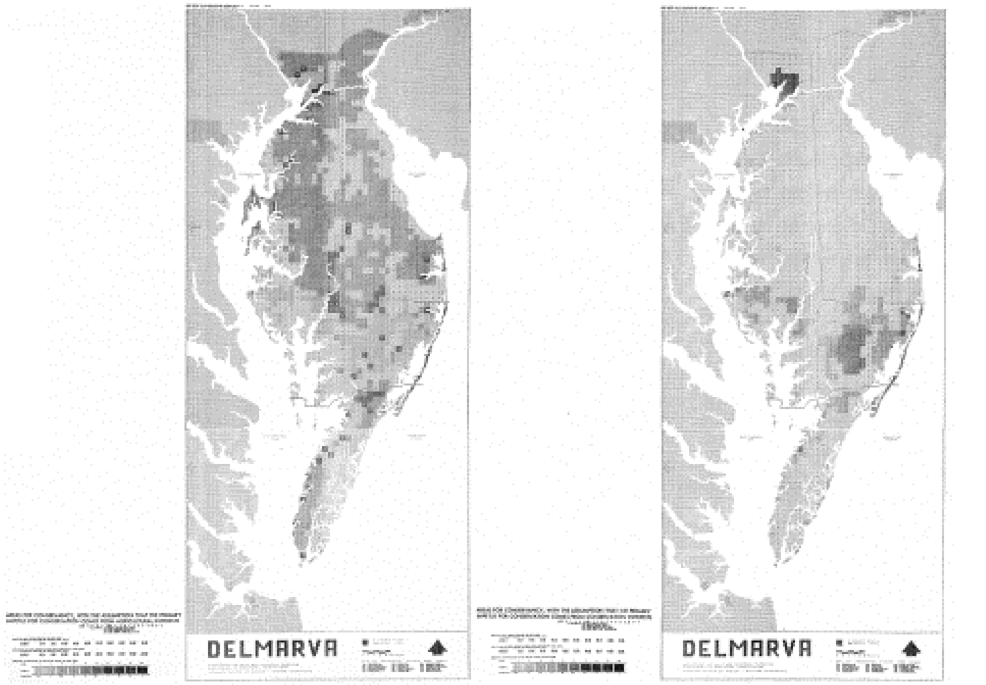


Fig. 45: DELMARVA: agricultural interests and ecological interests

Soon after that experience I made this diagram. This represents what may be the most important set of ideas I've ever had in my life. I made this diagram of how I thought landscape change works, in 1965-6. It is not inevitably directed by ecology, as Ian McHarg thought it was… or should be. I thought that it's a war between development and environment. And what I thought we needed (and still do) are: systems thinking, data, models, designs, impact models, decision models… and to apply design in linked systems-based simulation models.

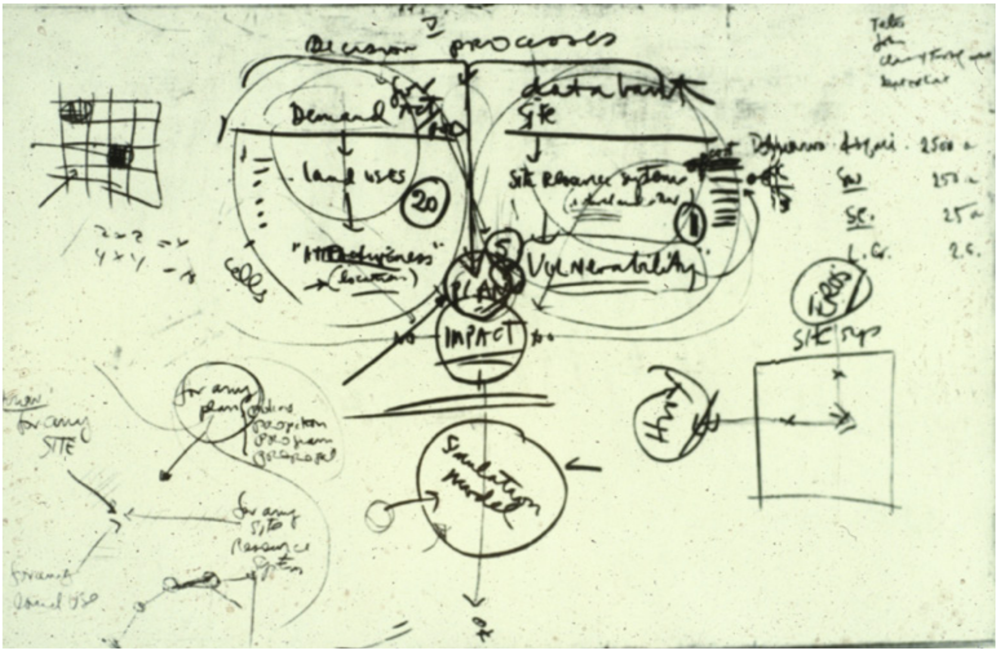


Fig. 46: Carl Steinitz, Diagram for a linked systems-based simulation model, 1965

And in 1997-8, Peter Rogers and I decided to do exactly that in our joint landscape architecture and planning studio, Urbanization and Change. Peter Rogers, who died last year, was an engineer, economist, and planner. I learned a lot from Peter, who was my close friend for very many years. And this is what we decided to do. We would grow and change about half of Boston by design within about ten linked systems models. We would have a population increase that drives growth and change, and the need for new industry, housing, recreation and commercial centers. This would require better transportation. The resulting urban pattern would impact local politics, local finances, visual quality and pollution. We would study these impacts and, if the design didn't work well, change the design, and if it did work well, add five years… and we would run it ahead for twenty-five years.

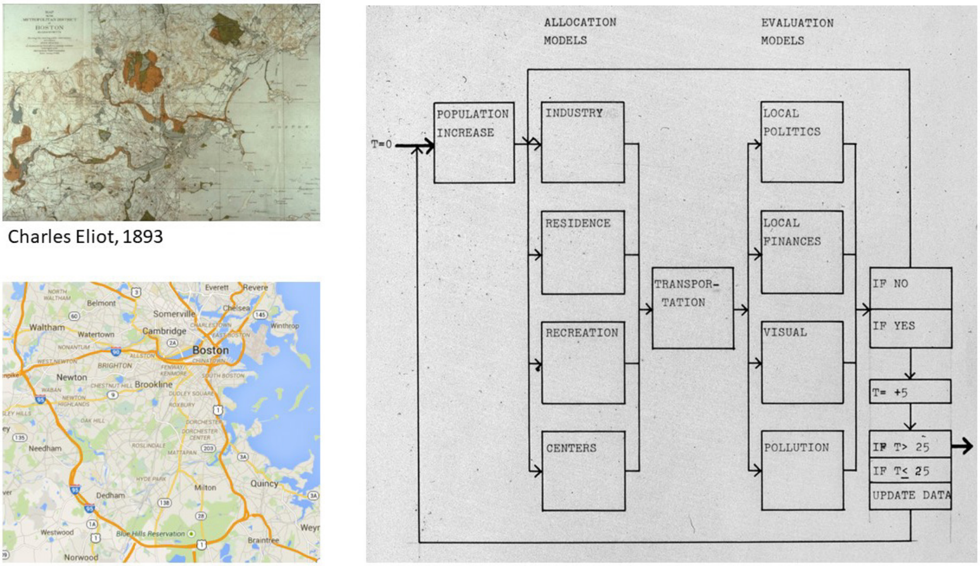


Fig. 47: Ten linked systems models for southwestern Boston

Each student selected the task of making and programming one of the digital models. For example, Jack Dangermond made the housing model and his design role would then be to find and acquire the land for housing. Jack now runs Esri, and his company makes the software that makes about half of the world's maps.

