7.1. Changes in vegetation productivity according to teledetection

Alcaraz-Segura, D.[1,2]; Reyes, A.[2] and Cabello, J.[2]
[1] University of Granada [2] University of Almería

Abstract

The analysis of the time series of spectral indices of vegetation supplied by the MODIS sensor from 2001 to 2013 provides valuable results concerning the functioning (productivity, seasonality, and phenology of the dynamics of carbon gains) of Sierra Nevada ecosystems. The Pyrenean oak forests, the pine plantations, and the Holm oak woodlands show strong negative trends of greenness at the beginning of spring. Finally, an east-west gradient was detected in the greenness trend. In the west the annual production decreased while increasing in the east. This may be related to the climate patterns of precipitation at the regional scale.

Aims and methodology

The aim of this work is to detect and describe the changes in several attributes of the seasonal dynamics of carbon gains, indicators of primary production, seasonality, and phenology in Sierra Nevada ecosystems. For this, a number of temporal vegetation indices were used.

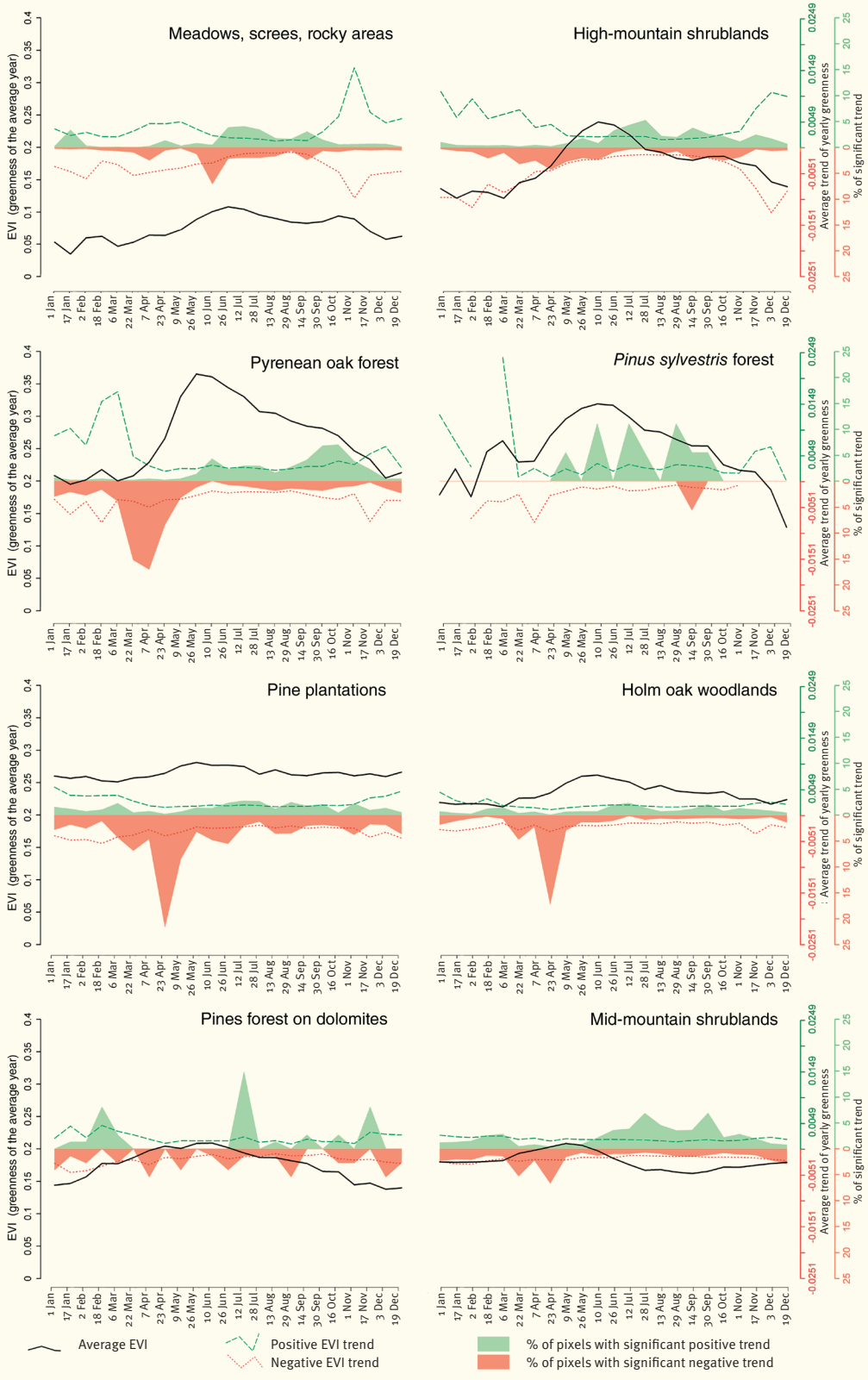
Spectral vegetation indices constitute the best tools for monitoring the primary productivity of ecosystems at the global level by satellite images [1]. These indices show a linear response with the fraction of photosynthetically active radiation intercepted by the vegetation (PAR). Because of this relation to primary productivity, spectral vegetation indices are often used to derive indicators of ecosystem functioning, such as total annual carbon absorbed by the vegetation or seasonality and phenology of the dynamics of carbon gains [2]. The images of the Enhanced Vegetation Index (EVI) were derived from the MODIS-Terra sensor between January 2001 and December 2013 (MOD13Q1 product). These images have a spatial resolution of 231 m and a temporal one of 16 days (23 images per year). First, the seasonal EVI curve was drawn for each year and the mean, maximum, and minimum EVI was calculated for each year. Next, the trends of these variables and in each compound were explored over the period 2001-2013 [3]. The trends were evaluated for the entire geographic context of Sierra Nevada, differentiating between the different representative ecosystems present in the protected area. The pure representative pixels of each ecosystem were selected from each ecosystem map of the Sierra Nevada Global Change Observatory.

