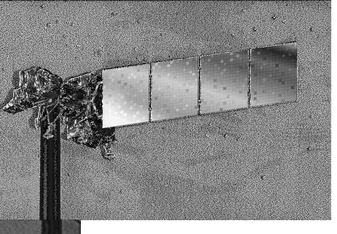

Adequacy of remote sensing to assess productivity-habitat quality associations in Mediterranean-type ecosystems

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Introduction

Ongoing global changes are affecting ecosystem productivity, being expected to affect productivity-biodiversity and productivity-habitat quality relationships.

Higher biodiversity leads to more productive ecosystems, and more productive environments support more biodiversity. At the population level, more productive ecosystems often provide a higher habitat quality in which species persist.

Mediterranean-type ecosystems are hotspots of biodiversity threatened by ongoing changes in land use and climate, and these changes likely affect ecosystem productivity and the inherent habitat quality.

Research question:

Are changes in climate affecting cork oak woodland productivity, and do these changes affect habitat quality for medium-sized mammals?

Study system

Cork oak woodlands in southern Portugal hold high biodiversity levels and provide economic income that supports livelihoods.

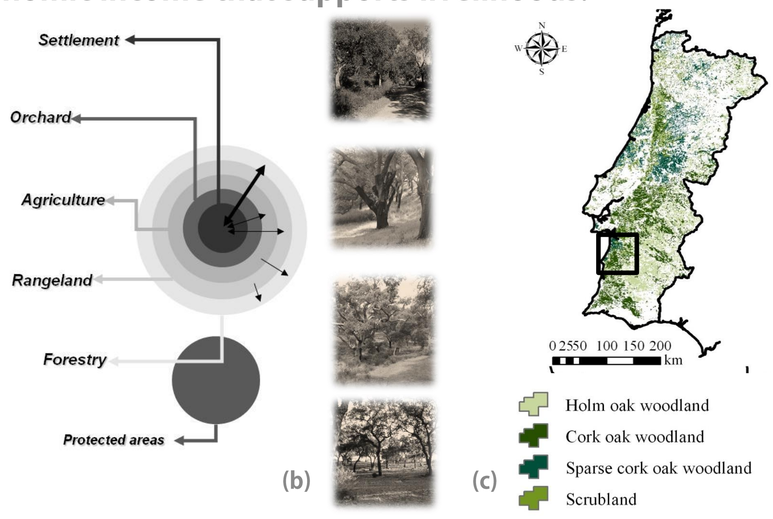


Figure 1. (a) Spatial configuration of land uses in Mediterranean Europe; (b) some land uses involve number of trees per area and presence-absence of shrubs; and (c) distribution of cork and holm woodland and shrubland.

Mediterranean vegetation has adapted to two key environmental stressors: water availability and nutrients.

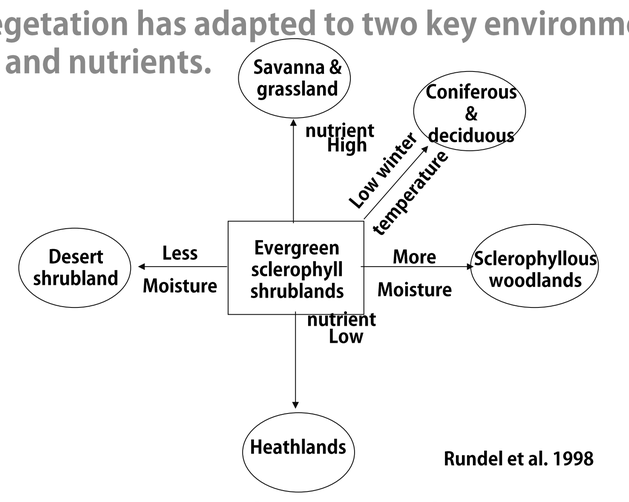
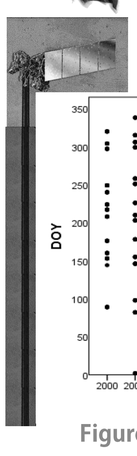


Figure 2. Mediterranean ecosystems along nutrient and water environmental axes.

A diverse community of mesocarnivores have adapted to take advantage of the resources provided by these oak woodlands.

Data



Landsat time series

Figure 3. Available Landsat time series.

Micro-meteorological station data

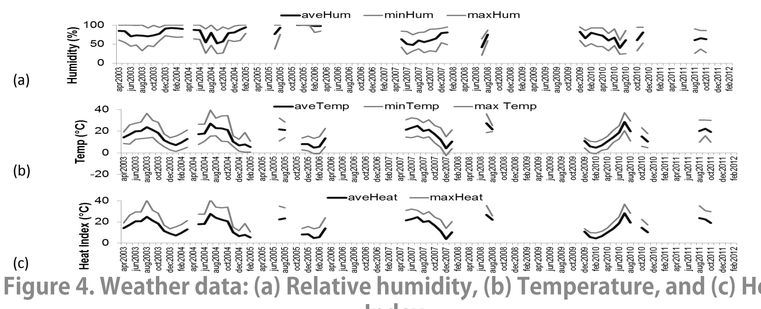


Figure 4. Weather data: (a) Relative humidity, (b) Temperature, and (c) Heat Index.

