N:P imbalance effects on the seasonal C cycle in a Mediterranean Tree-Grass Ecosystem

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N limited ecosystems worldwide are shifting towards other limitations due to anthropogenic N deposition exceeding the rate of change in other drivers. Mediterranean ecosystems are among those thought to be shifting to P limitation and ‘N:P imbalances’ but this occurs alongside strong environmental limits on C uptake in both winter and summer in a distinct bimodal phenological cycle. At the ecosystem scale, carbon cycle components such as gross and net primary productivity, respiration or ecosystem carbon use efficiency, are a result of accumulation of physiological and community effects in both plants and soils. The functioning of such systems is commonly measured at plot or individual level, but scalable, inter-site comparisons are complicated because multiple interacting gradients of driving factors, weather and seasonal timing do not correlate through geographic space.

Here, we explore the interaction of seasonal conditions and nutrient treatment on eddy-covariance derived C cycle properties in a ecosystem-scale ‘stoichiometry manipulation experiment in a Mediterranean tree-grass system (5 years after a large, one off fertilization, ‘MANIP experiment’) where the close location means sites can be compared with similar local weather and seasonality.

During the 5 year study period, N:P ratios in soil pools regress towards pretreatment conditions in both N and NP treated footprints, and generally plant level effects decline through time. Nonetheless, holistic C uptake differences between nutrient treatments (e.g. in GPP) remain for the entire 5 year study period. Effects are particularly strong in spring (late in the phenological year) where the accumulation of biomass magnifies treatment differences and water is not limiting. The effects of increased nutrient availability and altered N:P stoichiometry are also visible on resource use in winter, a relatively fallow period rarely studied in non-continuous measurements. Treatment effects in these winter periods differ from effects in spring, but both contribute to overall ecosystem-level responses to the nutrient treatments. The effect of nutrient
balance on carbon cycling and carbon use efficiency is seasonally driven as fertilized treatments have both higher ecosystem-scale carbon use efficiency and light use efficiency, including in winter. However the fertilized treatments are also relatively less affected by years with warmer winter temperatures than the unfertilized treatments. N:P imbalanced treatments are also more water sensitive than those with balanced stoichiometry. Physiological and community change response studies in such systems must consider both year round and multi-year representation for scalable and transferable understanding.