Instituto de Investigación y Formación Agraria y Pesquera
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Monitoring pasture quality and production in extensive systems for an integrated management of oak savannas

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ABSTRACT

This work explores the monitoring of grassland production and quality in extensive systems using remotely sensed data with different spatial and temporal scales. Pastures net primary production was estimated using an adaptation of Monteith model. A regional approach for *dehesa* (oak savannah) area in the north of Cordoba (Spain) has been developed combining MODIS products at 250 m of spatial resolution with spatially interpolated meteorological data. When compared with field measurement, grassland production estimations presented an overestimation at the beginning of the growing season, with a mean absolute error (MAE) equal to 118 kg/ha that decreases to 61 kg/ha at the end of the season.

In order to estimate pasture quality, canopy hyperspectral reflectance was measured in the 350-2500 nm wavelength range over natural pastures and Nitrogen concentration of the ground samples was determined using an automated combustion instrument. The equation calculated allowed for a good prediction N concentration (calibration r^2=0.76 and validation r^2=0.86). The relationship obtained between Canopy chorophyll concentration index (CCCI) and N concentration was poor (r^2=0.16). When the total analytical data set was analyzed by farms, or were considered N values lower than 2.0, the relationship accuracy was slightly improved (r^2= 0.22 - 0.42 and r^2=0.47 respectively) .

INTRODUCTION & METHODOLOGY

Extensive livestock is the main economic activity supporting Mediterranean pastures. Oak savannas, known as *dehesas* in Spain and *montados* in Portugal, cover about 3 million hectares in the Iberian Peninsula. The monitoring of these large areas requires effective tools that provide timely and accurate data to assist management and decision-making at different levels.

MODELS DESCRIPTION AND FIELD MEASUREMENTS

1) PASTURE BIOMASS PRODUCTION

The estimation of pasture net primary production is obtained using an adaptation of Monteith model (1977):

NPP = ∫ fAPAR * PAR * *ε* * dt

where:

NPP (g/ha): Net primary production

fAPAR (dimensionless): Fraction of photosynthetically active radiation absorbed by the vegetation. It is estimated from daily NDVI series, based on MODIS reflectance products

TREE EFFECT REMOVAL: An annual average value of fAPAR corresponding to sparse oak trees canopies is subtracted from daily data for each pixel. This value is taken from values obtained during the dry season, when annual pasture is dry and the only photosynthetic activity canopy corresponds to oak trees. The stability of this value during the year was verified with field measurements during the 2013/2014 growing season.

PAR (MJ): Photosynthetically active radiation, derived from total solar radiation data provided by ground weather stations,

ε (g/MJ): Light use efficiency. A maximum value of 0.77 gC/MJ is modified according to meteorological variables that reduce plant efficiency, as daily minimum temperature (Tmin) and average humidity (VPD). Thresholds values for both variables were taken from Running et al. (2000) for a similar ecosystem.

Pastures biomass samples were taken at plot level to serve as validation dataset. These biomass samples were collected during the growing season (March to June 2014) in three farms. The production was calculated using the Comparative Yield Method (Haydock and Shaw, 1975).

