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Supplement of

A remote-sensing-based dataset to characterize the ecosystem functioning and functional diversity in the Biosphere Reserve of the Sierra Nevada (southeastern Spain)

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Supplement A. Identification of informative and biologically meaningful metrics: Ecosystem Functional Attributes

To define EFTs, we used three meaningful metrics or descriptors of the EVI seasonal dynamics (our surrogate for annual dynamics in primary production). Biologically, these three metrics can be interpreted as surrogates of the total amount and timing (seasonality and phenology) of primary production (Paruelo et al., 2001, Pettorelli et al., 2005, Alcaraz-Segura et al., 2006). Statistically, these three metrics are known to be highly correlated with the first two or three axes (and hence capture most of the variance) of a Principal Component Analysis (PCA) carried out on the NDVI or EVI annual dynamics in different regions (Townshend et al., 1985, Paruelo and Lauenroth 1998, Paruelo et al., 2001, Alcaraz-Segura et al., 2006, Alcaraz-Segura et al., 2009, Ivits et al., 2013). To know the statistical meaningfulness of these metrics in the Sierra Nevada Biosphere Reserve, we examined their correlation with the first axes of a PCA run on the EVI annual curve of the average year (i.e., 12 EVI values calculated as the inter-annual means of the 18 (one per year) maximum value composites for each month). The first two axes cumulated 96.5% of the variance (PC1 87.3%, PC2 9.2%). The eigenvectors showed that the weights along the months were similar along the first PCA axis (i.e., even weights throughout the year), while for the second axis they showed a contrast between winter and summer months (Table S1). This indicated that PC1 can be related to the total or average amount of EVI and that PC2 can be related to the intra-annual differences in EVI (Figure S1).

Table S1. Eigenvectors and cumulative variance explained by the first two axes of a principal component analysis (PCA) performed on the annual curve of EVI values for the average year in Sierra Nevada.

		Scores											
PCA axis	**%[a]**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1	87.3	0.334	0.328	0.333	0.318	0.293	0.246	0.236	0.239	0.242	0.251	0.287	0.325
2	96.5	0.329	0.365	0.326	0.109	-0.244	-0.454	-0.380	-0.301	-0.252	-0.154	-0.007	0.229

[a] *Cumulated variance*

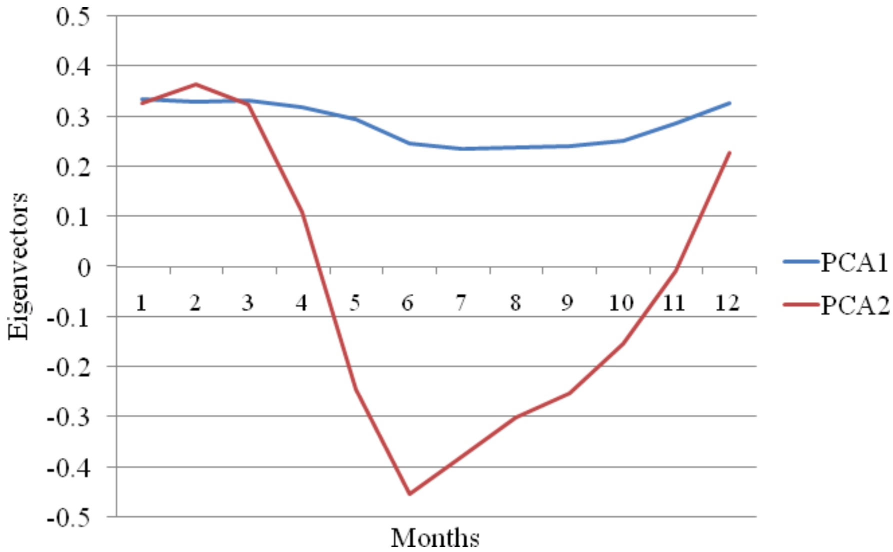

Figure S1. Eigenvectors of the first two components of a PCA performed on the annual curve of EVI values in Sierra Nevada (X-axis: months; Y-axis: eigenvector values). The first PCA axis accounted for 87% of variance and showed even weights throughout the year, while the second PCA axis accounted for 9% of the variance and showed a strong contrast between seasons.