Results

The main ecosystems of Sierra Nevada (Figure 1) differed in their primary annual production and seasonality but were similar in their phenology, with maximum photosynthetic activity values in late spring (May and June), and minimums in winter (except middle-mountain shrublands, the only ecosystem with minimums in summer). The most productive ecosystems were the *Quercus pyrenaica* oak forests, the native *Pinus sylvestris* forests, and pine plantations. The Holm oak woodlands and the native pine forests had intermediate primary production. The high- and middle-mountain shrublands registered low primary production values while the high-mountain meadows and rocky areas had the lowest. The ecosystems with the greatest seasonality were the high-mountain shrublands and the oak forests, while the least seasonality was found in the Holm oak woodlands and the conifer plantations.

The spatial pattern of the trends in the functional attributes of the EVI showed an elevational gradient and an east-west orientation (Figure 2). On the western edge of Sierra Nevada, increased annual productivity was found, while in the central and western sectors of the massif, this diminished. In general, the greater mean annual productivity (Figure 2a) resulted more from the higher minimums (Figure 2c) than from productivity maximums (Figure 2b). On the contrary, the lower mean annual productivity values (Figure 2a) were provoked more by lower maximums (Figure 2b) than by minimums in productivity (Figure 2c).

Figure 1

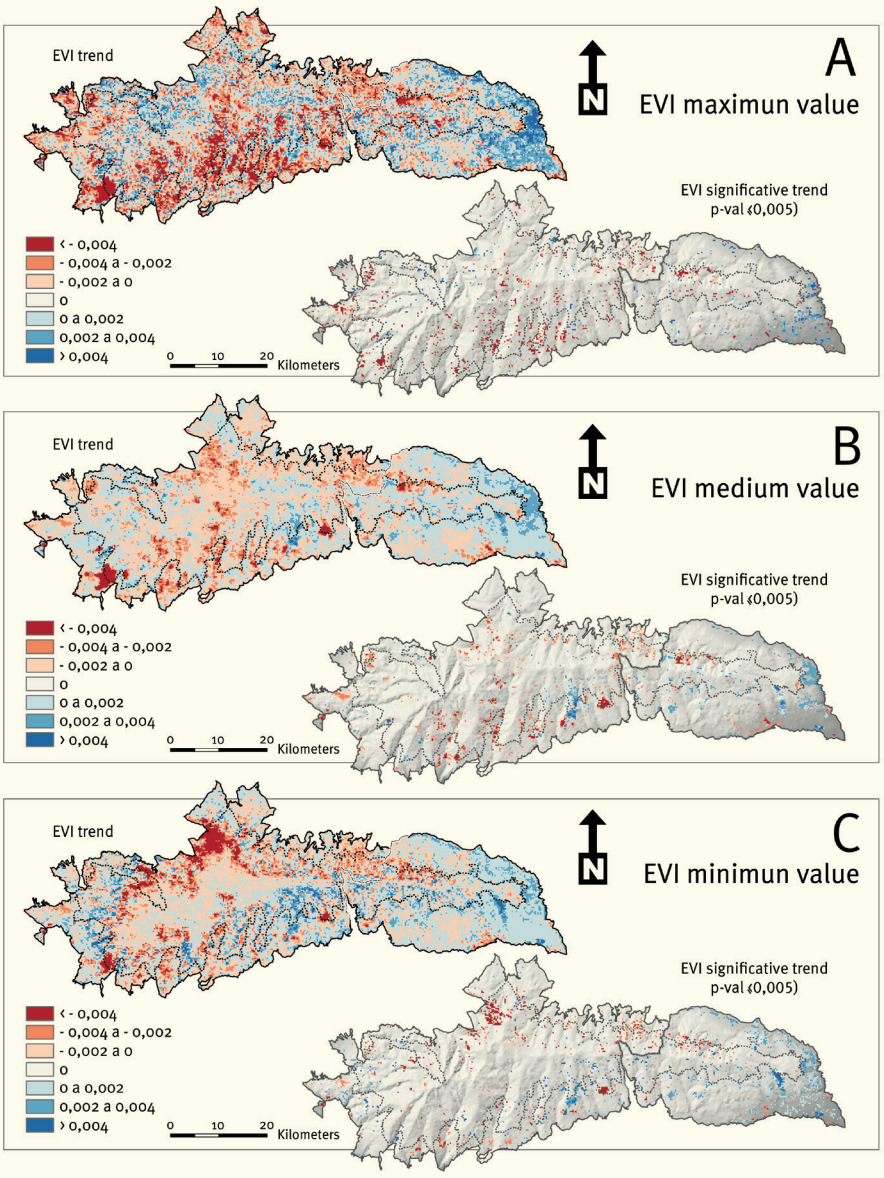


Seasonal dynamics and trend of EVI (Enhanced Vegetation Index) in the period 2001-2012. The left blue axis represents the mean seasonal dynamics of the EVI in the ecosystem. The red axis represents the average of the significant slopes found with the Mann-Kendall test (P<0.05).

Discussion and conclusions

