EVALUATION OF BULK DENSITY AND VEGETATION AS AFFECTED BY MILITARY VEHICLE TRAFFIC

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INTRODUCTION

Military vehicle use for training exercises in rangelands may result in one or more of the following adverse consequences:

1. Significant removal of vegetative cover
2. Destruction of soil aggregates
3. Soil compaction
4. Increased susceptibility to wind/water erosion

Military training lands require management to minimize ecological damage. WEPS (Wind Erosion Prediction System) (Wagner & Tatarko, 2001), with proper modifications, could be used to provide estimates of susceptibility to wind erosion from different training scenarios, thus allowing a manager to choose the timing and type of training regimes to reduce or eliminate adverse impacts on the environment. However, critical process parameters in WEPS originally developed for agricultural fields need to be adapted or modified to military lands. Among the parameters needing characterized are changes in bulk density and vegetation that occur under varying levels of military vehicle traffic.

Fig. 1. Picture of an M1A1 Abrams tank (top left); Humvee (top right); portion of the tank track (bottom left); and the Humvee wheel track (bottom right)

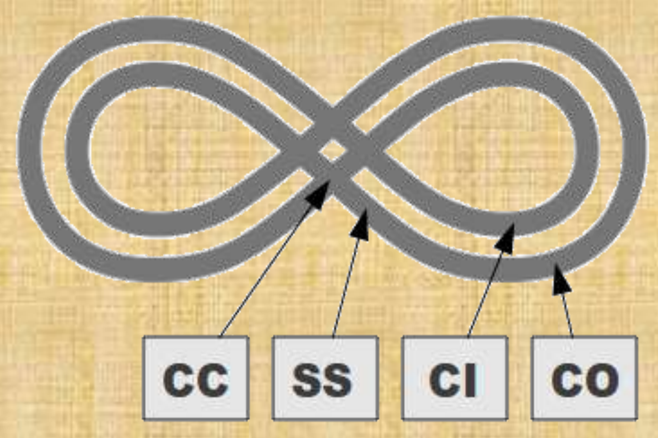

Fig. 2. Diagram of figure-8 vehicle track and sampling locations

OBJECTIVE

Determine from multi-pass trafficking of military vehicles the effects on the soil/vegetation state and assess the change in susceptibility to wind erosion.

METHODS

40m X 70m rectangular field plots were established at Fort Riley, Kansas on which vehicles were driven in a figure-8 pattern. Two vehicle treatments, "tracked" and "wheeled", were arranged in a randomized block design in three replications. The experiment was carried out on silt loam and silty clay loam soils. The tracked vehicle used was an M1A1 Abrams tank and the wheeled vehicle was a Humvee (Fig. 1). On each plot three sets of repeated trafficking passes were made on each plot (designated as: p1, p2, p3). For the "tracked" plots 1, 5 and 10 total passes were made and for the "wheeled" plots 10, 25 and 50 passes.

In each of the figure-8 plots, samples were taken from four distinct segments of the vehicle tracks (relative sampling locations shown in Fig. 2). The sampling segments were designated as "center cross" (CC) (where the tracks crossed), "curve inside track" (CI), "curve outside track" (CO), and "straight section" (SS). At each sampling site bulk density, gravimetric soil water content, standing biomass and total vegetative cover were taken. Standing biomass within a 0.25 m^2 quadrant was clipped to ground level, dried and weighed. Residue cover was measured using a modified step-point method (Althoff, P.G., 2007). Statistical analysis was performed on all data using the SAS PROC MIXED procedure.

RESULTS: BULK DENSITY

The analysis of variance of bulk density indicates (table not shown) that:

- The main factors of vehicle type, vehicle trafficking passes, location within the track and soil depth were significant ($p \leq 0.05$).
- Two-way interactions of vehicle X pass, pass X location, vehicle X depth, pass X depth, and location X depth were significant ($p \leq 0.05$).
- The three-way interaction of vehicle X location X depth was also significant ($p \leq 0.05$).

RESULTS: BIOMASS

The analysis of variance of biomass and cover shows (table not shown) that:

- The main factors of vehicle type, vehicle trafficking passes, and location within the track were significant ($p \leq 0.05$).
- Two-way interactions of vehicle X location and pass X location were significant ($p \leq 0.05$)

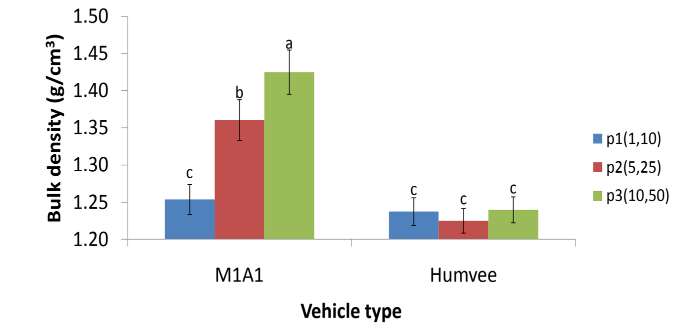

Fig. 3. Interactive effects of vehicle types and trafficking passes on bulk density in the silty clay loam soil. Bars with different letters are significantly different (p≤0.05). For the M1A1 tank bulk density increased as the trafficking passes increased. For the Humvee differences in bulk density between the different pass levels were not significant.

