The Use of Hyperspectral Proximal Sensing to Determine Moisture, Age, and Nutrient Content of Dung Pats in the Field

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Hypotheses

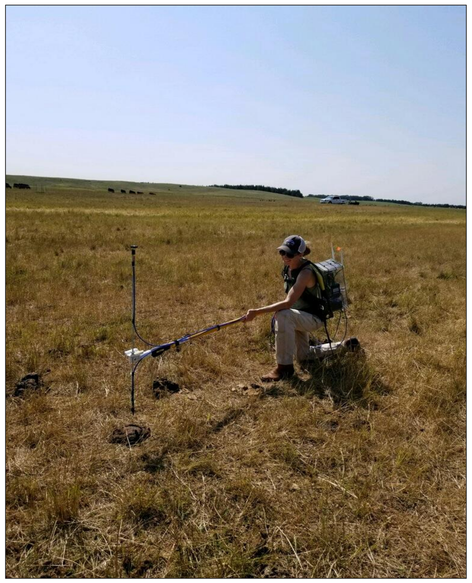
1. **Reflectance patterns of visible and near infrared light can be used to predict dung pat moisture and age.**
2. **Reflectance can also be used predict the following nutrient values in dung pats: water-extractable nitrogen, organic carbon, and phosphorus.**

Objectives

To evaluate the predictive power of hyperspectral reflectance data for the above properties when scans are performed on as-deposited dung pats in an ultra-high stocking density grazing system in the Nebraska Sandhills.

Introduction

- Nutrient deposition via cattle dung and urine in the grazed ecosystem is essential for vegetation re-growth and is a major driver of nutrient cycling and carbon sequestration dynamics in a system that otherwise has few nutrient inputs.
- Movement of nutrients out of dung is a complex process which depends on biotic and abiotic factors and is still poorly understood at both the microscale and field scale.
- Nutrient content of dung (N, P, TOC) is highly variable, making standardization of values challenging and prone to error.
- Sampling of individual dung pats for the above nutrients is time- and cost-intensive
- A non-destructive method of determining nutrient content of dung could provide insight into dung nutrient movement and the factors that influence it, leading to the creation of more accurate nutrient cycling models for grazinglands.



Methods and Materials

Research Site:

- All scans and dung were collected at the University of Nebraska's Barta Brothers Ranch in the Nebraska Sandhills during 2016 and 2017.

Hyperspectral Data Collection:

- An Ocean Optics USB 2000+ spectrometer (Dunedin, FL) was used to obtain reflectance readings from the dung.
- This spectrometer also included two fused silica fiber optic cables (upwelling and downwelling sensors) and a cosine detector on the downwelling cable. Calibrations were performed using a white Spectralon panel (Labsphere, Inc., North Sutton, NH)
- Scans were taken between 10 am and 2 pm to minimize radiometric distortions due to sun angle.
- Processing of the spectral data was performed using CDAP-2 software (University of Nebraska, Lincoln, NE)

Physical Sample Collection and Analysis:

- Dung samples from pats of known ages (1 day to 28 days old) were taken within one hour of performing the reflectance scans and immediately put in a cooler with ice
- Water extraction for determination of nitrogen, phosphorus, and total organic carbon was standardized for dung dry weights and extracts were analyzed using an OI Analytical Aurora 1030 machine (OI Analytical, College Station, TX).