2) PASTURE QUALITY

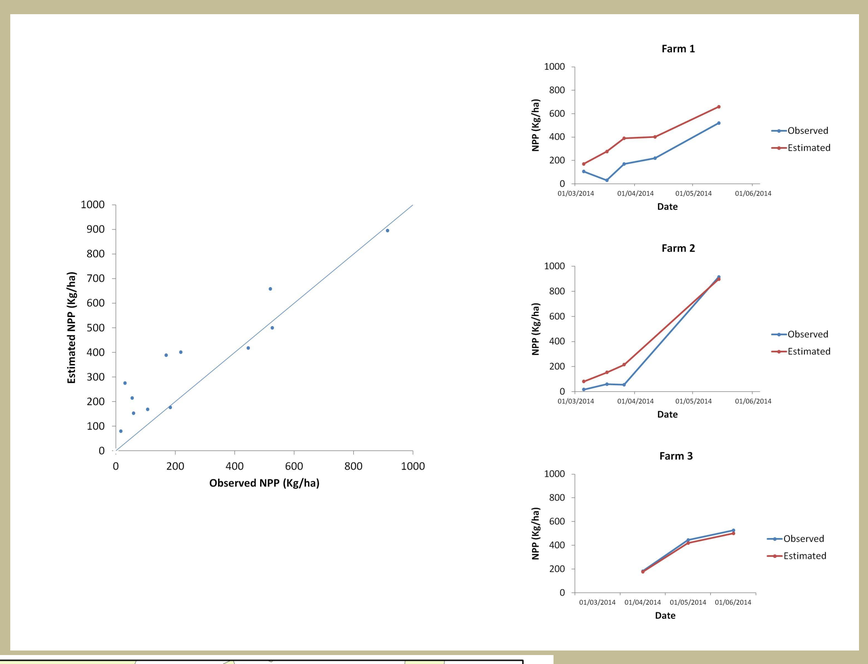
Ground surface reflectance was measured in the 350-2500 nm wavelength range over natural pasture in three *dehesa* farms from early January to late June 2013 using a portable ASD FieldSpec FR spectroradiometer. Nitrogen concentration of ground samples was determined in the laboratory using an automated combustion instrument (LECO).

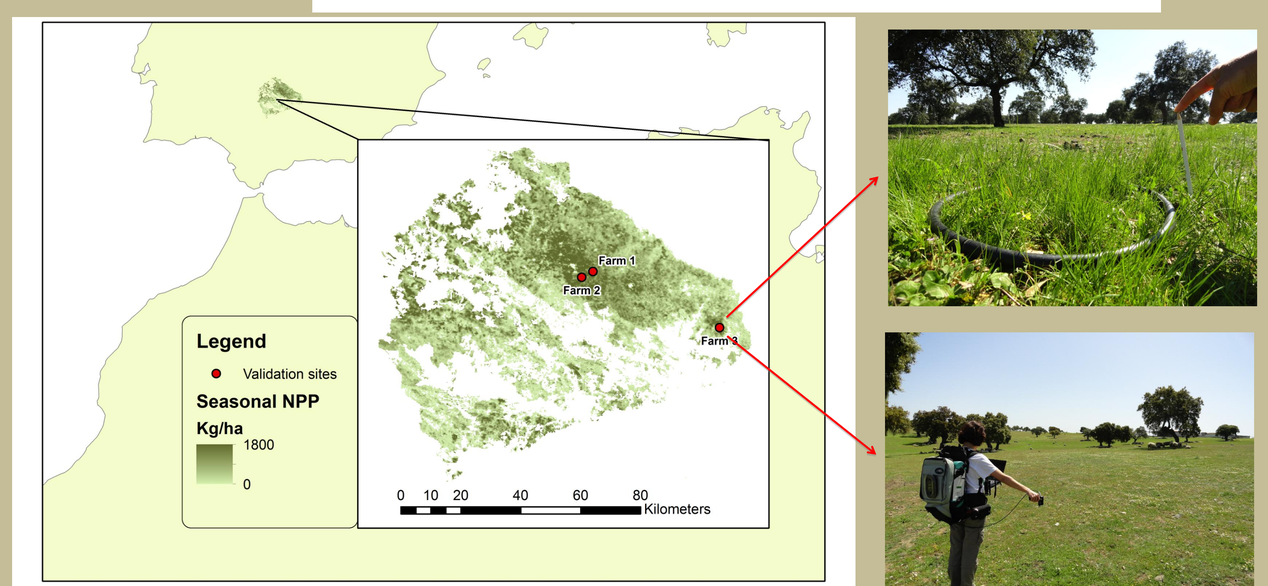
The estimation of nitrogen content using the spectral data was carried out by two different methods:

