ON SCALE AND COMPLEXITY AND THE NEEDS FOR SPATIAL ANALYSIS

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First, I thank the organizers of this very special conference on design and GIS for inviting me. The best definition of “design” is that of Herbert Simon.

“Everyone designs who devises courses of action aimed at changing existing situations into preferred ones”

Herbert Simon
The Sciences of the Artificial
1968

I come from a professional culture in which I began as an architecture student in a School of Architecture, I then studied city and regional planning and urban design, and I have taught in a landscape architecture department and organized landscape planning studies for more than forty years. Working at a territorial scale—in which algorithmic thinking and spatial analysis are essential—is, in my opinion and in my experience, very different from what is taught to and practiced by most designers. I want to discuss the implications of scale and complexity, two themes that differentiate design activities and their needs for spatial analysis methods. In doing so, I will purposely sharpen contrasts that are really more subtle and frequently mixed.
"Many devices which work on a small scale do not work on a large scale."

Galileo

Scale matters, and Galileo was right. Many methods, many processes, many ideas which work at one scale, don’t work at another scale. My school has architects, landscape architects urban planners and designers. We have a studio-dominant culture, and there are different scales of “problem”. Most students’ studio sequence starts small and gets larger and more complex but does not include the full range of scales. Problems dealing with the landscape include placing a building on a difficult site, designing a garden, and then designing an urban complex in a difficult ecology, or a large urban park. Most students who think about the landscape stop at what can still be considered “project scale”. They stop at the scale where the assumption is that you have a client, a site and a program and eventually something will be built. Relatively few students, the ones who work with me at the end of their studio sequence, think about regional scale urbanization and regional conservation.
There are many people in the world who think in the other direction, from large to small. Geographers, cultural historians, hydrologists, geologists, ecologists, political scientists, and even lawyers and bankers, tend to see things and work from large to small and they almost never get to the details so important to architects and landscape architects. The question is: what is the lens through which we should look at the problem. I'm interested in the larger scales. I have spent a long time working at the territorial scale, and sometimes I get to the project scale but I stop before the details. I tend to think from larger to smaller.

The focus of design decision changes with scale. At large scale, you are dealing with strategy, at middle scale you are dealing with tactics and at small scale, you are really dealing with details, and here the details do matter.

The wise school mixes scale-direction, but must recognize that there are real differences at the extremes of these two scales. At the large scale, if you make a mistake or decide something badly, you have a very high risk of harmful impact. The concept of risk dominates working at this scale. You want to minimize it. Why? Because the landscape is big, it has lots of people, lots of money, lots of change, and the larger decisions are very important. The benefits can be great, but the risks are serious.

As you go to a smaller scale, the risk goes down: I don’t care so much if my neighbour has a modern house or a baroque garden. What’s the risk to me? However, I do care greatly if I don’t have drinking water. That’s a very important
risk. The greater the risk, the greater the need for serious analysis, and this is much more a need as scale-related risks gets larger.

Minimizing social risk, economic risk, ecological risk, etc. makes a landscape plan essentially defensive. Here, the design processes emphasize "allocation", deciding what goes where or where not. At a municipal or large project scale, it is more decentralized, with different professions, different neighbourhoods, and different clients all coming together. At large project scale the design emphasis is on "organization", how different elements relate to each other. At small project scale, the emphasis is more on "expression", what does it look like, what does it feel like. These are very different.

At large scale, you must have a high reliance on science; and you must have a much more complicated formal strategy. At the larger scale, the idea that you can make a simple "design concept" diagram and really see it on the ground is foolish; it doesn’t work. At this scale, however, you must have much more public understanding, and this is not easy. At large scale there is no single well informed ‘client’. At small scale there usually is. People normally understand their own house, they may understand their neighbourhood; they usually don’t understand their city and they surely don’t understand their regional problems. In a democracy, informing the public requires clarity and transparency in both assessment and presentation. There is necessarily a difference in roles between experts and the popular will in decision-making.
As a result, at large scale, landscape decisions are made by experts and elected people and unelected people. Elected people are the people who you vote for, your government. Unelected people are the heads of banks and development companies who make planning decisions. These larger decisions are not normally made by popular vote. However, at small scale, everybody makes decisions.

