Yale SCHOOL OF THE ENVIRONMENT

Ucross High Plains Stewardship

FELLOWSHIP BRIEF

Investigating Soil Organic Matter in a Disturbed Big Sagebrush Ecosystem of Southwestern Wyoming

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The Need.

Big sagebrush (*Artemisia tridentata*) ecosystems play a crucial role in maintaining the ecological integrity of much of the western United States by providing key services such as carbon storage, fire mitigation, and wildlife habitat. Despite their resilience over millennia, these systems are increasingly vulnerable to pressures from climate change and human land use. Projected increases in soil moisture variability threaten sagebrush regeneration, while surface disturbances from natural gas development accelerate vegetation loss and facilitate invasion by nonnative annual species. Natural gas well pads create persistent landscape disturbance that favor invasive grasses and forbs, altering fire regimes and suppressing native plant recovery. The Jonah Field in Wyoming represents both a hotspot of energy development and one of the regions expected to retain climatic suitability for sagebrush under future conditions. However, the ecological consequences of soil disturbance in this potentially stable refuge remain poorly quantified. Addressing this gap is essential for informing evidence-based reclamation practices and land management strategies on public lands, where effective intervention could safeguard sagebrush ecosystems under a changing climate.

The Project.

Myroslav's research quantified differences in soil organic matter (SOM) across seventeen reclaimed well pads and adjacent undisturbed big sagebrush areas (reference areas). Two 80-meter transects were established at each site, extending 40 meters into the reclaimed well pad and 40 meters into the reference area. Along each transect, six soil samples were collected from both disturbed and reference zones at depths of 0–5 cm and 5–10 cm. After air-drying, the samples were analyzed using a loss-on-ignition protocol to quantify the percentage of soil organic matter. Resulting data were analyzed using R to produce the following results

The Findings.

Percent soil organic matter ranged from 0.6% to 4.6% across all samples. After accounting for site differences, reclamation year was not a significant predictor of SOM content ($p > 0.05$), indicating that no recovery trend was detected over time.

Similarly, we did not see a significant effect of "disturbance zone" (whether the sample was taken on a well pad or in a reference area) on SOM. However, we detected a significant interaction between zone and sample depth ($p < 0.01$). At 5–10 cm soil depth, well pads had 0.23% lower SOM compared to reference areas ($p < 0.01$), suggesting that differences in SOM between well pads and reference areas may only be detectable at deeper soil layers.

