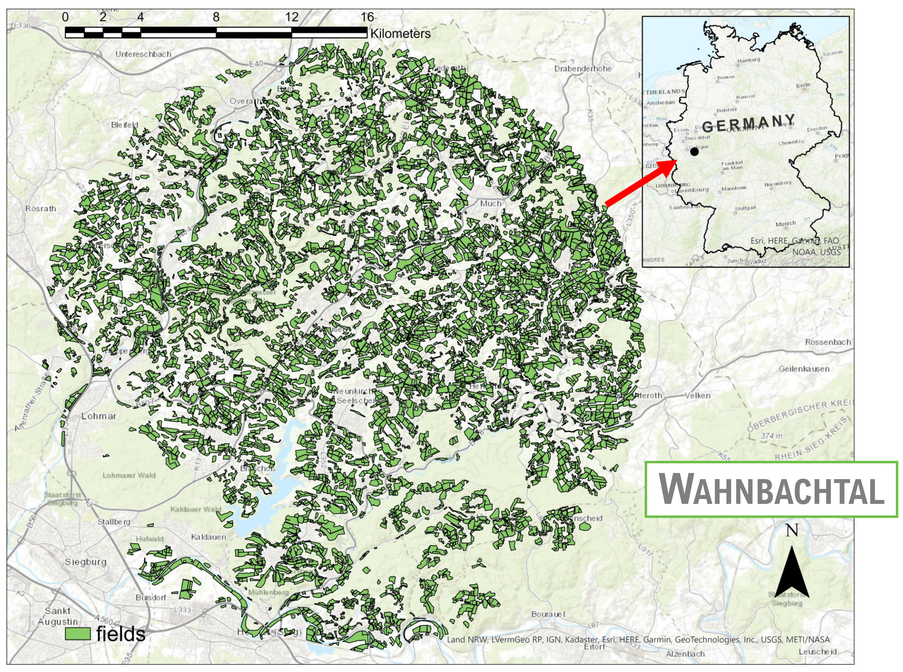
Using Remote Sensing Methods to Characterize Grassland Landscapes for Scenario Development and Biodiversity Assessment

Jillian LaRoe[1], Christopher M. Holmes[1*] and Thorsten Schad[2]
[1]Applied Analysis Solutions LLC, Winchester, VA, USA; [2] Bayer AG, Crop Science Division, Environmental Safety, D-40789 Monheim, Germany

Introduction

- Grasslands support essential **biodiversity** and **ecosystem services** and are threatened by climate change and land use intensification
- Monitoring grasslands and characterizing management practices (cutting frequency, grazing intensity, etc.) can reveal key information related to insect habitat quality and biodiversity to **support risk assessments**
- Leveraging remote sensing techniques can increase the spatial extent and temporal resolution of grassland monitoring; we leveraged satellite imagery to **characterize use intensity and management of grasslands** in Wahnbachtal, Germany
  - Thresholding techniques were applied to the satellite images to estimate annual **cutting frequency** of each grassland field/parcel
  - Satellite images through time were used to train models to predict annual **grassland management type** for each field/parcel

Study Region & Datasets



Training Data

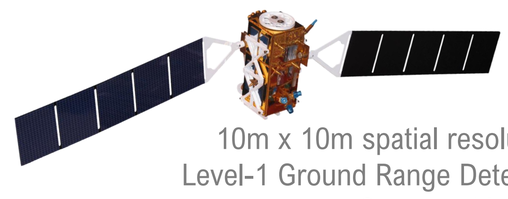
- More than 6,000 grassland parcels were derived via ocular sampling/manual digitizing efforts.
- Landscape experts for the region used aerial imagery from multiple dates to determine grassland type for ~400 parcels

Grassland Type

Natural Grassland	Not used for farming purposes; max. 1 cut per year (1%)
Hayfield	Meadow cut 2x per season (3%)
Mixed Grassland Arable	Field was used for both purposes over different seasons; high use intensity (6%)
Mixed Pasture Silage	Grazed by livestock and contains foiled hay balls for silage process (26%)
Pasture	Grazed by cattle/livestock, categorized by the type of farm nearby (14%)
Silage	Foiled hay balls for silage process (different cultivation than hayfield) (50%)

Sentinel-1

Synthetic Aperture Radar (SAR) C-band



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

Sentinel-2

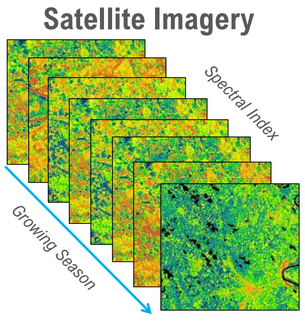
Multispectral Instrument (MSI)