In addition, we explored the correlation between the PCA axis and the EVI metrics (i.e., EFAs). The EVI metrics showed a high correlation with the PCA axes. PC1 accounted for most of the total variance in the seasonal dynamics of the EVI (87.3%) and was strongly correlated with the EVI annual mean (PC1 vs. EVI_Mean r = 0.94). PC2 accounted for 9.2% of the total variance (PC1 and PC2 cumulated 96.5% of total variance) and was related to seasonality and phenology metrics (as in Alcaraz-Segura et al., 2006, 2009) (PC2 vs. EVI_sSD r = -0.75; PC2 vs DMAX_Sine = 0.67; PC2-vs DMAX_Cosine = -0.61) (Table S2). To correlate DMAX with the PC axes and keep the continuous nature of the annual period and the relative distance between months (i.e. December is as close to January as July is to June, that is, the distance between December (12) and January (1) is one month, but not 11 months), we transformed months into polar coordinates (sine and cosine). The entire circumference of a year was divided into 12 portions and each month was equated to an angle (30º for January and 360º for December). DMAX months were therefore characterized by their sine and cosine values.

In summary, PC1 was very highly correlated to EVI_Mean and then can be interpreted as annual primary production. PC2 shows a high contrast in the eigenvector values between winter and summer and is highly correlated with EVI_sSD and with the Sine and Cosine components of DMAX, so it can be interpreted as a combination of seasonality (SD) and phenology (DMAX). Mathematically, it could be expressed as follows: PC2 = f(a*SD + b*DMAX_Sine + c*DMAX_Cosine + d + e) (Table S1 and S2), and the r-square of this multiple regression was 0.70.

Table S2. Correlation values between PCA axis 1 and 2 and Ecosystem Functional Attributes (EFA).

EFA	**PC1**	**PC2**
EVI_Mean	**0.94**	-0.01
EVI_sSD	-0.14	**-0.75**

DMAX_Sine	-0.10	**0.67**
DMAX_Cosine	0.017	**-0.61**

In addition, the EVI metrics were orthogonal, since the correlation between them was low so that each EVI metric contributed independently to explain the variance of the EVI time series (Table S3).

Table S3. Pearson correlation values between metrics.

	EVI_Mean	**EVI_sSD**
EVI_Mean	**1**	
EVI_sSD	-0.14	**1**
EVI_DMAX	0.10	-0.05

Supplement B. Sensitivity and uncertainty analysis on quartile boundaries among EFT classes

1. Assessment of the number of years needed to reach stability in quartiles to set boundaries among EFT classes

We determined the minimum number of years that were needed to reach stability in the quartile boundaries among EFT classes. For each quartile of EVI_Mean and EVI_sSD, we plotted the maximum inter-annual Coefficient of Variation (Y-axis) among the n consecutive years considered, with n ranging from n= 2 years to n=18 years against the number of years considered (X-axis) (i.e. the maximum value of the Coefficient of Variation among all possible combinations of two consecutive years, three consecutive years, four, five, etc. throughout the 2001-2018 period (Figure S2 a - f). The three EVI_Mean quartiles tend to stabilize around an inter-annual Coefficient of Variation of 5%, which required around 14 years of the study period. The three EVI_sSD quartiles tend to stabilize around an inter-annual Coefficient of Variation of 10%, which required around 17 years of the study period. Hence, the 18-year study period provided in this dataset would be enough to serve as a reference situation for this protected area. For example, if someone wants to use these limits for the 2001-2020 period, it would not be necessary to derive the quartiles boundaries again for the year 2020, since our 18-year study period is representative enough to extrapolate quartiles to the new year.