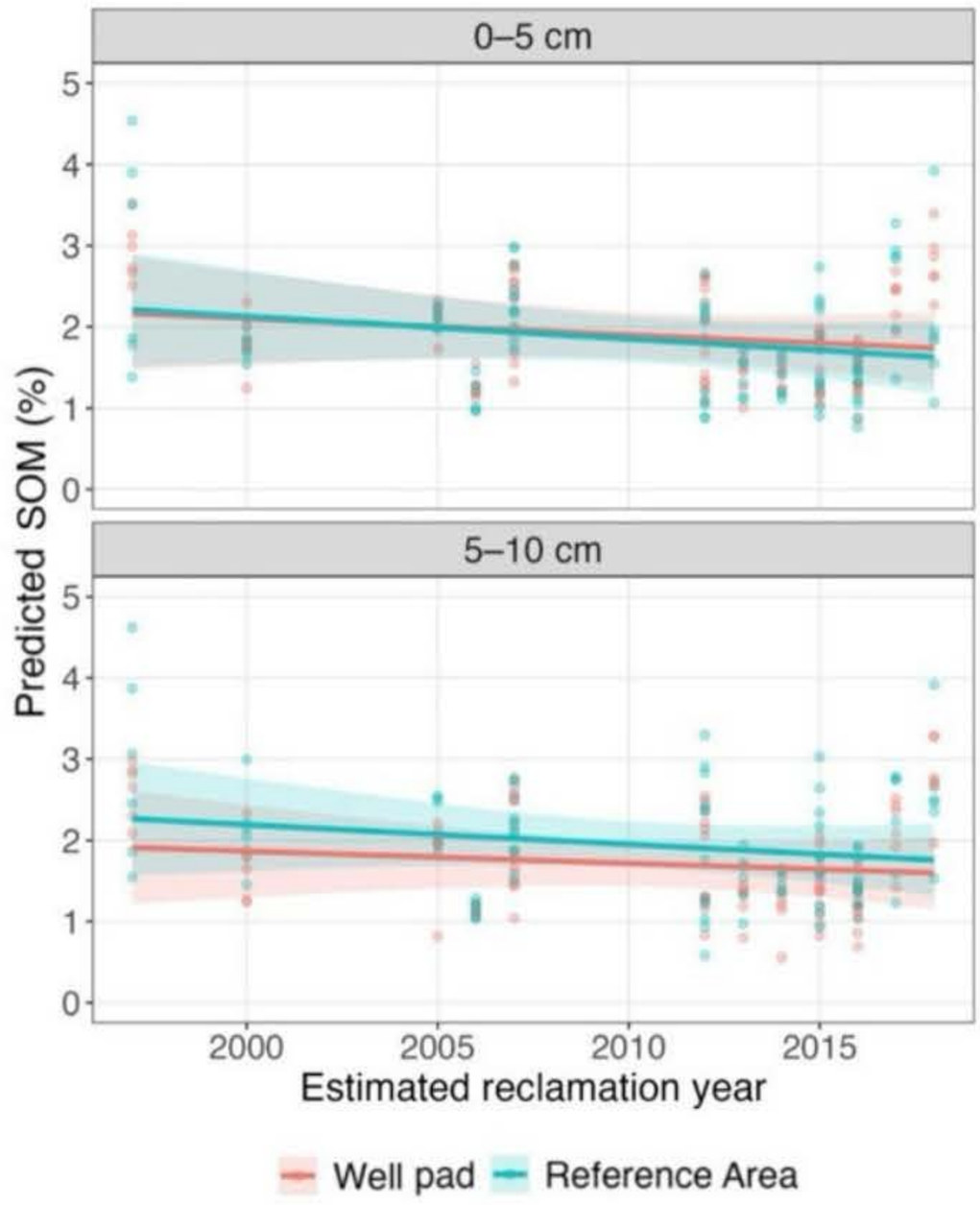

Figure 1: Predicted % soil organic matter across estimated reclamation years (1997-2018), comparing well pad and reference areas at 0–5 cm depth and 5–10 cm depth. Bands indicate 95% confidence intervals.

The Impact.

This research contributes to a deeper understanding of how natural gas development in sagebrush steppe ecosystems influences SOM dynamics, with implications that may extend to other disturbance-prone dryland systems. By quantifying SOM differences between reclaimed well pads and adjacent undisturbed areas, this study addresses a critical knowledge gap, as the effects of well pad construction on soil carbon pools remain poorly documented. These findings enhance our current understanding of how surface disturbance alters belowground ecosystem processes that are essential for vegetation recovery, soil stability, and long-term carbon storage in the sagebrush ecosystem. Furthermore, this research highlights the potential of SOM as an additional and measurable indicator of reclamation success. Incorporating soil-based metrics into reclamation monitoring can provide actionable insights for land managers and policymakers overseeing energy development on public lands in Wyoming, particularly as climate change intensifies pressures on sagebrush ecosystems.

The Student.

Myroslav Bur – Western Resource Fellow | Myroslav Bur is a Yale College undergraduate studying Chemistry, with a focus on soil chemistry and sustainable agriculture. He is particularly interested in agricultural systems that emulate natural ecosystems, and how soil dynamics shape plant communities in arid landscapes. Through studying the sagebrush ecosystem of the American West, he hopes to better understand plant-soil interactions in dry environments and apply this knowledge to both conservation and agricultural resilience. In his free time, Myroslav enjoys reading scientific literature while drinking home-brewed full-leaf tea