TAKING ADVANTAGE OF GRASSLAND AND ANIMAL DIVERSITY IN MANAGING LIVESTOCK SYSTEMS: A SIMULATION STUDY

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INTRODUCTION: THE MANAGEMENT CHALLENGE

In grassland-based livestock systems, grass production is highly heterogeneous and variable in space and time. This fact reflects the between-field differences of vegetation types in relation to management intensity and environmental factors, mainly soil conditions and topography. Weather variability within and between years is another explanation. Through organizational and in-situation decision making, farmers strive to make efficient and opportune use of grass production by livestock grazing or mowing. The overall objective is to secure the feeding of the herd in compliance with desired and attainable grass production.

The idea that livestock farming systems should further integrate consideration of plant species, grassland, animal, and farmland diversity is now commonly acknowledged (e.g. White *et al*., 2004). All three constitute a source of flexibility that can be used in organizational and in-situation decisions to cope with uncertainty of environmental factors such as weather. For instance, grassland diversity enables farmers to have fields that are suitable for different and sometimes multiple uses fitting with the feeding requirements of different livestock classes. In addition to this organizational flexibility, within-field plant diversity makes it possible to take advantage of timing flexibility in grassland management, i.e. the extent to which the use of a given grassland may be brought forward or deferred on a temporal interval at various times of year. This paper describes the SEDIVER model-based approach that aims to design grassland-based livestock systems and management strategies that enable efficient exploitation of diversity in plant species and grassland against weather variability.

DESCRIPTION OF THE SIMULATION MODEL

The SEDIVER model is a dynamic farm-scale simulation model intended to be used by researchers. In the SEDIVER model, the production system can be decomposed into evolving and interacting subsystems, manager, operating system and biophysical system (Fig. 1). The biophysical system is considered as a set of managed entities, such as plot or cow, that are themselves changing over time through interacting processes such as herbage growth or animal intake implemented in dynamic biophysical submodels. The manager is an explicit system that produces decisions and eventually implements these decisions into actions. The simulation model harnesses this structure and the interactions among subsystems, such as those occurring between the weather, the biophysical system, and the farmer's decisions and actions. This is supported by the modeling framework DIESE (DIscrete Event Simulation Environment) that relies itself on a generic conceptual model of agricultural production systems (Martin-Clouaire and Rellier, 2009).

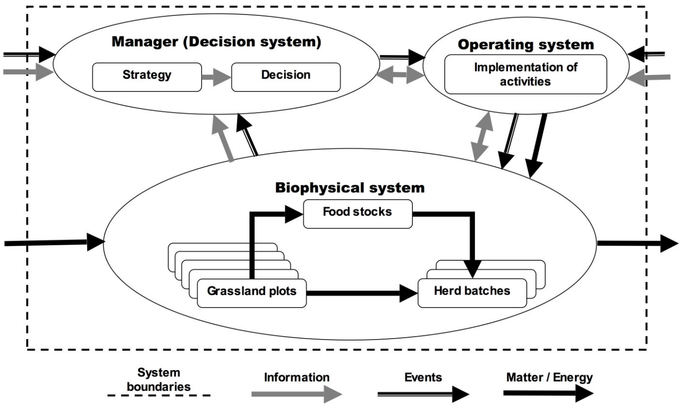

Figure 1: Livestock production system

The two main novel features of the SEDIVER model are (i) a representation of diversity in plant species, grassland, animal, and farmland into an encompassing farm-scale model, (ii) a representation framework in which realistic management strategies can be expressed through flexible activity plans. Such a plan is the result of the farmer's reflection on prior experiences and conveys the temporal organization of activities that the farmer sets up to meet his particular goals and anticipate likely occurrences of important events. Due to uncertainty, plans must be flexible and adaptable to circumstances. Different climatic scenarios lead to different realizations of the plan.

RESULTS AND DISCUSSION: A SIMULATION-BASED EXPERIMENTATION

The simulated example concerns a grassland-based production system of 6 to 8-month old just-weaned beef calves (Gasconne breed) in the French Pyrenees Mountains. In this area, long and cold winters preclude grazing-based feeding for several months. About half of the farms have access to roughly 20% of external hay supply to cover winter feeding of their herd. Forage self-sufficiency during winter is thus a key performance factor for such systems. Management of forage stock production and grazing are closely interdependent. These have traditionally been based on dates and herbage allowance characterized by height or biomass and stocking rate. Increasing herbage utilization rate to reach forage self-sufficiency requires careful consideration of the diversity of grassland production patterns encountered within a farm through their temporality, productivity and nutritive value. Indeed, the trade off between herbage growth and senescence, which depends on leaf life spans and phenological stages of grassland plant species (Duru *et al.*, 2009), has strong consequences on production and nutritive value.

We conducted a simulation-based experiment over 7 real year-long weather series to evaluate the advantages provided by an alternative forage stock production and grazing management mode paying increased attention to plant species and grassland diversity. We compare it with a traditional management mode. The results (Tab. 1) showed that while maintaining animal production performances, the alternative management mode allowed harvesting almost twice the quantity of forage with the traditional management mode. This tendency was accentuated in favourable years, diminished but remained substantially higher, i.e. one-and-a-half-fold, for years including a prolonged drought event. Average nutritional value of harvest increased as well by .05 kg.kg^{-1}, and grazed herbage nutritive value rose by .04 kg.kg^{-1}. The relative quantity of grazed herbage in yearly animal intake increased during favourable years. Herbage utilization rate increased by 13% on average, and still by 10 % for years including a prolonged drought. All these facts suggest that encouraging farmers to pay increased attention to plant species and grassland diversity in their management would offer them promising potentialities to cope with weather variability.

Table 1 : Minimum, average and maximum values for aggregated simulation output indicators between the traditional and the alternative management modes

Management Mode	Harvested Quantity per Animal Unit	Digestibility Of Harvest	Forage Stock Consumption per Animal Unit	Relative Part of Grazing	Digestibility Of Grazed Herbage	Herbage Utilization Rate	Live Weight Production per Animal Unit
Traditional	457/1373/1780	0.56/0.61/0.67	1814/1951/2091	0.56/0.58/0.61	0.67/0.72/0.75	0.36/0.53/0.61	184/207/219
Alternative	964/2589/4066	0.64/0.66/0.69	1764/1867/2009	0.56/0.60/0.62	0.71/0.76/0.77	0.49/0.66/0.73	183/206/223

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