

Assessing the long-term persistence of legume-rich mixtures sown in Mediterranean Dehesas through NDVI analysis

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Abstract
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Abstract

Mediterranean silvopastoral systems are suppliers of ecosystem services (ES) as fodder production and biodiversity conservation (Moreno et al. 2018). These systems are under threat because of both abandonment and intensification trends (Mahyou et al. 2016; Rossetti and Bagella 2014). To pursue the long term ES provision, innovative practices and tools are needed in alternative to these diverging trends (Moreno et al. 2018). Pasture improvement by sowing legume-rich mixtures is gaining importance due to their contribution to the improvement of forage production and quality, soil fertility and C sequestration, thus turning grasslands into climate change-resilient ecosystems (Hernández-Esteban et al. 2018). However, the persistence of costly sown legume-rich pastures is always a concern and could make the practice unprofitable. The hypothesis of this study is built on the new insights on Remote Sensing (RS) that can contribute to the systematic collection of proxy data on pastures aboveground biomass production and quality. Furthermore, the combination of new software resources and big-data analytics for predictive modelling can provide cost-effective, integrated farm-level decision support tools for sustainable grassland management (Wachendorf et al. 2018). The specific objective of this study was to assess, through the analysis of Normalized Difference Vegetation Index (NDVI) dynamics, how long-lasting and intense are the impacts of pasture improvement actions based on sown legume-rich mixtures in Mediterranean silvopastoral systems.

The study was conducted in two dehesa farms (Atoquedo and La Villa) in Extremadura, Spain (Hernández-Esteban et al. 2018), where different legumes-rich mixtures had been sown over years (from 2003 to 2015) in distinct areas. In the first farm (Atoquedo), five plots were sown in 2010, 2011, 2012, 2013 and 2014, respectively, while in the second farm (La Villa), the legumes were sown in three distinct areas in 2003, 2005 and 2015, respectively. At each farm, large unsown areas were identified as control.

The persistence of legume-rich mixtures after sowing was assessed in spring over the years through the NDVI analysis. The NDVI dynamic was reconstructed at each plot from 4 years before the first sowing to present. Trees and ungrazed areas were excluded by creating polygons with the eCognition® software (ver 9.0.1, Trimble Inc., Sunnyvale, California, USA) starting from the most recent orthophotos. These latter polygons were therefore overlaid to Landsat images (at least three per year, from March 1st to May 31st) and then processed with QGIS software, in order to calculate the yearly average NDVI. The average NDVI values were normalized with respect to the NDVI values observed in the control (unsown) areas. The effects of the year on the normalized NDVI before and after sowing was tested with linear regression analysis. The differences between the average normalized NDVI values before and after sowing and the reference value in the control plots (normalized NDVI=1.0) were tested with one-tail t tests. The significance of statistical computations was evaluated at P<0.05.

The effect of the year on the normalized NDVI value was not significant in both farms and did not change before and after sowing (Figure 1). In the Atoquedo farm, the average normalized NDVI values before (0.92) and after (1.08) the sowing were significantly lower and higher, respectively, than the reference control value ($P < 0.001$). At La Villa farm, the average normalized value before sowing (0.96) was different (but at $P = 0.07$) from the control (1.00) and the average normalized NDVI value after sowing (1.22) was significantly higher from the control ($P < 0.001$).

The lack of significance of linear regressions after sowing (9 and 13 years after, respectively) suggested that the effect of legumes enrichment in dehesa systems could be persistent for a long time. Whereas the NDVI is related to pasture quality, these preliminary results suggest that the impacts of the legumes enrichment could be effective as a strategy to improve the quality of the forage production and consequently to enhance ES in Mediterranean silvopastoral systems.

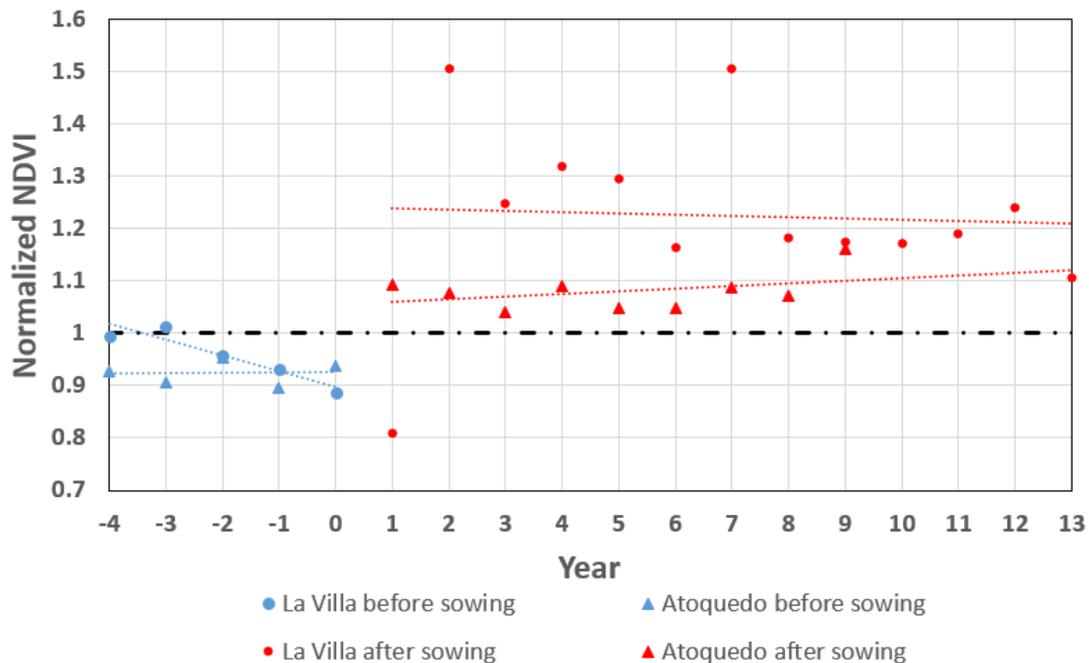


Figure 1. Mean of the normalized NDVI values before (blue) and after (red) sowing at “Atoquedo” (triangles) and “La Villa” (circles) farm. NDVI values were normalized by dividing mean values of the sown plots by mean values of the control plots.

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