From Meta-Studies to Modeling: Synthesizing a Changing Landscape

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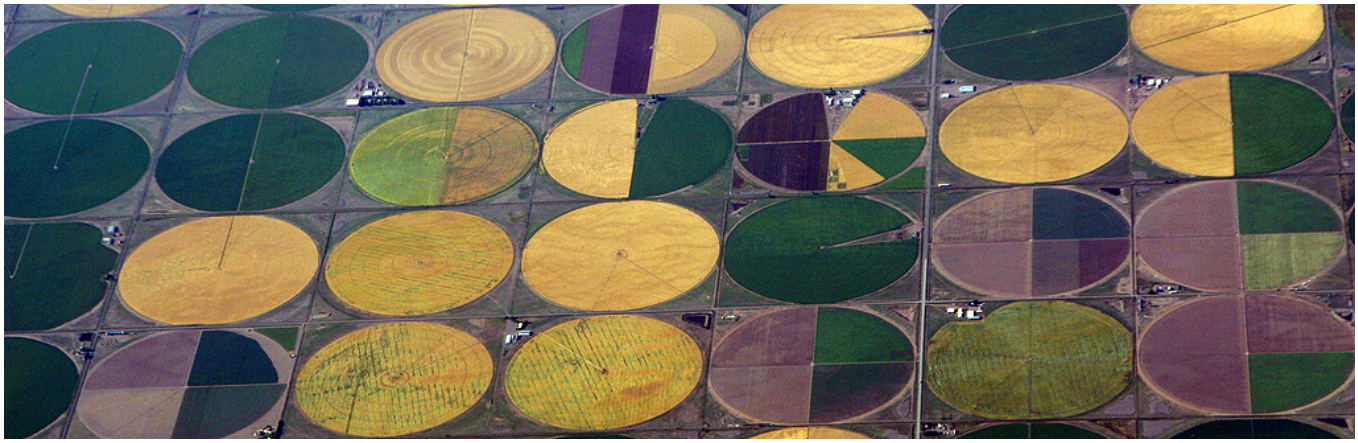

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Question? Research. Answer!

It may be simple and straightforward, yet it's rarely how the scientific process actually works. Rather, scientific discovery is wrought with complexities that may lead to more questions than answers—but that's precisely where things get interesting.

Take land change science, for example. From deforestation and irrigation to urbanization and restoration, humans are transforming the surface of the Earth, and on massive scales. The patchwork of landscapes covering the globe are as numerous as they are diverse. At the same time, they are linked: ecologically, socio-economically, culturally. The land use choices of a farmer, pastoralist, or housing developer both influence and are influenced by local contexts such as per capita income as well as broad-scale pressures such as climate change and economic globalization. As a result, landscapes breathe as much life and undergo as much change and growth as the people, plants, and animals living within them.

Land change scientists endeavor to make sense of it all: the various drivers of land use change, and how those changes feed back into people's livelihoods and land use decisions. To accomplish this feat, they must overcome several challenges. First, traditional scientific experiments aren't feasible in land change science. It's neither ethical nor even logistically possible to manipulate the global food trade market in order to measure its influence on a village's food security, for example. Second, the layers of complexity are all but endless. How can researchers possibly isolate the effect of a land use decision made in urban Chicago or rural China?

Here, land change scientists may very well agree with philosopher and political theorist Isaiah Berlin: the key to understanding is in the identification of patterns.* Dr. Nicholas Magliocca, an assistant

research professor at the National Socio-Environmental Synthesis Center (SESYNC), uses synthetic and modeling approaches to find patterns among land uses and changes. As a resource to the wider land change science community, he recently co-published a related series of articles outlining how synthesis, meta-studies, and agent-based modeling can help us understand how humans interact with and change the landscapes in which they live.

Local case studies inform much of what we know about how humans use land and how those practices change over time. But determining whether individual cases are merely anecdotal, or the extent to which they can be scaled up to explain regional or even global land use patterns, is a challenge. The research approach of synthesis is especially useful in this context: it draws upon and distills many sources of data, ideas, explanations, and methods to generate knowledge that is applicable across spatial and temporal scales.

