Twenty Years After People and Pixels

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History

In the early 1990's we had the start of what came to be known as the human dimensions of global change. This resulted from the invitation from the IGBP, International Geosphere Biosphere Program, to the social sciences (via the International Social Science Council) to engage with global change research together with them. Soon a Human Dimensions of Global Change Committee was created at the National Research Council to address this issue. From its deliberations came the 1992 volume *Global Environmental Change: Understanding the Human Dimensions* (NRC 1992), also known as "the rainbow book" because of its colorful cover. From its recommendations, many agencies began to sponsor human dimensions research, whether through the LCLUC (Land Cover and Land Use Change) Program at NASA, the GIS and Population program within NIH's Population and Social Sciences Study Group, NOAA's human dimensions of climate change, and two centers of excellence on human dimensions of global change funded by NSF at Indiana University and Carnegie Mellon.

In short, there were multiple initiatives reflecting a mutual need to connect the climate sciences with the social sciences. Specifically, there was a need to expand the user base for the data archive of Landsat on the part of the remote sensing community, and a recognition by the social sciences engaged in land use research of a need to expand its spatial coverage and context of study areas. The challenge for both was in making this connection by finding integrative approaches, and this made it an exciting period to engage these issues.

After a couple of years, there was an active community engaged in making this connection, and also a need to provide further guidance on what was working, and not working, in making this connection between the remote sensing and social science community. NASA sponsored a study through the National Research Council Committee on Human Dimensions of Global Change. Diana Liverman was chairing the committee and she invited Emilio Moran and Ronald Rindfuss to join the Committee, with the explicit intention to organize a workshop that would result in a volume that came to be known as People and Pixels. NASA wanted to grow the community of Landsat users by showing how this new community of social scientists could use these data and methods. The pioneers in the use of these techniques were invited to discuss their efforts to use and link remote sensing to their social science questions, to focus on the challenges, what worked and what did not, and what sort of training should be encouraged to create a well-trained community of users.

The Volume

In the volume (NRC 1998), and the workshop, there were discussions of what remote sensing could do for the Social Sciences. Examples: improve the measurement of landscape context of social phenomena; give richer detail of the biophysical context within which people live; time series data with greater frequency than the decadal census; measure the effects of decisions e.g. deforestation, particular land use choices, tillage practices; and improving the collection in time and space and across regions of needed measurements.

The use of remote sensing time series made levels of analysis an important set of considerations in research by facilitating moving from household to landscape to regional analyses. It also permitted the social science community to address the behavior of individuals in the context of their communities and regions. It enriched the data sets by allowing a connection between remote sensing time series as complements to economic time series data and facilitated modeling human-environment interactions. Advances in methods in how to do this created excitement and important progress. Nesting these levels of analyses became a particularly important set of advances (Brondizio 2005; Walsh and Crews-Meyer 2002).

Conversely, social science could provide some benefits to the remote sensing community by providing a new source of validation and interpretation of remote observations, enhancing what was meant by "ground truth" -- given the lengthy fieldwork of social scientists on the ground. The social science community brought to the attention of the remote sensing community early concerns about confidentiality and about the public use of remote observations than had not been part of the thinking before-- such as the need for data aggregation, removal of geo-identifiers in the published data, and other new challenges that have only grown in importance over the years.

The coming together of the remote sensing community with the social science community was necessary to advance human-environment research. It made possible addressing important questions such as global deforestation, land conversion, food security, population migration, and the development of early warning systems, improve public health forecasts and interventions, and to begin to address many questions about the process of urbanization.

The volume identified important issues and began to address them, such as finding the appropriate spatial and temporal scales; building a community of scholars linking remote sensing and social science; developed training programs which emphasized bi-skilled interdisciplinary training and the importance of team-based science; and giving priority to providing the necessary data at the right scale for a given question at a reasonable cost.

