Riverscape Geography, or Why I am a Geographer

Presentation by Mark Fonstad on November 9, 2008

Good evening ladies and gentlemen; my name is Mark Fonstad. I am honored to be your faculty guest for tonight; a time when we are about to set you free to sail the seas of research. I know well that that sea can be a mysterious and terrifying place, but I hope you can remember that as much as we discuss the world and its need for competent geographers such as you, the exploration of the world's geography is a voyage of self-discovery. This is a wonderful time to be a geographer. Jobs for well-trained and worldly geographers are many. The need for geographers in almost all aspects of society, be it technical, cultural, militarily, philosophical, political, economical, or whatever, is today tremendous. Yet at the same time, we are surrounded by geographic illusions and ineptitude. We live, they say, in the information age, yet almost none of the geographical information we think we possess is true. Eskimos do not rub noses. The rickshaw was invented by an American. Joan of Arc was not French. Lenin was not Russian. The world is not solid, it is made of empty space and energy, and neither haggis, whisky, porridge, clan tartans nor kilts are Scottish. So we stand silent with a vast rolling, teeming, untrodden territory before us: Geography. Whatever is interesting we are interested in. Whatever is not interesting we are even more interested in. Everything is interesting if looked at in the right way. At one extreme, geography is serious and intensely scientific, deeply mystical; at the other it is hilarious, silly, and frothy enough to please the most indolent couch-potato.

I study the riverscape. It is somewhat like the landscape, but it inhabits a different kind of space, has different kinds of geographical rules and forms, has different human-environmental interactions than do landscapes, and it is essentially unexplored. The first president of the AAG, William Morris Davis, studied the riverscape. The newest president of the AAG, Carol Harden, studies the riverscape. The river has been used as an analogy for the rest of the geographic universe since the dawn of time. Machiavelli used it as an analogy of political fortune, and Heraclitus used it as an analogy for the flowing nature of reality. Those who have studied rivers were some of the earliest cartographers, the earliest geomorphologists, early contributors to the quantitative revolution, the first practitioners of humanistic geography, the earliest of GIScientists, the earliest modern geosimulation practitioners. The fact that every other branch of geographers has a history as rich and varied as ours should keep riverscape geographers humble, but does so only occasionally. Riverscapes, as a field of study, is uncommonly communal; in the past there have been major scholars that dominated the field such as G.K. Gilbert, Luna Leopold, Jim Knox, or Will Graf. They still have staying power today; three of your professors in this department are students of Will Graf, for example, myself included. But the reality today is that there are hundreds of riverscape researchers, working in large groups on large projects, and it is these projects that often lead my field into new realms. Luckily, such projects are populated not just by a tiny elite, but by everyone from full professors down to 5-hour-a-week undergrads, everyone can participate. So we don't really have scholars who are as "major" today as they used to be; there are just far more people today. The difficulty for new researchers is in carving out a space amongst the masses doing something new, useful, interesting, and publishable!

Consider our local area. We have floods bigger than almost anywhere, and that's not just Texas brassiness. Yet why floods are bigger in some areas and some particular times is not understood well, even around San Marcos. The whereabouts of particular fish, for example, are of interest to bean-counting state governmental offices as well as the fisherman on the bridge, but the geographic methods for finding them is woefully inadequate. Even in San Marcos there are active stream restoration efforts with members from different parts of our society, but nobody there knows exactly what the river will do in a given restoration situation. The reality is that there are only a few handfuls of people in our area charged with figuring out erosion and sedimentation, riverine ecosystem dynamics, mapping of low-water crossings, floodplain delineation, the hydrological shifts in the river due to climate change, the complex landscape of local water law and policy, the cultural resource quality of having rivers in various states of naturalness, rivers as transportation corridors, rivers and energy producers, rivers as conveyors of people and goods, rivers as supply, as demand, as dreams, and as nightmares.

Most questions about riverscapes first require me to know about the physical geography processes going on; so that is what I start with. To know how a flood might affect a subdivision, for example, you first have to know why a river flows as fast as it does. This leads you into asking where do the forces driving or resisting river flows change, and why? I might look at these forces in the field using hand equipment, I might try to learn about them by mathematically analyzing their amounts. I might look at their spatial distributions through empirically-measured map information, for example, or perhaps I might try and combine these techniques into rules that can be used for simulation. I've had students interested in these forces of motion and resistance as well; my student Mindy has published on why and where rivers get slowed down more in some place than in others, and on why they then have more available energy to do more than just flow forward.

