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Access Mats Reduce Mixedgrass Prairie Soil Physical Responses to Industrial Traffic

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Introduction

Access mats, three ply spruce mats, are used to minimize industrial construction impacts on rangelands, and are routinely recommended by the Alberta government (ASRD 2010) as a best practice conservation strategy despite limited data testing their effects (Dollhopf et al. 2007, Mitchem et al. 2009). Mats redistribute the weight of heavy equipment thereby creating a temporary buffer for prairie soil and vegetation. In the absence of mats, vehicle traffic is thought to create soil compaction, increase soil bulk density, negatively impact plant growth, and alter hydrologic function. Here we report on a controlled field study testing the initial effects of industrial traffic, with and without underlying mats, on Mixedgrass Prairie soil penetration resistance (PR), moisture content (SMC), and water infiltration (WI).

Materials and Methods

This field study was conducted on the Mattheis Research Ranch, 40 km N of Brooks, Alberta, Canada, in the Dry Mixedgrass Prairie. The area has mean annual precipitation of 348 mm and temperature of 5.3°C. Soils range from Orthic Brown Chernozems (sandy sites and uplands) to Brown Solonetz (lowlands). Four sites were used for the experiment, two with loamy soils and two with sandy soils, with 1-3% organic matter. At each site, in a randomized block design, we tested industrial traffic impacts with and without mats over time (Fig. 1). Mats weighed approximately 1500 kg and were in place for 12 weeks (April 30 – July 22) during 2015. Traffic consisted of 8 passes by a 28 ton loader, split into 4 passes on April 30 and another 4 on July 22, 2015 (Fig. 1). PR measurements were taken immediately after mat removal (July 23) and again 6 (September 03) and 12 weeks (October 15) later. PR was sampled using a DICKEY-john Soil Compaction Tester (Dicky-john Corp., Auburn, IL, USA) with a 1.27 cm^2 cone tip. Resistance was measured to a maximum of 4200 kPa, while penetrating to a depth of 15 cm. SMC was assessed immediately after treatment completion (July 23) on the control and mat treatments, but not traffic only areas as soil was too compacted for the moisture probe to penetrate. A TDR 100 Turf Soil Moisture Meter probe was used to quantify SMC in the top 15 cm, on the same dates as above. WI was assessed on July 25 by installing a 21.2 cm diameter plastic ring at least 7.5 cm into the soil, and recording the length of time necessary to infiltrate 2.5 cm of water. PR, SMC and WI data were analyzed separately for loam and sandy sites using Mixed Model ANOVA, with treatments as fixed effects and site and block as random. Significance was set at 5%, with *post-hoc* comparisons done on treatments with significant responses. As SMC and PR were collected at several intervals, time was included as a repeated measure.

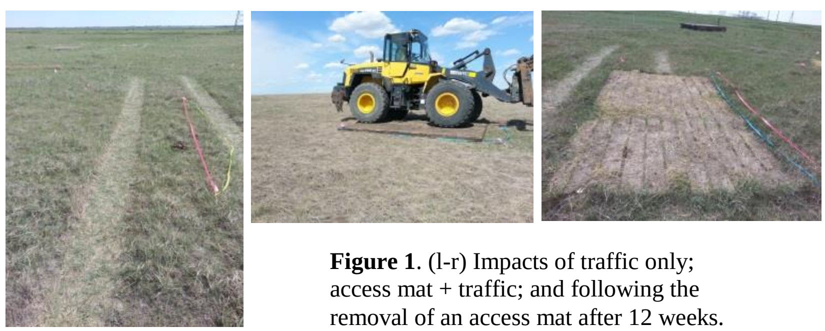

Figure 1. (l-r) Impacts of traffic only; access mat + traffic; and following the removal of an access mat after 12 weeks.

Results and Discussion

Penetration resistance was highest under the traffic treatment, followed by the control, and lowest where mats were used (Fig. 2). Six and 12 weeks later, PR was similar in the control and matted treatments, with both lower than the traffic only. Overall, WI took longer on loamy soils, and 1.5 (sandy) – 1.8 (loamy) times longer on traffic treatments, with loamy soils 1.25 – 1.5 times longer to infiltrate compared to the mat treatment and controls (Table 1). Initially, SMC was greater (2.5 times) where mats were recently removed than in controls, but there was no difference 6 and 12 weeks later (data not shown). Industrial traffic results in compaction and increased PR, likely limiting root growth. This effect persisted to the end of the growing season even though mats were moved in late spring. It remains unknown how long this effect will persist for, and may require many freeze-and-thaw cycles to correct.

Use of mats with traffic resulted in no increase in PR, and therefore mitigated the impact of traffic on soil compaction. Mats increased SMC likely due to the conservation of winter snow melt through reduced plant water use or reduced evaporation. After mat removal, SMC declined quickly to levels similar to controls. Plots with mats had reduced litter and vegetation and the loss of these insulating layers likely led to increased evaporation. Loss of moisture may also explain the increase of PR in the matted treatment over time. Post-construction management of sparsely vegetated matted prairie will be important to their future recovery. WI rates help understand the effect of heavy equipment on soil hydrologic function. Matted treatments had much faster WI rates relative to the traffic treatment. Slower WI can lead to increased runoff or evaporation before water enters the soil, reduced water availability for vegetation, and increased risk of erosion on tracked areas.

Table 1. Comparison of mean infiltration rates and soil moisture among treatments

Soil	Treatment	Infiltration Rate (minutes)	Soil Moisture (%)
Loamy	Control	9.98 b	10.5 b
	Mat + Traffic	10.49 b	29.0 a
	Traffic	17.99 a	-
Sandy	Control	8.25 B	3.9 B
	Mat + Traffic	8.17 B	11.6 A
	Traffic	12.14 A	-

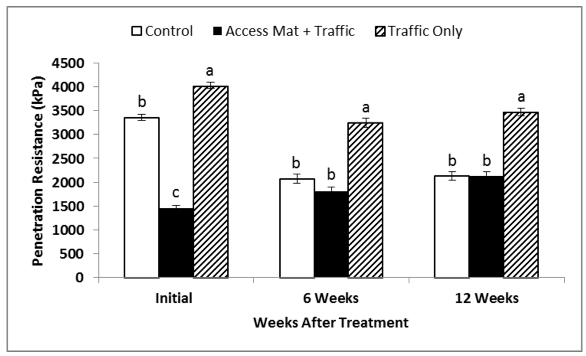

Figure 2. Comparison of mean (±SE) penetration resistance among surface treatments at 3 sampling times. Within each date, means with different letters differ, $p < 0.05$.

Conclusions and Implications

These results indicate best management practices for maintaining soil physical characteristics during industrial construction activities on Mixedgrass Prairie should include reducing or minimizing direct traffic impacts to grassland ecosystems, a process that can be at least partly achieved with access mats.

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