DE-INTENSIFICATION OF GRASSLANDS: CURRENT STATE AND TRENDS

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Introduction

De-intensified use of grasslands, and more generally of the livestock systems they support, has been triggered by a growing sensitivity of citizens to environmental quality (nitrogen) and quality of animal products, and by the warnings addressed to political authorities by scientists about the environmental consequences of economic imbalances (decreasing biodiversity, drop in soil fertility, greenhouse effect), and in particular of food overproduction in Europe.

From an ecological standpoint, grassland de-intensification must be envisaged whenever the techniques implemented disrupt resource sustainability. The grassland resource itself may be at risk when a rate of vegetation offtake by herbivores that is incompatible with the resources available starts generating problems (sustainability of grasslands, of biodiversity or of soil fertility). Air and water may also be threatened in the case of excess nitrogen inputs (mainly in Western Europe). Whatever the situation, technical solutions to such imbalances cannot consist only of decreasing inputs or offtake rates. In most cases, grassland de-intensification will require changing animal feeding systems, land use (type of vegetation used to feed animals) and more generally the organization of technical systems of production. In countries where vegetation growth stops for several months for instance, animals will need to be fed with conserved forage: such forages are often grown in intensive systems, which is the only way to cut down fodder production costs. In such livestock systems, de-intensification will involve decreasing the share of conserved forage in favor of grazing of perennial grasslands. This can be achieved either by increasing the grassland area available for earlier grazing at the end of winter, or through deferred grazing to extend the grazing season into a period with reduced grass growth.

In the first part we review available scientific knowledge that can help us rethink and diversify grassland management. De-intensification may rest on changing only the grassland species being sown but may also involve re-organizing the whole production system. More generally, besides altering the animal feeding calendars and land use patterns, the units and objects managed by the farmers as well as the necessary anticipations required to implement such systems (Part 2) will need to be reconsidered.

Rethinking and diversifying grazing management at field parcel or paddock scale

Grassland studies have so far focused mostly on optimizing inputs or grazing intake. They need to be complemented by concerns other than the exclusive short-term optimization of plant and animal output. For this we need to (i) produce models to assess changes in sward characteristics as consequences of nitrogen inputs and defoliation patterns, by integrating the regulation properties of agro-ecosystems; (ii) use these models to define different grazing management options in terms of possible animal and plant performance, but also in terms of the means required to implement these options.

Modeling the effects of fertilizers and defoliation on the vegetation characteristics of natural and sown grasslands

Nitrogen inputs, growth and composition of a grass sward

Decreased nitrogen application results in reduced growth rates and in changes in sward composition and animal performance. In grazing situations, what one needs to consider is how much to extend the time needed to reach a given amount of biomass rather than the decreased amount of biomass following decreased nitrogen inputs. A minimum mass of leaf blades – whose level depends on the animal species considered – is needed so as not to penalize intake quantities per day. For a given grassland species, reduction of the grazing pressure either by extending the period between two grazings, or by higher residual sward height following grazing, will result in increased losses through senescence, i.e. decreased grazing efficiency and consequently lower stocking rate. The degree of decrease depends on the grassland species in relation with the life span of grass leaves.

As regards sward composition, protein contents are lower in treatments with no nitrogen input, especially those with short regrowth times. Given the dilution of nitrogen during a regrowth period, the same nitrogen content may therefore be reached quickly following defoliation in the case of decreased nitrogen input, or later in the case of higher N input. The sward nitrogen content gives an indication of both the nitrogen value of the grass on offer (blades and above-ground biomass) and the potential level of nitrogen surpluses and losses. Minimum and maximum thresholds may be set to define the defoliation regimes adapted to these constraints.

Fertilizer application, defoliation and biodiversity in natural grasslands

Species diversity in natural grasslands is limited as a result of strong competition among species, in particular competition for light. Conversely, low levels of mineral resources enable a greater number of species to coexist, insofar as they are capable of conserving resources. Reducing inputs could therefore cause the species number to increase, while simultaneously decreasing the sward growth rate. On the other under high defoliation intensity, the remaining number of species is small since many species reach the limits of their phenotypic plasticity. They are no longer able to maintain their meristem below that of offtake by animals. The only species that will survive are those which develop strategies of avoidance or tolerance to grazing. Such situations correspond to overgrazing, which also results in lesser growth owing to the decreased efficiency of sunlight interception by the sward. Inversely, with a strongly decreased grazing intensity there is a risk of invasion by unwanted species, resulting in reduced species diversity.

