Response to the comment by McGuire (2021) on Mosier et al. (2021), Adaptive multi-paddock grazing enhances soil carbon and nitrogen stocks and stabilization through mineral association in southeastern U.S. grazing lands.

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Abstract: In Mosier et al. (2021) we assessed differences in soil carbon and nitrogen stocks on five replicate pairs of rangeland farms, with each pair having a farm practicing conventional grazing and the other adaptive multi-paddock grazing. High care was used to identify comparable soil types between the farms in each pair, and the comparability was tested using soil spectral analyses, so that measured differences could be ascribed to management effects. The study objectives did not need pre-treatment baseline measurements since we never claimed to determine stock changes withing a farm over time. Similarly, while the study did not aim, claim, or need to quantify soil carbon stock variability within a farm, it used a fully replicated design at regional scale. Therefore, the criticisms by McGuire regarding lack of pre-treatment baseline data and for the use of pseudoreplication are not pertinent and indicate a lack of understanding of the study design and objective

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McGuire (2021) criticized our study (Mosier et al., 2021) for the lack of pre-treatment baseline soil measurements and of surveying soil carbon stock variability within each farm, and argued that “no conclusions regarding the grazing management treatment effects on soils nor estimates of effect sizes could be made”. A meaningful assessment of adaptive multi-paddock (AMP) grazing effects requires on farm comparative studies, replicated in several farms across a broad geographical area (Teague et al., 2013). This is what we did in Mosier et al. (2021). We carefully reported our data as differences between AMP and conventional grazing farm operations, and never reported soil carbon accrual rate over time for the two management treatments. We also did not claim to study the variability of soil carbon stocks within a farm or management operation. Thus, the criticisms by McGuire (2021) are misplaced and denote a lack of understanding of our study goals and design.

While baseline measurements would be ideal and enable assessment of rate of soil organic carbon (SOC) accrual within a management treatment, they have been rarely available on farms until now. Given the recent rise in interest for SOC farming, farms have started to be broadly sampled, soon enabling future resampling. Therefore, until now, space for time research methods that substitute for baseline measurements have been widely applied and many studies published results using this experimental approach (Shrestha and Stahl, 2008; Pineiro et

al., 2009; Bai et al., 2012; Shaoxuan et al., 2016; Williams et al., 2020). The prerequisites for using a space for time study design are that the soil has undergone the same regional patterns in precipitation, temperature, soil texture, and land-use history. All of these prerequisites were presented in our paper and were fulfilled across our farm pairs. Additionally, our site and soil sampling selection went beyond these requirements, and accounted for the same slopes and aspects between replicate farm pairs.

The McGuire (2021) comment cites Allen et al. (2010), Singh and Whelen (2020), and Robertson et al. (1993) as evidence that soils have high spatial variability. In the Singh and Whelen (2020) paper they only found such high soil carbon variability in the top 0-30cm of soils and had fewer cores representative of each site. While our study did not aim to asses SOC stock variability within each farm, we intentionally took four times as many cores as Singh and Whelen (2020) and we also measured SOC stocks down to one meter to account for the variability often found from lower numbers of cores and shallow soil sampling. We are aware that soils have high spatial variability and therefore follow the recommendations from Allen et al. (2010), that (1) it is important to work with randomized sampling, (2) pairing sites is the most effective way of detecting SOC stock changes, and (3) measuring soil fractions is a more powerful method to detect SOC stock changes due to management. We have followed protocols for sampling soils with high heterogeneity by implementing high density sampling with replication in multiple catenas. Many of the comparisons in Singh and Whelen (2020) and Robertson et al. (1993) are across different cropping systems and many sites had big differences in their disturbance history. Additionally, in Singh and Whelen (2020) the paper highlights that soil type, climate, and land use were the main drivers of spatial variation in soil carbon. In our study we controlled for soil type, climate, historical and current land use. Our farms were screened for historical land use and after cropping (many years ago) they had similar management strategies until AMP grazing was implemented [see Mosier et al. (2021) Table 2].

Finally, Singh and Whelen (2020) and Olsen et al. (2014) calculate SOC stock changes and aimed to measure SOC sequestration rates, which was not in the scope of our paper. We presented the differences between grazing managements and across farm pairs, but we did not attempt to attribute those differences to greater SOC sequestration rates in a given management. We are aware that one management practice could appear to be sequestering more SOC based on measured differences in SOC stocks, when that management practice could be losing SOC at a slower rate. For this reason we made no claim of SOC rate changes in our paper.

We also believe the comment that our study uses pseudoreplication is inaccurate. Our study design used two levels of replication: first at regional scale comparing five farm pairs (AMP vs. CG), and second within a farm, where we sampled 6 zones across 2 catenas on each farm. Additionally, we sampled intensively across each of the three sampling zones within a catena using a randomized soil core sampling design, with an average of seven cores per sampling zone. In Mosier et al. (2021), we often aggregate the results across our five farm pairs (by management practice), but we always provide results and variability between each replicate pair.

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