Using Remote Sensing Methods to Characterize Grassland Landscapes and Management Practices for Ecological Health Investigations

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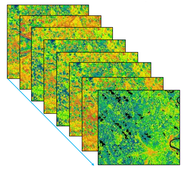
Introduction

- Grasslands support essential **biodiversity** and **ecosystem services** and are threatened by climate change and land use intensification
- Monitoring grasslands and characterizing the **management practices** implemented (biomass, cutting frequency, grazing intensity, etc.) can reveal key information related to the **integrity and ecological health** of these systems
- To increase the spatial extent of grasslands monitored and temporal resolution of monitoring, we utilized remotely sensed satellite imagery to characterize intensity and usage of grasslands
  - **4 years of satellite imagery** (growing season, March – October)
  - **Over 6,000 grassland parcels** in Wahnbachtal, Germany
    - Thresholding techniques were applied to the satellite images to estimate the **cutting frequency** of each grassland field/parcel for each year
    - The satellite images were summarized through time and used to train models to predict the **grassland management type** for all fields/parcels each year

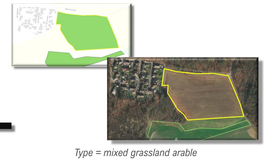
Grassland Type

Satellite Imagery *(Spectral Indices)*



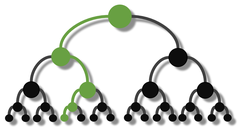
Summarized spectral information across the growing season related to the health and physical attributes of vegetation captured by satellite images

Training Data



Extracted spectral values (satellite data) for each grassland field/parcel. *Parcels with assigned type are used to train model (~400)*

Machine Learning

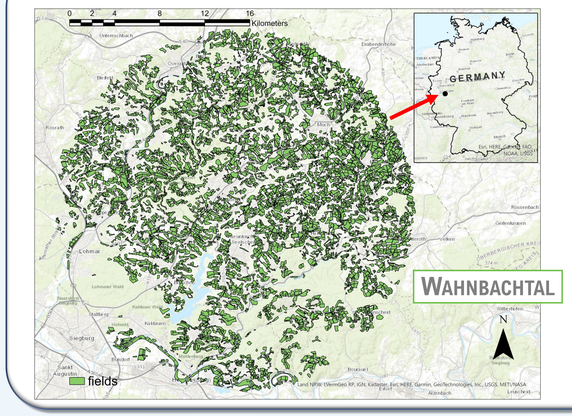


Random forest is a non-parametric **decision tree classifier** (Liaw & Wiener, 2002). Satellite imagery and training data were used as model inputs.

Resulting Grassland Type *(for all Parcels)*

Models used to **predict grassland type** for the remaining ~5,600 parcels/fields

Study Region & Datasets



Training Data

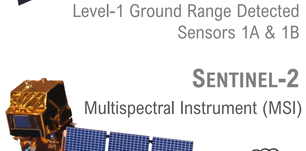
- More than 6,000 grassland parcels were derived via ocular sampling/manual digitizing efforts.
- Landscape experts for the region used aerial imagery from multiple dates to determine grassland type for ~400 parcels

Grassland Type

Natural Grassland	Not used for farming purposes; max. 1 cut per year
Hayfield	Meadow cut 2x per season
Mixed Grassland Arable	Field was used for both purposes over different seasons; high use intensity
Mixed Pasture Silage	Grazed by livestock and contains foiled hay balls for silage process
Pasture	Grazed by cattle/livestock, categorized by the type of farm nearby
Silage	Foiled hay balls for silage process (different cultivation than hayfield)

Sentinel-1

Synthetic Aperture Radar (SAR) C-band



10m x 10m spatial resolution
Level-1 Ground Range Detected
Sensors 1A & 1B

Sentinel-2

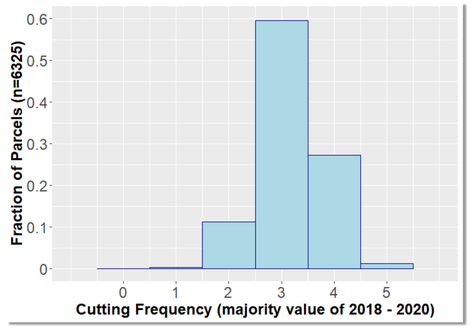
Multispectral Instrument (MSI)

10m, 20m, & 60m spatial resolution
Level-2A (Surface Reflectance)