In open-access papers published in *Regional Environmental Change* [1] and *Ambio,* [2] Magliocca and co-authors map the landscape of synthesis within land change science and identify tools to integrate diverse data sets from multiple disciplines. The papers aim to help researchers identify which synthesis methods are most appropriate for what they're trying to do and what types of data they have—and then to actually do them. Specifically, the authors discuss meta-studies, which they define as "specific synthetic methods that distill the findings of many narrowly focused analyses (i.e., 'cases') to produce knowledge that is more generally applicable than may be derived from a single case."

Cases of deforestation, restoration, and other global change phenomena are happening right now all across the world. But whether pasture cover is converting to agricultural land in Laos or Brazil, it has something in common: the conversions can be measured consistently, regardless of where they take place. Accordingly, these place-based changes can be compared to reveal both commonalities and differences in their causes and consequences.

Agent-based models—used as "virtual laboratories," as Magliocca calls them—are a practical computational tool that help with such syntheses. They offer a powerful means of simulating the land use choices of individuals and groups in order to assess their interactions within a landscape. And although land use change has been studied mostly by researchers creating highly detailed, specialized models that apply to a single location and are highly context-dependent, there's also much to be learned through comparative research across different sites.

In an open-access paper published in *Environmental Modelling & Software,* [3] Magliocca and co-authors illustrate where and how meta-studies can inform the modeling process (e.g., when conceptualizing, coding, or implementing a model). And in another open-access paper published in *Land,* [4] Magliocca puts it all to task by applying a generalized agent-based model to six different agricultural case studies. In this paper, he analyzed the relative importance of local and larger-scale influences on land use changes throughout the six sites. In a nutshell, he found that the more remote a location, the more sensitive land use decisions are to ecological factors such as soil quality; the less remote a location, the more sensitive they are to individual's perception of risk and economic factors such as crop prices.

More importantly, says Magliocca, the "results demonstrate model-based synthesis as a promising approach to overcome many of the current challenges of synthesis in land change science" because it rigorously embraces complexity.

"And the insights you can gain from the land change perspective are almost always applicable to the larger socio-environmental context, because land change science is already so integrative. Whether you start with a question about fluctuations in land markets or valuation of a restoration project, the

lessons to be learned through synthesis and modeling are broadly relevant," he adds.

* Isaiah Berlin, "Historical Inevitability" (1954).

Above photo: Aerial view of center-fed farms in the San Luis Valley of Colorado. Courtesy Doc Searls via Flickr/Creative Commons.

Further reading

Nicholas R. Magliocca, Thomas K. Rudel, Peter H. Verburg, et al. (2015). "Synthesis in land change science: methodological patterns, challenges, and guidelines" in *Regional Environmental Change*. Access online: http://dx.doi.org/10.1007/s10113-014-0626-8 [1]

Jasper van Vliet, Nicholas R. Magliocca, Bianka Büchner, et al. (2015). "Meta-studies in land use science: Current coverage and prospects" in *Ambio*. Access online: http://dx.doi.org/10.1007/s13280-015-0699-8 [2]

Nicholas R. Magliocca, Jasper van Vliet, Calum Brown, et al. (2015). "From meta-studies to modeling: Using synthesis knowledge to build broadly applicable process-based land change models" in *Environmental Modelling & Software*. Access online: http://dx.doi.org/10.1016/j.envsoft.2015.06.009 [3]

Nicholas R. Magliocca. (2015). "Model-Based Synthesis of Locally Contingent Responses to Global Market Signals" in *Land*. Access online: http://dx.doi.org/10.3390/land4030807 [4]

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[1] http://dx.doi.org/10.1007/s10113-014-0626-8
[2] http://dx.doi.org/10.1007/s13280-015-0699-8
[3] http://dx.doi.org/10.1016/j.envsoft.2015.06.009
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