



THE PAPER TRAIL

Breaking Through Ecosystem Boundaries: Editor's Note

Editor's Note: In this issue of *The Paper Trail*, an arising and established researcher knew early on that pushing the boundaries to better understand and quantify ecosystem interactions was where they wanted to focus their careers. One knew that it was by messing in the dirt and detritus of the field, while the other went with a more “back of the envelope” approach. There is nothing simple about meta-communities and conducting empirical studies on them or quantifying them in the theoretical realm, and that may be what makes these two have an even stronger connection. They talk about it in this joint article that includes the first Paper Trail interview.

— *Stephen L. Young*

Breaking Through Ecosystem Boundaries

Amanda Klemmer began her undergraduate degree at Allegheny College in Pennsylvania—passionate about biology, but not in the ever so

popular “pre-med” track of many of her peers. This divergence began with her first course in introductory biology. As the class progressed and they started to learn about plant physiology, her pre-med peers were bemoaning how pointless it was for them to understand plants, yet she found



Amanda Klemmer in 2014 sampling a cattle tank experiment on terrestrial-aquatic meta-ecosystem dynamics in the Southern Alps of New Zealand. (Photo credit: Helen Warburton)

the subject completely fascinating! It was at this point that she realized she was headed straight for a career studying organisms in the natural world and the complexity of their interactions within ecosystems.

Her research career really began in her sophomore year when she spent a summer studying caddisflies in Colorado ponds at the Rocky Mountain Biological Laboratory (RMBL) with Scott Wissinger, entomology professor. It was the first-hand experience studying communities, food webs, and terrestrial plant detritus—not sure what a pre-med student would say about dead plants, probably yuck!—that sent her on her journey to Canada and New Zealand to study the role of terrestrial resources in freshwater ecosystems.

While at the University of British Columbia (UBC), Amanda found herself drawn more deeply into research on cross-ecosystem resources (i.e., subsidies or allochthonous resources),

becoming fascinated with the world of food webs and their spatiotemporal connections. It was then that she discovered Michel Loreau's 2003 paper "Meta-ecosystems: a theoretical framework for a spatial ecosystem ecology" (*Ecology Letters* 6:673–679). His paper extends the meta-community concept to include not only the dispersal of organisms, but also the bi-directional flow of materials and energy connecting ecosystems in space.

After discovering the breadth of work from Michel and his lab, her calling was complete and Amanda began in earnest to experimentally test hypotheses derived from novel meta-ecosystem theory. She continued her work with John Richardson at UBC to understand how resource gradients exchanged across ecosystem boundaries alter trophic cascades. During her Ph.D., she worked with Angus McIntosh at the University of Canterbury to experimentally test the effects of different cross-ecosystem resources on source/sink dynamics within terrestrial and aquatic meta-ecosystems. If it had not been for Michel's paper during the first year of her M.S. degree, it is hard to know if Amanda's path would have reverted back to following her pre-med colleagues or continued to where she is today.

Considering the impact that Michel and his lab have had on the trajectory of Amanda's career, we thought it would be fun to ask him some questions about his path to breaking ecosystem boundaries and the scholarly connections he has made with his predecessors.

Paper Trail: Michel, when did you first realize that you wanted to focus your career on ecology?

Michel Loreau: I made this choice when I was in the third year of my undergraduate studies at the Free University of Brussels. I will always remember the day when I first registered at the University. I was in the queue to register with my forms filled in but I had left the discipline box blank because I was still hesitating between philosophy, mathematics, physics, and biology.

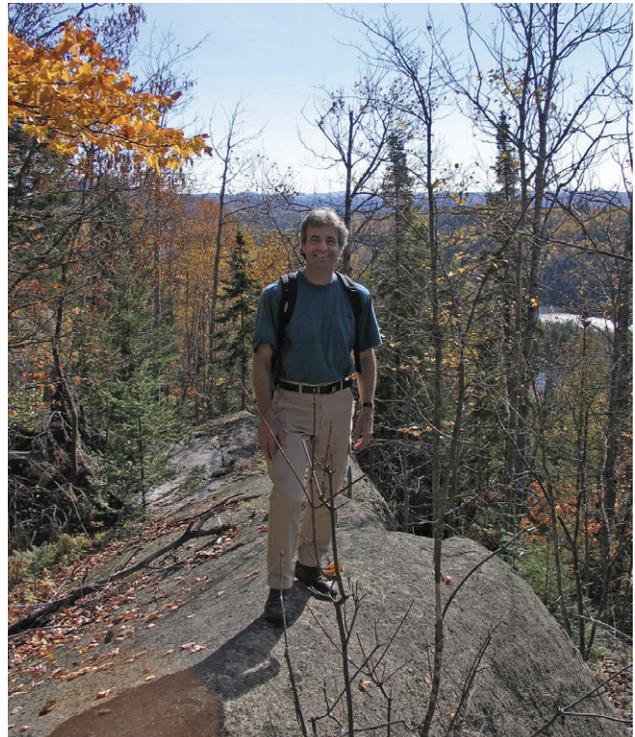
When the clerk asked me to fill in that box, I stopped thinking and my heart told me to write “biology.” But I always kept an interest in philosophy, mathematics, and physics. When I discovered scientific ecology during the third year of my undergraduate studies, I soon felt that ecology was the kind of integrative science that would allow me to satisfy my other interests and develop the synthetic worldview I was aspiring to. And that is exactly what happened since I am now a theoretical ecologist working at the interface between philosophy, mathematics, physics, and biology!

PT: Was there a particular researcher or paper that led you down your path?

Michel: I have always had broad interests, so I cannot say that any particular researcher or paper led me down my research path. But Robert MacArthur and Richard Levins stand out as particularly influential in my choice to move toward theoretical ecology. I started as a field ecologist working on ground beetle communities. I switched to theory only later, when I realized that I was much better at doing theory than observations and experiments in the field. Only theory would allow me to fully develop and synthesize the new ecological ideas I had in mind. Robert and Richard were a major source of inspiration at that time, along with many others.

PT: Can you briefly explain how your concept of meta-ecosystems came about?

Michel: The meta-ecosystem concept grew out of work that I did with my former Ph.D. student Nicolas Mouquet and discussions with Nicolas and Bob Holt as part of a National Center for Ecological Analysis and Synthesis (NCEAS) working group on meta-communities. I have always had a strong interest in building a new ecological synthesis merging the principles and approaches of community and ecosystem ecology. This interest guided most of my research



Michel Loreau in the Laurentian Mountains, Quebec, in 2006.
(Photo credit: Claire de Mazancourt)

throughout my career and led to the publication of my book, “From populations to ecosystems: theoretical foundations for a new ecological synthesis” (*Monographs in Population Biology*, Vol. 46. Princeton University Press, 2010). So, after having developed meta-community theory based on principles and models from meta-population ecology, the next logical step for me was to extend this theory to meta-ecosystems and consider the spatial connections between ecological systems that arise from movements of energy and materials, not just living organisms.

PT: Where do you see the field of meta-ecosystem ecology moving in the future?

Michel: Meta-ecosystem ecology is still a relatively young area of research, which I think can grow in a large number of exciting new directions to explore the many facets of ecosystem science in a spatial context. Recent theoretical developments have, for instance, extended ecological stoichiometry and eco-evolutionary dynamics to a

meta-ecosystem context, leading to new hypotheses and predictions on the emergence of either nutrient co-limitation or complex food-web structure in space. Understanding the role of space in ecological patterns and processes remains an important challenge, and meta-ecosystem theory is a versatile approach that has much to offer in this respect.

PT: Very good. Thanks, Michel.

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