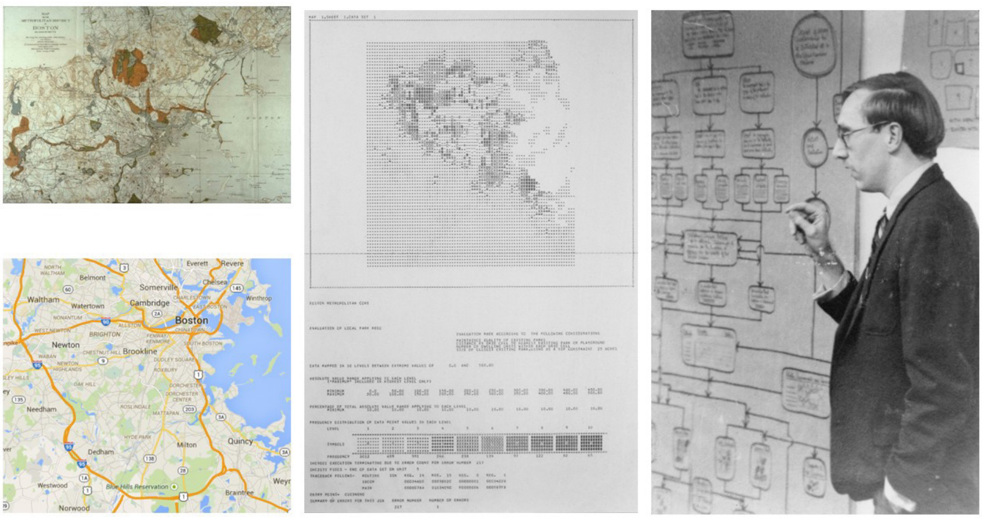


Fig. 48: The housing model, Jack Dangermond

Peter and I then took the students' models and we put them together into a chain of computer programs which would produce about twenty needed maps during each simulation period.

Fig. 49: Peter Rogers and Carl Steinitz

And then we ran a sequential land grabbing game where each square had a land use in a standard color and if you changed the land use you put a piece of colored paper in it with a pin and that represents changing that land use… and we remove one cell from our requirements. Today, this would be considered a human "agent-based model".

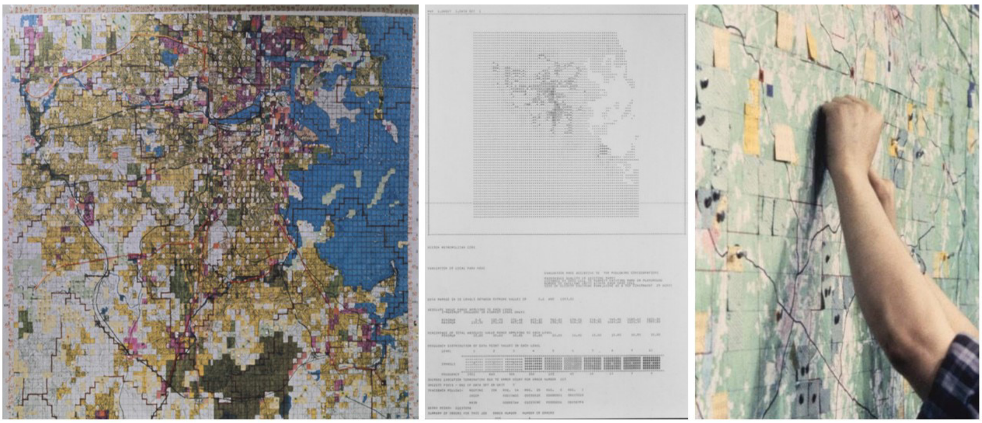


Fig. 50: Allocating new uses

We then ran each stage through the digital impact models that the students had made, had discussions and revisions as needed, and moved to the next stage in the design. This time, at the studio's final review we had a fully supportive faculty, by a different set of reviewers.

Fig. 51: Assessing impacts

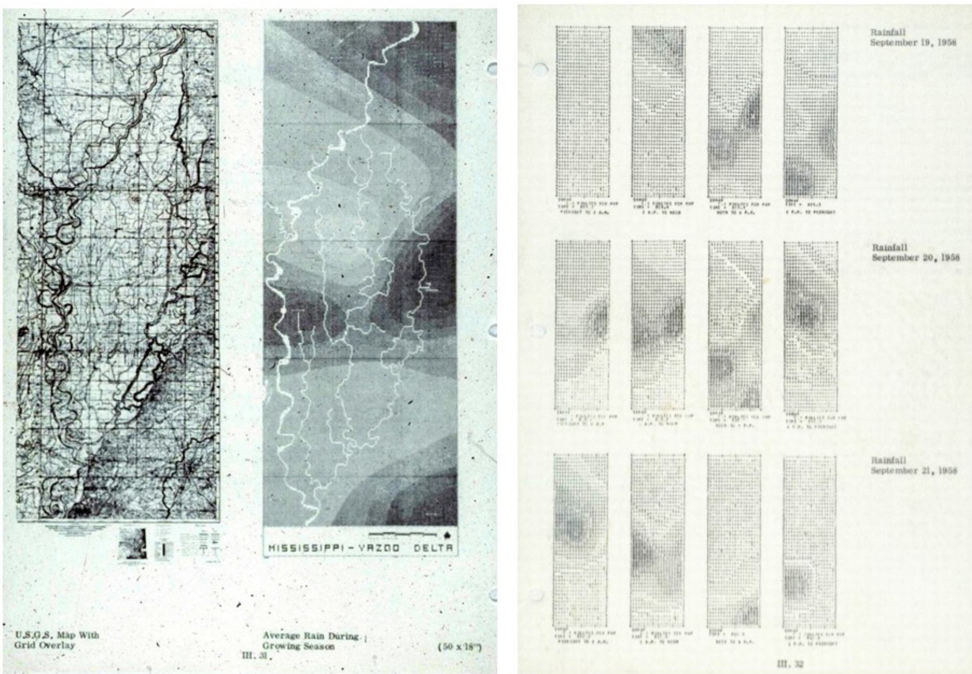


Fig. 52: The 1958 Mississippi flood, Peter Rogers

This early period of transition to digital methods from 1964 to about 1968 was an exciting and inventive one, but it was not always a happy period… except for the early adopters and those students who worked with us, all of who have had very substantial careers. It was an exceptionally creative period for digital innovation.

A lot was happening at the Harvard Laboratory for Computer Graphics and Spatial Analysis. There had been an enormous flood on the Mississippi in 1958 and Peter Rogers made the first digital time series maps, tracing the flows of rain and flood water through the Mississippi River.

Howard Fisher was really interested in three dimensional mapping. He devised many techniques for making maps in three dimensions based on blocks covered with maps of comparable slices… like a Rubiks cube… and take them apart and see them in different ways. Everybody understood that this three-dimensional mapping could be four-dimensional with time added.

