Visual Evaluation of Soil Structure (VESS): The Effect of Different Grazing Regimes on the Soil Structure on Sandy Soils

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Introduction and Problem Statement

Brandenburg is among the driest regions in Germany, evident by comparatively low annual average rainfall levels. Soils in Brandenburg are characterized by high sand content often resulting in low water holding capacity, low nutrient retention, and often low contents of organic matter (OM). With anthropogenic climate change, prolonged periods without precipitation and increasing temperatures during the vegetation period are likely to occur more often (Stanley et al. 2023). Sandy soils are more sensitive to climate change, compromising forage yield stability in Brandenburg. Mob grazing (MG) is a grazing strategy introduced for dry regions to increase soil fertility and carbon storage (Roberts & Johnson 2021, Wagner et al. 2023). However, many processes especially regarding soil-carbon-dynamics and the influence of MG are complex (Roberts & Johnson 2021). Core principles include a high stocking density, short intensive grazing intervals, followed by a long resting period (Gurda et al. 2018). Vegetation growth is usually much taller than what is known from more traditional forms of grazing and the aim is to trample about 50% of the forage and to leave behind a mulch layer. Besides the positive aspects that can be achieved with mob grazing, it could also negatively affect the physical soil quality, namely in the form of topsoil compaction (Byrnes et al. 2018). Whether mob grazing can be an efficient and ecological form of grazing in drought-prone regions, is the core question of the EIP-Project "Mob grazing in arable forage production". For this purpose, mob grazing is compared to the reference grazing regime rotational grazing (German: Umtriebsweide). The effect of mob grazing on soil structure and soil health plays a crucial role to determine whether mob grazing can be considered a sustainable and profitable grazing strategy.

Visual soil evaluation techniques provide a simple and cost-effective approach to monitor soil structural quality. The VESS method (Ball et al. 2007, Guimaraes et al. 2011) was selected to assess the effects of the two different grazing regimes on the soil structure. Here, the first question to be answered was, to which extent the VESS method is suitable for the given site conditions. The VESS assessment was complemented with bulk density (BD) measurements to evaluate whether MG leads to a decline in physical soil quality. In addition, the correlation between VESS scores and BD was analyzed to evaluate if the VESS method can be effectively applied to the sandy soils prevalent in Brandenburg. This article is based on the results of the bachelor thesis by Johrden (2024).

Materials and Methods

The VESS method was applied in May 2023 at the research site of the EIP-Project which is located at Gut Temmen (Stegelitz Agrar GmbH) in the Uckermark in Brandenburg at 53°"N 13°"E and encompasses 11.82 ha. The long-term precipitation average for Brandenburg is 566.48 mm (DWD 2024). The site is certified organic in accordance with the "Bioland" guidelines. The soil type is a loamy sand (German: schwach lehmiger Sand) with <4 %, 5-12 %, and <50 % OM, clay, and silt, respectively (own investigation, data not shown). Prior to the start of the experiment, a grass-legume mix was established in 2021 (60 % *Medicago sativa/ x varia*, 10 % *Trifolium pratense*, 30 % DSV 2214).

Tab. 1: Details of the grazing treatments in 2023 (LW = live weight)

	Paddock size [ha]	Compressed sward height [cm]	Stocking density [kg LW / ha]	Residual herbage [%]
MG	0.25	25-30	400.000	30-50
UW	2.97	15	30.000	8

The experimental site is divided into four 296.82 m x 100 m corridors. Within each corridor, two 1 ha plots are embedded, which are used for data collection. Treatments include the two grazing regimes mob grazing (MG) and rotational grazing (German: Umtriebsweide) (UW) which are arranged in a

split-plot design. However, only whole-plot level treatments exist (MG and UW), which alternate between the corridors, resulting in four replicates each.
Details regarding the two grazing treatments can be found in Tab. 1. The grazing regimes are described in detail in Zahn et al. (2022) and Johrden (2024). In 2023, the grazing treatment was applied per corridor for the UW regime and per plot for the MG regime. The same herd ("Uckermärker") is used for both treatments. The compressed sward height, measured with the "Grasshopper" (TrueNorth Technologies, Ireland) at 150-200 points on every plot, and the developmental stage of alfalfa and the main grasses determine the timing for grazing.
The VESS method was applied in each of the eight treatment plots at nine GPS-marked measuring points. VESS samples were taken 1 m to the north of the measuring points to avoid overlap with the repeated implementation of the method. The $VESS_{2020}$ scoring sheet (Johannes et al. 2020) was used for the assessment. After digging the "pre-hole" a 25x20x17cm soil block was extracted with a spade and evaluated following the $VESS_{2020}$ methodology and a soil quality score (Sq) ranging from 1 (very good) to 5 (very poor) was assigned. Bulk density was determined for undisturbed soil cores (100 cm^3), collected at a depth of 15 cm at the backside of the "pre-hole", according to VDLUFA methodology.

