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# **How to classify permanent grasslands? Conclusions from a French national network**

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## **Abstract**

Since agronomists and ecologists began to study permanent grasslands, they have set various classifications to describe the variety of grasslands or to suggest clear interpretations of their functioning. First classifications due to phytosociologists described the structures of plant communities, and their relations with environment. Recent advances in plant ecology introduced typologies based on life plant traits. It is now clearly established that ecosystemic services provided by grasslands (ie grass production or red list species protection) cannot be predicted by the same characteristics of vegetation. We aimed to compare these contrasted ways of classifying grasslands, estimating the redundancy of vegetation characteristics. Therefore, a national network of 178 grasslands was studied in 2009 with a common experimental protocol to determine the botanical composition. The main result is the low redundancy between taxonomical and functional (i.e. life traits) characteristics of vegetation, despite a dependence between these variables. Single criterion based classifications must thus be avoided for the full prediction of grassland ecosystem services.

Keywords: Typology, grassland, taxonomy, functional classification, services

## **Introduction**

Permanent grasslands occupy almost 40% of the land used by the European Union. A huge variety of pedoclimatic and management conditions result in a wide variety of the types of vegetation. Agronomists and ecologists have described this diversity for a long time, with various criteria: presence, frequency, dominance or abundance of species, sward biomass or height, forage quality, etc. More recently, progress in functional ecology lead to measure plant life traits. On this basis, diverse classifications of permanent grassland have been established, depending on their initial purpose: describe, understand or predict. It is clearly stated that the agronomical and ecological services delivered by permanent grasslands greatly depends on the characteristics of the vegetation (De Bello et al., 2010). For example, forage yield is closely linked to criteria like grasses proportion and type, legumes proportion influence forage quality, and the maintenance of patrimonial and ordinary biodiversity rely on botanical composition. The aim of the present work is to study the potential redundancy of some criteria involved in the classification of permanent grasslands. One key issue of this approach is to assess the need to perform a multicriteria vs monocriteria study of grassland to predict agro-ecosystem services.

## **Materials and methods**

A network of 178 French permanent grasslands was set in 2009, covering a broad climatic and edaphic gradient in France. It included most pedoclimatic areas from oceanic to alpine conditions and covered most of grassland type in France, excluding Mediterranean conditions. Altitudes of grassland range from sea level to 2000 meters. This environmental gradient was crossed with a management gradient, defined by a diversity of farm systems (dairy or meat cattle and sheep) and management practices (type and number of uses, type of animals and livestock density, type and amount of fertilization). Use of grasslands was divided into three categories: 44.38% only grazed, 12.36% only cut and 43.26% grazed and cut. The botanical composition was observed once during the spring 2009: full list of present species within an

homogeneous station (1000 to 5000 m<sup>2</sup>), and visual estimation of species dominance in 8 quadrats (0.25m<sup>2</sup>) randomly located in the station. Floristic relevés were managed with eflorasys (Plantureux *et al.*, 2010), which was used to calculate the following 6 functional criteria (mean value for the grassland, weighted by species dominance): Leaf Dry Matter Content (LDMC), Specific Leaf Area (SLA), Leaf Life Span (LLS), Date of Inflorescence (DI), Number of Oligotrophic species (NOS) (linked to ecological value) and the Proportion of Entomophily Species (PES) (linked to the pollination service). Two classifications of grasslands were set to determined taxonomic criteria, respectively based on Presence (PRE) and Dominance (DOM) of species. This was achieved with a Multiple Component Analysis (MCA) followed by an ascendant hierarchical classification, and a tree cut with a characterization of classes. To compare the criteria we made: i) a linear regression between the 6 functional characteristics, ii) a variance analysis between the 2 taxonomic characteristics (qualitative variable) and the 6 functional characteristics (quantitative variables), and iii) a Khi2 test between DOM and PRE.

## Results and discussion

Main results for the links between vegetation characteristics are presented in table 1. Most of relations show a link between criteria, except for 2 criteria poorly linked to the others: the date of inflorescence and the proportion of entomophily species. Except for NOS with taxonomic criteria, the coefficients of determination are quite low, demonstrating that none of these criteria can be used to predict another one.

|   | LDMC    | SLA     | LLS     | DI      | NOS     | PES     | DOM                   |
|---|---------|---------|---------|---------|---------|---------|-----------------------|
| Leaf Dry matter Content (LDMC)          | .       |         |         |         |         |         |                       |
| Specific Leaf Area (SLA)                | 0.33*** | .       |         |         |         |         |                       |
| Leaf Life Span (LLS)                    | 0.42*** | 0.05**  | .       |         |         |         |                       |
| Date of inflorescence (DI)              | ns      | 0.16*** | ns      | .       |         |         |                       |
| Number of oligotrophic species (NOS)    | 0.26*** | 0.06*** | 0.18*** | ns      | .       |         |                       |
| Proportion of entomophily species (PES) | ns      | ns      | ns      | 0.09*** | 0.02*   | .       |                       |
| Dominance of species (DOM)              | 0.41*** | 0.14*   | 0.41*** | 0.40*** | 0.51*** | 0.32*** | .                     |
| Presence of species (PRE)               | 0.29**  | 0.19*** | 0.27*** | 0.45*** | 0.58*** | 0.31*** | Khi <sup>2</sup> =516 |