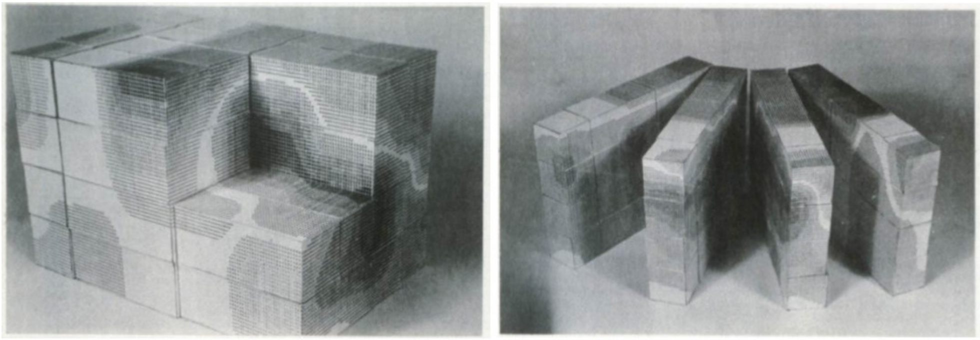


Fig. 53: Three dimensional mapping, Howard Fisher

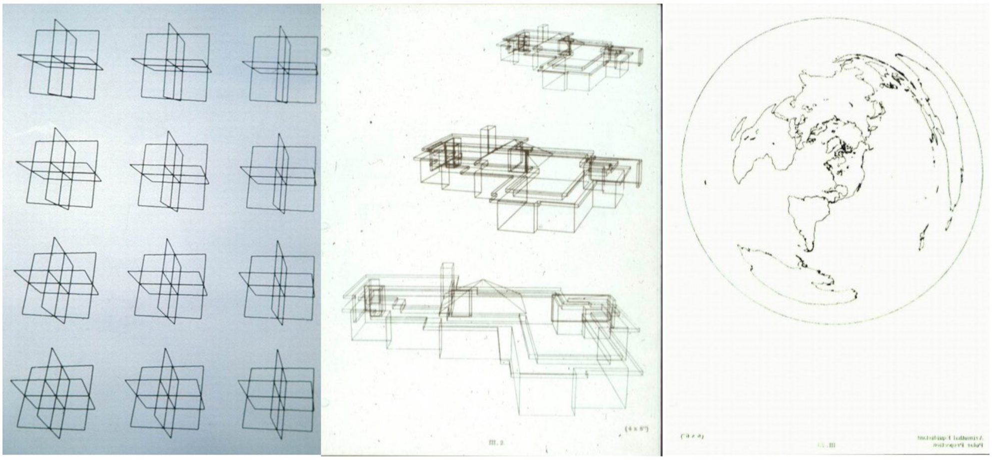


Fig. 54: Moving and Rotating 3-D forms in SYMVU, Frank Rens

Frank Wrens had designed a plotter program by 1966. He could take a set of lines and rotate them, like for the building, or the globe. We could move or rotate the line-based shapes and make any view or location the central point… the middle of the globe instead of whatever is the middle of the globe when you see it.

Bill Warntz (1922–1988) was a geographer who was interested in analyzing and representing surface topology and geometry. There are four kinds of geometry in terrain: pits, passes, peaks and pales, and they have different characteristics.

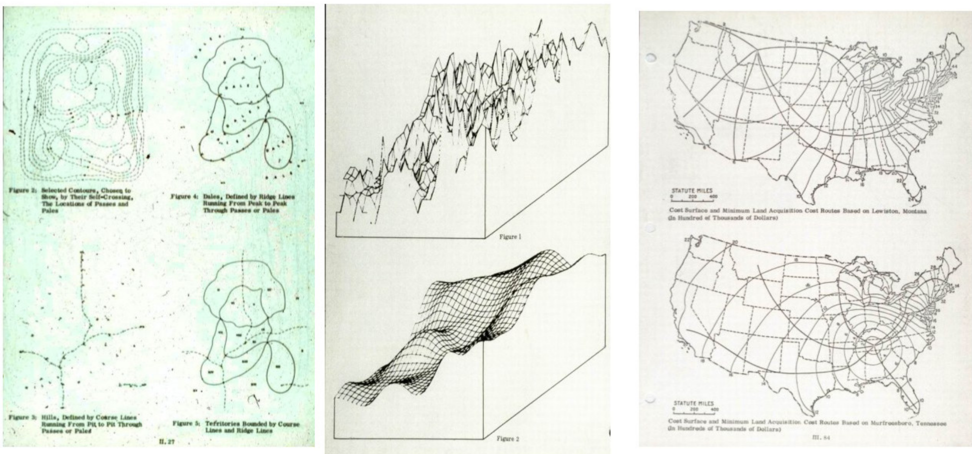


Fig. 55: Surface analyses, William Warntz

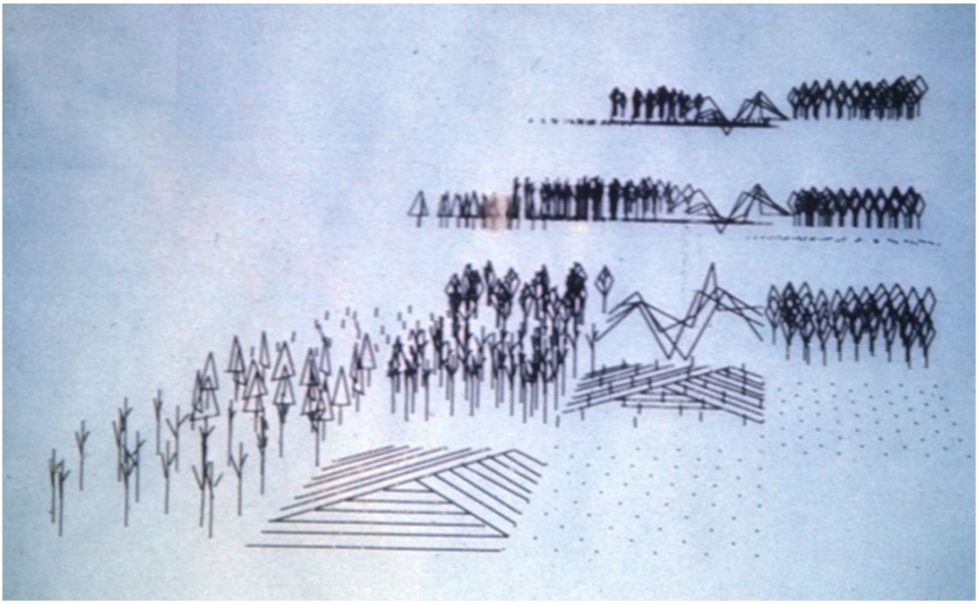


Fig. 56: Computer-generated allocation and varied views, CS

By 1966 I was algorithmically populating different kinds of trees and buildings into flat landscapes and seeing them in perspectives generated by Frank Wrens' SYMVU program. The U. S. Forest Service was also experimenting with these techniques.

And this is the same landscape with houses and an industrial building. My computer instruction placed a factory and houses in it. Look loosely… the houses don't hit the ground. So what? The next time we did hit the ground. So I knew we could animate viewing sequences in an automated landscape.