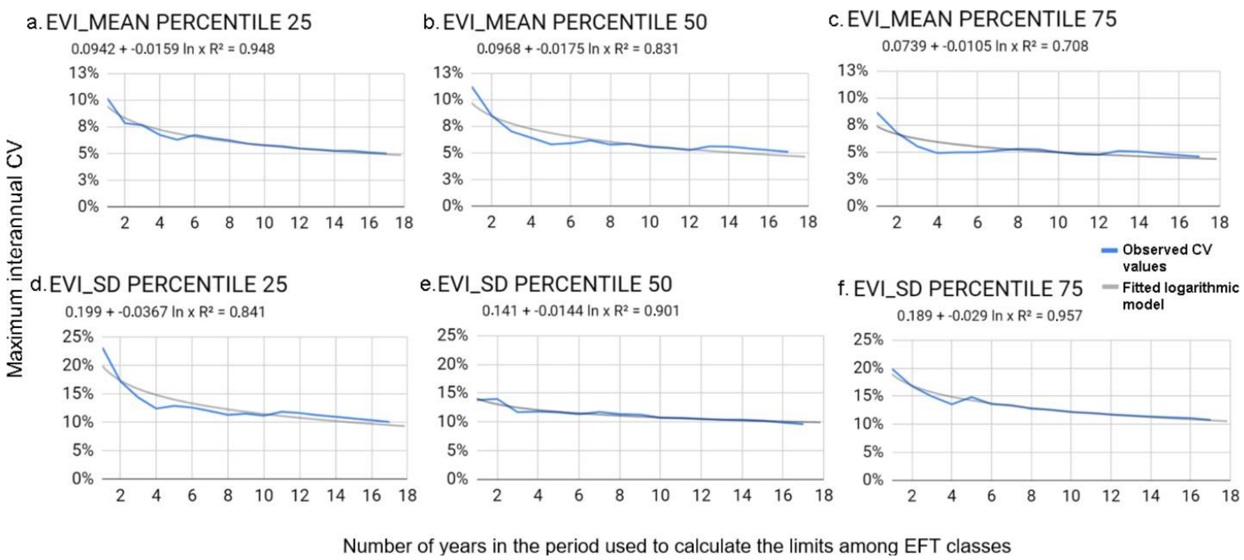

Figure S2. Stabilization of the inter-annual Coefficient of Variation (CV) of the limits (quartiles) among ecosystem functional type (EFT) classes as the number of years included in the study period increases. For each quartile, we plotted the maximum inter-annual CV (Y-axis) among the n consecutive years considered, with n ranging from n=2 to n=8 (X-axis). The quartiles of EVI_Mean (our surrogate for productivity) required at least 14 years to stabilize around 5% of CV. The quartiles of EVI_sSD (our surrogate for seasonality) required at least 17 years to stabilize around 10% of CV.

2. Assessment of inter-annual variability of quartile boundaries among EFT classes

To know how variable the quartiles were across years, we obtained the quartiles of each year, their inter-annual mean, their inter-annual standard deviation, and their inter-annual Coefficient of Variation (Table S4). The variability among years or Coefficient of Variation (CV) was around 5% for EVI_mean quartiles and lower than 11% for EVI_sSD quartiles, increasing in the upper quartiles compared to the lower quartiles (Table S4).

Table S4. Annual quartile boundaries (percentile P25, percentile P50, percentile P75) for EVI_mean and EVI_sSD and summary of the period (Inter-annual mean, Standard Deviation (SD) and Coefficient of Variation (CV)).

YEAR	EVI_mean P25	EVI_mean P50	EVI_mean P75	EVI_sSD P25	EVI_sSD P50	EVI_sSD P75
2001	0.133	0.187	0.245	0.030	0.044	0.063
2002	0.139	0.190	0.243	0.031	0.042	0.057
2003	0.130	0.184	0.242	0.031	0.046	0.068
2004	0.142	0.197	0.251	0.032	0.047	0.068

2005	0.123	0.168	0.222	0.023	0.039	0.056
2006	0.126	0.174	0.229	0.030	0.046	0.066
2007	0.142	0.184	0.232	0.028	0.038	0.051
2008	0.133	0.176	0.229	0.029	0.042	0.062
2009	0.133	0.180	0.235	0.032	0.048	0.070
2010	0.139	0.190	0.242	0.034	0.048	0.072
2011	0.149	0.200	0.258	0.032	0.045	0.069
2012	0.139	0.187	0.238	0.027	0.037	0.052
2013	0.142	0.197	0.258	0.032	0.044	0.063
2014	0.130	0.184	0.241	0.026	0.037	0.056
2015	0.139	0.194	0.245	0.030	0.042	0.060
2016	0.134	0.182	0.233	0.024	0.036	0.054
2017	0.142	0.187	0.238	0.030	0.039	0.057
2018	0.145	0.206	0.264	0.032	0.047	0.068
Inter-annual mean	0.137	0.187	0.241	0.030	0.043	0.062
Inter-annual SD	0.007	0.009	0.011	0.003	0.004	0.006
Inter-annual CV (%)	5.001	5.103	4.593	10.040	9.597	10.745