Once you know a little about the driving forces of the water, it becomes possible to ask a bit about why the solid material in and around the rivers change. Your first thought might be that there is a fairly smooth relationship between water and solid material; as you get more and more water, it should be able to push around more and more material. But we have learned that this is not always the case. In fact, much like in driving in traffic, a complex system like a river can respond in a myriad of ways to forces. On a freeway, a single accident can cause a traffic jam if the conditions are right. Well, the same things can happen in rivers, and we can tell that by looking at the probabilities of the river becoming unstable in different areas. Studying complex systems might sound too difficult or even impossible, but we are helped by the fact that there are a great many similarities between seemingly different complex systems. The probabilities of riverbank instability along the river have the exact same statistical distribution as do the sizes and frequencies of forest fires, for example, or of cities. While the forces changing the river, a fire, and a city are entirely different, the harmony of force interactions can be very similar. You may have a read a little bit on this subject in my "self-organized criticality" article. I have had other students, such as Jane Heath, do theses based on these ideas.

The more and more I look at how the spatial distributions of river forms, processes, and constituents vary though space, the more I realize that mapping these things is as much a product of my mapping technique as it is on reality. This is because most of our tools were developed decades ago for use on land. A main area of my research has been to develop tools and techniques to fix this problem, and in

doing so create maps of riverscapes that we can use for explanation, prediction, management, and communication. About a decade ago I began to study remote sensing as a way of "seeing" rivers. Remote sensing has been used for a long time in river studies, but for very restricted things such as the change in river channel position. But over the past decade, a new discipline has been borne, and everything is changing.

For smaller, relatively clearwater streams, it is apparent to anyone that as the water gets deeper, it gets darker. Building on these basic observations, I have worked with a group to study how light interacts with water, and that information then provides us with a way to convert images of rivers into maps of river environments. Water depth, for example, is related to the absorption of light, particularly red light. By quantitatively measuring the brightness in image pixels taken from airplane or high-resolution satellite, it is possible to make three-dimensional depth maps. By combining such maps with related GIS data such as DEMs of the land surface, it is then possible to make maps of river processes, such as my student Dave Jordan's work on mapping stream power throughout large areas of rivers.

But we don't have to stop with water depth. By looking at different kinds of light and/or with different optical instruments, it is possible to map things such as the water turbulence, its turbidity, the kinds of things that might be growing at the bottom of the river, even composition of materials on the beds of rivers. By combining these now-mapped properties, we begin to be able to make maps of total stream habitats, maps of utility for resource management. The future is bright, even today colleagues of mine are developing tools to measure the sizes of sediments across entire riverscapes, mapping the spatial distributions of heat inside rivers, and figure out ways to use old imagery to extract some of the very same kinds of information. A generation of river scientists has lamented that we didn't collect very much river data as most of the rivers in America were enormous changed by humans in the 1950's and 1960's. Well, this is a set of ways that we can, in fact, go back in time and make new measurements. We are also looking forward: I am on the working group of NASA's SWOT mission (Surface Water Ocean Topography), a large radar-based instrument which within ten years should be orbiting the earth and making high-resolution measurements of earth's entire riverscape every month or so.

These observations not only extend our geographical abilities, but these give us data that we can then use to test our theories about how watersheds affect the rivers which drain them. By combining topographic datasets and our knowledge of fluvial processes in a computer, it becomes possible to make geosimulations of individual events, such as the travel of a floodwave, or the cutting of Canyon Lake Gorge. These two cellular automata simulations of rivers were done with my student Jay Parsons, and they are one or several new methods for simulating the total river environment. Water not being restricted only to the river channel, I have other students study watershed hydrology on a large scale, such as my current student Andy Day, and a former student Sue Dunham, who looked at how it is possible to map hydrologic drought conditions through remote sensing techniques. I nonetheless find I have to work quite hard to become enshrouded by the very tools I have created for myself. I work to do more than look at images and push computer buttons. As such, I find it quite annoying that because I sometimes use technical approaches, I am labeled or thought of as a technologist. To me, that is like being labeled a typist because I have learned to type.

I've spent about a decade and a half actively studying riverscapes. Small rivers in the Driftless Area of southwestern Wisconsin, whitewater rivers on the Canadian Shield, high mountain cascades in the Southern and Northern Rockies and Yellowstone National Park, desert channels in central Arizona, deep incised rivers in northern England, cobble-bed rives in the Scottish Highlands, braided rivers in northeastern Italy and the Olympic Penninsula, and bedrock gorges in the Texas Hill Country. But the variations within rivers, at least spatially, is often much greater than between rivers, which is one of the reasons riverscape geographers are so at ease going to different regions and studying rivers. It's kind of like being in a university. Yes, universities in Texas are different than those in Russia or in London. But universities are far more like one another than they are like their local culture and politics. Also, the diversity of philosophies, methods, and topics within a university is enormous, and that diversity is interesting. Well the river is exactly that way; spatial variations within rivers are important, somewhat systematic (though not always), and very, very interesting. Going to rivers in different landscape regions is like shifting from the University of Texas to King's College London. Different, yes, but not really all that different.