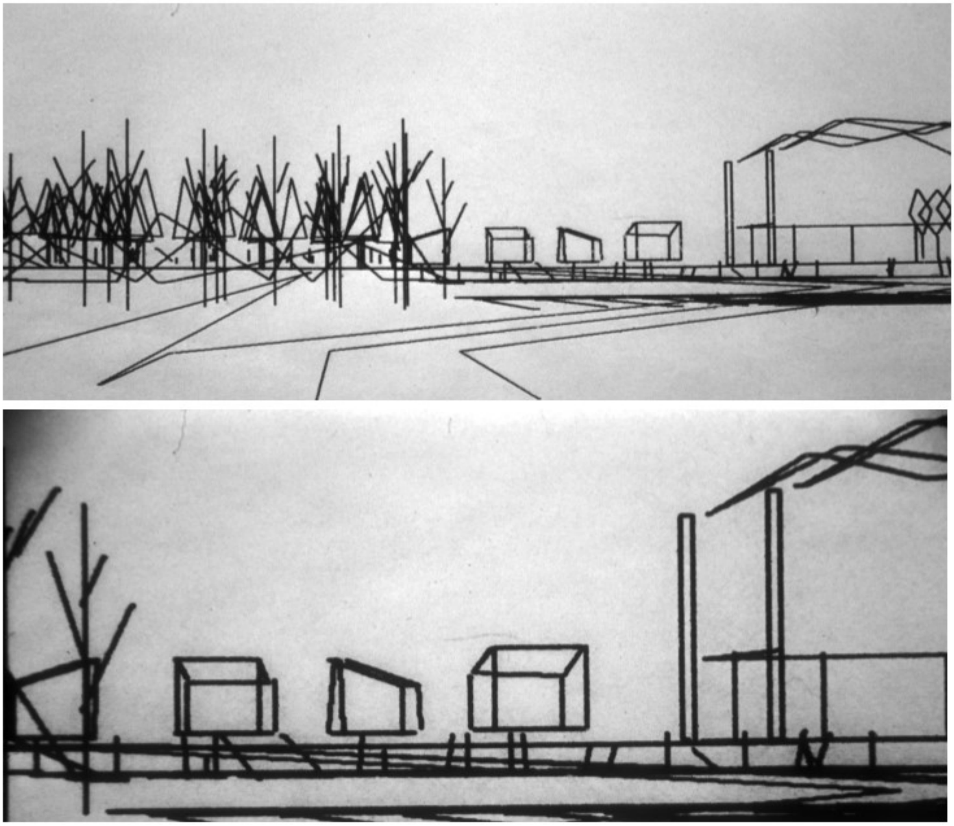


Fig. 57: Perspectives for animation, CS

Then Eric Teicholz and I decided to see if we could write the rules so that a more complex housing design could be automated. We wanted to be able to rapidly test the design implications of varying the requirements among different amounts of different housing types. Eric did all the computing. I said, "Eric we need 200 houses. They have to be orthogonally organized. They can't go in the water. They have to protect every tree and they have to be parallel to the street. There are four kinds of houses and they should connect in small groups. We will decide different numbers of each type of house for each variation of the design… you have to set the program up." And Eric wrote a program that would take about half an hour of computer time. If we changed the distribution of housing it would change the layout of the design but none would go in the water and none would cut down the trees.

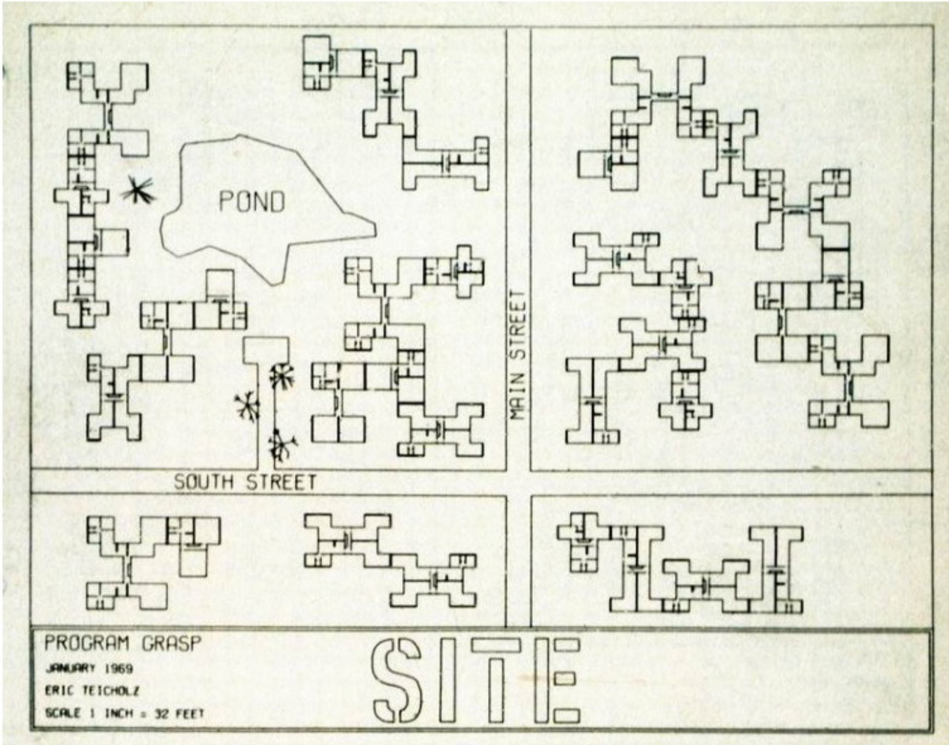


Fig. 58: Rule based design, Eric Teicholz with CS

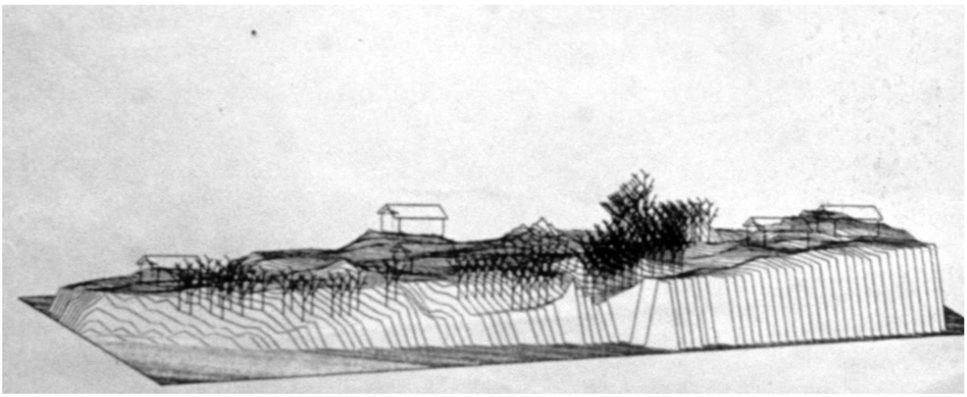


Fig. 59: Computer-allocation on 3-D terrain, CS

About two months later I figured out how to do that on 3-D terrain. We were automating the houses and the trees, and they fit on the 3-D terrain. This one computer-generated drawing in 1966 cost thirty-five dollars, the equivalent of about three hundred fifty to four hundred euros today. I didn't have that money. My salary was thirteen thousand dollars a year. So this is the only one ever made… but I knew we could do it… and also that we could move through it in an animation.

I'm now going to show you one other important project of this time. In 1956, there was a huge flood on the Connecticut River, which flows from Canada, separates Vermont from New Hampshire, and then flows through Massachusetts and Connecticut, The U. S. Army Corps of Engineers then made a plan to make about forty dams and lakes as part of a flood mitigation strategy, and in 1968 they funded us to study the Honey Hill project, one of these forty places where they wanted to temporarily store water.

