e-FLORA-sys, a website tool to evaluate the agronomical and environmental value of grasslands

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Abstract

e-FLORA-sys is a free website tool (http://eflorasys.inpl-nancy.fr/), designed by Nancy University and INRA, in order to provide a research and decision-making tool. The system is based on databases describing features of most European grassland species (ecological indices, plant traits, productivity, and forage quality), floristic composition, agricultural practices, soil and climate characteristics, and vegetation associations. From this information, the system calculates numerous indices to evaluate the agronomical and ecological value and management of grasslands. For instance, indices of forage productivity or grassland value for pollinator insects are provided by e-Floras-sys. Users can freely record their own observations (botanical relevés, agricultural practices, etc.), which are protected by a login device. One of the key goals of e-FLORA-sys is to produce real time and useful information to decision makers and scientists concerned with the management or the understanding of grasslands.
Keywords: permanent grassland, software, evaluation, plant traits

Introduction

Over the last decades, evaluating and managing forage production and environmental aspects (biodiversity, water quality, etc) simultaneously in permanent grasslands has become a key question in agriculture. Perennial grasslands occupy almost 40% of the land used by the European Union. Despite this importance, the functioning of these grassland ecosystems remains only partially understood, and farmers and their advisers are still waiting for relevant tools to manage grasslands. Therefore, there is a need for research works that link, on the one hand, management, soil and climate, and grassland flora and, on the other hand, forage production (grass quantity, forage quality, seasonality of production, resistance to climate change, etc.) and environmental services (protection of biodiversity, carbon sequestration, landscape preservation etc.). This research must lead to decision-making tools being available for farmers. The purpose of e-FLORA-sys is to contribute to these goals, providing an easily accessible tool for grassland researchers, farmers and their advisers. In comparison with existing systems that are botanically, environmentally or agronomically oriented, the ambition of the system is to provide elements to understand and manage permanent grassland from a mixed agronomical and environmental point of view. There are numerous available computer applications (programs or websites) for the description of species (i.e. LEDA plant traits base), or for ecological data processing such as CANOCO, PC-ORD and SYNTAX compared by Gilliam *et al.* (2003). e-FLORA-sys does not aim to replace these tools but to provide a complementary tool at the interface of agronomy and the ecology of permanent grassland. A first and simpler version named 'FLORA-sys' was set up in 1995 (Plantureux, 1996).

System structure

e-FLORA-sys is a free website tool based on a relational database management system (MySQL). The system has been developed with CakePHP, a development framework for PHP. Database structure can be modified by administrators to improve the system (i.e. introduce new criteria). It is available in English and French languages, but species names are also translated into German (German and Spanish versions soon). Everyone can access the

system, but an authentification (login and password) is needed to fully use all the features of e-FLORA-sys. This guarantees the confidentiality of data entered by users (i.e. botanical relevés). All the calculations are performed and data stored on a central machine, but users can export in various formats (txt, pdf, csv) input data and calculation results.

There are twelve tables managed by the system (Fig. 1):

The species table contains information on plants (currently 3000 species) found in most European grasslands, including some tree species sometimes found in abandoned or very extensive situations. For each species, the information concerns the following criteria (more than 100 variables per species): identification (translations and synonyms), agronomical value (potential production level, quality for cattle, sheep, goats and horses), patrimony value (rarity, inscription on red lists), reaction to abiotic factors (soil and climate) and agricultural practices (i.e. adaptation to frequent cutting or trampling) including Ellenberg indices, biological and ecological characteristics (aerial part, root and diaspore morphology, germination, reproduction and dispersion, life traits, classification in typologies like Raunkier types).

