Effect of Long-Term, Year-Round Grazing on Extent and Functionality of Riparian Wetlands
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Introduction
The National Trails Management Corridor (NTMC) is located within the Upper Sweetwater River Basin of Wyoming (Fig. 1) and has been subject to at least a century of year-long grazing practices, starting with European settlement. This historically significant area provided Oregon Trail emigrants passage for over the Rocky Mountains in the late 1800s and is managed by the Bureau of land Management (BLM) Lander Field office to retain its distinctly Western character. The study area is located in the semi-arid sagebrush steppe ecoregion at approximately 2,100 m

Herbaceous wetlands in the NTMC have been negatively impacted by grazing management practices, resulting in dramatic hummock interspace microtopography (Fig. 2) as shown by Ritcho and others (2015). Grazing enclosures have been established to determine whether the wetlands have retained the resilience to recover under improved grazing management. Impacts have likely included subsidence, decrease in wetland extent and soil carbon storage (Fig. 3), driven by compaction, increased runoff, lowering of the water table, and subsequent decomposition (Fig. 4).

Objective: Estimate change in wetland extent and soil carbon storage due to long-term livestock grazing practices

Background
Wetlands are characterized by a three parameter approach including the presence of hydrophytic vegetation, wetland hydrology, and hydric soils.

Soil morphological features are used to meet Field Indicators of Hydric Soil (USDA-NRCS, 2016) required to determine a soil as hydric. Morphological features can persist as relic features in the soil even after significant wetland alteration or drainage

Indicators of reduction in soil (IRIS) tubes
• Approved for use as a Field Indicator of Hydric Soil (USDA-NRCS, 2016).
• PVC pipe coated with synthetic Fe oxide paint.
• Fe oxide paint is reduced from Fe³⁺ to Fe⁰ under reducing conditions.
• Installed in groups – if>50% meet reduction standard the location is hydric (Fig. 5)

IRIS TUBES IDENTIFY CURRENT WETLAND BOUNDARY
RELICT FEATURES IDENTIFY A PAST OR RELICT WETLAND BOUNDARY

Methodology
Wetland Extent
Transsects were established at wetland five study sites with 3 to 5 sample locations (Fig. 6) along both sides of each drainage (Fig. 6)
Sample locations were based on morphological hydric soil boundary
Soil profiles were described at each location and field indicators were identified if present.
In late June 2017, IRIS tubes were established in groups of three at each location within interspace locations
IRIS tubes were removed in September 2017 and reduction was quantified using a systematic grid system (Rubenhorst 2017).
Determined whether locations were hydric per the IRIS tube technical standards

Grazing Enclosures and Soil Organic Carbon
Soil samples were collected inside and outside exclosures (Fig. 7)
At both locations, samples were taken from hummock and interspace positions.
Soil organic carbon was measured and analyzed with a paired comparison T-test.
Soil temperatures were recorded from February to August, 2015 and 2016, at four depths and three locations inside and outside each enclosure using Button sensors (ButtonLink Technology, Whitewater, WI).

Results

Wetland Extent
Results for two of four wetland study sites are displayed in Fig. 8. Overall data is summarized in Table 1.

<table>
<thead>
<tr>
<th>Study site</th>
<th>Estimated historic wetland extent (m)</th>
<th>Estimated wetland decrease (m)</th>
<th>Percent decrease</th>
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Grazing Enclosures and Soil Organic Carbon
Results for soil organic carbon are displayed in Fig. 9. Samples from inside exclosures show a homogenization of distribution of carbon between hummocks and interspaces when compared to samples outside exclosures. Soil temperature results for one site are found in Fig. 10.

Discussion
• A decrease in wetland extent was quantified at all wetland study sites; this represents loss of as much as one-third the potential soil water storage in this riparian wetland system, with implications for sustained stream flow and other downstream ecosystem services.
• Morphological hydric features have persisted as relic, as hypothesized, despite grazing disturbance and subsequent erosion.
• Long-term grazing exclusion has begun to increase soil carbon storage and reverse the effects of the severely hummocked soil surface in the riparian wetlands
• Soil temperature data indicate that soils outside exclosure are as much as 5°C warmer in August than soils inside exclosures. This trend is consistent across all five study sites and likely results from residue removal under grazing. Soil temperature is a primary driver of microbe-driven organic matter decomposition. This scale of difference in the warmest time of the year partly explains the decrease in wetland extent under long-term uncontrolled grazing. It also indicates potential for recovery under management that conserves residues.
• Results show that despite a century of disturbance, most wetlands have retained the resilience to recover under better grazing management.

Future studies
• Quantifying the impact of grazing management practices on soil carbon storage and decomposition by landscape position
• Estimating spatial loss of soil organic C at study sites and across the landscape, and estimating impacts to ecosystem services such as water storage