Software: Google Earth Engine, R Studio

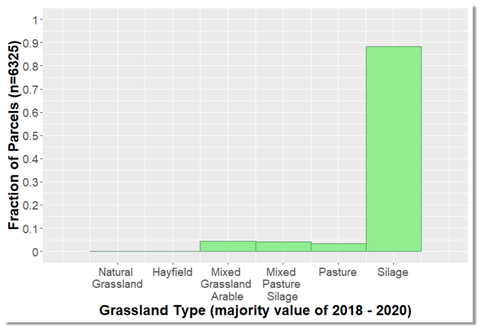
Results

Cutting Frequency



- **88% of parcels were cut 3 or more times each growing season**
- Validation has not been performed yet. However, the published methods integrated into this approach had accuracies that ranged between 60 – 80% (De Vroey et al., 2021; Lobert et al., 2021). Further validation is ideal

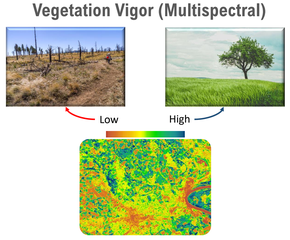
Grassland Type



- **88% of the parcels were predicted to be silage fields**
- Mixed grassland arable, mixed pasture silage, and pasture made up the other 12% of parcels
- Patterns in class prediction reflect patterns in training data
- Model training accuracies were consistent across years, ranging between 58 – 62%

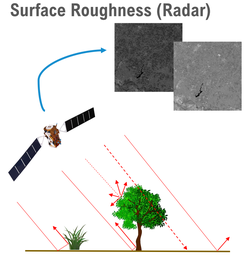
Cutting Frequency

Vegetation Vigor (Multispectral)



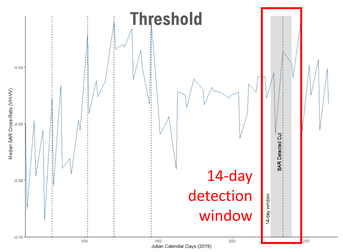
Spectral index related to the health or vigor of vegetation; grassland field/parcel **values decrease immediately after cutting** or mowing

Surface Roughness (Radar)



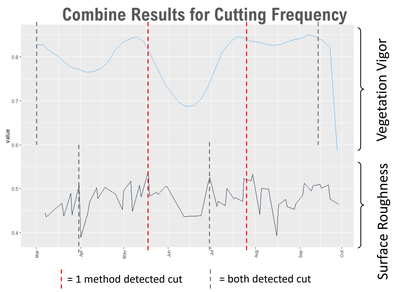
Surface roughness determined through microwave backscatter; **After cutting a field/parcel, backscatter values sharply increase, followed by a decrease**

Threshold



Applied value thresholds to satellite images to isolate individual cutting events throughout the growing season. Thresholds are based on the expected vegetation response after a cutting event.

Combine Results for Cutting Frequency



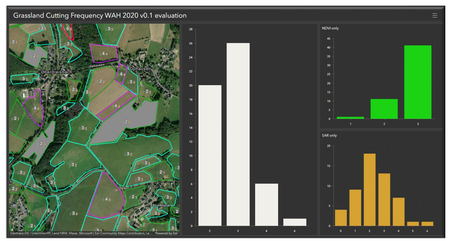
The **average of the two methods** used to estimate the number of cuts for a given grassland parcel.
Methods adapted from De Vroey et al., 2021 and Lobert et al., 2021

Conclusions

- Remotely sensed satellite imagery can be leveraged to inform grassland type and cutting frequency at broader spatial extents
- Results can **guide in-situ monitoring efforts** to help target critical insect habitat overlapping with grassland areas of more intense management
- Application across other regions may **reveal broad scale patterns** or correlations that exist **between insect habitat quality and grassland management practices**
- Grassland Type model has room to improve by balancing number of samples between classes and additional training data
- Testing the thresholds and models against an independent validation dataset would be ideal

Outlook

- Web applications to guide in-situ monitoring and surveying efforts (ArcGIS Online)



esri ArcGIS Online

Dashboard development and visualization created by Karl Schad

De Vroey, M., Radoux, J., & Defourny, P. (2021). Grassland Mowing Detection Using Sentinel-1 Time Series: Potential and Limitations. In Remote Sensing (Vol. 13, Issue 3, p. 348). MDPI AG. https://doi.org/10.3390/rs13030348
Liaw A, Wiener M (2002). "Classification and Regression by randomForest." R News, 2(3), 18-22. https://CRAN.R-project.org/doc/Rnews/.
Lobert, F., Holtgrave, A.-K., Schwieder, M., Pause, M., Vogt, J., Gocht, A., & Erasmi, S. (2021). Mowing event detection in permanent grasslands: Systematic evaluation of input features from Sentinel-1, Sentinel-2, and Landsat 8 time series. In Remote Sensing of Environment (Vol. 267, p. 112751). Elsevier BV. https://doi.org/10.1016/j.rse.2021.112751

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