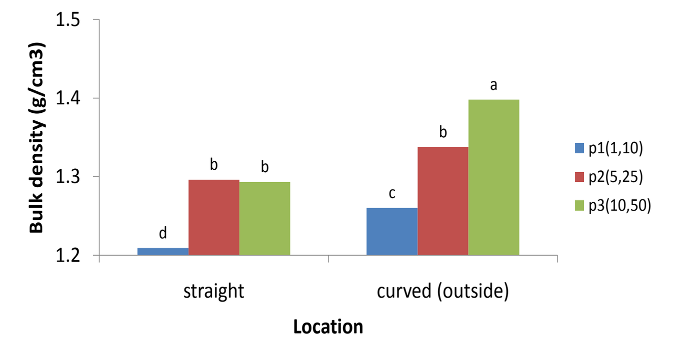

Fig. 4. Interactive effects of trafficking location and trafficking passes on bulk density in the silty clay loam soil. Bars with different letters are significantly different (p≤0.05). In the straight section of the track bulk density increased aftertrafficking pass sets of p1 & p2. In the curved section bulk density increased at all pass levels.

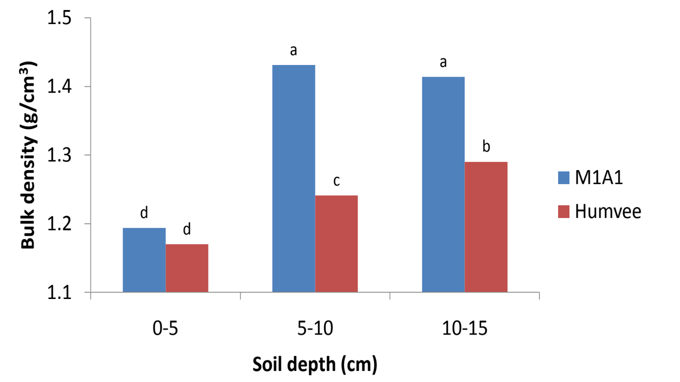

Fig. 5. Interactive effects of vehicle X depth on the silty clay loam soil. Bars with different letters are significantly different (p≤0.05). At the 0-5cm depth differences in bulk density between the M1A1 and Humvee trafficked tracks were not significant. At lower depths bulk density under the M1A1 was significantly higher than under the Humvee.

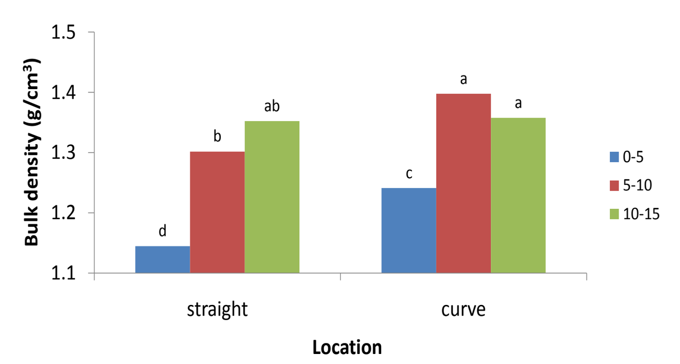

Fig. 6. Depth X Location interaction for the silty clay loam soil. Differences in bulk density at the 0-5cm and 5-10cm depths within, and between the straight and curved sections were significant (p≤0.05).

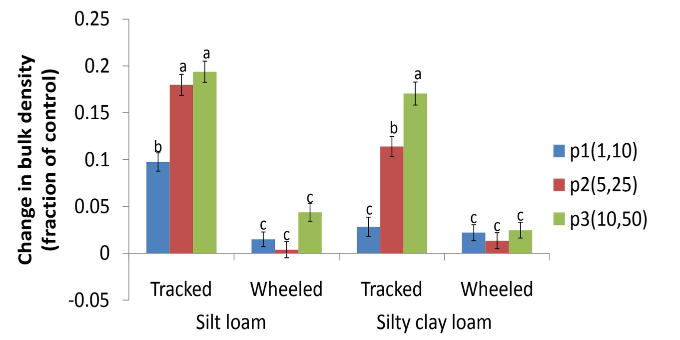

Fig. 7. Vehicle X Pass interaction for changes in bulk density between trafficked and non-trafficked ground. Bulk density in the M1A1 trafficked areas were up to 20% higher than on non-trafficked areas. Differences between the Humvee-trafficked and non-trafficked areas were less than 5%.

