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Why grasslands?

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Where do we find permanent grasslands? Approaches and shortcomings of existing European-scale maps

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Abstract

Knowing the area and distribution of permanent grassland (PG) is crucial for agricultural and environmental policy-making, quantifying ecosystem service delivery, or modelling effects of global change. The Copernicus High Resolution Layer Grassland (HRL) and the Ecosystem Types of Europe map (ETE) are the two most detailed European-scale maps of permanent grasslands available today. We compared the regional PG area predicted by the two mapping approaches and found considerable differences between the two, with direction and extent of these differences varying greatly between European regions. We related the ratio between the PG area predicted by ETE and HRL to the dominance of other land use classes in each region. ETE appeared to be more likely to classify heterogeneous agricultural areas as well as sparsely vegetated areas as PG than HRL, while the opposite was true for wetlands and urban green areas. However, these relationships explained only a small proportion of the differences between ETE and HRL. PG areas mapped by either approach were found to be mostly larger, but in some regions smaller, than PG area reported in agricultural statistics. Applications of these datasets need to take these limitations into account.

Keywords: permanent grassland, Europe, mapping, land use, remote sensing, inventories

Introduction

Knowing the area and distribution of different types of permanent grassland (PG) is crucial for agricultural and environmental policy-making, quantifying ecosystem service delivery, or modelling the effects of global change. The Copernicus High Resolution Layer Grassland (HRL) and the Ecosystem Types of Europe map (ETE) are the two most detailed European-scale maps of PG available today. The ETE maps habitats following the European Nature Information System (EUNIS) classification, and distinguishes seven PG habitat classes. It has a 100-m resolution and is based on the Corine Land Cover 2012 map (CLC), with crosswalks informed by auxiliary datasets. The Copernicus High Resolution Layer Grassland 2018 maps PG at a 10-m resolution, based on time series data of the Sentinel-1 and Sentinel-2 satellites.

The definition of PG within both ETE and HRL includes agriculturally managed and unmanaged PG, but excludes areas with extended periods of inundation ('wetlands'), with >10% woody plant cover ('heathland') or vegetation cover <30% ('sparse vegetation'). These habitats, however, often occur in mosaics with grasslands, and may be difficult to distinguish from these. The same is true for complex mosaics of agricultural land use that include PG together with arable land and other land uses. In the CLC, which uses a minimum mapping unit of 25 ha, the latter are captured in three classes of 'heterogeneous agricultural areas'. As the ETE is based on the CLC, we expected its PG mapping to be less accurate in these areas than that of the HRL. Lastly, urban grasslands are included as PG in the HRL, but not in the ETE, all leading to potential differences between the two resulting PG maps.

Our aim was to assess the differences between ETE and HRL mapping of PG. We firstly tested if these are related to the importance of 'heathland', 'wetlands', 'sparsely vegetated areas', 'urban green areas' and 'heterogeneous agricultural areas' in the mapped area. Secondly, we mapped the spatial distribution of the observed differences, with statistical data on agriculturally used PG as a third point of comparison.

Materials and methods

For our analyses, we used 100-m resolution raster of ETE (EEA, 2019), HRL (EEA, 2020b) and CLC 2012 (EEA, 2020a) over 33 European countries (Fig. 1a). While a pixel-by-pixel comparison would permit more detailed assessments, it risks compounding errors due to positional accuracy issues. Accordingly, we aggregated the raster data to quantify the PG area over statistical regions ('ETE-PG' and 'HRL-PG') and calculated their quotient ('ETE/HRL ratio'). We tested the relationship between that ratio and the relative area of the following CLC land cover classes: 'urban green areas' (CLC codes 112, 124, 141, 142), 'heathland' (322, 323, 324), 'wetlands' (411, 412, 421), 'sparse vegetation' (333) and 'heterogeneous agricultural areas' (241, 242, 243). We obtained the relative area of each class by dividing its area by the mean value of ETE-PG and HRL-PG per NUTS-3 region. We then fitted a linear model predicting the ETE/HRL ratio as a response to the relative areas of these five classes. The variance inflation factor of the five variables was 1.03–1.89, indicating only limited multicollinearity. We selected the minimum adequate model based on the model AICc and tested the significance of each variable when it was fitted after all other explanatory variables. In a second step, we used data aggregated at the level of NUTS-2 regions to map the ETE/HRL ratio. In addition, we related ETE-PG and HRL-PG to the PG area data from the Eurostat farm structure dataset of 2016 (Eurostat-PG; Eurostat, 2023).