The Relevé table includes the floristic composition observed on a station, and all the calculations, graphs and texts generated by the system for an agronomical and an ecological diagnosis. Several methods of relevé are available. Each relevé is linked to a station (station table) which is itself linked to three tables describing the climate (temperature, precipitation and radiation), the soil (physical and chemical parameters) and the agricultural practices (fertilization, grazing and forage harvesting management, other practices). The 'plant associations and typology' table enables the users to link the relevés to record known types of grassland vegetation or European habitats. Relevés can be gathered in projects, in order to study grasslands of a particular region, to compare evolution in time, or to focus on a specific aspect (i.e. effect of nitrogen fertilization amount). Pictures of species and grasslands can be stored in a table. The access to information is controlled by a system of user rights defined in the table of 'people and rights'. A dictionary allows a full translation of all technical and software command terms in English and French (German and Spanish in progress). Finally, a table describing decision rules mobilized to produce the agronomical and ecological interpretation, and to predict floristic composition (see Flora-predict description below).
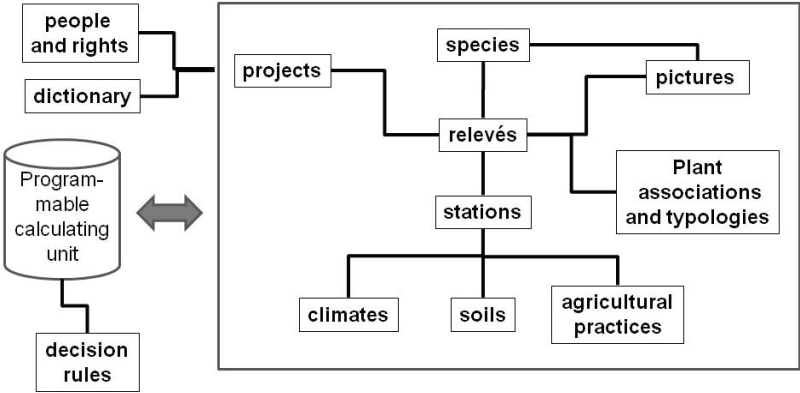

Figure 1: General e-FLORA-sys database organisation - Tables with the main links

Applications for research and decision making

Data management and collection: For those who collect various data on grassland and biotic and abiotic factors influencing vegetation, e-FLORA-sys is a secure and a comprehensive

solution. It allows the users to record data in order to perform studies over long time periods or studies on metabases (almost 10000 relevés currently in the database). This can be very useful for researchers, for example to set or to improve the precision of response curves or ecological profiles of species. For decision makers, it can be used as a frame of reference on grassland types and agronomical and ecological values.

Calculation of indices: These indices can be sorted in four categories : 1) Ellenberg or similar dominance in sward, and evaluating the state of vegetation, soil or agricultural practices (i.e. soil nitrogen fertility, soil moisture, trampling level, etc), 2) diversity indices : species richness, Shannon indices, Red List plants counting, 3) agronomical indices such as pastoral value or mean forage quality, and 4) (under construction) indicators evaluating agri-environmental services like preservation of pollinator activity, habitat conservation, aromatic quality of the forage for cheese production, landscape aesthetic value, etc.

Plant species richness prediction (FLORA-predict): FLORA-predict is a mechanistic model built by Amiaud *et al.* (2005) in order to predict the floristic composition of a grassland from agricultural practices, soil and climate conditions and biogeographical area. Model output is a probability of presence of species. In e-FLORA-sys, this model can be used either to validate the hypotheses and the formulae of FLORA-predict or improve them (research objective), or to test scenario of changing agricultural practices (decision making objective).

Evaluation of agronomical and ecological value: This evaluation is mainly based on the calculation of indicators. For instance, the nitrogen indicator designed by Pervanchon *et al.* (2005) will assess environmental risks due to nitrogen management. Although the main purpose of this evaluation is decision making, research applications can be found.

Research tool: A key feature of e-FLORA-sys is the possibility to modify decision rules, calculation formulae and database structures without rewriting the program instructions. This parameterization allows an evaluation of new hypotheses, calculations and interpretation methods. Researchers elsewhere are thus invited to suggest improvements. Moreover, the broad range of relevés recorded in the database can be used in research programmes, for instance to set ecological profiles of species. e-FLORA-sys is currently implemented to test whether plant life traits can predict agronomic and environmental performances of a French network of 200 grasslands along an intensification and a climate gradient.

Conclusion

e-FLORA-sys is already providing key information on agronomical and environmental values for scientists and decision makers. The system was built to allow continuous improvements by its designers, but also by the scientific and technical community. It appears as a tool for sharing knowledge and data on permanent grassland.

References

Amiaud B., Pervanchon F. and Plantureux S. (2005) An expert model for predicting species richness in grasslands: Flora-predict. In: Proceedings of the 13th International Occasional Symposium of the European-Grassland-Federation 2005, Tartu Estonia, *Grassland Science in Europe* 10, 103-106.

Gilliam F.S. and Saunders N.E. (2003) Making more sense of the order: A review of Canoco for Windows 4.5, PC-ORD version 4 and SYN-TAX 2000. *Journal of Vegetation Science* 14, 297-304.

Pervanchon F., Bockstaller C., Amiaud B., Peigné J., Bernard P.Y., Vertes F., Fiorelli J.L. and Plantureux S. (2005) A novel indicator of environmental risks due to nitrogen management on grasslands. *Agriculture Ecosystems and Environment* 105 (1-2), 1-16

Plantureux S. (1996) FLORA-sys: a software for the data management and the interpretation of botanical composition of permanent pastures. *Acta Botanica Gallica* 143(4-5): 403-410.