

Comments by Mark Fonstad and W. Andrew Marcus
on their acceptance of the
GK Gilbert Award for Excellence in Geomorphic Research from the
Geomorphology Specialty Group, Association of American Geographers
April 6, 2005

Both Andrew and I would like to thank the Geomorphology Specialty Group awards committee for this honor, Dick Marston for our nomination, and the many others who have supported this paper since its publication.

The “Self-organized criticality in riverbank systems paper” grew out of a large, EPA-funded project developed to find the direct, quantitative linkages between watershed uses and processes and river patterns, and it ended with a theory that places specific limits on how much of that linkage can actually be known. Who says you can’t make a career out of negative results?

This project, based around the rivers of northern Yellowstone National Park, allowed us to measure many properties of rivers at high resolution over large distances. One of the linkages between watershed uses and rivers is the instability of a river’s banks, and we mapped the presence or absence of active riverbank instability over approximately 100 kilometers of several streams. The next obvious step was to relate the presence or absence positions with other geomorphic variables, such as available stream power or channel confinement. The result of this typical analysis was to find barely any relationship at all. Scatter was everywhere in the regression lines. Then we began to think about Wolman’s difficulties in sorting out why rivers below dams could behave so radically differently from one other, and then about Jonathan Phillips’s multiple modes of adjustment, and finally about whether the scatter itself could tell us something about the probability of failure.

We were dimly aware of SOC theory and its postulated power laws for the magnitude and frequency of geomorphic events it postulated, but its possible connection with the multiple modes of fluvial adjustment completely escaped our thinking until we tried plotting our data as magnitude and frequency plots. That was a simple exercise, yes, but one that took us about six months to think of. We wrote a simplistic cellular automata model of sediment transport through channels and from riverbanks that produced the same power law magnitude/frequency relationships as our Yellowstone field data displayed. While this didn’t prove SOC (in our view, no one ever has), it certainly made the work interesting and plausible.

The decision to submit our work to the Annals was not straightforward. SOC theory was exploding onto the scientific scene, and we thought about submitting to journals ranging from Nature to Environmental Management. However, the Annals afforded us with something very important: the page space and freedom to speculate on the possible implications of our work. To be able to put such thorough speculation, such guessing, into the same article as the primary data analysis, allowed us to present our work as a unified whole, and not have it leak out a little at a time in half a dozen articles and conference papers. We thank the editors of the Annals for allowing us this freedom.

The two of us are deeply indebted the hard work of the other two members of Team Fluvial, Jim Rasmussen and Carl Legleiter, both excellent geomorphologists and wonderful friends. Carl destroyed his track career for us by hobbling around in the icy waters of Soda Butte Creek each summer, and Jim completed the survey himself by climbing out on a log suspended 80 feet over the treacherous Icebox Canyon to map the river against our explicit orders. To their efforts we would like to add those of our project's hardy field assistants: Justin Balhiser, Wendy Bigler, Chad Heidtke, Brent Nickola, and Keith Van Etten.

We had basically been looking for a way to better connect geomorphic field observation with the geospatially continuous data sources provided by remote sensing and digital elevation models. The utility of walking down the river and mapping visually estimated yet high resolution riverbank patterns was a cheap, fortuitous throwaway compared to the "real work" we were supposed to be doing. Both of us have completed many traditional surveys based on regularly spaced cross-sections, and both of us are somewhat sobered that had we chosen that type of procedure for this work, we would not have observed the magnitude-frequency relationships that ultimately led to this paper. It certainly begs the question: "What other geomorphic properties are we missing simply because geomorphologists are looking at the wrong scale?"

The SOC model of geomorphology is not a panacea. It obviously does not explain a great deal of fluvial geomorphology (for example, repeating bedforms) much less the rest of the discipline. Nevertheless, the sandpile model of geomorphology postulated by SOC is highly infectious, it makes a lot of predictions, such as how a human action will transfer instability to neighboring areas, how common geomorphic events of a certain size should be, and also the probable limit of predictability of river channel change through space and time. To this we can only admonish that field observation at the right scale allowed us to test the idea, and the lack of that suitable observation would have made it simply another arm-waiving motion.

My mother, the fantasy cartographer Karen Wynn Fonstad, passed away this month, not long after being ecstatic upon hearing of this award. At her drafting table, she taught me many things; she taught me that imagination was more important than reality, because the reality I saw was mostly what I already expected to be there. I like to think that her advice helped us to look at the river in a new way. We are deeply indebted to our colleagues in the Geomorphology Specialty Group for this honor. Thank you.