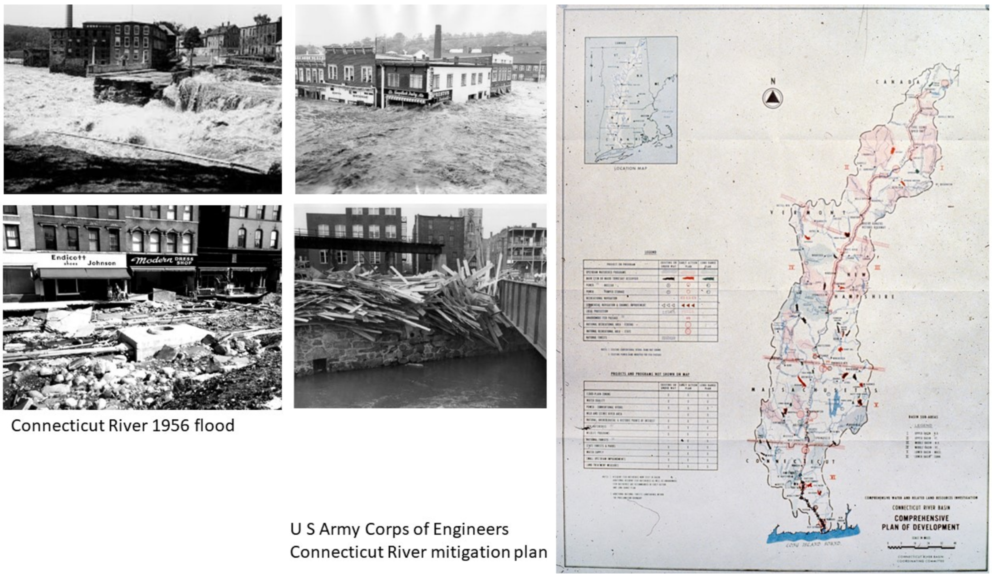


Fig. 60: The 1956 Connecticut River flood, and the mitigation plan

This is Honey Hill. The Corps of Engineers proposed to make a dam at this location and sell the surrounding impacted land to the State of New Hampshire for use as a state park. This area would occasionally be purposely flooded, but most of the time it will be a state park with different winter and summer activities, and in this case it also has to make money for the State of New Hampshire.

Fig. 61: Honey Hill, New Hampshire, USA

By that time we could make viewshed assessments in 3-D terrain. I could tell you what you can see from any spot and we could have viewpoints moving along any path. That is the visibility pattern from points along the proposed reservoir edge when full, and does take into account the pattern of surrounding trees.

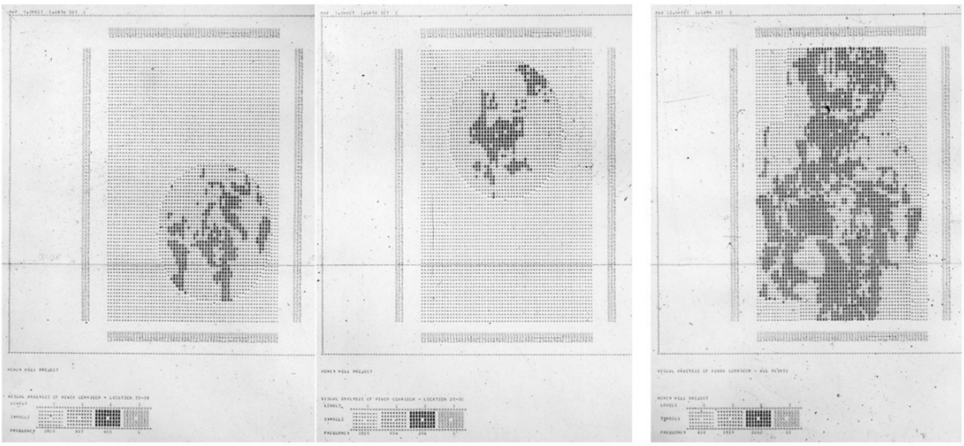


Fig. 62: Honey Hill, single and multiple points of inter-visibility assessment in 3-D terrain, CS

Four of us… Doug Way, Tim Murray, Dick Toth (who also died last year) and I… all capable designers… decided to have a competition and see what might happen with the future park's design and management. We made a shared set of digital capability and impact models. Then each of us assumed a quantitative program of requirements from a standard list, and we each made a design for winter and summer in a standard set of colors. We then gridded the designs for digital mapping and impact assessment.

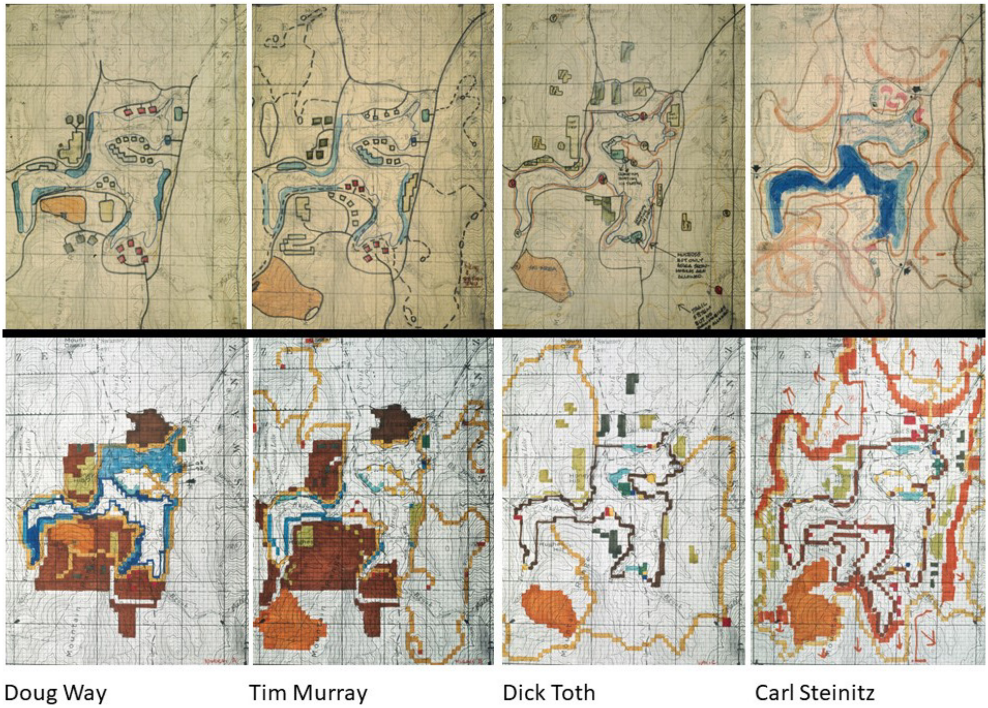
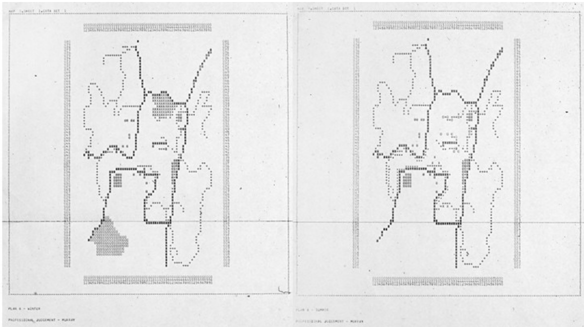


Fig. 63: Four designs for Honey Hill State Park

The designs were then assessed for the following: Attractiveness of the Locations, their Impacts, The Number of People Crowded, The Number of People Turned Away, Local Income, Regional Income, Capital Cost and Capital Cost with the Reservoir. And in several simulations for each design we had five hundred people at a time coming to the entrance and deciding where they go for their activities… and based on assumed crowding factors, at some point these facilities get too crowded and people have to go away… so income drops. So the question at the core of the design problem was: Should we put in more facilities and have more people and make more money but worsen the environment? Or should we have fewer people and keep the environment better… and what will they pay for it? And this is Tim Murray's design in the winter and in the summer.