Results and Discussion

Fig. 1: Sample from UW_1. The picture was rotated 90° degrees. The top of the sample is at the left-hand side. The sample presents with very litte recognizable structure.

Applying the VESS method was simple and quick to learn. It took 15-20 minutes to complete the assessment for each sample. This could potentially take longer if the soil is not as saturated and/or of another soil type with higher clay content and/or includes more rocks. Preparing the "pre-hole" a few centimetres wider than the VESS sample improved the extraction considerably. Despite the expected low cohesion due to the high sand content, the extraction of the VESS sample blocks provided no difficulties. Large differences between VESS samples were easily recognized and scored. If samples presented with more complex differences, such as including traits from two Sq scores and being scored in between (e.g. 2.5), it was more difficult to assure that samples scored with 2.5 are equal to one another. All VESS samples except for one were identified with one single layer to the depth of 25 cm.
On the UW_1 plot, the observed soil structure for some samples was very fine and crumbly with almost no visible aggregation (Fig. 1). These samples were assigned to Sq score 1 and lead to the overall lower (better) Sq score for the UW_1 plot (Fig. 2). However, while scoring these samples with hardly any visible pedal structure, the descriptions and visible cues from the $VESS_{2020}$ scoring sheet seemed to be unable to fully resemble the samples that were attempted to be scored. The main issue was the almost entirely absent aggregation and single sand grain structure. Samples of that origin were also found on other plots as well. After personal communication with Dr. Alice Johannes of Agroscope it became clear that Sq score 3 should have been assigned to these samples. This was not evident by using the $VESS_{2020}$ scoring sheet and not indicated in the literature. It calls for a revision of the VESS method, especially for sandy soils, where low aggregation can be expected, as their OM content is low. This discrepancy between the scoring sheet and the samples without visible pedal structure led to inconsistent scoring.
No effect on VESS scores and BD was observed for the two grazing regimes (Fig. 3). Statistical analysis confirmed the non-significance of the grazing effect. Soil structural quality was good in the top 25 cm if a VESS score of ≤ 2 is considered good structural quality (Ball et al. 2007). The lack of a difference in soil structural qualities, despite the great differences in the grazing regimes, may be due to the short duration of the experiment at the time of sampling, which happened prior to the second grazing period. Additionally, the site is not grazed during the winter. It is possible, that an effect would have been visible shortly after the first grazing period in fall, and that effects were reduced over the winter due to natural processes affecting the soil structure (Drewry 2006).

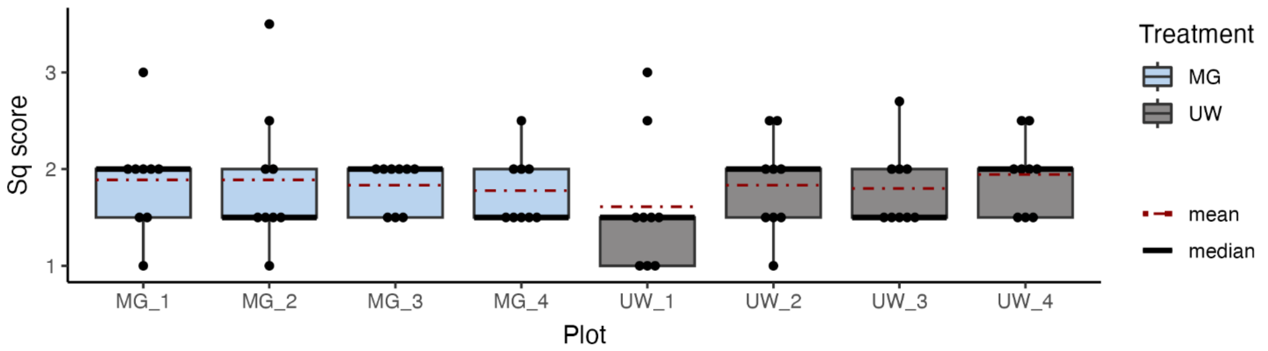

Fig. 2: Visualization of VESS scores across all individual treatment plots. UW_1 exhibits a lower (better) overall Sq score possibly due to scoring difficulties. Each recorded score is shown.

