PRABIES

How livestock farming practices 'transform' grassland biodiversity into bundles of ecosystem services

Métaprogramme BIOSEFAIR

Projet Report: 2021 - 2024

July 2024

The PRABIES project aimed to describe the impact of climate change adaptation practices on the provision of ecosystem services (ES) in grassland environments. The aim was to understand whether adaptation practices would have a positive or negative effect on biodiversity and the services it provides. To do this, PRABIES set out to describe how interactions between practices, climate and biodiversity impact the provision of ES packages in a climate change context.

PRABIES made it possible to describe the complex interactions between all these factors through the implementation of structural equation modelling (SEM), a statistical tool for assessing the strength and significance of variables in direct and indirect interactions. This tool was applied to a dataset of 100 permanent grassland plots in the Massif Central (France). This dataset included management data, i.e. nitrogen fertilisation, animal stocking rate per hectare and three types of ES proxies: provisioning, regulating and cultural. The dataset included plots along an altitude and latitude gradient, which provided a wide range of average annual temperatures. SE proxies were aggregated into a multifunctionality index, and SEM was used to demonstrate the pivotal role of biodiversity in the value of this biodiversity index. This biodiversity, assessed via species richness, modulates the indirect effects of temperature and fertilisation.

PRABIES also collected information on the strategies of 15 dairy farmers in the Massif Central through interviews. These interviews described the role of permanent grasslands in the herd feeding system and their management, particularly fertilisation. They made it possible to

characterise farms where more than 75% of the crop rotation included permanent grasslands, and that on some of these farms, farmers felt ready to face a new climate.

Results

The SEM showed that at an average temperature of 6.7°, multifunctionality was proportional to fertilisation, whereas at an average temperature of 12.2°, the relationship between multifunctionality and fertilisation took the form of a bell curve. This curve indicates that at 12.2°C, multifunctionality peaks at 70 kg of N per hectare per year. These patterns can be explained by the fact that multifunctionality is positively correlated with biodiversity and that the latter is more or less favoured by fertilisation depending on the temperature.

We believe that it has a positive effect in cold, and therefore constrained, environments, whereas it has a negative effect above a certain threshold in mild, and therefore less constrained, environments. Above this threshold, so-called “competitive” plant species are over-favoured compared to other species, which reduces species richness.

By applying the fertilisation data obtained from the survey to the models established by SEM, it was possible to model the level of multifunctionality of permanent grasslands in a climate that is 1.5°C warmer. These models suggest a modest decline, which varies depending on the type of livestock farmer. PRABIES has therefore made it possible to assess the decline in multifunctionality within permanent grasslands and the risks of their conversion to fodder crops.

- **Direct effects of climate change on permanent grasslands**

The Massif Central was used as an ‘open-air laboratory’. We used a database from the ‘Typology of the Massif Central grasslands’, which brings together grasslands representative of the diversity of grassland environments in the Massif Central (n=100). The climate of the Massif Central is structured by spatial gradients where the average annual temperature is negatively correlated with altitude, and where the frequency and severity of droughts are negatively correlated with latitude (these gradients are independent of management practices such as fertilisation, mowing and grazing).

We studied the effect of climate and management, via fertilisation, on species richness and multifunctionality, expressed as a normalised average (between 0 and 1) of six ecosystem services (ES):

- Forage quantity (provisioning ES),
- Forage quality (provisioning ES),
- Carbon stock (regulating ES),
- Stability of biomass production (regulating ES),
- Habitat quality for pollinators (regulating ES)
- Rarity of plant species (cultural ES).

We conducted a path analysis, which is a type of structural equation modelling (SEM), where soil factors, topography, and land use (grazing vs mowing) were taken into account as covariates. We identified species richness as a pivotal variable in the effects of fertilisation and

climate on multifunctionality. i.e. fertilisation and temperature decrease species richness as well as, to a lesser extent, the severity and frequency of droughts. Species richness interacts with fertilisation and temperature to influence multifunctionality (Figure 1).

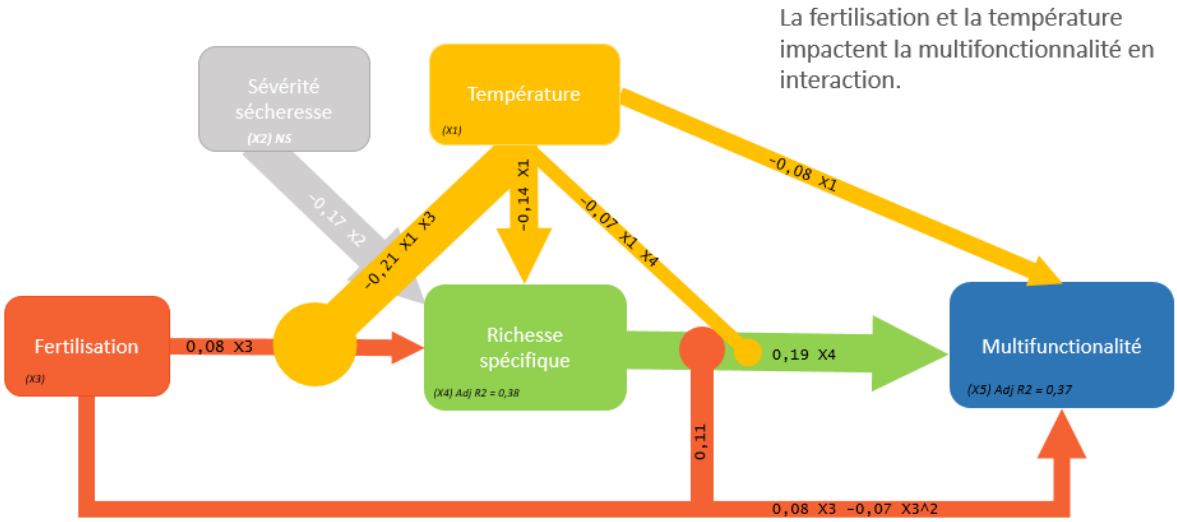

Figure 1 : Structural Equation Modelling (SEM) results representing the direct and indirect effects of climate and fertilisation on multifunctionality (average of six standardised ecosystem services).

