Google Earth Engine based monitoring of cork and holm oak woodlands NDVI trends in Portugal

Valentine Aubard (vaubard@isa.ulisboa.pt), **Joana A. Paulo** & **João M. N. Silva**
School of Agriculture - University of Lisbon, Forest Research Centre, Lisbon, Portugal

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Introduction

The Mediterranean area currently suffers a general decline of oak woodlands' health and productivity. Cork oak (*Quercus suber* L.) and holm oak (*Quercus ilex* L.) are widely exploited in Portugal and are an important economical and ecological resource for the country.

The **Normalized Difference Vegetation Index** (NDVI) is a common remote sensing index used as a proxy for vegetation biomass, chlorophyll activity, health and stress (1). NDVI **can be monitored for 34 years (1984-2017) at 30-meter of resolution** using Landsat imagery. The online platform Google Earth Engine (GEE) allows the free access and fast handling of this huge amount of satellite images.

OBJECTIVE

Providing to researchers, land owners and policy-makers **a high-resolution map of cork and holm oak long-term trends for the whole Portugal**.

Materials and Methods

STUDY AREA

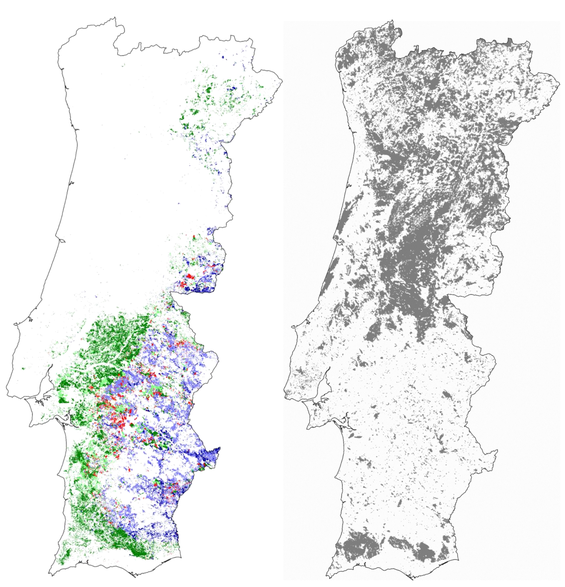
Five classes of oak woodlands, without burned areas.

Fire mask

Burned areas (1984-2017)

Areas with a constant land cover from 1995 to 2015

- Class 1 - Cork oak forests
- Class 2 - Holm oak forests
- Class 3 - Cork oak agroforestry systems
- Class 4 - Holm oak agroforestry systems
- Class 5 - Agroforestry systems with cork and holm oaks



TIME SERIES

To focus on the tree layer, the 34-year time series was constructed with **summer NDVI mean composites** (July-August), when the herbaceous understory is dry.

NDVI adjusted between two sensors:
- Landsat-5 (1984-2013),
- Landsat-7 (1999-2017).

$$NDVI_{Landsat\text{-}7} = 1.0370 * NDVI_{Landsat\text{-}5} \quad (2)$$

TREND STATISTIC TESTS

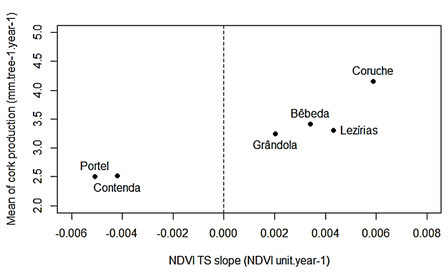
For each pixel, the trend significance and sign were obtained with the non-parametric rank tests for monotonic trends: the pixel-based **Mann-Kendall** (MK) and the eight-neighbor-based **Contextual Mann-Kendall** (CMK). The trend slopes were calculated with the **Theil-Sen** (TS) estimate of linear regression.

A **Pettitt** test was run on six study-sites times series to detect significant slope change-points within the trends.