As the spatial scale gets smaller, you have more of a demand-based strategy. What I mean by that is that a client says, I want something! You happen to agree and you do it. It is based on demand; it is based on the push of the market. At large scale, it is more supply-based and defensive: you have to understand the landscape, you have to understand the cultural values, you have to establish priorities, and then you do have to defend them.
At small scale, you can get famous for making new changes, while at large scale, you do not generally get famous for protecting old landscapes. These are very different. A good analogy is the first law of thermodynamics. Energy can be converted to light, or heat, or any combination. Energy, in our case, is the investment of cost, time, research, people, expertise, etc. Light means knowledge; heat means excitement. At large scale, there is usually little that is exciting relative to the newness sought of and seen in the small scale.
There is another important complication related to scale. There are two fundamentally different ways to make a design. (I am purposely making this contrast, fully aware that the two ways are frequently combined). The first way is anticipatory and deductive. You are sitting in the middle of the night, at your table, and you have an idea. And you see the future. You see the future, and then you have to figure out how to get there. Every designer has had this experience, likely many times. You have thought about the problem and you see the solution, and then you have to figure out how you get there, and you almost always fail. It’s hard!

The other way is explorative and inductive. You basically put together a set of issues and choices—a “scenario”. A scenario is a set of assumptions and policies that guide you to the future. There are basically two ways to navigate this I scenario chain. In the first and typical way for designers, one goes ‘out’ as far as one can, and recycles back when confronted with a design ‘problem’. You decide to do this and this and this.....etc. The second way is to simultaneously test several different scenario combinations and systematically compare them before proposing a solution. You realize that you could do this, this or this, let’s suppose I do this: I then can do this, this or this; let’s suppose I do this, this one, or maybe I should have done this way...

And either way, you almost always fail, because a typical large plan might have a sequence of 20 to 50 important decisions. And if you can make 20 correct
decisions in a row, you should be a gambler in Las Vegas. That’s why you frequently say, I’ve done enough, I don’t care what color the carpet is. It’s normal. It is a function of scale, of the lens through which you assess the problem and its solution.

At small scale the deductive method is absolutely appropriate. The history of architecture and the history of landscape architecture are full of examples. The idea-- let’s make a white garden, let’s make a round building-- these are appropriate inspirations. But at large scale, the inductive methods are better. Why? Because if you make the wrong decisions in the beginning, you have created the likelihood of a very high risk. Early, high risk choices require the most serious assessment methods.

In making a design at large scale, you have four fundamental considerations. One of them is “history”. You must know the history of the place, and especially the history of the plans for the place. I have never in my life worked in a place that didn’t already have past plans. And the people who made them were not stupid.

The next things are “facts”. Facts are things that will not change in the life of your own plan and your own study. I might work towards 20 years or 30 years in the future, and the bedrock geology is not going to change (if is not volcanic).

Then there are “constants”, which are the things that are going to happen
during the course of your plan. You must find out about them, because if you
don’t, your plan will never be implemented.

And then there are the “contingencies”, the things that could happen, and
here it is really important to capture the major generating assumptions and their
alternative choices. You have to be able to say: either here, here or here. The
beginning assumptions in the scenario ‘chain’ are the most important because if
you make the wrong first steps, you will end up wrong. If you make the right first
steps you still may end up wrong but you have a better chance.

The good learning tool (for design AND spatial analysis) is the Japanese
game of GO. In GO, the first moves tell you a lot about what the territory will look
like at the end, and it is very good training for designers, especially at larger scales
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My second theme, complexity, interacts with scale. It represents the level of
complexity that the analytic methods underpinning any design must achieve,
especially in its understanding of process models. I think that there are six
questions which must be asked in any design problem and at any scale. They are
How should the state of the landscape be described in content, space, and time? This question is answered by representation models, the data upon which the study relies.