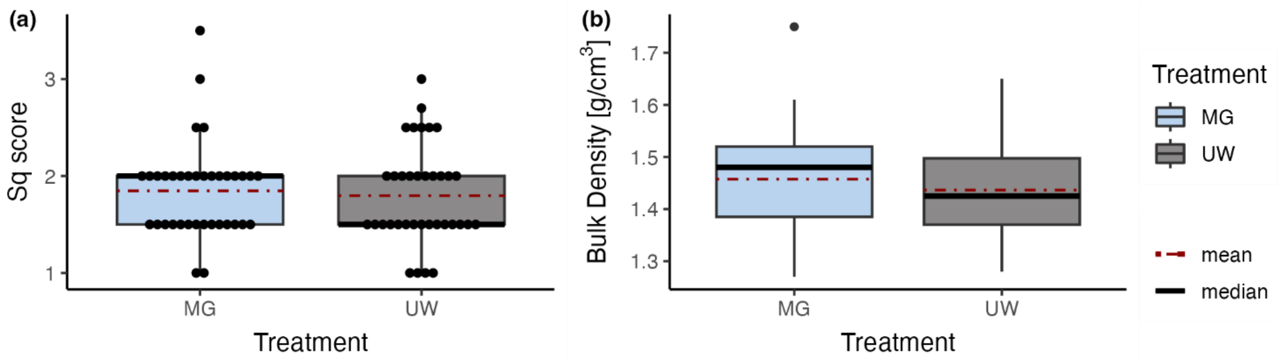

Fig. 3: Visualization of VESS scores (a) and BD (b). Each recorded VESS score is shown. Mean values for VESS scores and BD do not differ statistically significant (p=0.675 (a), p=0.332 (b), Mann-Whitney U Test).

The lack of decline in soil structural quality observed for the MG regime, despite high stocking densities, may be due to the frequent rotation associated with MG-like systems. Frequent rotation has previously led to improved soil physical quality indicators such as bulk density and VESS scores, compared to longer grazing periods (Byrnes et al. 2018, Teutscherová et al. 2021a, Teutscherová et al. 2021b). The resting period appears particularly important, as it allows for natural structural recovery (Drewry 2006) of the soil. However, Teutscherová, et al. (2021a) highlight the multi-faceted interdependence of natural structural recovery, soil micro- and macrofauna, and carbon and nutrient input in high stocking density and more conventional grazing systems.
VESS scores and bulk density showed no significant correlation (R^2=0.032), though a slight positive relationship was observed (Fig. 4). VESS scores and BD are often correlated, but this was not the case here, possibly due to operator subjectivity, methodological constraints, and the specific influence of soil texture on the VESS method.

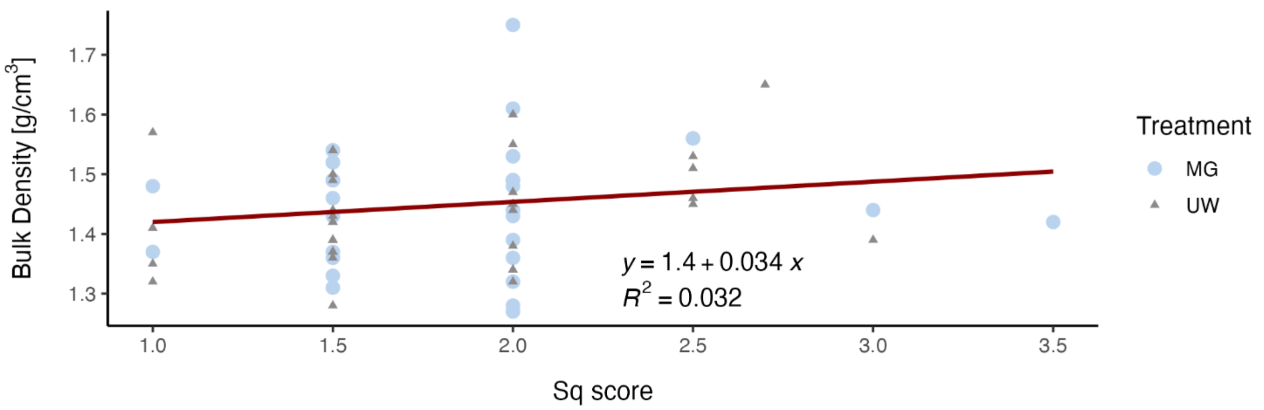

Fig. 4: Correlation between VESS scores (Sq score) and bulk density

The VESS method, being semi-quantitative, is inherently influenced by the subjective judgment of the operator, particularly in detecting soil layers. Inconsistent scoring in samples lacking visible pedal structure may also contribute to this lack of correlation. Additionally, in sandy soils, the relationship between quantitative parameters like BD and VESS scores appears less certain, compared to finer textured soils (Johrden 2024). Therefore, relying solely on BD as an indicator may not adequately validate the applicability of the VESS method, especially in coarse-textured soils. It has been highlighted repeatedly that the soil texture exerts an influence on visual soil evaluation criteria (e.g. van Leeuwen et al. 2018) and this appeared to be true in this study as well.

Conclusion

This study suggests that improvements in the VESS methodology are necessary. The applicability of the VESS method seemed to be influenced by the sandy texture of the soil, as indicated by difficulties in scoring samples lacking visible pedal structures. This highlights the need to carefully integrate the influence of the soil texture into the VESS assessment criteria. Improvements in the methodological approach will determine the applicability of the method under the given conditions at the experimental site. Apart from the methodological limitations, no significant influence of the grazing regimes on soil structure has been found so far.

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