Supplement C. Effect of kernel size on EFT richness

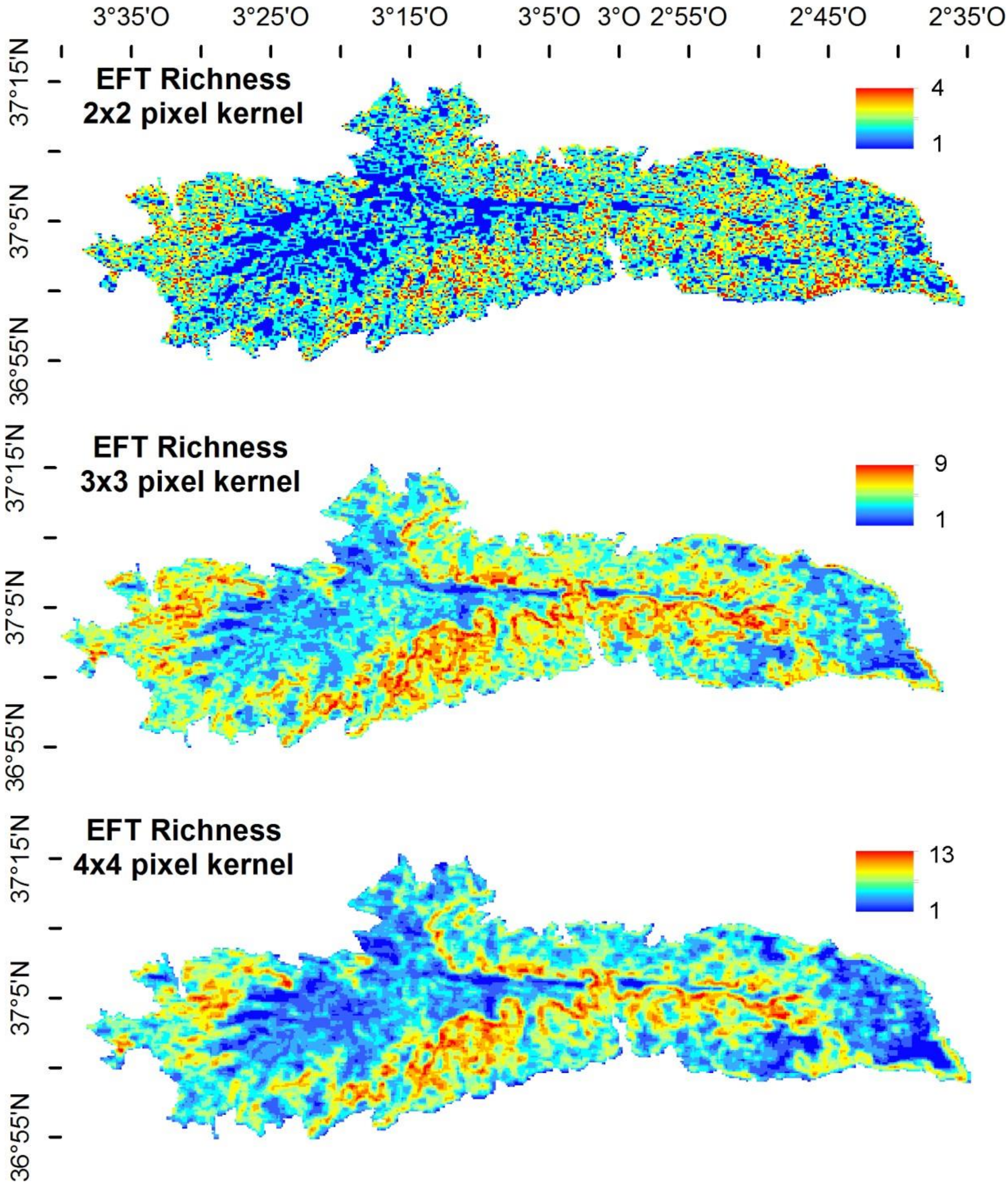

Figure S3. EFT Richness for 2x2, 3x3, and 4x4-pixel kernel sizes. A 4x4-pixel kernel was chosen sinceit offered the finest spatial resolution that did not saturate the number of EFT classes per kernel.