Radio-tracking data

Table 2. Radio-tracking locations for meso-carnivores.

	Species	Year	Ind.	Fixes
	*Genetta genetta*	1997-1999	5	368
	*Martes foina*	1999-2006	5+6	441 + 1590
	*Meles meles*	2000-2001	8	2458

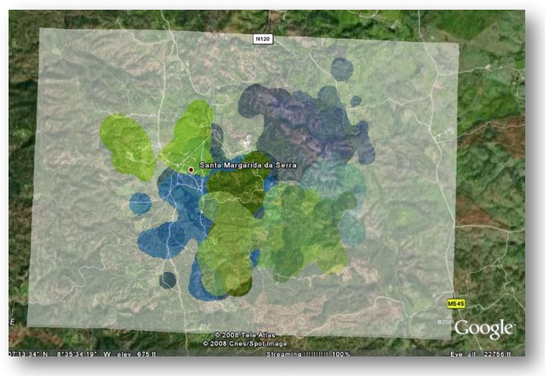


Figure 5. Stone marten home ranges in 05-06.

Results

(1) On average, EVI did not change while there was a significant decrease in max EVI and increase in min EVI (Fig. 6 and Table 3)

(2) EVI was strongly correlated with relative humidity and negatively correlated with temperature (Fig. 7)

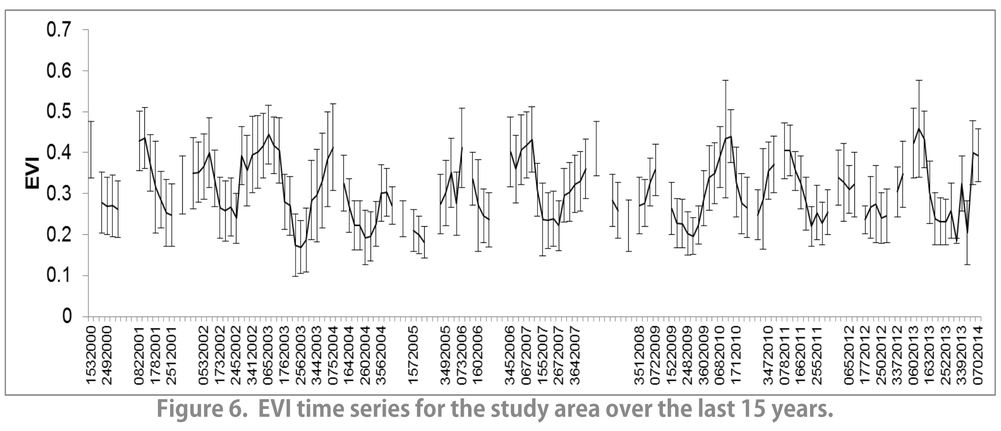


Figure 6. EVI time series for the study area over the last 15 years.

Table 3. Kendall trend test for the EVI time series in different land cover types in the study area.

	Kendall's tau					
	ave/date		max/date		min/date	
	Tau	*P-value*	Tau	*P-value*	Tau	*P-value*
DCoW	-0.16	0.686	-0.038	0.324	0.062	0.108
DCoWt	-0.037	0.338	-0.072	0.062	0.112	0.003
SCoW	-0.026	0.51	-0.11	0.005	0.067	0.088
SCoWt	-0.01	0.799	-0.008	0.828	0.03	0.432
G	-0.003	0.942	-0.02	0.596	0.075	0.052
All	-0.011	0.394	-0.049	0.0001	0.059	0.0001