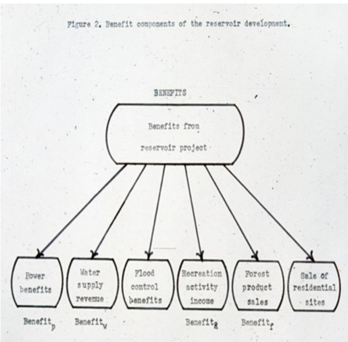
Tim Murray



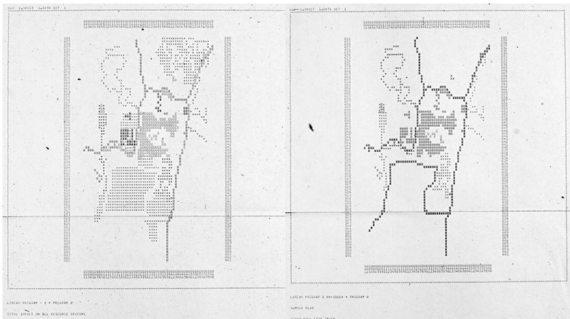
	Initial Plan	+ Impact Evaluations	+ Attractiveness Evaluations	+ Simulation Evaluations
1. SUMMER PLAN				
Attractiveness (mean mean)	36.13	32.22	42.65	44.97
Impact (mean mean)	1.314	1.373	1.298	1.261
No. of people crowded	234	0	0	0
No. of people turned away	1,084	0	0	0
$ local income	69,541	118,814	118,814	118,814
$ regional income	172,211	302,165	302,165	302.165
$ capital cost	19,784,000	17,077,098	19,934,079	20,023,072
$ capital cost w/o res.	1,184,000	1,477,098	1,334,079	1,423,072
2. WINTER PLAN				
Attractiveness (mean mean)	40.11	34.72	47.42	48.63
Impact (mean mean)	1.314	1.373	1.298	1.261
No. of people crowded	234	0	936	0
No. of people turned away	568	0	94	0
$ local income	162,336	200,760	195,613	196.764
$ regional income	430,833	536,698	535,281	538,458
$ capital cost	19,744,078	16,862,013	19,962,032	20,009,072
$ capital cost w/o res.	1,144,078	1,262,013	1,262,032	1,409,072

Fig. 64: Honey Hill State Park, Winter and Summer, Tim Murray

Meanwhile, Peter Rogers had made a linear programming model for assessment of an optimal profit strategy among the required program elements, and made a fifth design based on the resulting mix of activity facilities in the same shared analyses. An economic model was driving his design…



Peter Rogers
Design guided by a linear program



	Initial L. P. Plan	+ Program "B"	+ Simulation Evaluation
1. SUMMER PLAN			
Attractiveness (mean mean)	37.79	41.65	45.41
Impact (mean mean)	1.090	0.706	0.699
No. of people crowded	0	0	0
No. of people turned away	0	0	0
$ local income	97,349	143,661	143,661
$ regional income	266,117	370,744	370,744
$ capital cost	1,657,027	20,013,002	20,084,037
$ capital cost w/o residence	1,657,027	1,413,002	1,484,037
2. WINTER PLAN			
Attractiveness (mean mean)	42.05	62.19	63.34
Impact (mean mean)	1.090	0.706	0.699
No. of people crowded	0	0	0
No. of people turned away	0	0	0
$ local income	207,249	213,162	213,162
$ regional income	559,220	570,926	570,926
$ capital cost	1,635,017	19,935,017	20,182,017
$ capital cost w/o residence	1,635,017	1,335,017	1,582,017

Fig. 65: Honey Hill State Park, Winter and Summer, Peter Rogers

When we compared Peter's design to those by Tim Murray, Doug Way, Dick Toth and me, we all agreed that his was the best design. That experience taught me two things that I've never forgotten. First, that projects which are different in type, size or complexity may require different methods of design. And second, that regardless of type, size or complexity, you will need to organize the design process. And from that day on I always organized my Theories and Methods lecture course and my studios based on step-by-step methodology.

This early period of digital innovation at Harvard has been written about in a 2006 book by Nick Crisman, and a 1998 book on the history of GIS by Tim Foresman**,** of which the purple ones in his figure 1.1 are studies in which I participated.

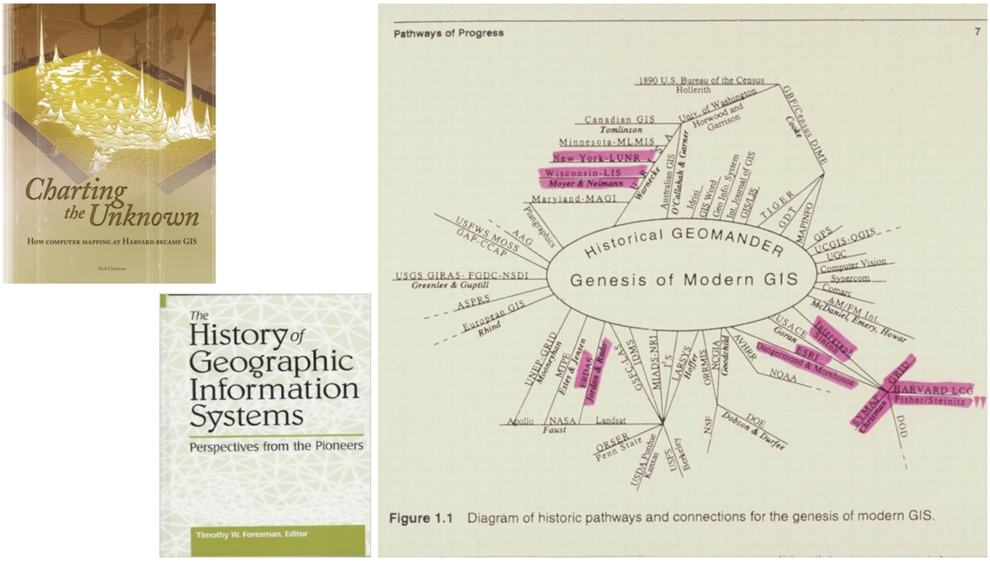


Fig. 66: Nick Crisman, and Tim Foresman, Fig.1.1

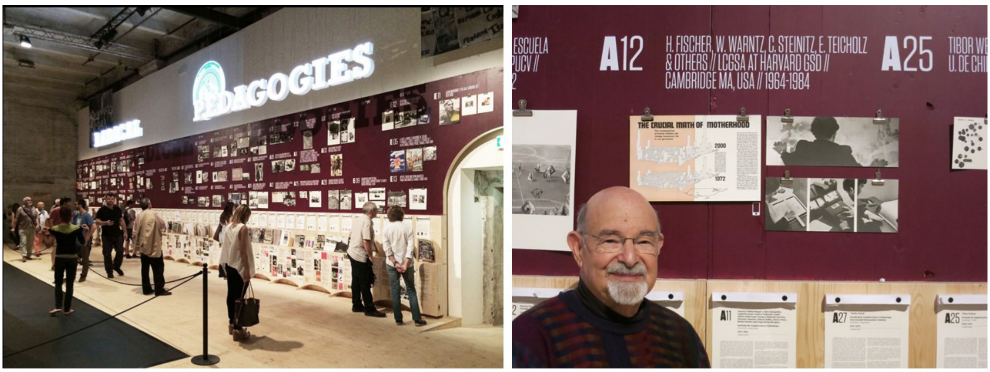


Fig. 67: 2014 Venice Biennale of Architecture, "Radical Pedagogies", COLOMINA et al.

I want to now say one more thing about the transition period in the 1960s. In 2014, Tess and I were at the Venice Biennale of Architecture. The Italian pavilion had an exhibition called "Radical Pedagogies" which showed the fifty people who had the greatest impact on Italian design education in the postwar period from 1945 to 2000 (COLOMINA et al. 2014). I was walking there… and Tess stopped me and pointed… because there we were: H. Fischer, W. Warntz, C. Steinitz, E. Teicholz… I was very surprised and very happy.