Results and discussion

The most parsimonious model explaining the ETE/HRL ratio at NUTS-3 level included all explanatory variables except 'heathland/scrub'. 'Heterogeneous agricultural areas' (regression coefficient β=0.063, p=0.02) and 'sparse vegetation' (β=0.143, p=0.02) increased the ETE/HRL ratio, while 'wetlands' (β=-0.258, p<0.001) and 'urban green areas' decreased it (β=-0.022, p<0.001). However, with an adjusted R^2 of 0.036, the model only explained a small proportion of the variance of ETE/HRL ratios at NUTS-3 level.

At NUTS-2 level, the ETE/HRL ratio ranged from 0 to 5.24 (mean=1.14, SD=0.55, n=285). Averaged over all NUTS-2 regions, HRL thus underestimated PG area compared to ETE, albeit with substantial geographical variation (Fig. 1a). In most NUTS-2 regions, the PG area reported in Eurostat was smaller than the area of either ETE-PG or HRL-PG (Fig. 1b, 1c). This can be explained by the scope of the Eurostat dataset, which only encompasses PG on farms above a certain size threshold. However, in 38 and 47 out of 278 NUTS-2 regions, the PG area reported in Eurostat was larger than that mapped by ETE and HRL, respectively. Some of this discrepancy may be due to certain countries using wider definitions of PG in their agricultural statistics than the two mapping approaches, e.g. by including areas with >10% shrub or tree cover, such as in the dehesa and montado areas of Spain and Portugal, or inundated areas such as peat bogs, as in the upland areas of the British Isles. By contrast, ETE and HRL definitions of PG are very similar, except for the inclusion or exclusion of urban green areas. Nevertheless, the two mapping approaches appear to treat wetlands, sparsely vegetated areas and heterogenous agricultural areas differently, even after effects of urban green areas are accounted for. Heterogenous agricultural and sparsely vegetated areas appear to be more likely to be classified as PG by ETE than HRL, while the opposite is true for wetlands. The low values of the regression coefficients and the adjusted R^2 indicate, however, that this is only a minor contributing factor to the observed differences between ETE and HRL.

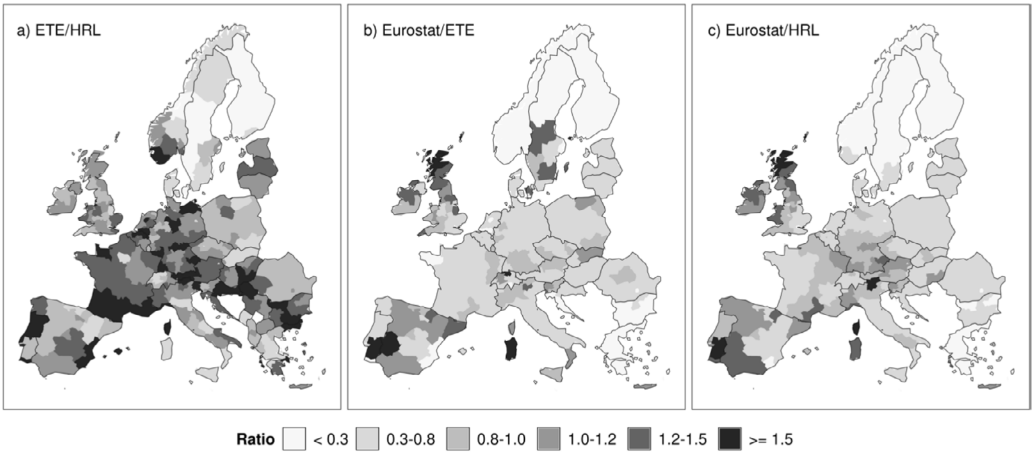

Figure 1. Pairwise ratios between the permanent grassland area per NUTS-2 region, according to the Ecosystem Types of Europe Map (ETE), the Copernicus High-resolution Grassland Layer (HRL) and the Eurostat agricultural crop area statistics (Eurostat).

As ETE and HRL have different reference periods (2012 and 2018, respectively), land use changes may have contributed to the differences. However, the ETE/HRL ratio was not correlated with the relative change of PG area between 2010 and 2016 for the 262 out of 285 NUTS-2 regions where the relevant Eurostat data were available (r=0.049, p=0.43).

Conclusion

The two most detailed pan-European maps of PG differ considerably in the regional PG areas they predict. The direction and extent of these differences varies between regions and could only partly be related to the presence of land cover classes that might affect prediction accuracy of the two mapping approaches. Ongoing progress in remote sensing technology and application is likely to lead to increasing accuracy and consistency in ongoing EU mapping programmes. In the meantime, applications based on the spatial distribution of PG across Europe need to take into account the limitations of the currently available datasets.

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