Information for design: Interacting environmental systems in space and time

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Thesis

Effective planning for environmental resource protection and sustainability happens best when all stakeholders understand the impacts of changes in one system on another, and can be shown and understand the implications of those changes over a variety of short- and long-term time scales. Good decision-making relies as much on accurate understanding of those system interactions as it does on the emerging results of the analysis.

As an educator in landscape design and planning, that is where I must focus, on developing understanding of the system interactions and change through time, because it is critical that beginning designers be clear about the ways that their design decisions shape those interactions. I also believe that that holds for most decision-makers and citizens turning to GIS to tell them how close and how bad things are going to be, and how soon they need to act to avert disaster or flee.

I want to raise four issues here:

1. We have done a great job of developing tools that allow us to access vast amounts of data, manipulate it smoothly, and create beautiful and compelling images of the resulting analysis. Where we are weaker is in having nimble and smart tools to inform scenario development—the GIS/modeling equivalent of the back-of-the-envelope or cocktail napkin sketch.
2. Cultural and social issues are often critical constraints on development in the minds of citizens—and they may dominate thinking regardless of the sophistication and completeness of a technical planning solution. We don't have good ways to use qualitative information in the context of technical planning, so it may be valued too much or too little, or simply go un-addressed.
3. Time is critical in planning, but we don't yet know how to explore time. The concept of discounting, establishing the present value of a future resource, embodies the idea of time as a linear progression, but for natural or cultural

resources the time-frames are much larger and the perceived "shape" and implications of time may be quite different.

4. GIS analyses are increasingly shared as visual presentations, often highly detailed 3-d representations. However, there has been depressingly little study done of the effectiveness of, say, photo-realistic renderings vs. diagrammatic images in supporting rational decision-making.

Direction

Scenario-development: We need rapidly-configured and intuitive "what-if" tools that I can use to test an hypothesis and learn about the underlying dynamics of a system—which are the important and which the less-important variables, does the system move along steadily or spiral out of control? Ironically, it is the dynamism and complexity of environmental change that excites us intellectually but then makes it so challenging to project outcomes and make sound decisions that will get us there.

We have vast information about environmental change that is inaccessible for day-to-day decision making because it is distributed over many disciplines, each with its own way of using and representing data. Potential connections between independent systems have been acknowledged and implemented in sketch planning systems such as CommunityViz. But while CommunityViz makes complex combinations of issues palatable, and the underlying spatial dynamics derived from agent-based modeling may be readily grasped, the overall system remains a magical black box if there is no ability to decompose the analytical processes so that each is clearly understood. The complexity of most land-use questions will take decision-makers into new disciplinary territory where, no matter where their individual expertise lies, they will not be familiar with the basic underlying systems.

I believe that we need to re-focus energies on creating system understanding among planners and citizens using simpler, exploratory, "front-ends" to GIS. The beauty of an envelope or napkin is that it responds in the moment of an intuition, immediately provides a medium for further exploration, and is quickly discarded when the "what-if" is rejected as inadequate. Interactions between resources and agents must be explored and the salient relationships understood before they become embedded in bigger design and planning systems—substantively changing the way we understand the implications of our plans vs. just doing them faster with better graphics.

Cultural and social issues: Decision-making in the public policy arena is constrained by the challenge of reconciling multiple perspectives on complex environmental issues and has clear implications for areas such as environmental adaptation, stewardship via incentives programs, multi-scale and grounded management, and shared responsibility and governance. Often the issues are framed in subjective, qualitative terms rather than the quantitative descriptions we expect for natural systems and populations.

The challenge with qualitative data is to identify metrics by which those and quantitative data may "talk" to one another. Some qualitative methods such as Q-methodology provide measures, such as the subjective relationships between the values of people involved in evaluating a scenario, but oral histories, historic photos and the like may not possess suitable attributes. A heterogeneous data approach might include some resources represented by numerical models or stored data tables, others by Q-sort evaluations of scenes within a geographic area, while others may be, say, events listed in tables of cause and effect relationships derived from focus groups of domain experts. In operation, information such as records from oral histories could be indexed by key words that are triggered when particular data conditions arise in running a projection or other scenario. The goal would be to deliver to the decision-maker the widest range of data germane to making the evaluation at hand. However, within this range of possibilities there is no emerging accepted or generalizable approach.

Dealing with time: We are all challenged when asked to evaluate alternate responses to anticipated large time-scale environmental impacts, whether the result of direct human agency such as policy change, or more indirectly through climate change or natural disaster. Interactions within environmental systems are extensive and complex, but our ability to comprehend the urgency of action to address change is limited.

While we are very good at evaluating current environmental conditions we are less good at projecting those conditions into the future. Models tend to report singular outcome conditions but even with robust projections, complex systems acting over significant time horizons accumulate significant "error" that could result in numerous plausible outcomes. Urgency is based on our perceptions of risk, the severity of the event, and how soon action must take place. If we have no firm understanding of future conditions it will be a huge challenge to discount impacts back to the present to enable us to mobilize the appropriate immediate responses. We act now to divert impacts that may not occur for tens or hundreds of years.

Time plays a central role in the development of environmental problems, and in their solution, but there is no substantial literature that examines how time is represented or interpreted. While the concept of discounting is critical to business and investment modeling, there is no equivalent focus on how decision-makers perceive future impacts, develop attitudes towards them and then behave when making resource management choices.

Visualization: Visual imagery is a key means to making information accessible to all disciplines. An entomological model describes the spread of insect damage but a visual image illustrates the implications of that spread to non-specialists. Similarly, other germane environmental factors can be projected via the same visual interface, providing a platform for sharing disciplinary perspectives of a complex problem.

However, there is a serious gap in the development of scientific and environmental visualization to date. While we can create sophisticated images of hitherto poorly explained phenomena, there has been relatively little study of the effects of the visual tools being employed. While the choice of visual signals to represent the advance of a cold front across a weather map may be inconsequential, the representation of change at a real location as a result of environmental factors must inform policy choices but not manipulate them by use of, say, an exaggerated image. The validity and reliability of visualizations illustrating environmental change is a topic begging for some concerted scientific study.

Closing the loop on these comments, we have to shift focus away from the product to the system driving the product; to factor in not just the scientific but the attendant cultural issues; to learn how to understand change over long time scales; and to avoid fooling ourselves with the brilliance of our wizardry.