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How does moisture regulate microbial life in soils?

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Moisture regulates microbial life in soil, and therefore also the terrestrial carbon (C) cycle. Soil moisture not only directly affects the microbial activity, where dry conditions reduce rates, but its fluctuations also dramatically affect microbial process rates. Rewetting a dry soil induces the most dynamic event that can happen in a soil; an enormous CO_2 pulse is released to the atmosphere, which can significantly affect the ecosystem C-balance.

To understand the effects of moisture and its fluctuations on soil microbial communities we can use different approaches. We can assess microbial functional stability by measuring how microbial communities withstand desiccation ('resistance') and how they recover to a pre-disturbance state after a drying and rewetting (DRW) perturbation ('resilience'). Finally, we can also track the microbial resource-use, distinguishing between growth and respiration, which will capture the dependence of microbial carbon use efficiency (CUE) on moisture. We propose a framework where we need to understand microbial (a) resistance to water loss, (b) resilience to DRW and (c) CUE to resolve how moisture regulates microbial life in soils. Two cases will be used as examples.

(1) Can soil bacteria become more resilient to DRW perturbations? Soil bacteria can have two different responses to a DRW perturbation that vary in resilience and CUE, with immediate implications for the ecosystem C-balance. We tested if soil bacteria in the laboratory could become more resilient after exposing them to several DRW events. Secondly, we tested if this could happen at ecosystem level, using samples from a long-term drought field-experiment. We found that both repeated DRW cycles and experimental field-drought selected for more resilient soil bacteria, which resulted in a lowered soil C loss. This demonstrated that bacteria can become more resilient to DRW perturbations and suggested that it can also happen in natural environments.

(2) Can drought have a legacy effect on microbial processes? It has been argued that past climatic conditions (e.g. precipitation regime) can have a lasting effect on contemporary microbial functions. To test this, we used soils from a precipitation gradient in Texas and investigated if there were differences in microbial drought tolerances and responses to DRW across the gradient. We found that exposure to different mean annual precipitation (MAP) did not have an effect on the resistance and resilience of microbial processes. However, differences in MAP coincided with differences in the partitioning between respiration and growth during a DRW perturbation, resulting in a higher microbial CUE in historically drier soils. We are currently verifying these results along a climate gradient in a subtropical location (Ethiopia), where we have installed rain exclusion shelters to compare long term drought with induced short term drought.