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

Software: Google Earth Engine, R Studio

Grassland Type

Satellite Imagery



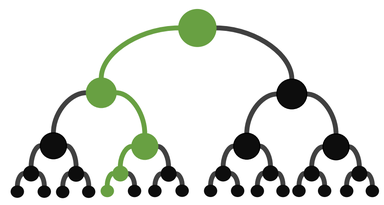
Summarized spectral information related to health & physical attributes of vegetation each year (2018 - 2021)

Training Data

Type = mixed grassland arable

Extracted spectral information for each grassland parcel.
Parcels assigned grassland management type for model training (~400)

Machine Learning



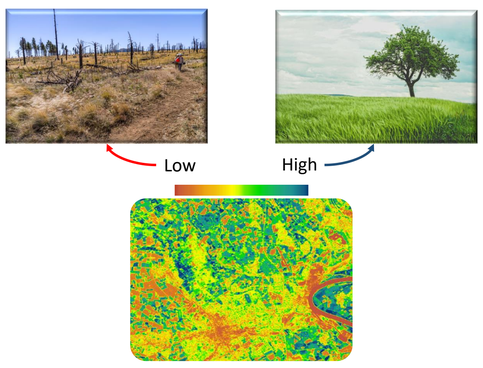
Random forest is a non-parametric **decision tree classifier** (Liaw & Wiener, 2002). *Input satellite imagery & training data*

Resulting Grassland Type

Models applied to satellite images to **predict grassland management type** for the remaining ~5,600 parcels

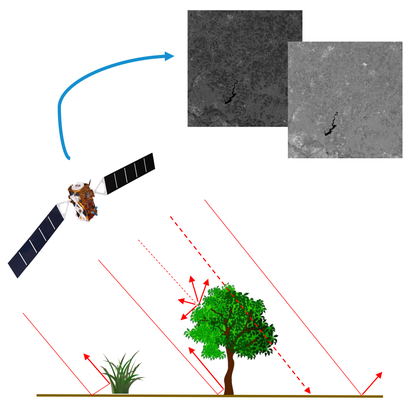
Cutting Frequency

Vegetation Vigor (Multispectral)



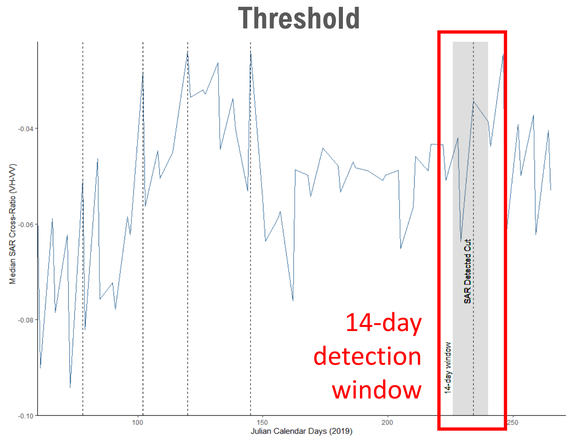
Spectral index related to the health or vigor of vegetation; grassland parcel **values decrease immediately after cutting** or mowing

Surface Roughness (Radar)



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

Threshold



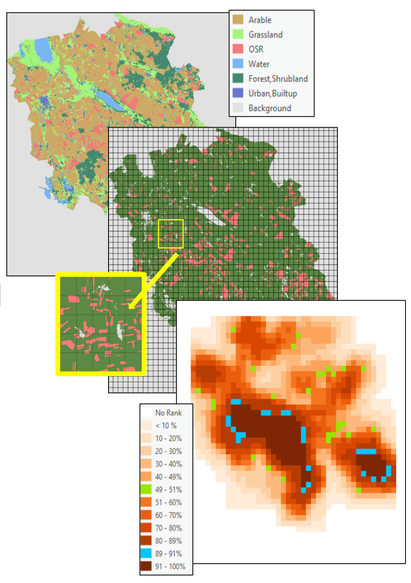
Applied value thresholds to satellite images to isolate individual cutting events throughout the growing season. Thresholds are based on the expected vegetation response after a cutting event. (*Average of the two methods*)