Results

2016 Results (86 samples)

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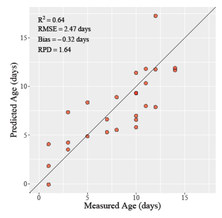

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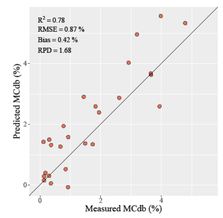
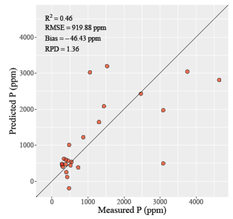


SVR



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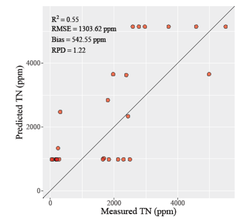

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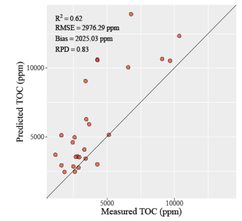

Combined 2016-2017 Results (269 samples)

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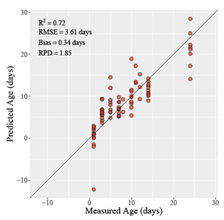

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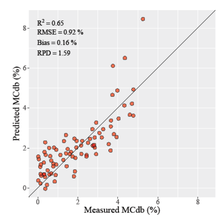

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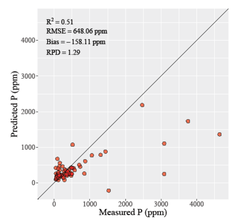

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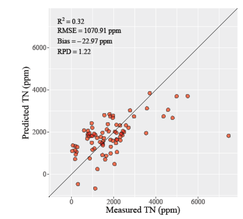

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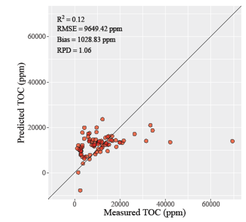

2017 Results (183 samples)

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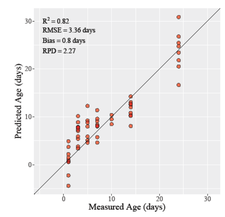

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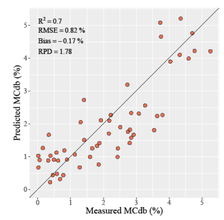

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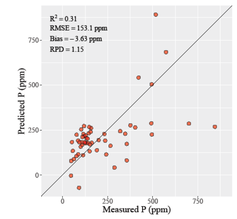

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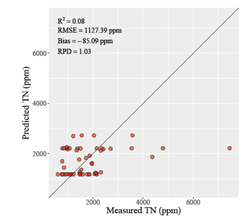

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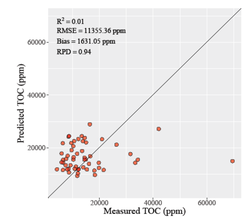

Data Processing and Analysis:

- Dataset contained 86 and 183 sample spectra from 2016 and 2017, respectively
- Pre-processing included smoothing to reduce noise and averaging of wavebands by 10 to reduce predictor variables (n=164)
- The dataset was randomly split in to calibration (70%) and validation (30%) sets
- The calibration set was used to calibrate models using four modeling techniques: partial least squares regression (PLS), artificial neural networks (ANN), random forests (RF), and support vector regression (SVR) with 10 random segment cross validation
- Models were then used to predict for the validation set and the prediction statistics (R^2, RMSE, Bias, RPD, and RPIQ) were calculated to evaluate model accuracy.
- All the data analysis steps were implemented in R

Conclusions

- Age and moisture content consistently show good modeling outcomes
- Nitrogen, phosphorus and carbon modeling success varied by data set
- Use of a full-range spectrometer (to 2500 nm) may help to model organic carbon more accurately due to known correlations with wavelengths in this region (SWIR)
- There is potential for improvement in modeling outcomes with better understanding of how sample storage (fresh vs. frozen) affects nutrient values (especially carbon)
- This analysis has provided valuable insight into the behavior of nutrients and moisture of dung at different ages and over time
- Exploratory statistical analysis on this data is ongoing and future plans for this data set include: obtaining total combustible carbon values for the physical samples to provide an additional modeling variable; use of all available wavebands for model generation; re-running laboratory analyses on 2017 samples to investigate the impact of frozen storage on water-extracted nutrient values

Acknowledgements

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