

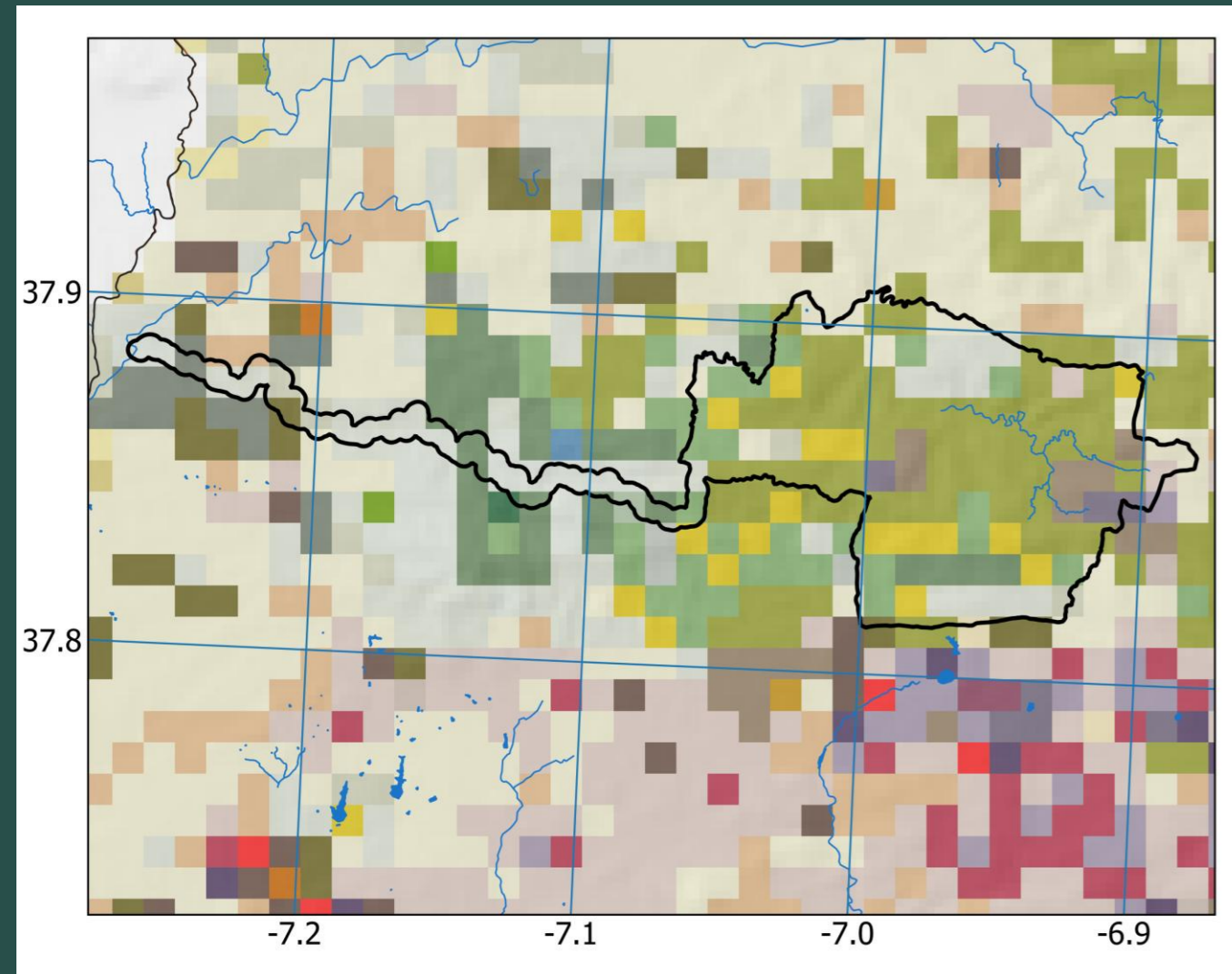
INTRODUCTION

The Land Condition Map (LCM) shows states and trends of ecological maturity in terms of energy flow through ecosystems:

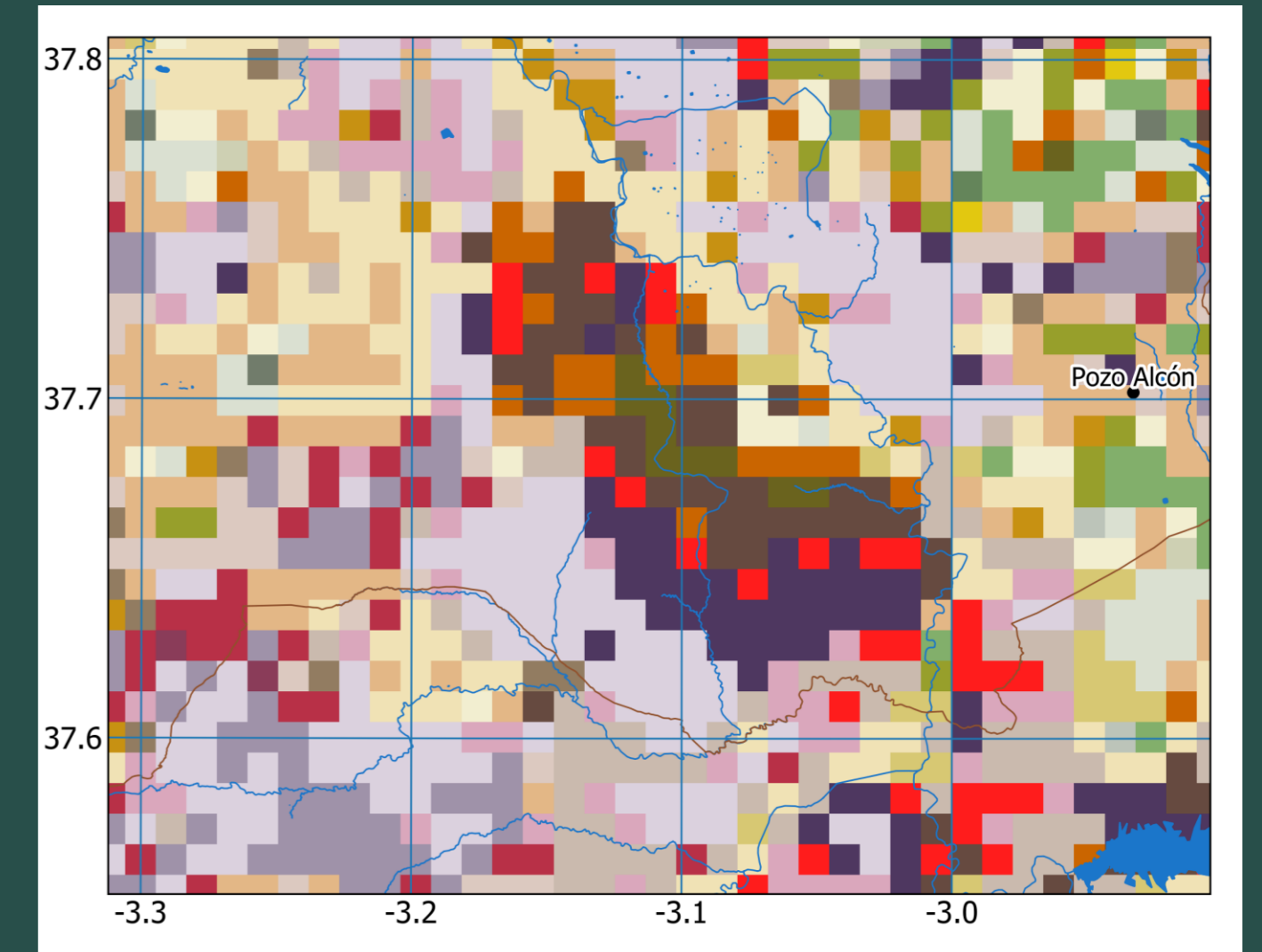
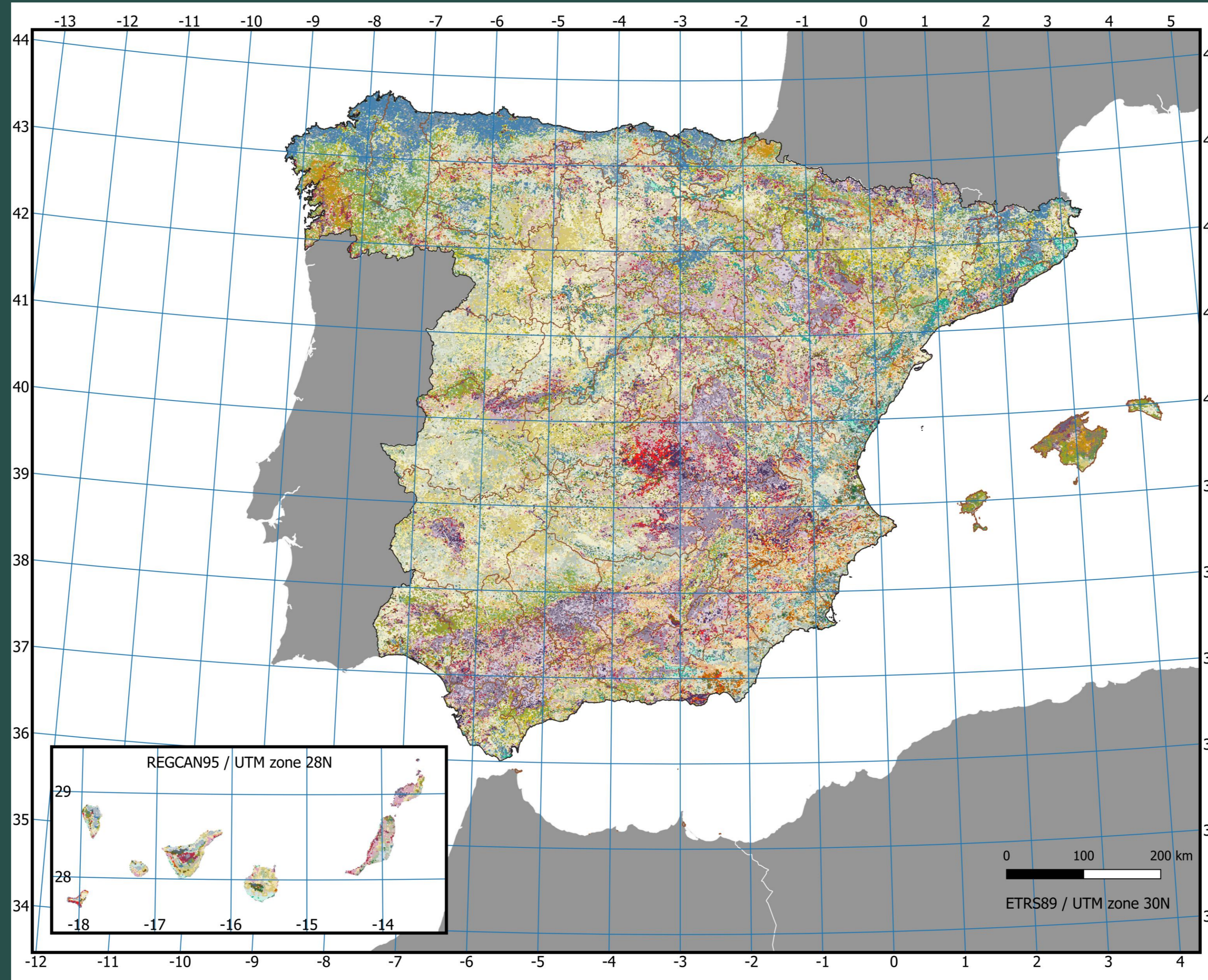
- The assumption for states is that mature ecosystems have a large biomass (B) and a low Net Primary Productivity (NPP), therefore their turnover rate (NPP/P) is low. As human exploitation proceeds, B decreases and NPP, which is the agricultural product, is maximized. Continuous harvesting raises the turnover. Exploitation beyond ecosystem resilience leads to degradation, where both B and NPP are low, and turnover is erratic¹. Ten maturity states are described this way that can be ordered according to a polarity between ecosystem self-organization and human (over)exploitation: *Overperforming anomaly*, *Reference performance*, *Mature*, *Sub-mature*, *Productive with high biomass*, *Productive with low biomass*, *Degraded*, *Very degraded*, *Baseline performance*, and *Underperforming anomaly*.
- Trends refer to biomass variations over the study period, explicitly separating effects of climate oscillations from ecosystem- or human-induced variations. *Fluctuating* trends are caused only by interannual oscillations of aridity. *Degrading* means a consistent decrease of biomass over time whatever the response to climate, and is therefore attributed to human intervention (e.g., overexploitation). An *Increasing* trend occurs where biomass accumulates over time irrespective of climate (e.g., an ongoing secondary ecological succession). Finally, if no change is detected the location is declared as *Static*.