Three of the eight ecosystmes analysed in Sierra Nevada followed heavily significant trends in carbon gains during the period 2001-2013 (Figure 1). The Pyrenean oak forests, the pine plantations and the Holm oak woodlands showed strongly negative trends in greenness at the beginning of spring, indicating a delay in the loss of vigour at the onset of the growth season [4]. In addition, the Pyrenean oak forests showed slightly positive trends at peak greenness in mid-autumn, indicating a delay in leaf senescence. The high- and middle-mountain shrublands showed similar trends towards a slight fall in productivity in spring and a modest rise in summer. The native pine forest was the ecosystem that presented the most stable photosynthetic activity during the period analysed. Finally, the annual EVI showed an east-west gradient. This divergence was related to two regional climate patterns that operate in this mountain range, the NAO exerting a greater effect on the western part of the Sierra Nevada (trend towards less productivity) and the WMO in the east (trend towards more productivity).

Figure 2



Spatial distribution of the trends of three indicators of the productivity estimators of ecosystem functioning derived from the EVI (Enhanced Vegetation Index) for the period 2001-2013. Trends in the a) annual maximum EVI, b) annual average EVI, and c) annual minimum EVI.

Relationships between snow and productivity of *Quercus pyrenaica*

Primary productivity depends on a multitude of biophysical factors. In mountain regions such as Sierra Nevada, the snow plays a determinant role. The quantity of water supplied by the snow can partly explain the functioning of nearby forest ecosystems at the tree line. A preliminary evaluation has been made for the relations between the snow and productivity in Pyrenean oak populations (*Quercus pyrenaica*) of Sierra Nevada. A coupling between primary production trends and duration of snow cover has been confirmed for the Pyrenean oak forests located in the western part of Sierra Nevada (Genil and Dúrcal river basins). In regions where the snow has a significant trend to melt early, productivity tends to increase in summer. This could explain why an early snowmelt provides water to oaks at the appropriate moment for their growth [5].