Prediction of grassland values by phytosociological or agronomical approach

Mesbahi G.[1,2], Bayeur C.[2] and Plantureux S.[1]
[1]*UMR 1121, Laboratoire Agronomie et Environnement (LAE) Nancy Colmar, Université de Lorraine-INRA, 2 avenue de la forêt de Haye, 54518 Vandœuvre-lès-Nancy, France;* [2]*Parc Naturel des Vosges du Nord, BP 24, 67290 La Petite Pierre, France*

Abstract

At the European scale, grassland classifications and policies are mainly based on a phytosociological approach. However, agronomists use other classifications, such as agronomical typologies, indicators, models, measurements of forage yield or quality. Grasslands in the Vosges Mountains (north-eastern France, 170 - 1,424 m a.s.l., 7,000 + km^2) have been studied following these two approaches in the last few years. Are these methods redundant or complementary? We compared a phytosociological classification made by botanists based on a sample of 550 grasslands and an agronomical classification from the study of 233 grasslands. This work did not show equivalences between the two approaches: the prediction of grasslands' ecological and agronomical values requires the association of both approaches. We, therefore, propose that current grassland classifications need both agronomical and phytosociological criteria in order to provide complete information on ecosystems and sustainable production.

Keywords: phytosociology, agronomy, typology, classification, methodology comparison

Introduction

Permanent grassland covers almost 60 million ha in the EU-27, which represents one third of total Utilized Agricultural Area (Eurostat, 2017). Since the 1970's, grasslands have been disappearing due to intensification and abandonment, with significant consequences for biodiversity. In order to protect biodiversity, the EU created a list of priority habitats based on phytosociology, which contain natural and semi-natural grasslands (European Commission, 2013). Phytosociology is the study of plant communities. It has been used since the early 20th century and provides a quick classification of the communities without accurate species abundance quantification (Ferrez *et al.*, 2016). Phytosociological classification mainly aims to describe communities and the conservation status of grasslands. Agronomical classifications allow the understanding of forage production and the impact of practices on the environment (Michaud *et al.*, 2013). Agronomical classifications are developed taking into account the abundance of botanical species. Estimating the ecological and economic values of grasslands is crucial for decision makers; no current classification allows the calculation of both values. The aim of this work is to compare the quality of assessment by both phytosociological and agronomical classifications.

Materials and methods

The study took place in the Vosges massif (north eastern France, 7,000+ km^2). Altitude varies from 170 to 1,424 m a.s.l., and geology differs significantly: from limestone and sandstone in the north to plutonic volcanic rock for the massif southern part. The climate is under oceanic and semi-continental influences and can be polar at the summits (Ferrez *et al.*, 2016). The phytosociological classification has been built by the Regional Botanical Conservatories, using 1,628 records from 1993 to 2015 on the entire Vosges massif (Ferrez *et al.*, 2016). The Botanical Conservatories identified 62 grassland types and selected 25 actually significantly present in commercial farms at the massif scale. We conducted our study on these 25 phytosociological types, based on 550 records. The agronomical classification was created from 2001 to 2013 by the Ballons des Vosges Regional Natural Park, the Vosges du Nord Regional Natural Park and the French National Institute for Agricultural Research (Collectif, 2006; Bayeur *et al.*, 2013). They

interviewed 47 farmers about the management of grasslands and estimated yields from the number of bales and livestock stocking rate. They studied the botanical composition of 233 grasslands and identified 25 grassland agronomical types.

We evaluated the capacities of both classifications to predict ecological (total and oligotrophic species richness) and agronomical (yield) criteria. We used oligotrophic species richness as a proxy for species of high ecological value. We obtained the botanical specific richness and oligotrophic species richness of 783 grasslands from both phytosociological and agronomical classifications. In order to calculate oligotrophic species richness, we used Ellenberg indexes (Ellenberg *et al.*, 1992): we considered species with a nitrogen index of 1 to 3 as oligotrophic species. In order to study yields of phytosociological types, we attributed phytosociological types to the 233 agronomical relevés, based on the botanical composition. We analysed homogeneity of variance using Levene's test to study the dispersion of each criterion (total richness, oligotrophic species richness and yields) within the types of both agronomical and phytosociological classifications. In order to choose the best prediction model, we studied the impact of agronomical types, of phytosociological types, of the combination of both classifications, of the interaction of both classifications, and finally of a null model. We ran linear models for data with a normal distribution (total and oligotrophic species richness), and generalized linear model for non-normal distribution (yields). The best model is the one with the lowest second order Akaike Information Criterion (AICc), and we assume it needs to have a weight of at least 0.8. We controlled the quality of this best model by calculating its R^2 and comparing the AICc of the best and the null models. We performed statistical analyses using MuMIn and car packages from the R software.

Results and discussion

Results of the homogeneity of variance analyses and model selections can be found in Table 1. Total species richness is only significantly discriminated by phytosociological types. However, according to the model selection, no model is better than others to explain the total richness: the union of both classifications or the use of phytosociological classification alone are good predictors. Regarding these two analyses, the phytosociological classification seems to be a good approach to study total richness in grasslands.

Oligotrophic species distribution is significantly discriminated by both agronomical or phytosociological distribution and the best model to estimate oligotrophic species richness is achieved by combining the two classifications. This concludes that if each classification can be sufficient, the union of both best estimates oligotrophs richness.

Only agronomical types are significantly able to discriminate yields and the model based on agronomical classification is the best for predicting yields. We can conclude that phytosociology is powerless in yield prediction.

Table 1. *P*-values of homogeneity of variance analyses (*** = $P < 0.001$; * = $0.01 < P < 0.05$) and best selected model (A = Agronomical classification; A+P = combination of agronomical and phytosociological classifications).

Criteria	Homogeneity of variance analyses		Model selections
	Agronomical types	Phytosociological types	Best model (R^2)
Total richness	0.639	0.038*	-
Oligotrophic species richness	< 0.001***	< 0.001***	A + P ($R^2 = 0.63$)
Yields	< 0.001***	0.095	A ($R^2 = 0.50$)

Conclusion

Both agronomical and phytosociological classification are useful in grassland criteria prediction. However, each classification has advantages and the two can be combined to improve criteria predictions. To implement this study in European-scale grassland classifications, this analysis should be verified with other soils and climates and more criteria should be included such as forage quality. This European classification could lead to a better prediction of both agronomical and ecological grassland value. It is important to know the ecological value of a grassland in order to target the most threatened. However, grasslands need to be profitable to become durable, which is why we assume that European grasslands need an approach which combines both the phytosociological and agronomical approach.

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