5 The Digital Future

We are now almost fully digital… and now what? Here is what I think and hope will be most important and influential developments for digital landscape architecture in the next years.

Designing will increasingly be collaborative. If a professionally oriented school isn't teaching at least one studio course that's collaborative across the professions the students will continue to be employees but they will unlikely be employers and leaders. The processes of negotiation and collaboration among the sciences and the arts are going to be paramount in their future practices. If they're not doing it in school, they likely won't do it successfully in the real world. Collaboration is central to larger projects and will also increase in smaller projects because they are getting more complicated.

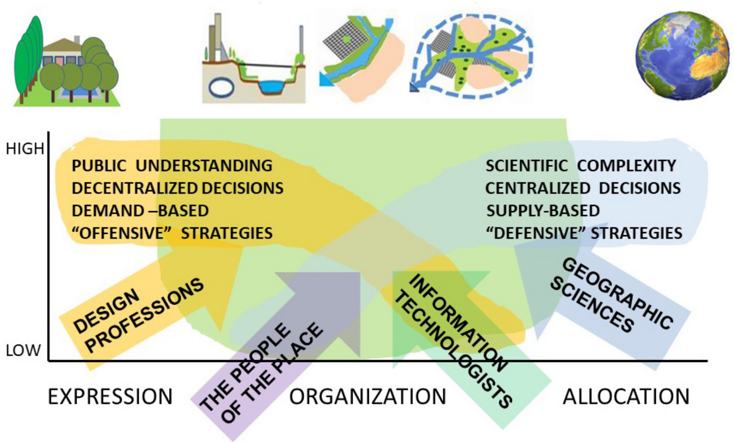


Fig. 68: Collaboration is central to larger projects

Design for increasingly large and complex areas will need a framework for organization, whether it's mine or somebody else's doesn't matter (STEINITZ 1990, 2012; HOLLSTEIN, 2019). If you don't organize it, it won't happen well. I'm not talking about somebody's private garden. I'm talking about anything bigger. You're going to have to teach design under uncertainty, and maybe only knowing the rules and not knowing where and how the design is going to develop (STEINITZ 2014).

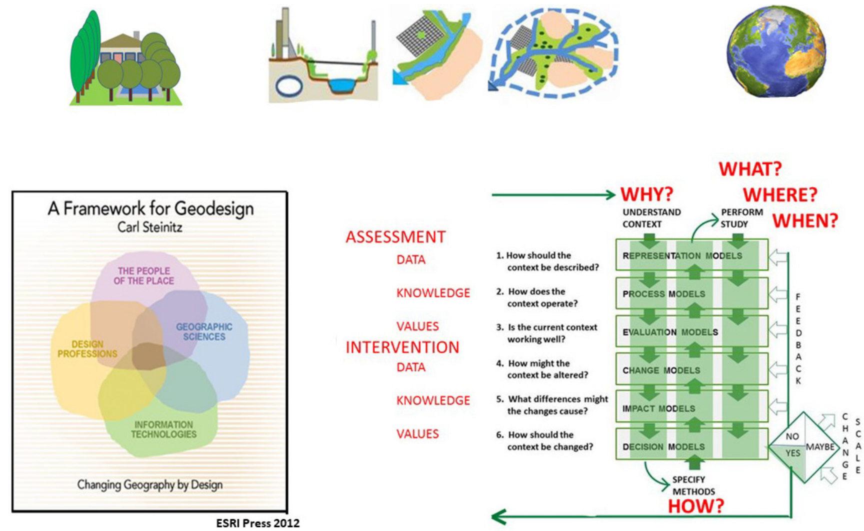


Fig. 69: Design will need a framework for organization

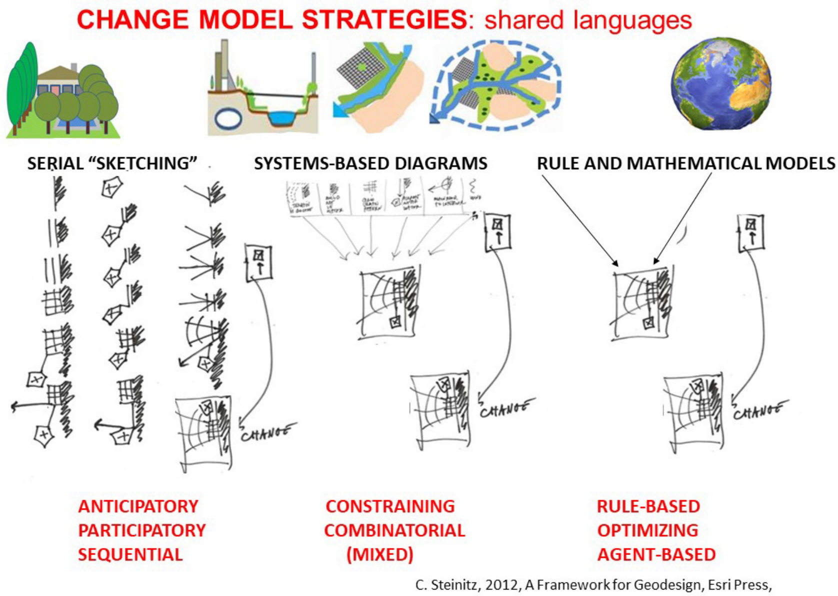


Fig. 70: Different project sizes and complexities will need different design methods

We need software that supports design workflows (STEINITZ 2016) and there already are all kinds of software that support synchronous collaboration over distance, and they will increasingly be adaptable and updateable as you (or your computers) design. They will need to support collaboration and negotiation towards agreement. They should also be easy to learn, set up, use and (most importantly) easy to understand (BALLAL & STEINITZ 2015).

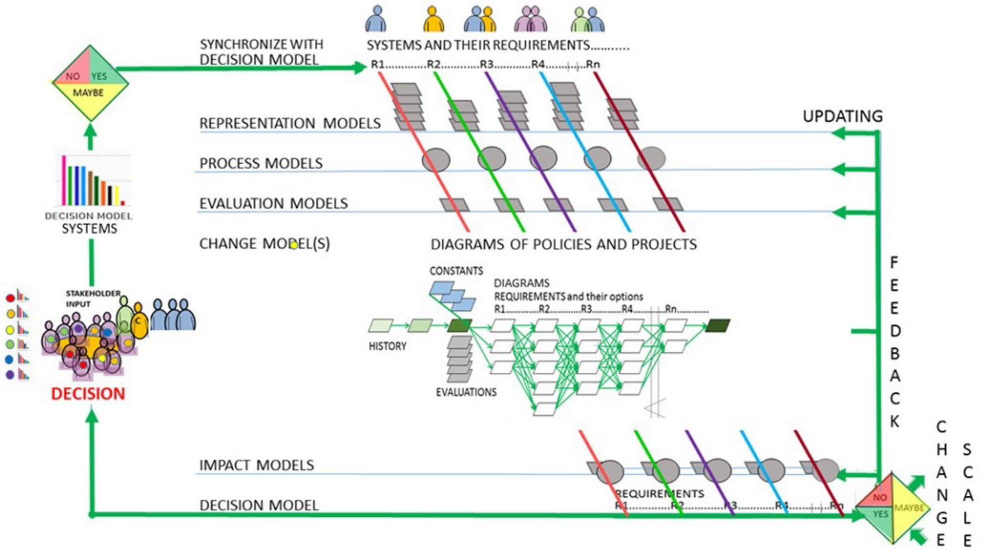


Fig. 71: A design workflow, CS

We are going to be designing in digital twins. The data will be ready for us. The problem will be making the design, and figuring out what to do and how to do it. We now are using internationally available data from anywhere in the world. Data are not the problem. We have too much data, and we need less. If you want to know to the centimeter where the flood is going to be, then you need lots of highly detailed data… but to decide whether to build in or conserve some place or not, you don't need that.