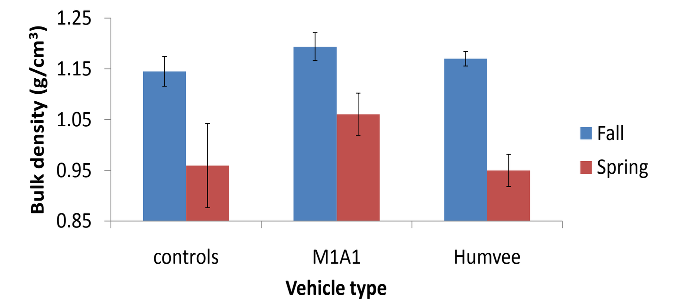

Fig. 8. Comparison between spring and fall average bulk density at the 0-5 cm depth for the silty clay loam soil. Spring bulk densities were lower by 12% to 23% than the fall bulk densities.

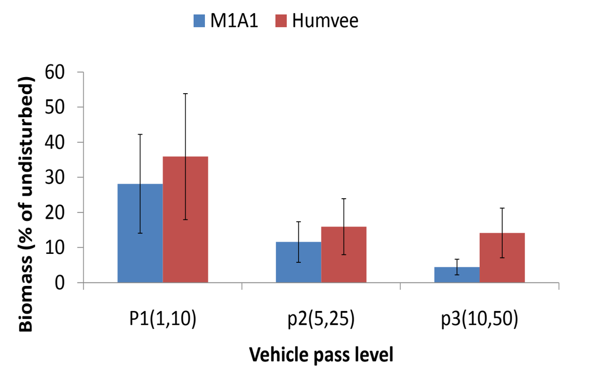

Fig. 9. Above ground biomass (% of undisturbed) at pass levels p1, p2, and p3 at the end of all vehicular traffic.

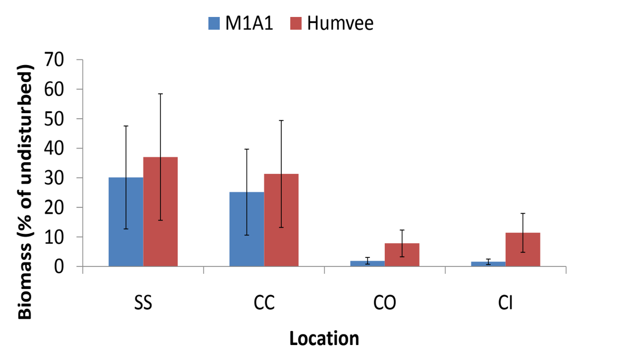

Fig. 10. Standing biomass (% of undisturbed) at the straight (SS), center cross (CC), curve outside (CO), and curve inside (CI) locations at the end of all vehicular traffic.

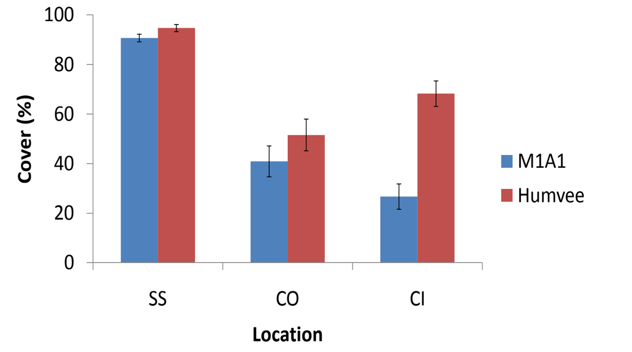

Fig. 11. Vehicle X Location interaction. Maximum reduction in cover occurred at the CI (curve inside) location under the M1A1 tracks. Reduction in cover is much lower for the Humvee.

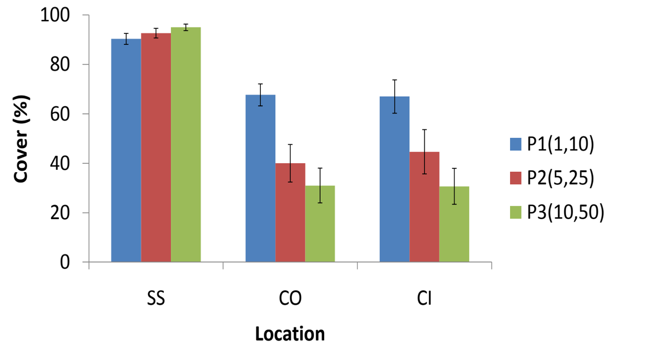

Fig. 12. Pass X Location interaction. Cover steadily declined as the number of passes increased at the CI (curve inside) and CO (curve outside) locations.

SUMMARY

- Bulk density under the M1A1 Abrams tank were significantly higher than under the Humvee in all soil layers below 5cm.
- As the number of passes increased the bulk density under the M1A1 tank showed significant increases; increases in the Humvee were much smaller.
- In general sampled bulk densities were higher in the curved portion of the vehicle tracks than in the straight segments.
- Bulk densities were lower in the spring than in the fall bulk due to over-wintering effects.
- The M1A1tank reduced above ground residue cover and standing biomass at the curved track locations by roughly 70% and 90% respectively.

REFERENCES

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