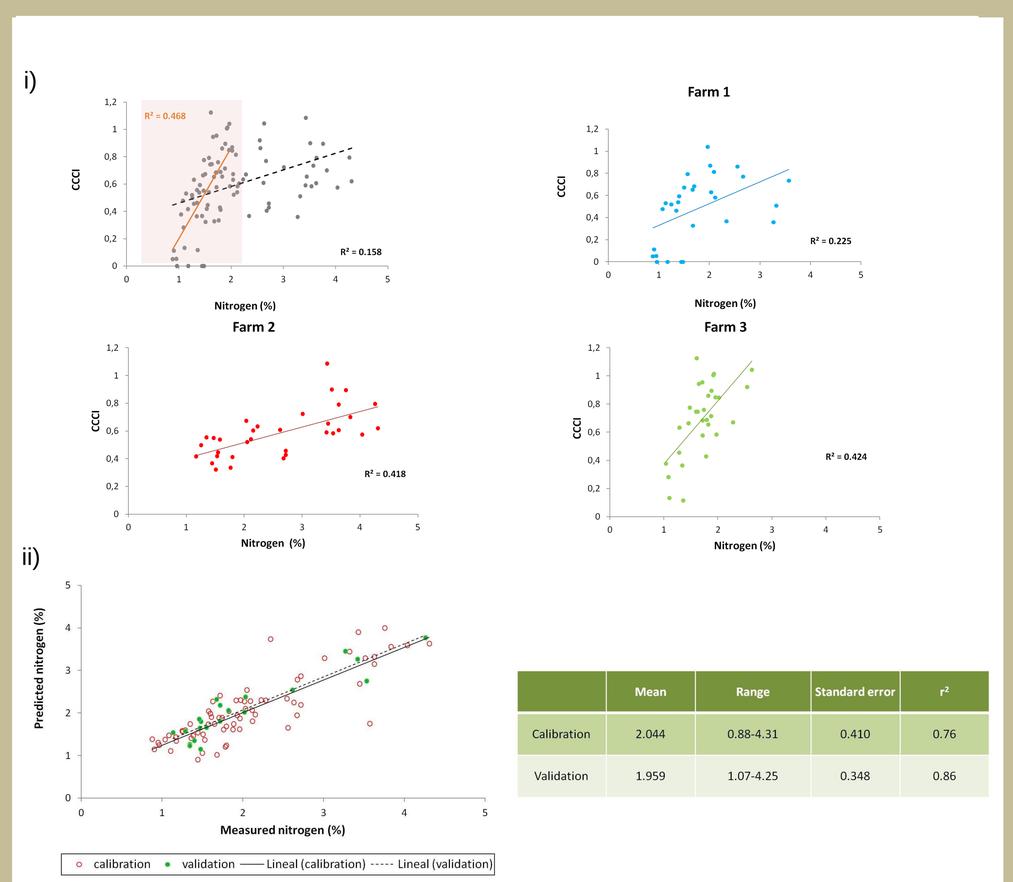
i) The canopy chlorophyll concentration index (CCCI) (Barnes et al., 2000). It is a two dimensional index, utilizing NDVI as an estimate of percent cover, and the normalized difference far red index (NDFR), which is sensitive to plant chlorophyll content or nitrogen status.

ii) PLS regression. This method reduces high dimensional data into a limited number of uncorrelated components based on the covariance between the predictors and response variables.

RESULTS







	Mean	Range	Standard error	r^2
Calibration	2.044	0.88-4.31	0.410	0.76
Validation	1.959	1.07-4.25	0.348	0.86

CONCLUSIONS

- The results of pasture production showed an overestimation at the beginning of the growing season, which might be due to the grazing management of the study plots. Farm 1 was the most grazed, in opposite to Farm 3 that was not grazed during the measurement period. The mean absolute error (MAE) at the beginning of the season, when farms 1 and 2 were grazed, was 118 kg/ha, while at the end of the growing season the model deviation was reduced to a MAE equal to 61 kg/ha. This estimation is considered appropriate to the scale and objectives of potential applications in pasture management and the initial error will require further data and analysis to account for overestimation.
- Regarding the pasture quality assessment, the equation calculated by PLS-regression allowed for a good prediction of N concentration, demonstrating the potential of using canopy hyperspectral reflectance to estimate N concentration of grasses through PLS regression, which uses all wavebands. However, CCCI showed little sensitively to nitrogen concentration, presenting a poor relationship (r^2=0.16) when all data were considered. When the total analytical dataset was divided into individual farms datasets or were considered N values lower than 2.0, the accuracy was improved. This relationship was improved for low nitrogen concentrations and some farms separately, suggesting an influence of external factors not considered in this analysis.
- Ground-based remote sensing systems offer an alternative for estimating natural pasture N concentrations, however their utility seems limited when only few bands are used.

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