Fig. 72: Digital twin of Helsinki, Finland

Design projects will become increasingly larger and more complex. This size-complexity emphasis has had historic ebbs and flows, and I have lived through three such shifts. But global change and regional issues will increasingly dominate local ones. Design and its consequent change is going to be hierarchically and globally linked, and assessed by global to local objectives. Design assessment by the United Nations Sustainable Development Goals (SDGs) will become common (UNITED NATIONS 2015).

Fig. 73: The United Nations Sustainable Development Goals (SDGs)

Fig. 74: IGC: 150 participating university teams in 50 countries

The International Geodesign Collaboration (IGC) was organized in 2018 (ORLAND & STEINITZ 2019) as a means to compare the approaches and experiences of different geodesign teams in tackling the larger projects they would do normally, but using a common framework of guiding assumptions, project sizes, scenarios, analytical systems, workflows, assessments via the UN SDGs and presentation formats. By doing so they enable direct comparison among projects revealing insights into the different priorities and constraints of design teams working in contrasting governmental, climatic and demographic settings (FISHER, ORLAND & STEINITZ, eds. 2020). At this time of writing, IGC has 150 participating university teams in 43 countries, and 96 completed studies (INTERNATIONAL GEODESIGN COLLABORATION 2020).

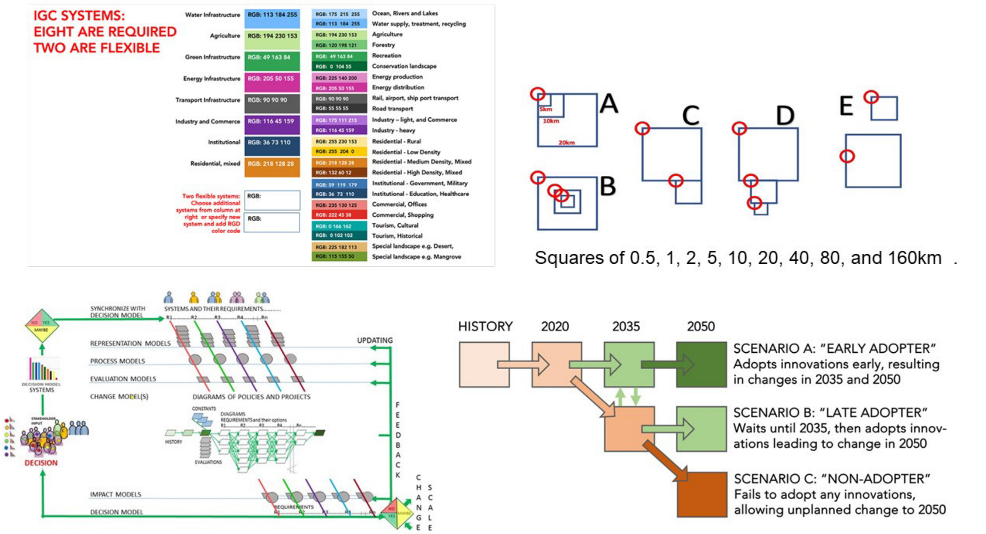


Fig. 75: IGC conventions: Systems, study area sizes, workflow and scenarios

A final thought about future digital technologies: The left figure shows the final design for the year 2050 for the CAMKOX zone outside London, England which includes Cambridge and Oxford. It was made under IGC conventions and assumptions of innovation in a two day workshop which I organized. On the right is one of Joseph Claghorn's algorithmic designs for informal housing in Medellin, Columbia (CLAGHORN 2018). The CAMKOX project is based on GIS technologies, while Joseph's project is easily capable of being moved into BIM. Both BIM AND GIS are data management technologies, and these technologies are increasingly merging. However, they are not design-support technologies. They require a design to be most useful and the question that's important is: Where is the design coming from? It's the design-support technologies and the design workflows that are the missing link. I don't want to have to go to a different technology. I want one linked technology. I want to be able to teach and design in a design support technology that goes either way: to the larger or smaller scales. And that's still missing. How should the design technologies be specified? How will we make the designs in those future technical environments? That's what we should be talking about and researching and testing. The digital technologies are what industry is going to develop. They're not going to be making the designs. We and our colleagues are the designers!

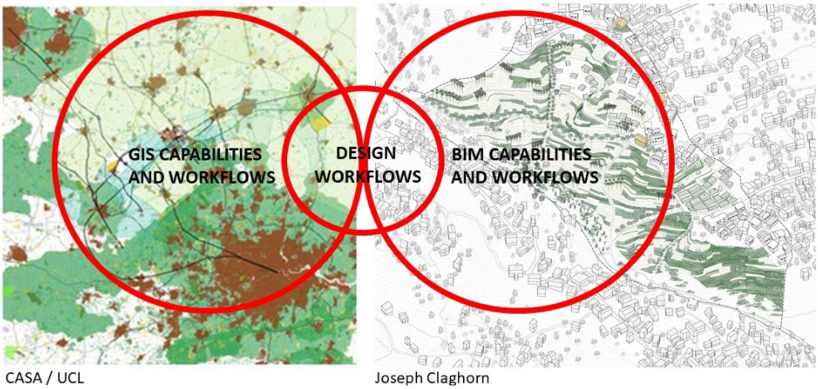


Fig. 76: CAMKOX Corridor, UK Medellin, Columbia

My opening image in the Philippines represented the pre-analog, while Joseph's Columbia study represents the digital future. Don't they seem similar? And this is the real message of my presentation: The most important things are not the methods or the technologies, but rather the "Why?" questions which initially define the context and objectives of design, and the rules which guide it. The methods and technologies change over time, often rapidly; the "Why" questions reflect basic human needs and rules that guide all of nature's systems, and these change very slowly. If we are to be part of significant designed change, we need to pay much more attention to these.

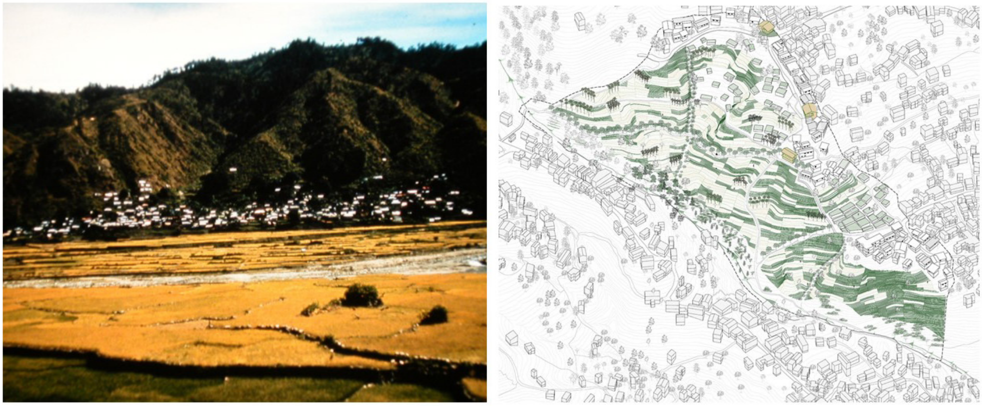


Fig. 77: "The most important things are not the technologies or the methods, but the "Why" questions and the rules." Carl Steinitz

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