Data mining on land-cover survey datasets to explore grassland conversion in France

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Introduction

Nowadays, 43% of the area of Europe and 36% of the world total area are dominated by agricultural land-use including both cropland (302.23 million hectares in Europe) and grassland (179.42 million hectares in Europe). Permanent grassland has various ecosystem functions and values. Extensively cultivated grassland belongs to the most species-rich land-use type in Europe (Nitsch et al. 2012). The conversion of grassland to cropland results in the decline of ecological functions regarding the quality of water and soil, biodiversity and climate protection (Nitsch et al. 2012). With the benefit of the increasingly data available on land-cover and the improvement of the ability to detect changes in grassland cover, several recent research investigate the accelerated conversion of grassland to cropland from regional to national scale (Nitsch et al. 2012; Weeks et al. 2013; Wright and Wimberly 2013). Our objective was to assess the conversion of grassland to cropland and further explore the crop sequence patterns which followed the conversion in France. Mining the historical (1992-2003) national land-cover survey datasets allow us to represent the transitions between grassland and other land-cover involving 8.5 million hectares were the most remarkable land-cover changes from 1992 to 2003 in France (Agreste, 2004).

Materials and Methods

We used 555,382 sampling points corpus of land-cover which was derived from Teruti databases. Teruti is an annual land-cover survey conducted by the French Ministry of Agriculture. The interest of using this data source is detailed nomenclatures (81 types of land-cover) used in the survey among which 41 types of crops were distinguished.

For assessing the conversions of grassland to cropland, we first grouped the 81 initial land-cover types to 8 more general categories: urban (U), forest (F), water bodies (Wa), rocky areas (St), grassland (G), cropland (C), undefined areas (Un) and other semi-natural areas (OS). The category 'grassland' included the permanent grassland, grass orchard, Alpine meadows and herbaceous vegetation area. Next, we counted the occurrence of 2-year land-use successions (LUS) using sliding windows with the size of 2-years in the corpus for each agricultural district (430 ADs in France). It means that during 12 years, 11 overlapping 2-year LUS can be observed. We then calculated the net change in grassland cover as the absolute change from G to C (the occurrence rate of 2-year LUS 'G-C') minus the absolute change from C to G (the occurrence rate of 2-year LUS 'C-G'). For further characterizing the transitions between grassland and cropland, we applied Hierarchical clustering analysis (HCA) of 430 ADs in French mainland according to the net change in grassland and the mean grassland proportion (the average value of 12 yearly grassland proportion of the total UAA) of the total utilized agricultural area (UAA). In order to explore the crop sequence patterns following the conversion, we first removed 18 ADs which had no conversion occurred from the corpus. We then retained all crops and grassland in individual category and grouped other land-cover: perennial natural surface (F, Wa and St), urban (including kitchen garden), Un and OS. Thirdly, we counted the occurrence of 4-year LUS using sliding windows with the size of 4-years within each AD. Next, we filtered all 4-year LUS in form of 'G-C-C-C' (means 3-year crop sequences followed the conversion of grassland to cropland) from 4-year LUS and retained them for clustering the 412 ADs using Principal Component methods prior to HCA. All clustering analysis was based on Euclidean distance and carried out with using R software packages 'FactoMineR' and 'clValid'. The results of clustering analysis were mapped with the aid of ArcMap10.

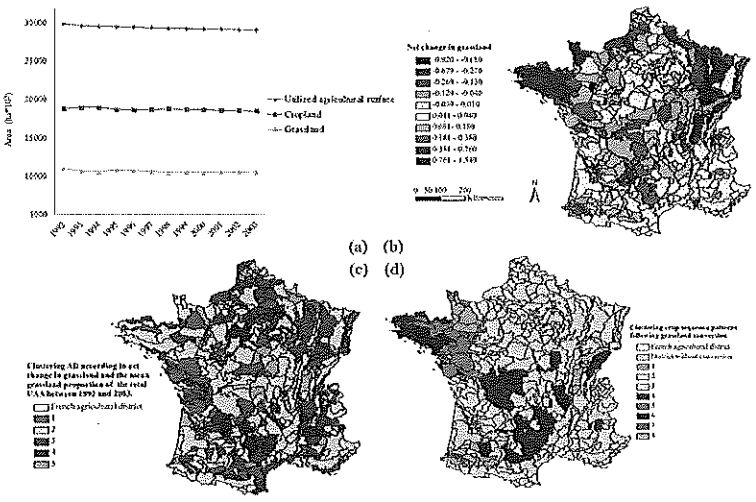

Fig. 1. Agricultural land-use change in French mainland between 1992 and 2003. (a) The evolution of the area of agricultural land-use. (b) Map of the net change in grassland. (c) Map of the clustering result of the 430 ADs based on the net change in grassland and the mean grassland proportion of the total UAA. (d) Mapping the crop sequence patterns following the grassland conversion to cropland.

Results and Discussion

The area of grassland decreased 350, 000 hectares which was converted to cropland from 1992 to 2003 (Fig. 1a). The change in grassland revealed the contrast across the entire territory (Fig. 1b). The net decline of grassland was mostly concentrated in north-eastern and Normandy. The conversion of grassland to cropland was lower than annual cropping to grassland change occurred in several ADs in Brittany and Massif central. The grassland conversion to cropland took

place in both livestock and mixed crops-livestock zone (clusters 4 and 2, respectively in Fig. 1c). We found that successive maize-based crop sequences (clusters 3, 5, 8 in Fig. 1d), temporary pasture and cereal-based crop sequences (clusters 4, 6 in Fig. 1d) and wheat/barley-based crop sequences (cluster 2 in Fig. 1d) turned out to be the dominant crop sequences after the conversion.

Conclusion

Monitoring the conversion from ecologically valuable grassland to cropland is of high importance for supporting a more targeted land use and agricultural policy making. Our results confirm that grassland conversion was most prominent on traditional livestock area for milk production where the management was continuing to be more intensive during the period of 1992-2003. The approach presented here provides us a tool for assessing agricultural land-use change using increasingly available time series data on land-over. We are pleased to collaborate with other agriculturalists to compare the trends on this matter.

References

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