Biodiversity may play a functional role. First, specific diversity within a plant community ensures greater regularity of production along the year and greater flexibility of use than in a monospecific pasture. Second, at the wider territorial level, biodiversity offers a means of maintaining species that will enable a management of the botanical composition geared towards obtaining grassland types with different characteristics in terms of production levels and utilization flexibility. This may be achieved by through recruitment of new species or decreasing the abundance of species already present, since agricultural practices (fertilization, defoliation) have a direct impact on the seedling survival rate of species that could potentially settle, as well as on the fecundity of species present and indirectly on competition relations.

Defining different grazing management styles

Based on the above information different styles of grazing management, i.e. combinations between levels of nitrogen inputs and defoliation regimes, may be defined in relation to the objectives being sought. De-intensification may involve decreasing nitrogen inputs only (Course 1). The assessment of the grassland intensification level due to nitrogen could be done using the critical nitrogen content, ie the N content producing maximum growth for a given biomass.

With this type of management low residual height of grazed grass is required as well as short intervals between defoliations and early harvesting of grass as silage. For sown grasslands, species with short-lived leaves are well suited to this management style. There are however certain limitations to this form of de-intensification. A comparison of defoliation intervals which satisfy the three constraints (minimum blade quantity, minimum and maximum nitrogen contents) shows that with decreased nitrogen inputs the risk of nitrogen losses can be curtailed, but with a delayed onset of possible sward utilization (due to limitation of grass offered) and earlier termination of possible use (limitation of N content). A decreased level of nitrogen input thus leads to reducing the interval between two defoliations that is compatible with the different constraints, and as a result diminishes the grazing management flexibility.

When de-intensification also involves decreasing the period of feeding conserved forages (Course 2), the grazing season must be extended. This means extending the intervals between two grazings, resulting in lower grazing efficiency and feeding value of the herbage on offer. Choosing species with long-lived blades, or with slow decreasing nutritive value such as white clover, may facilitate the implementation of this type of management. In the case of natural grasslands, this type of management will favor such species. Any change in the defoliation regimes will also involve changes in organizational decisions. Besides playing a role in herbivore feeding, grazing is also designed to prepare the herbage resource for later use. In intensified systems, the aim of this preparation is to create a favorable sward structure for the next grazing stage (usually from 1 to 5 weeks later). This preparation is achieved by selecting high grazing intensity that keeps the grass sheaths short and favors quality regrowth, and limits rejections. Sward height is used as an indicator to decide on stocking rate variations or paddock changes. This indicator, which is generally sufficient on its own, assumes constant or most often growing values along the grazing season. The grazing management requires a high degree of precision. The sward must be harvested as hay or silage to periodically regulate offer in order to reach these grassland states despite fluctuations in grass growth. Following de-intensification, this preparation no longer relies on a single criterion that remains stable throughout the grazing season. The sward will need to be cut to create standing grass reserves at the beginning of summer or winter, the purpose of the cutting operation being to initiate regrowth sequences to be used 5 to 7 weeks later. This is a preventive rather than a curative function. In this logic, the time elapsing between an action and its expected effects is longer, which requires a greater anticipation capacity on the part of the manager. But on the other hand, the same degree of precision is not required for sward states to be reached.

Rethinking and diversifying grazing management at the scale of the production system

With de-intensification, a sufficient land area must be available. With decreased fertilizer inputs or a less intensive defoliation regime, extra land will be needed if herbivore numbers remain constant. But the additional area needed will depend to a large extent on whether or not the length of stay of the animals on the grazed sward is maintained. Indeed if the share of conserved forage is decreased, the need for grazing area will increase more than if the feeding regime stays unchanged. De-intensification may also demand more radical changes, such as introducing different sown grassland species (or favoring the occurrence of other different dominant species in natural and semi-natural pastures), and/or altering herd management (animal performance objectives, breeding management). To design such reorganizations, we propose to represent the production system as a biophysical system and a decision system linked together by an information system. We will first describe a time-based decision structure for a livestock system.