How does the landscape operate? What are the functional and structural relationships among its elements? This question is answered by process models that provide information for the several assessments that are the content for the study.

Is the current landscape working well? This question is answered by evaluation models, which are dependent on the cultural knowledge of the decision-making stakeholders.

How might the landscape be altered, by what policies and actions, where and when? This question is answered by the change models that will be tested in the research. They are also data, as assumed for the future.

What difference might the changes cause? This question is answered by impact models, which are information produced by the process models under changed conditions.

How should the landscape be changed? This question is answered by decision models, which, like the evaluation models, are dependent on the cultural knowledge of the stakeholders and responsible decision-makers.

I believe that there are eight levels of analytic complexity associated with process models. Each of the eight levels is organized to answer a cumulatively more complex set of questions. I think that the larger the scale and the consequent greater risk, the more the analytic methods should aim to achieve more complex levels. The smaller the scale and less the risk, simpler analytic levels may suffice.
PROCESS MODELS
LEVELS OF COMPLEXITY

1/ DIRECT
+ 2/ PHENOMENAL
+ 3/ VERTICAL
+ 4/ HORIZONTAL
+ 5/ SPATIAL
+ 6/ TEMPORAL
+ 7/ MIXTURE
+ 8/ BEHAVIORAL

WHAT?

HOW MUCH?
WHERE?

WHAT?

CONTEXT?

SCALE?

WHEN?
WHAT IF?

FROM WHAT?
TO WHAT?

FROM WHERE?
TO WHERE?
Direct models ask “What is here?”. They are based on direct personal experience. If your feet are wet, don’t build here.
Thematic models add “Where and how much?”. The example is a soils map from the region of Camp Pendleton.
Vertical models add “What else?”. They are normally seen vertically, such as this example which relates geomorphology with soils and vegetation productivity.
Horizontal models add “What size and shape?”. In this example from Sullivan and Schaeffer, it is better for a faunal preserve to be large than small, one large than many small, compact than spread, etc.
What happens at different ‘nested’ scales?” In this example from Virginia Dale at Oak Ridge, different phenomena related to aphid infestation in the southeastern pine forest are investigated and related at their appropriate scales.
Temporal models add “What if...and when?”. In the example, mule deer habitat change over a thirty year period is projected for the region of Camp Pendleton.
Adaptive models add “From what and where to what and where?”. This example is Russell Smith's eight stage model of the transformation of tropical beach resorts.
8) Behavioral

Behavioral models add “From whom and where and when to whom and where and when?” The example is Michael Flaxman’s fire progression model, which accounts for hazard and fire management strategies.
Finally, the “bottom line”—What are the spatial-analytic needs of “designers”? It all depends on scale and complexity. There cannot be one answer. At its simplest, and frequently at smaller scales, the direct personal experience of the designer may be sufficient, and without ANY formalized analysis. At the other large scale extreme, it will frequently require a very complicated and costly effort, and yet it also may suffer from a lack of public understanding. Answering this dilemma and deciding on the appropriate methods and their level of complexity requires judgement and experience....there is no other way at this time.
However, there is a potentially important research study which can derive from this situation. There are many models of processes such as erosion, hydrology, forest succession, traffic, air pollution, noise and visual preference. Comparing the efficiency and efficacy of process models across scales and levels of complexity might result in a better understanding of which combinations are the most appropriate fit for any design problem. This comparative research, and the resulting ability to categorize the applicability of the many analytic models which already exist, would be a significant step towards the theme of this conference. It would certainly help the very broad-ranging community of “designers”.
“It is the mark of an instructed mind to rest satisfied with that degree of precision which the nature of the subject admits, and not to seek exactness where only an approximation of the truth is possible.”

Aristotle

“Be as simple as possible, but not more so.”

Albert Einstein