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Investigating the legacy effect of drought on microbial responses to drying and rewetting along a Texan precipitation gradient

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Hydrological regimes will intensify due to climate change, thus increasing the duration and intensity of drought and rainfall events. Rewetting of dry soil is known to stimulate dramatic CO_2 releases. A clear understanding of the mechanisms that determine the dynamics of CO_2 loss upon rewetting is therefore required to characterise ecosystem C-budgets and predict responses to climate change. Laboratory studies have identified two distinct responses upon rewetting; bacterial growth either increases linearly immediately, with maximal respiration also occurring immediately and decreasing exponentially with time ("Type 1"), or bacterial growth increases exponentially after a period of near-zero growth, with a sustained period of elevated respiration, sometimes followed by a secondary increase in respiration coinciding with the onset of bacterial growth ("Type 2"). A shift from a Type 1 to a Type 2 response has been observed with increasing duration and intensity of drying prior to rewetting. The size of the surviving microbial community after drying, relative to resources available after rewetting, is suggested to dictate whether a Type 1 or 2 response occurs, with more 'harsh' (i.e. longer or more severe) drying reducing microbial biomass such that carbon available upon rewetting is sufficient to support exponential growth (leading to Type 2 response). However, this is yet to be tested in intact ecosystems.

We investigated the legacy of drought on microbial responses to drying and rewetting using grassland soils from a natural precipitation gradient in Texas. Mean annual precipitation spanned a 500 mm range (400-900 mm $year^{-1}$) across the 400 km gradient, while mean annual temperature was constant. Soil properties (pH, SOM) did not vary systematically across the gradient, with differences reflecting land-use history rather than rainfall. Air dried soils from 18 sites were rewetted to 50 % water holding capacity with bacterial growth, fungal growth and respiration measured at high temporal resolution over 7 days. We predicted that there would be a shift in the type of response to rewetting (Type 1 to Type 2) across the gradient, as a consequence of exposure to harsher drying. Further, given the lack of systematic variation in other factors with rainfall, we expected levels of maximal growth and respiration as well as the level of steady state growth and respiration to be similar across the gradient.

All soils exhibited a Type 1 response, with respiration, bacterial and fungal growth increasing immediately upon rewetting and typically stabilising after $c.$ 20 hours. There were, however, differences in the magnitude of CO_2 release and microbial growth among soils, whereby rewetting of historically wetter soils stimulated higher rates of microbial growth and a greater release of CO_2, compared to rewetting of historically drier soils.

Contrary to expectations, there was no difference in the type of microbial response to rewetting, but instead a systematic dependence of overall microbial rates, depending on the legacy of drought. This contrasted with previous laboratory studies, suggesting that exposure to drought across the natural gradient was not perceived as 'harsh' by the microbial communities. This may be explained by either (i) differences in resource availability (i.e. plant input) mitigating the microbial susceptibility to drought in intact ecosystems or (ii) microbial tolerance to drought.