Table 1: Relations between vegetation taxonomic and functional characteristics of the French network of 178 permanent grasslands, Values indicate the coefficients of determination and are associated to statistical significances (ns, \*=P<0.05, \*\*=P<0.01 or \*\*\*=P<0.001)

Among functional criteria, LDMC is linked to SLA and LLS, as previously demonstrated by Ansquer *et al.* (2009). The relation between others functional criteria are either not statistically significant (i.e. LDMC and DI) or with a poor quality model explaining less than 30% of the variance. The relations between taxonomic criteria (DOM and PRE) and functional criteria are always significant (except for DOM and SLA). The same trend can be observed between DOM and PRE. Despite of the value of the khi<sup>2</sup> test, the similarity between classifications of grasslands based on presence and dominance was weak.

All these relations mean that the criteria are not independent, but the conclusion of the redundancy of the criteria cannot be drawn. The example of LDMC will be used to demonstrate this statement. Figure 1a confirms the good link between LDMC and SLA, whereas Figure 1b indicates that the number of oligotrophic species is not closely related to LDMC, despite a statistical significance in table 1. Figures 1c and 1d show that even if some

types of grassland (classified on presence or dominance) have higher or lower LDMC than other types, the variability within types can be as higher than the variability between types.

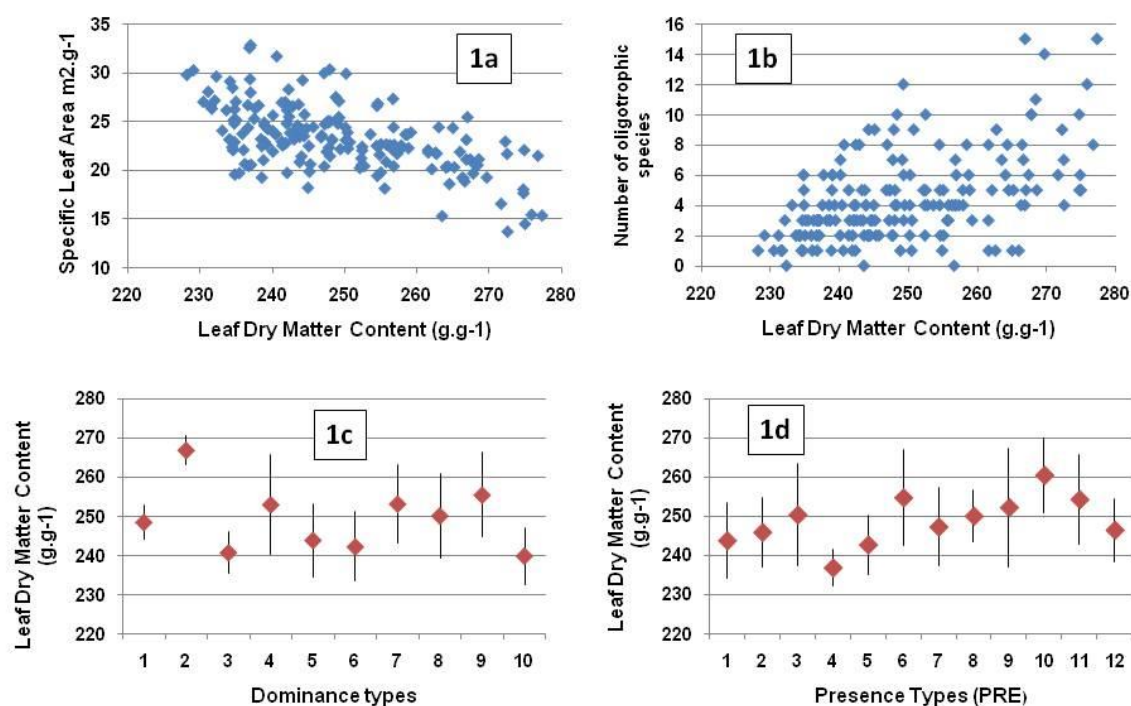


Figure 1: Relation between Leaf Dry Matter Content (mean life trait calculated at community level) and 4 criteria to classify permanent grasslands

## Conclusion

The criteria used to classify grassland that we have tested are not redundant (except for LDMC vs SLA and LLS), but at the same time are not fully independent. Taxonomical and functional characteristics are not redundant and each category of criteria provide specific information on sward features.. Thus, to predict from vegetation characteristics the agronomical and ecological services provided by grasslands single criterion based classifications must be avoided.

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