Conclusions

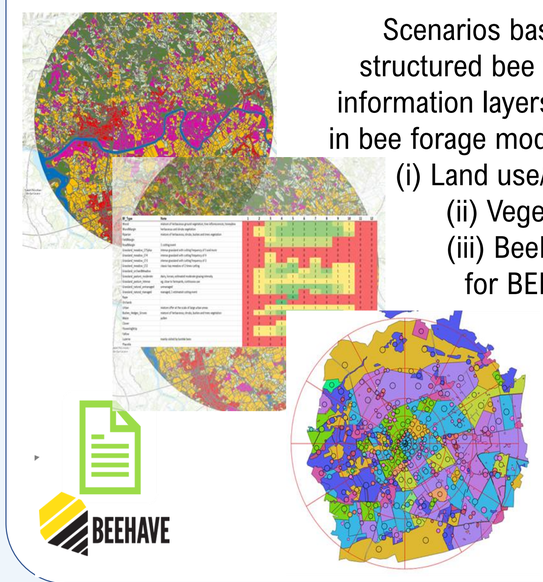
- Remotely sensed satellite imagery can be leveraged to inform grassland type and cutting frequency at broader spatial extents
- Results can **guide in-situ monitoring efforts** to help target critical insect habitat overlapping with intensely used grasslands
- Application across other regions may **reveal broader patterns** or correlations **between insect habitat quality and grassland management practices**
- Improve Grassland Type model by balancing number of samples between classes
- **Remote sensing techniques can advance landscape scenario development and risk assessment for key species**

Supporting Scenario Development

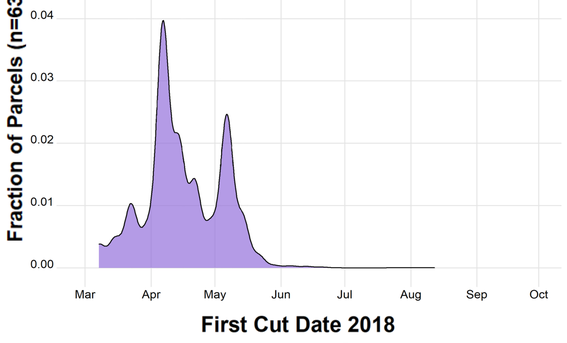
Relative vulnerability of the wood mouse (*Apodemus sylvaticus*) in relation to Oilseed Rape (OSR) fields for over 2000 landscape scenarios



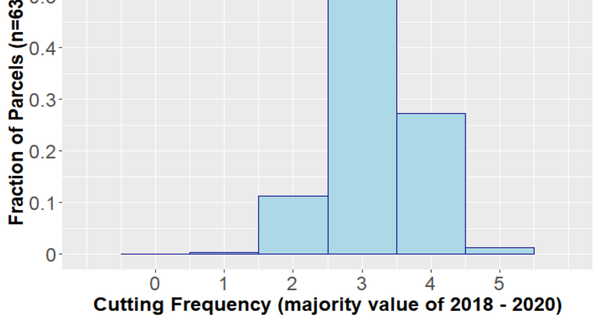
Scenarios based on structured bee forage information layers used in bee forage modelling: (i) Land use/cover, (ii) Vegetation, (iii) BeeForage for BEEHAVE



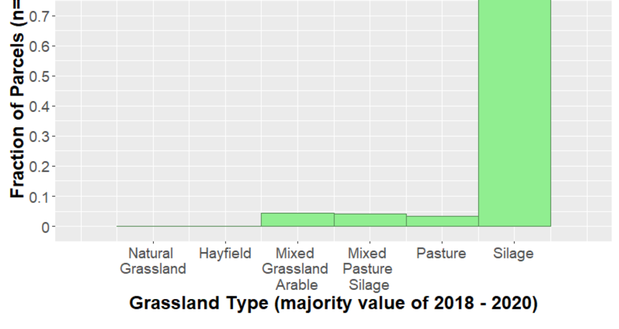
Results



- **First cut occurs early in the growing season** for the majority of parcels which is **characteristic of high use intensity** *(grazing vs mowing not differentiated)*
- Very few parcels have their first cut in June, which is characteristic of lower use intensity



- **88% of parcels** were **cut 3+ times** each growing season
- Validation has not been performed yet. The accuracy of published methods integrated into this approach ranged between 60 – 80% (De Vroey et al., 2021; Lobert et al., 2021).



- **88% of parcels predicted to be silage fields**
- Other 12% of parcels predicted to be mixed grassland arable, mixed pasture silage, and pasture *[Class predictions reflect skew in training data]*
- Model training accuracies were consistent between years, ranging between 58 – 62%

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

For more information contact ChrisHolmes@AppliedAnalysis.solutions or thorsten.schad@bayer.com

APPLIED ANALYSIS SOLUTIONS LLC