Outcomes from the Volume

Over the past 20 years, since the *People and Pixels* volume, we have made progress at finding the appropriate scales for the questions asked and a proliferation of satellites with growing spatial and temporal resolution is now available to users, making the granularity of the data ever more relevant to social science questions. The community doing social science and remote sensing has grown in size and expertise across the nation and the world. Funding from NSF created centers that, in turn, instituted programs to train future scholars in the use of GIS and

Remote Sensing as basic and necessary tools in socio-environmental research. Programs such as those created at Indiana University, e.g. the Anthropological Center for Training and Research on Global Environmental Change (ACT) and the Center for the Study of Institutions, Population and Environmental Change (CIPEC) ran summer training programs that introduced over 180 young scholars from 32 countries to linking social science to remote sensing, and who went on to practice what they learned and create other such centers worldwide.

In the meantime, Landsat data has become widely accessible for free with programs such as University of Maryland and USGS disseminating it freely and with provision made for even finer resolution data through special data purchases. Does anyone remember the days when we had to pay US$4,000 for one Landsat scene? Few users could afford to use Landsat data at that price and this important national resource languished for years due to this policy. Much of the progress since *People and Pixels* would not have happened without the price of images going down.

Following the *People and Pixels* volume, there was a proliferation of volumes that advanced the field:
- The NASA LCLUC synthesis volume in 2004, *Land Change Science*
- The NSF/CIPEC synthesis volume in 2005, *Seeing the Forest and the Trees*
- The Carolina Synthesis volume in 2003*, People and the Environment: Approaches to Linking Household and Community Surveys to Remote Sensing and GIS.*
- The NIH synthesis in NRC, 2005, *Population, Land Use and Environment: Research Directions*.
- The Clark/B.L. Turner II volume in 2004, *Integrated Land Change Science and Tropical Deforestation in the Southern Yucatan*

These volumes were led by participants in the *People and Pixels* volume, who went on to further advance the field in the 5 to 10 years after P&P with their own synthesis volumes reflecting the communities they had grown to create at their own institutions and networks. All this was made possible by a favorable and supportive funding environment from the U.S. Global Change Program and in particular the programs supporting human dimensions work at NIH, NASA, NSF, and NOAA. New journals came into being to disseminate the work such as Geospatial Health (2006- present) on applications of RS/GIS to human and veterinary health. Book Series were created to publish this sort of work, such as the Linking Levels of Analysis Series at University of Michigan, and the Human-Environment Interactions Book Series at Springer.

Advances in the last 20 years

We have seen more complex conceptualization of land change processes: from models aiming at identifying causal relationships based on types of drivers and types of outcomes to social-ecological models giving more attention to social processes and feedbacks. We have seen new challenges appear in understanding land change processes, such as landscape complexity continues to increase along with accelerated transformation of rural populations and economies, including ever stronger rural-urban linkages that challenge analytical boundaries.

Role of GIS and other spatial analysis tools has increased substantively in relation to remote sensing, e.g. widely available public and private data, easier to generate spatial data and greater access to GPS devices and mobile technology. Increased attention to participatory research using mobile technologies now allow new forms of data collection, including crowdsourcing. Local and indigenous communities taking on monitoring their own territories using these technologies, rather than depend on outsiders. New techniques have developed to incorporate non-spatial data along with spatial analysis. Open access GIS software has allowed expanded use and access to these tools. It is common now to see research and publications using participatory mapping.

The Landsat system continues to be central to land change studies, arguably it has growing importance as it is the longest, continuous time record available for earth observations from space, and its current low cost of acquisition. There is improved availability and access to high quality pre-processed data (geo-referenced and calibrated) that has facilitated the use of imagery by social scientists. New families of multi-sensor platforms have opened up new possibilities for fine-grained analysis, although the high costs of very high-resolution imagery still limits applications. Google Earth has opened up new possibilities for using RS data at every stage of research, from research design to ground-truthing, using online high-resolution images.

And what might we expect in the next 20 years?

- Use of Big Data algorithms linking social media, on the ground and drone sensors and remote sensing;
- Civil society demanding more "results" from these data and greater challenges in commercial vis a vis scientific priorities;
- RS and GIS routinely taught in high schools, alongside programming and coding, giving access to everyone; AND
- People might forget what a major advance *People and Pixels* volume represented in 1998.

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