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# Microbial ecology of tropical forest soils

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Widely acknowledged for over a century for their vital importance in the functioning of terrestrial ecosystems, our understanding of the identity and activities of soil microorganisms has lagged behind that of the larger organisms that live above-ground. This knowledge gap may be partly due to the lack of visibility of the below-ground microflora. The varied roles of micro-organisms – in the cycling of carbon and other elements, in aiding (and competing with) plants for acquisition of resources, and in the formation of soil aggregates that provide protection from erosion and habitat for a myriad of soil flora and fauna, among others – are apparent only when natural and anthropogenic disruptions interfere with their activities. Evidence for their existence and function must be pursued intentionally, since they are by nature invisible to the eye. By contrast, the highly visible (often flashy) nature of many of the organisms found in the above-ground compartment of terrestrial ecosystems – mammals, insects, plants – has resulted in a more thorough cataloging and advanced understanding of their biology and ecology. The physical accessibility of above-ground organisms makes them much easier to study: to classify, count, weigh, map, and identify their interactions.

Our understanding of soil microorganisms and microbial communities during the 19th and 20th centuries was made possible by the adaptation of a variety of microbiological methods (many originally developed to study pathogenic microorganisms) to the study of soil microorganisms. Thus, the application of pure culture techniques, microscopy and chemical and biochemical assays to study soils has allowed us to classify and quantify the myriad bacteria, fungi, protozoa and viruses present below-ground and the processes they carry out. However, rapid developments in the field of molecular genetics towards the end of the 20th century, and the successful application of these techniques to the study of microbial ecology, has made soil microbiologists and microbial ecologists reconsider what they thought they knew about their subject. For example, nucleic acid analysis of soils has demonstrated that the conventional methods employed by soil microbiologists can detect only a tiny fraction of the species of microorganisms found in soil – fewer than 1 % by most estimates (Amann *et al.* 1995). Imagine if forest ecologists were able to "see" only 1 of every 100 plant species present in a tropical rain forest. Our system of classifying microorganisms – based on morphological and biochemical similarities – has also been shaken to its deepest roots, replaced by measures of genetic similarity (Woese & Fox 1977). The tools of molecular biology have expanded our view of below-ground ecosystems and our ability to ask questions about who is there and what they are doing (Torsvik & Øvreås 2002).

The papers in this Special Section of *Tropical Ecology* provide excellent examples of the use of molecular tools to study soil microbial communities and to improve our understanding of the interactions between the above- and below-ground components of tropical ecosystems. In a series of studies of two forest ecosystem in Costa Rica, Eaton and his colleagues have employed a variety of nucleic acid and conventional techniques to examine the role of soil microorganisms as indicators of environmental change (Eaton & Chassot 2012a). Focusing on nitrogen-fixing bacteria (*Frankia* and *Rhizobium* spp.), Archaea, methanotrophs and lignin-degrading fungi, these authors have assessed the effects of the nitrogen-fixing tree, *Pentaclethra macroloba*, on microbial

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communities of non-rhizosphere soil of lowland secondary forests (Eaton *et al.* 2012b; Lowe *et al.* 2012), compared microbial communities of grasslands and secondary forests (Hafich *et al.* 2012), examined the influence of maya (*Bromelia pinguin*), a ubiquitous plant of primary forests of Central America, on nutrient cycling and soil microbial communities of these forests (Looby *et al.* 2012), and assessed the relationship between soil moisture and the structure and function of soil microbial communities of tropical montane cloud forests (Eaton *et al.* 2012c). Together, these studies begin to provide a rationale for employing microbial metrics to monitor the effects of disturbance and restoration efforts in tropical forests.

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