Regardless of the intensification level, the decisions at annual and multi-annual scales are connected with the feed profiling which is the setting of long-term policy, such as stocking rate, timing of parturition and general stock buying and selling policy. A key indicator of success is the profile of average farm pasture cover throughout the year. It should show no marked peaks or troughs that could lead to sustained periods of reduced pasture availability or quality. Condition score and live-weight of stock should show planned seasonal variation. The planning consists of allocating a specific objective to given land areas (conserved forage, grazing by a particular mob of animals) for a given period of time, i.e. a set of land x mob combinations per period within the year. It also includes readjustments either in the allocation of grassland areas, or in the length of the feeding periods, in order to meet environmental or resource variation.

Intensification corresponds to an “insurance” policy based on correcting limiting environmental factors and seeking to achieve high animal production levels. It generally involves stockpiling conserved forage to ensure the security of the feeding systems by disposing of sufficient reserves to meet production hazards. De-intensification on the other hand implies that one does not necessarily aim to reach the potential permitted by climatic conditions and that lower levels of animal performance per ha, or even per animal are acceptable. Interventions on grasslands are planned in a longer-term perspective since what is sought is to ensure sward sustainability in the long term to avoid grassland deterioration and the need for resowing. Adaptation to variation in grass growth (between-year variation in the period of continuous grass growth…) relies on the regulation properties of the sward: with the extra area allocated, intake rates are lower in years with the most favorable grass growth. Grazing management is more flexible than in intensive systems. There is greater spatial heterogeneity of vegetation and wider variation in production levels between years, since these are not corrected by high nitrogen inputs. The organization plan must take account of these problems rather than bypass or ignore them, in order to turn them to advantage and reinforce the system’s flexibility and security.

For a given herd breeding management, these different policies may be expressed *ex ante* in the form of land utilization rules (grassland type, grazing, cutting, fertilizer applications) and animal feeding rules that can translate into grazing and feeding calendars. These projective calendars also take account of the nature and extent of adaptations to be anticipated in response to environmental fluctuations: extension of the transition period, provision of buffer or stockpiling areas, etc. As for grazing proper, the calendars specify the nature and order of interventions as well as their succession in time.

At seasonal scale, for given land x mob combinations, the grazing plans are designed to achieve production (sward states) targets, and include decisions on rotation length, daily supplemental feeding and when to move the grazing animals. At this point in the reasoning process, some choices have already been made and decisions taken, the resources and feeding modes to be privileged are known, and a hierarchy set for the types of forage resources to be used. These management modes may be described by rules and indicators. For a given period and a set of field parcels, rules define the timing and conditions of intervention (e.g. date of turnout to grass at the end of winter, length of transition period, number of field parcels allocated and evolution during the period), as well as the succession of interventions (intervals between two sward utilizations). Adaptation rules to environmental variation or variation in the states of the biological systems allow to plan for changes in the nature, intensity or order of interventions. At this point, the role of the information system is to provide access to the relevant data concerning the biophysical system and the external environment. The information system has two functions: (i) interpreting and storing some decision-relevant data about the biophysical system and external environment and communicating the results to the decision system; (ii) monitoring some expected events in the biophysical system or external environment and notifying their occurrence to the decision system that uses them as decision-making temporal landmarks. Key indicators are for example daily lactation, pasture residual sward mass, plant phenology and its sensitivity to grazing.

The design of more or less intensive livestock systems calls on an iterative process that mobilizes in situ observations in order to circumscribe organizational constraints, and information on agro-ecosystems to define intervention constraints on swards and animals. The models may be developed from real livestock farming situations in which the farm operation has been analyzed and formalized, or from prototypes designed by scientists and development experts. In the latter case, two or three systems with different operational logics are assessed through farmlet experiments. In each case, the models are completed by assessing commercial farms and experimental situations. This approach is illustrated by three examples taken from literature. The objectives were: (i) to reduce production costs while upholding dairy cow performance by extending the grazing season from 50 to 150 days in western France, (ii) to reconcile animal production and environment maintenance aims on dairy sheep farms in a mountain area, and (iii) to decrease the stocking rate to safeguard the sustainability of herbage resources and stabilize animal production in the Brazilian Pampas.