Part of the problem in studying riverscapes is that we are not by nature river-borne organisms, so we have difficulty "seeing" the river as we do automatically for the landscape. And I want desperately to be able to see the river with the ease I see the land. This paucity of technique and data leads to a lot of lack of geographic knowledge for rivers. We have very little understanding of where and when rivers are more or less stable, though we do have so understanding of why they would be one way or another. We have a poor understanding of the historical interactions between human and rivers, even though human civilizations grew up along rivers and have modified them significantly over at least the past 4000 years. Our observations of rivers are entirely limited by or tools, and even though the past decade has seen an increase in observed river data by approximately 7 orders of magnitude, we still have a fairly poor understanding of how to use or interpret this quantity of data. Because of the strange, non-landscape connectivity of riverscapes (into unidirectionally-flowing networks), we don't understand how individuals or groups of various sizes spread their effects throughout rivers, especially when the effects are overlapping and competitive. The legal gerrymandering of water rights is one example. In a phrase, we know far less about the riverscape than we do about the landscape, so it is easy to find to the research cutting-edge. In this endeavor, GIScience is the beginning of geographical wisdom, not the end, and I always have a need for students that are able to start with GIScience and then go forward to bigger and better things.

About one day a week I get thoroughly tired of working on rivers and I let myself free to explore other geographical systems. I have published a couple of papers on alpine treelines, for example, and have made several numerical models of how they change with climate change. I've also studied mountain and snowy environments, coastal and hillslope geomorphology, the regional geography of Europe, neural cognition and geography, and the spread of wireless networks through space. I am spending more and more time working on projects that observe and simulated human-environment interactions; I have lead course projects on that subject, and I am currently working on proposals to do such work in East Africa.

After spending my entire life surrounded by geographers, I have come to have a rather unusual definition of geography. Instead of identifying our discipline with some specific topic, methods philosophy, or media (which any scan through the AAG meeting list will reject), I have come to believe that geography is a unique field of study because it is founded on a particular mode of thought; a brain operation, if you will. This mode is the capacity of the human mind to use spatial relationships as the first approach to learning about the world. The mode of thought is housed in a distinct part of the brain, the hippocampus and the associated entorhinal cortex, and while it is intimately connected with and corresponds with all other modes of thought (linguistic, computational, referential, self-cognitive, reflexive, and so on), our field is special in that we rely more heavily on this particular mode of thought than any other field. This part of the brain is wired in a specific and unusual kind of way (using so-called place and grid neurons), and from which we can see how the basis for cognitive geography and GIScience is hard-wired into the brain into patterns GIScientists call "geographic primitives". We literally "see" the world anew when we use our mind's geographic capacities. In this sense we are all GIScientists. Because almost all people and many animals use this mode of thought, we also are all geographers. The difference is, those who inhabit the academic discipline of geography trust, focus on, and nurture this mode of thought more than the average person.

People sometimes ask me what my topical specialty within geography is, or perhaps what might be my intellectual geographic tradition. I no longer know how to respond to these questions. I was originally hired by Texas State for "Water Resources and GIScience". It is true that in studying riverscapes I do study a lot of physical geography. But rivers can be as much about international water law, the mind of the lonely fisherman, the flooded family, the dam-builder or the dam-buster. It is true I do use and develop a fair amount of GIScience in looking at riverscapes. But I also use qualitative reasoning, fieldwork, art and cultural history to come to conclusions. It is true that I done a lot of work in a mainly a few general terrestrial regions, such as the Rocky Mountains. But I have also done work in the Italian Alps, the forests of the Canadian Shield, the limestones of the Texas Hill country, the wolds of northern England, the Utah deserts, the Pacific coast, and the Cascade Mountains. On Mondays and Tuesdays I am a post-positivist, on Wednesdays I am a realist, on Thursdays I am a pragmatist, on Fridays, I am a thoroughgoing social constructionist (to study something as fictional as a floodplain, one almost has to be), and on the weekend I'd like to think I am a humanistic geographer; if they would have me, that is. I suppose the best labels for me would be as a systematic geographer, or as a regional geographer, with the riverscape being my region (much like many geographers consider urban geography a regional specialty). But no one believes me when I try to use these labels. I disdain these labels; I am not a number, I am a free man! I will not be pushed, stamped, indexed, briefed, debriefed, or numbered! My life is my own. I am simply a geographer, and with the right thinking, you could be one as well.