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Grassland in Wallonia: expected location based on key ecosystem services

Ninane M., Hautier L., Planchon V., Burny P., Campion M., Goffart J.P. and Stilmant D.
Walloon agricultural Research Centre, Agriculture and Natural environment, 9, rue de Liroux, 5030 Gembloux, Belgium

Abstract

In Wallonia, grassland covers about 48% of the utilised agricultural area. This proportion is around 20% at the European scale. One challenge is to allow these agroecosystems to produce enough food but also to supply regulation and cultural services to improve human well-being. As ecosystem services depend on the location of the ecosystem in the landscape, we mapped, at the Wallonia scale, areas where grasslands are the best choice as agricultural land use in regard to soil and environmental constraints, in particular to limit erosion risk. To this end, we selected three criteria. The first one is the erosion issue due to tillage practices. The second one focuses on soil quality constraints limiting tillage ability. The last one is based on environmental priorities for biodiversity conservation. These surfaces and their locations, defined through the development of a GIS model, are compared to current agricultural use to define potential improvement. The results underline that the actual proportion of grassland would allow preserving the ecosystem services targeted by this study. Nevertheless, the location of 20% of these grasslands should be adapted to optimise regulation services; this was especially true in agricultural areas specialised in crop production.

Keywords: ecosystem, erosion, soil quality, biodiversity conservation, mandatory grasslands

Introduction

One of the main agricultural challenges is to maintain and/or improve the capacity of agro-ecosystems to deliver ecosystem services (ES), from production; including food, feed and biomass production; to regulation, support or cultural services. Nevertheless, some key ES such as erosion regulation, pollination support or cultural services, rely on the location of agro-ecosystems in the landscape (Villamagna *et al.*, 2013). Therefore, the use of a spatialized approach is necessary to objectify the ES potentially delivered by an agro-ecosystem. Among the different agro-ecosystems, grasslands play a key role in terms of fodder production, carbon sequestration, erosion and water leaching regulation, pollination support and cultural services. The key role played by grassland in the limitation of soil erosion is related to permanent soil cover with living vegetation. This induces a reduction of the volume and speed of water running off. In order to mobilize regulation ES delivered by grasslands in terms of nutrients or pesticides leaching risk reduction, implementation of this agroecosystem as buffer zone all along streams and in alluvial area is promoted. Such buffers lead to a reduction of leaching of 30 to 80% when well located. Grasslands have also the ability to value soils unsuitable for crop production, such as high rocky content or superficial soil, to support animal production without competition with man for the natural resources. In this context, based on these constraints and ES optimization, this research aims to quantify the surface of 'mandatory grasslands' (MG) in the Walloon area and to compare it with the current grassland surface and location in the regional utilised agricultural area (UAA).

Material and methods

Walloon Region, the southern part of Belgium, covers 16,903 km². Agriculture valorizes 45% of this surface, currently 52% as crop and 48% as grassland productions. In order to model MG areas two levels of constraints were integrated: (1) areas in which grasslands are necessary to limit soil erosion within an acceptable level and (2a) soils with a limited depth and/or a high rocky rate, and (2b) soils of high ecological value and/or alluvial soils – river banks area.

1. Mandatory grasslands to limit soil erosion risks

Soil losses risks were modelled through the universal equation of Wischmeier and Smith (1978): $E = R * K * LS * C * P$ [Equation 1], where: E is the long term, annual soil losses [$10^3 \text{ kg ha}^{-1} \text{ year}^{-1}$]; R is the rain erosivity [$\text{MJ mm ha}^{-1} \text{ h}^{-1} \text{ an}^{-1}$]; K is the soil sensitivity to rain erosivity [$10^3 \text{ kg ha}^{-1} \text{ mm}^{-1} \text{ MJ}^{-1}$]; LS is the topographic factor taking into account slope length and intensity (≥ 0 , without dimension); C is the cropping factor ([0,1], without dimension); P is a factor reflecting the effect of measures aiming to limit erosion ([0,1], without dimension). In this model, the possible hydric inter-connectivity existing between the parcels is not taken into account. Potential erosion ($R * K * LS$) was calculated from equation 1, simulating an absence of plant cover ($C=1$) (GISER, 2014). For a given parcel, the suitable cropping factor (sC) was defined based on the hypothesis that erosion must be lower than an acceptable level. This factor is positively linked to the soil 'reserve', thus positively linked to soil depth and negatively connected to stone content (Maugnard *et al.*, 2013). On this basis a shape file was generated. The ratio of acceptable erosion on potential erosion gave a raster of sC factor connected to 100 m^2 pixels. This raster was superposed to the shapefile of agricultural parcels from Wallonia to obtain the average sC value of each parcel. As sC directly depends on land use (Maugnard *et al.*, 2013), it was possible to determine, in order to reach these sC values, the parcels that must be covered by permanent grasslands ($sC < 0.10$) or with grassland for two years ($sC < 0.23$) or one years ($sC < 0.37$) out of three, on average. We defined that parcels that must be covered for a minimum of two years out of three; grasslands that must be permanent grasslands ($sC < 0.23$).

2. Mandatory grasslands due to soil cultivation limitation

Three parameters, extracted from numeric soil map of Wallonia, were taken into account to quantify soil cultivation limitation: stone content (three classes: 5-15%; 15-50%; >50%), soil depth (three classes: <20 cm; 20-40 cm; ≥ 40 cm) and soil series drainage class. Some of these parameters being mobilized to evaluate erosion risks, there is an overlap between these two constraints. Soils characterized by a poor drainage (gley soils) are MG. Crossing stone content and soil depth led to nine combinations, ranked, following the consultation of experts, on the basis of their ability to support crops. Soils with more than 50% of stone or with a depth lower than 20 cm are also MG. Conversely, soils with a stone content lower than 15% and deeper than 20 cm could be used for any crop. For soils with a stone content ranging from 15 to 50%, grassland cover is recommended whether soil depth is lower than 40 cm. When soils are deeper than 40 cm, with a stone content ranging from 15 to 50%, we considered that the current soil occupation took into account the local constraints.

3. Mandatory grasslands in area of high biological value

Alluvial soils and soils with huge carbon content (peat soil) are classified as MG. 12 m-width buffers of MG are also delimited all along Walloon's rivers network, and was determined from the map of hydrological network in Wallonia.

4. Integration of these levels of constraints and comparison to the current situation

Soil and biological constraints were superposed to the shapefile of agricultural parcels from Wallonia to calculate the proportion of each parcel that is under constraint. On this basis, three options were developed. The first one fixed that a parcel must be covered by grassland as soon as 25% of its surface is under constraint. For the second and the third options this limit was set to 50 and 75%, respectively. These three options were superposed to the surfaces of MG aiming to limit soil erosion risks ($sC < 0.23$) in order to characterize three final scenarios. These results were compared to the current permanent grassland coverage. These approaches were performed with ArcGIS® software (version 10.3).

Results and disc

While the proportion MG decreases from 7 surface of MG aiming to 1). The proportion o from 47 to 71% as th identify it as MG de Wallonia. Whatever to identify this parce proportion of discrej while considering n: occurrences: the hig -0.561*% Grassland surface discrepancy : These two parameter location in order to

Conclusions

Considering that pa value would be man absolute value, near order to maximize t in the UAA allow ecological constrain

Table 1. Evolution of the s currently cultivated with c

Soil and ecological constrain
Erosion risk limitation
Total
Only due to soil and ecologic
Cumululating the different cor
Surface of MG currently cult

¹ MG = mandatory grassland.

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