The LCM is determined using the geomatic method 2dRUE, which is based on archived time series of a vegetation index (e.g., the Normalized Difference Vegetation Index) and corresponding climate surfaces^{2,3}. Spatial and temporal resolutions are of 1 km and 1 month respectively, and the study period typically extends over 10 years. States are computed applying the Rain Use Efficiency approach (RUE, the ratio of NPP to precipitation), and proxies to biomass and NPP are determined after implementing RUE at two temporal scales, long- and short-term respectively. Further detrending for aridity is performed to obtain comparable estimates across large study areas. On their side, trends are determined for every location by stepwise regression of annual biomass against aridity and year number. These regressions are done in standard form to enable comparing the relative strengths of climate and ecosystem sources of variation⁴.

The inception objective of the LCM was to report land degradation to the United Nations Convention to Combat Desertification, as done with its 2000 – 2010 release by the Spanish Government^{5,6}. It is now being adapted to report on the indicator 15.3.1 'Proportion of land that is degraded over the total land area' of Sustainable Development Goal 15.3 to achieve land degradation neutrality by 2030. However, the fact that a full scale of ecological maturity is determined makes the product suitable for diagnoses on which to base land policies related to desertification and land use⁷, ecological restoration and conservation of natural habitats. As an example, it was used recently to determine whether the Natura 2000 network is meeting its conservation objectives⁸.



Example 1



Example 2

Example 1. Special Area of Conservation of Sierra Pelada and Rivera del Aserrador (Huelva). This landscape, subject to intensive human use, exhibits suboptimal levels of native cork oak (*Quercus suber*) and holm oak (*Quercus ilex*) vegetation. The original forest cover was cleared using heavy machinery to prepare the land for afforestation with pine and eucalyptus species. This intervention accounts for the predominance of the 'Productive with Low Biomass' state. Google Earth imagery reveals progressive vegetation development in these newly established forest stands, explaining the prevalence of areas classified under an 'Increasing' trend. The area is home to one of the most important colonies of black vultures (*Aegypius monachus*) in Europe.

Example 2. Forest fire of 2015 in the counties of Quesada and Huesa (Jaén). Google Earth imagery reveals the extent of the damage. Thousands of hectares were affected. The loss of vegetation cover is evidenced by changes between the two time points and is represented in the LCM as a persistent dark area, corresponding to a mosaic of heterogeneous degraded states dominated by a prevailing trend of degradation.

	UNDER-PERFORMING ANOMALY	BASILINE PERFORMANCE	VERY DEGRADED	DEGRADED	PRODUCTIVE WITH LOW BIOMASS	PRODUCTIVE WITH HIGH BIOMASS	SUBMATURE	MATURE	REFERENCE PERFORMANCE	OVER-PERFORMING ANOMALY	TOTAL
<i>Degrading</i>	1.6%	0.6%	1.0%	1.0%	0.8%	0.2%	0.9%	0.3%	0.1%	0.0%	6.4%
<i>Fluctuating</i>	3.0%	1.4%	4.0%	3.3%	5.9%	1.7%	4.0%	0.9%	0.5%	0.0%	24.8%
<i>Increasing</i>	0.5%	0.3%	1.3%	1.6%	2.9%	1.6%	4.6%	2.3%	4.0%	0.5%	19.6%
<i>Static</i>	5.5%	2.5%	7.4%	5.0%	10.7%	3.4%	8.5%	3.3%	2.7%	0.3%	49.2%
Total	10.6%	4.8%	13.7%	10.9%	20.2%	7.0%	18.0%	6.7%	7.3%	.9%	100.0%

HIGHLIGHTS OF THE 2011 – 2019 RELEASE

In general, approximately 24.6% of mainland is in degraded or very degraded states, and in many of these cases the processes that caused degradation in the first place remain active. The land uses most significantly associated with this pattern are rainfed crops, vineyards and olive orchards. Interestingly, 22% of irrigated crops appear as degraded or very degraded, and 8.4% of these lands are actively degrading over time. At the opposite end, 32% of land in mainland Spain is in a favourable land condition state. Associated land uses are agroforestry systems, broad-leaved and coniferous forests and other types of natural and seminatural vegetation. Most of these lands are improving over time due to biomass accumulation following land abandonment. Such striking bipolarity between bad states that worsen and good states that improve is interpreted as a result of intensification of agroecosystems coupled to abandonment of marginal lands. The proportion of land undergoing active degradation in the study period at least triples that of the previous decade (2000 – 2010).

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