Our SEM also shows that, at an average temperature of 6.7°C, multifunctionality increases proportionally to fertilisation, whereas at an average temperature of 12.2°C, the relationship between multifunctionality and fertilisation takes the form of a bell curve, peaking at 70 kg of N per hectare (Figure 2).

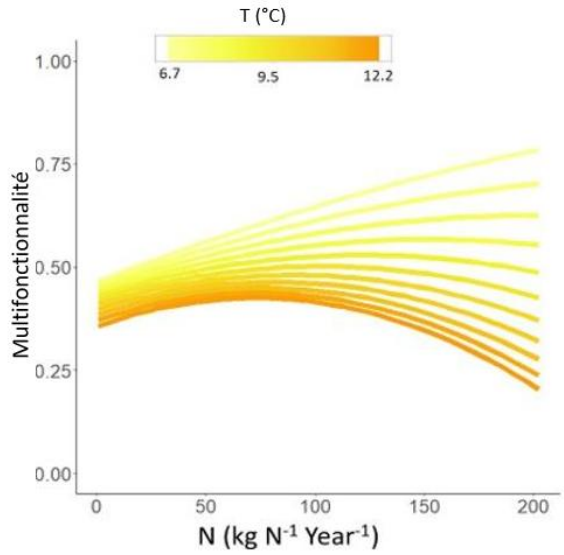

Figure 2 : Interactive effects of fertilisation and temperature on multifunctionality according to SEM

These patterns can be explained by the fact that multifunctionality is positively correlated with biodiversity and that biodiversity is more or less favoured by fertilisation depending on the temperature. The effect of climate suggests that in a context of rising temperatures linked to climate change, it would be essential to consider fertilisation in order to preserve the specific richness and diversity of the ecosystem services provided by grasslands.

- **Livestock farmers' climate change adaptation strategies**

We interviewed 15 dairy farmers whose grasslands had been recorded in the Massif Central Grassland Typology database. We asked them about their strategies for adapting to climate change, their perceptions of climate change and their permanent grasslands.
We analysed these perceptions by applying a socio-cognitive model of adaptation to climate change and a framework for analysing the relationship between humans and nature, in relation to the climate of their farms, using altitude and latitude gradients.

It turns out that adaptation strategies modulate the maintenance of permanent grasslands (among farmers who perceive them positively, in a climate that is not very dry or cold) or their conversion to fodder crops or temporary grasslands (among farmers who perceive them negatively, in a hot and dry climate), but not the level of fertilisation. All farmers wishing to adapt had already established the crop rotation considered appropriate to cope with climate change. Farmers in the north and at altitudes above 800m tended to have positive perceptions of permanent grassland and, when they were certain of their intention to adapt, maintained as much of their land as possible as permanent grassland.

In the south and at low altitudes, where droughts are frequent and severe and temperatures are high, permanent grasslands are not favoured in climate change adaptation strategies.

- **Changes in multifunctionality resulting from a rise in temperature**

Using the structural equation model, we simulated the evolution of multifunctionality resulting from a 1.5°C rise in temperature within a sample of permanent grasslands that the farmers surveyed consider representative of their forage systems. We also considered the proportion of permanent grassland in the farm's usable agricultural area and differentiated between farmers based on these criteria.

The results show that the degradation and conversion of permanent grassland do not affect all systems in the same way, and that some systems limit both phenomena, but by purchasing more fodder and concentrates per livestock unit (LU) and selling less milk per unit of area (ha) than others.

Scientific perspectives

PRABIES facilitated discussions in which strategies based on permanent grasslands and fodder crops were described. Farmers relying on fodder crops were also interested in planting trees to reduce the effect of dry winds. It would therefore be relevant to study the multifunctionality of this mosaic of habitats at the farm level. We believe this scale is of scientific interest, as mosaics of habitats are generally studied at the landscape level.

Valorisations

Thèse de Lucie Allart ‘Maintien de la multifonctionnalité des prairies permanentes et adaptation des systèmes fourragers au changement climatique dans le Massif central’ soutenue le 24/06/24 à Clermont-Ferrand (Ecole Doctorale des Sciences de la Vie, Santé, Agronomie, Environnement, Université Clermont Auvergne)

Allart, L., Dumont, B., Joly, F., Mosnier, C., Alvarez, G., Galliot, J.-N., Luna, D., Pottier, J., Gross, N., 2024. *Species richness: A pivotal factor mediating the effects of land use*

intensification and climate on grassland multifunctionality. Journal of Applied Ecology. https://doi.org/10.1111/1365-2664.14627

Allart, L., Joly, F., Oostvogels, V., Mosnier, C., Gross, N., Ripoll-Bosch, R., Dumont, B., 2024. *Farmers' perceptions of permanent grasslands and their intentions to adapt to climate change influence their resilience strategy*. submitted to Renewable Agriculture and Food systems.