VALIDATION

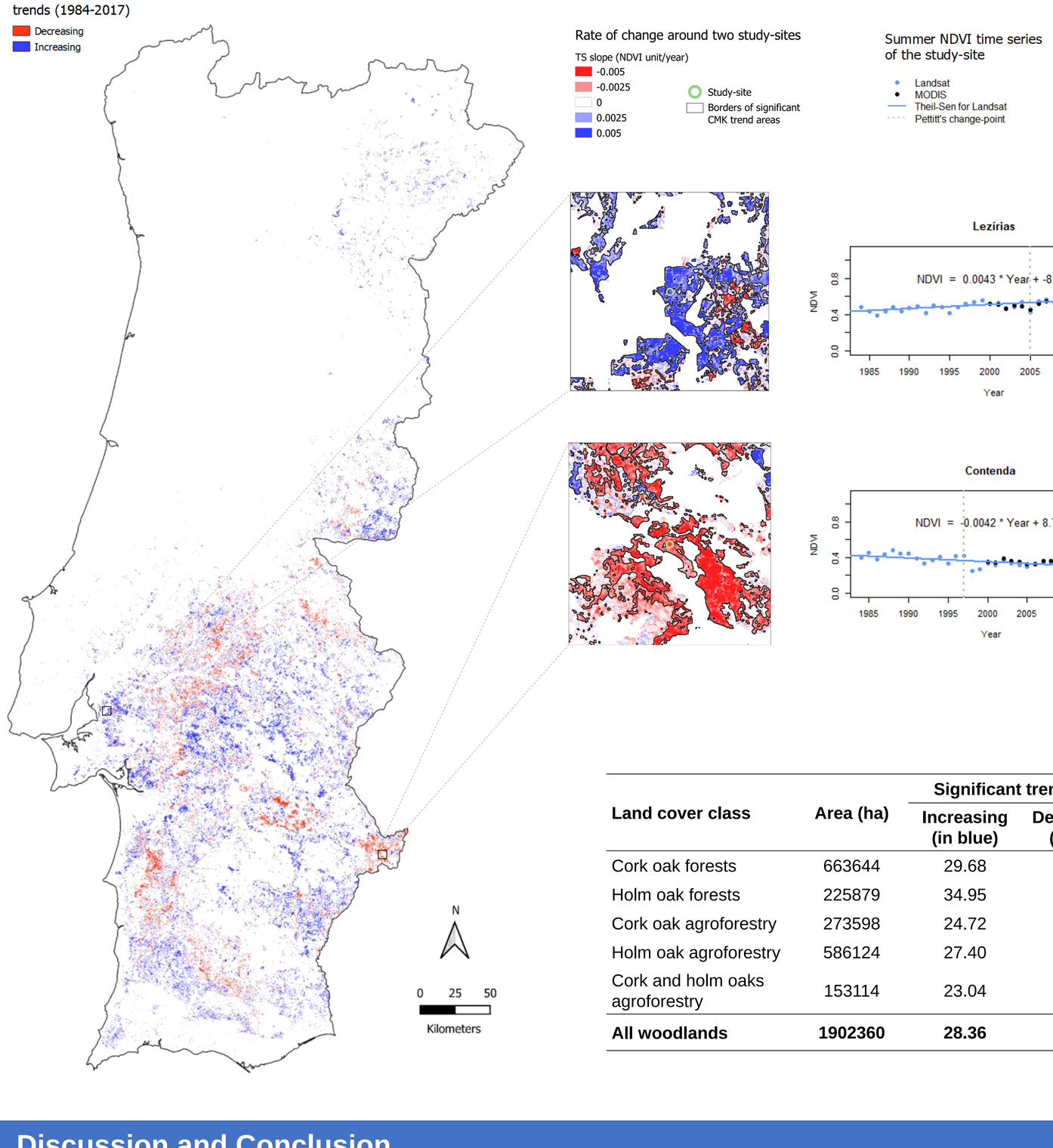
Results were compared with the 500-meter daily Moderate Resolution Imaging Spectroradiometer (MODIS) NDVI values and 17-year trends.

Landsat summer NDVI trends were compared with field cork productivity for six study-sites.



Results

Contextual Mann-Kendall significant NDVI trends for cork and holm oak areas in Portugal (1984-2017), with two enlargements around study-sites showing TS slopes and CMK significant trend areas, and study-sites time series with the rate of change and Pettitt significant change-point. The table gives the proportions of increasing and decreasing CMK significant trends for each class of woodland.



Land cover class	Area (ha)	Significant trends (%)	
		Increasing (in blue)	Decreasing (in red)
Cork oak forests	663644	29.68	13.13
Holm oak forests	225879	34.95	12.06
Cork oak agroforestry	273598	24.72	16.66
Holm oak agroforestry	586124	27.40	7.68
Cork and holm oaks agroforestry	153114	23.04	12.49
All woodlands	**1902360**	**28.36**	**11.78**

Discussion and Conclusion

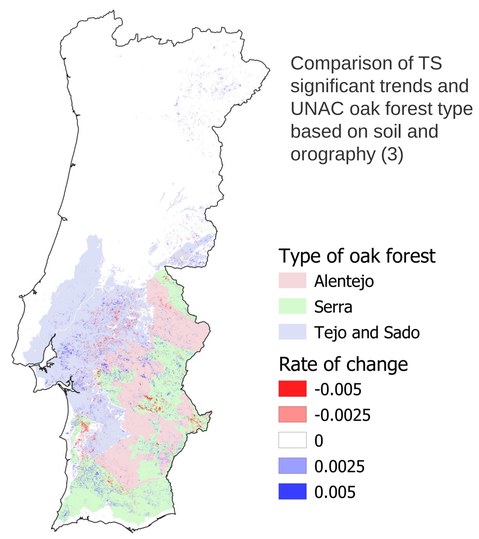
Summer NDVI revealed to be a good proxy of cork oak stands health and productivity, when compared with field data. The six study sites had a significant change-point of Landsat trend in the same decade, between 1996 and 2005, possibly due to two severe drought events in 1990-1994 and 2002-2006.

Increasing NDVI trends were expected in most of the stands, caused by canopy regular extent and natural or artificial regeneration replacing dying trees.

Oaks decline is a complex multifactor process: drier summers and decrease in photosynthesis activity; pests and diseases; soil depth, compaction, and texture, which are directly impacted by cultural practices. The most declining stands are situated on the 'Serra' UNAC forest type, the poorest in soil quality and rentability: a consequence of low levels of management and investment?

The comparison of woodland types reveals cork oak agroforestry has the highest percentage of downward trends and holm oak agroforestry systems the lowest: the sparse canopy cover does not allow an effective water retention in summer, necessary to cork oaks' health and regeneration, while holm oaks have a better adaptability to xerophytic climatic conditions and could benefit for the moment of the low competition in agroforestry stands.

The procedure developed in GEE can be easily adapted and updated for other regions and species and be used to monitor long-term changes in forest and agroforestry ecosystems.



Comparison of TS significant trends and UNAC oak forest type based on soil and orography (3)

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