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Fertilization and irrigation effects on the time scale of carbon cycling in New Zealand Pastures

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Soil organic matter is the largest terrestrial stock of carbon, and agricultural soils have potential to store large amounts of carbon (C), dependent on management practices such as fertilization and irrigation. Soil C is composed of a complex mixture of organic molecules of varying sources, energy contents, and degrees of stabilization, and are cycled at different rates in soils. Thus the "age" of these molecules can be largely variable and widely distributed. Since management practices can modify both the amount of carbon that enters the soils and the rates at which C is cycled, we expect management practices to affect times scales of soil carbon cycling. In this contribution, we present results from a unique set of archived soil samples collected between 1959 and 2008 from a long-term pasture production study in New Zealand. Thirteen subsamples were analyzed for radiocarbon analyses, and a three-pool feedback model was fit to the data, which spans over 60 years. Such highly constrained models can accurately investigate differences in management effects on mean system age (MSA) and mean transit time (MTT). Management effects were observed showing significant differences in MSA and MTT across both irrigation and fertilization trials. In particular, we observed: 1) irrigated pastures have a large fast-cycling pool due to higher productivity in spite of lower system transit times. 2) Frequent irrigation decreases the amount of long-term stable C in pastures. 3) Despite no difference in soil C accumulation, fertilized pastures store C longer than unfertilized pastures. These results suggest a potential paradigm shift toward prioritizing management that promotes long-term storage of C above simple increases in soil C content, which could lead to more effective methods of addressing rising atmospheric C. Results from this study could be applied to systems that are lacking spatio-temporal resolution present here.