I wish to add my thank you to Mark's comments. This award is particularly meaningful to me because the AAG is professional family, and within that family, the Geomorphology Specialty Group is my home. That sense of family is particularly profound at this moment. The first professional talk I ever gave was given under the auspices of the Geomorphology Specialty Group. The specialty group award that will be given after this one, the Melvin G. Marcus Distinguished Career Award, is named after my father; a fact that still brings great pleasure and joy to me and my family.

But the family connections today go deeper today. As some of you know, it was with great sorrow that we witnessed the loss of Mark's mother, Karen Wynn Fonstad, to cancer just three weeks ago. Karen was internationally known as a cartographer, but not for the classic types of maps we are used to producing in our research environments. Rather, she was the author of atlases of the imagination, including the *Atlas of Middle Earth*, *The Atlas of Pern*, the *Atlas of the Land*, and others. A small joy in the sorrowful time of losing Karen is that the Awards Committee notified us of this award well over a month ago. Mark's mother and father, a physical geographer like Mark, thus knew of this award prior her death. And this is an award that brought Karen real pleasure, not only because Mark is her son, but because she contributed the cartography to this article. As a contributor she thus shares in this award. As for me, I now find that the fact that Karen contributed to this article means as much to me as the award itself. My thanks to the specialty group are thus doubly felt; no one could know just how timely, poignant and special this award would be. Thank you.

And since we are on an overtly family note, I am under orders from my mother – whom many of you know quite well – to tell you that “You made a brilliant decision this year.”

I would also like to thank Dick Marston for allowing my mother to write many of his remarks.

I also want to thank Mike Slattery and Jonathan Phillips. Mike for having the honesty to present the negative results he achieved using cross sections. His talk led to the mapping scheme used for this paper, where we mapped a suite of variables every 100 m for 180 km of stream length. And to Jonathan whose unswerving commitment to evaluating the potential for nonlinear behavior in geomorphic systems has profoundly influenced our thinking over the years.

Finally, I want to take a moment to philosophize about research directions in geomorphology. Our present research approaches for studying contemporary geomorphic systems are dominated by mechanistic, process-based approaches - as they should be. But at the heart of these approaches is a giant assumption that we sometimes talk about, yet rarely explicitly evaluate – the assumption that we can scale up from local processes to system-wide prediction.

But what if a system is in a Self Organized Critical state? If this is the case, then the system-wide distribution of magnitude and frequency of events are knowable, but this system-wide knowledge cannot be used to predict behavior at a given point, nor can understanding at one point (or even a lot of points) be used to explain system-wide distributions. We can't scale up, or down, in an SOC system. In an SOC system, one can explain changes after the fact, but can never foresee them.

The system, at least in this sense, is unknowable.

As we look at rivers, we should therefore think of testing the often untested assumption - that process models can be scaled up from local physics to predict basin scale behavior.

Otherwise, we risk that trap that Roger Coates warned us of in 1713 in his Preface to Sir Isaac Newton's *Principia Mathematica*:

Those who assume hypotheses as first principles of their speculations... may indeed form an ingenious romance, but a romance it will still be.

Do I even dare point to all the situations where we (including myself) form wondrous models based on scaling up, only to create a "romance?" Insofar as we wish to use process models to predict behaviors or identify cause and effect, we should ask this question with regard to: distributed watershed models, sediment transport equations, even Mark's and my favorite – cellular automata, to name just a few examples.

Rather than focusing on expanding evermore the application of mechanistic models to basin scales, which is our discipline's trajectory of research endeavor, Mark and I argue that more research needs to focus on first principles of system behavior. If we wish to avoid pursuing illusory outcomes, we should ask more often: "Is the system chaotic, at the edge of chaos, or predictable?" or "Can we scale processes up or down in this system?" Might there be some geomorphic equivalent to the Heisenberg Principle, which by demonstrating the limits of knowledge, radically improved our ability to understand the nature of matter and energy?

To those of you familiar with chaotic systems literature, there is nothing new in what we are saying. But given the emphasis we continue to see in much geomorphic research, we believe it is worth reiterating.

Oscar Wilde had it right when he said "The true mystery of the world is the visible, not the invisible." In an SOC system, our inability to predict is NOT because a process or parameter is invisible to us; it's NOT because we need to measure more or model better. Rather, the system organizes itself, right before our very eyes, in ways that are fluid, mysterious and beyond our ability to know. Is this not a beautiful thing, to know its form, but to find it forever perplexing? It is this tantalizing mystery, the desire to grab and hold this shifting ghost-like creature, almost seen, but never entirely perceived, that draws us again and again to rivers. It is why, I believe, most of us who are river scientists are - in the very truest sense of the word - haunted by rivers.