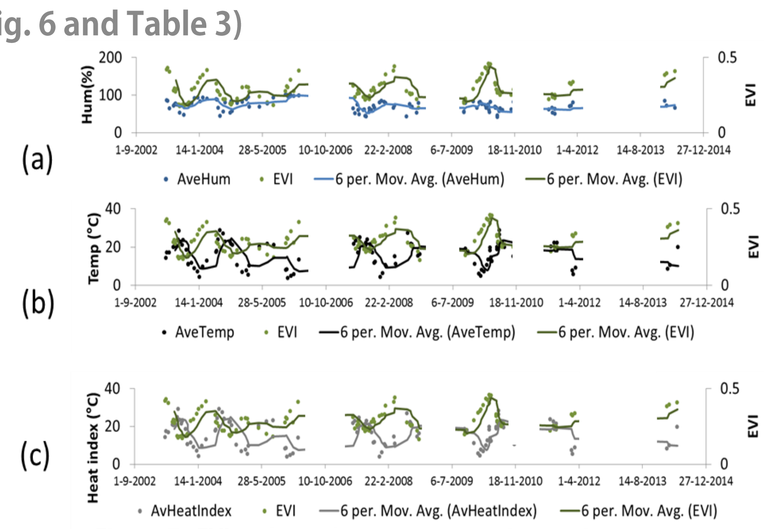


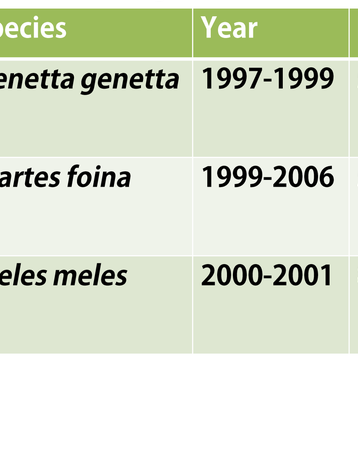
Figure 7. EVI and weather parameters time series.

(3) Stone marten and badger presence was positively associated with productivity (EVI and NDVI) while genet habitat model was not significant (Table 4)

Table 4. GLMM for the three mesocarnivore species using land cover types and vegetation indices.

	Variable	Stone marten	Genet	Badger
Type	Urban/rural area	-0.11	0.27	-0.53
	Eucalyptus plantation	na	15.76**(a)	-1.69*(a)
	Dense oak woodland w/ understorey	0.61**(a)	1.12	1.74**(a)
	Dense oak woodland w/out understorey	-0.37	0.46	0.12
	Sparse oak woodland w/ understorey	-0.77*	0.5	-0.12
	Sparse oak woodland w/out understorey	-0.12	0.29	0.74**(a)
	Orchard	0.07	0.85	1.03*(a)
	Grassland	1.11**(a)	0.35	-0.39*(a)
	Riparian vegetation	2.1**(a)	0.72	-0.2
	Agroforestry	na	0.14	na
	Broad leaf forest	na	0.74	na
	Transition woodland-shrubland	na	1.91	na
Structure	$Patch_{AE}$	-0.05	-0.14	-0.17**(a)
Function	Productivity+Stress	na	na	na
Function+Structure	TCC+Productivity+Stress	-0.12**	--	-0.12**(a)
AUC		0.66	0.62	0.72

* indicates significant variable, (a) represents confidence in the coefficient estimate, that is, when the confidence interval around the estimate does not cross zero. na - are variables not included in the candidate variable set; -- represents a variable that was not selected within the best models



(4) Stone marten habitat preferences before and after a drought period showed that the species still preferred oak woodlands over other land cover types.

Cork oak woodlands are still the land cover type with higher EVI despite its significant reduction from 1997-1998 to 2005-2006 (EVI_{97-98}=0.32, EVI_{05-06}=0.25).

Table 5. Stone marten habitat before and after a drought. (SCo - Sparse cork oak woodland, DCo - Dense cork oak woodland, RV - Riparian vegetation, DCo+ - Dense cork oak woodland with shrubs, SCo+ - Sparse cork oak woodland with shrubs, G - Grassland).

Time period	Variables	Rank order
1999	Land cover type	SCo>DCo>RV>DCo+>G>SCo+
	EVI	0.34>0.33>0.33>0.32>0.29>0.26
05-06	Land cover type	SCo>DCo>RV>DCo+>SCo+>G
	EVI	0.27>0.25>0.24>0.24>0.23>0.22

Conclusions

The results suggest that:

(1) Cork oak woodlands are responding to changes in relative humidity, likely because these species have modified leaves that have trichomes in the lower leaf layer. Trichomes can retain water and therefore justify the relation with relative humidity and the increase in minimum EVI despite the drought period.

(2) Mesocarnivores respond to the productivity of cork oak woodlands, more specifically to the stress levels of oak woodlands. Despite changes in productivity over the drought period, stone martens still select for cork oak woodlands. This is likely because cork oak woodlands maintain their capacity to provide resources despite the stress. This could be because oaks are well adapted to drought or may have a lag response to water stress.

(3) Cork oak woodlands productivity can be monitored using remote sensing time series and through this approach we can track the multi-year phenology. This study illustrates the capacity of remote sensing to monitor effects of drought across multiple trophic levels.

Acknowledgments

- Copernicus Institute for Sustainable Development at Utrecht University
- Matthias Baumann gratefully acknowledges funding through the European Commission (the European Commission (HERCULES, No. 603447) and the Volkswagen Foundation (BALTRAK, No. A112025).
- LTSER Montado platform (FCT/LTER/BIA-BEC/0048/2009)

Fulbright · Institute of International Education · Fundação Calouste Gulbenkian