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Characterizing sown biodiverse pastures using remote sensing data with machine learning

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In Portugal, beef cattle are commonly fed with a mixture of grazing and forages/concentrate feed. Sown biodiverse permanent pastures rich in legumes (SBP) were introduced to provide quality animal feed and offset concentrate consumption. SBP also sequester large amounts of carbon in soils. They use biodiversity to promote pasture productivity, supporting a more than doubling in sustainable stocking rate, with several potential environmental co-benefits besides carbon sequestration in soils.

Here, we develop and test the combination of remote sensing and machine learning approaches to predict the most relevant production parameters of plant and soil. For the plants, we included pasture yield, nitrogen and phosphorus content, and species composition (legumes, grasses and forbs). In the soil, we included soil organic matter content, as well as nitrogen and phosphorus content. For soils, hyperspectral data were obtained in the laboratory using previously collected soil samples (in near-infrared wavelengths). Remotely sensed multispectral data was acquired from the Sentinel-2 satellite. We also calculated several vegetation indexes. The machine learning algorithms used were artificial neural networks and random forests regressions. We used data collected in late winter/spring from 14 farms (more than 150 data samples) located in the Alentejo region, Portugal.

The models demonstrated a good prediction capacity with r-squared (r2) higher than in 0.70 for most of the variables and both spectral datasets. Estimation error decreases with proximity of the spectral data acquisition, i.e. error is lower using hyperspectral datasets than Sentinel-2 data. Further, results not shown systematic overestimation and/or underestimation. The fit is particularly accurate for yield and organic matter, higher than 0.80. Soil organic matter content has the lowest standard estimation error (3 g/kg soil – average SOM: 20 g/kg soil), while the legumes fraction has the highest estimation error (20% legumes fraction).

Results show that a move towards automated monitoring (combining proximal or remote sensing data and machine learning methods) can lead to expedited and low-cost methods for mapping and assessment of variables in sown biodiverse pastures.