

Days consumption in hand: a tool for planning and monitoring conserved forage and grazing resources

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Summary:

On livestock farms, grassland management is generally based on the stocking rate. This ratio is however insufficient as a tool for short - term decisions, so we propose another approach that of the "cash" of available forage. The amount of cash results from the difference between production and consumption flows for grazing, silage or hay. It is measured in terms of Days' Consumption in Hand (DCH) of a given herd or flock. We give some examples of forage management in dairy farms. We suggest that Days' Consumption in Hand could be:

- a target coherent with animal performance level and safety level of available forage
- a yardstick for monitoring plot utilization and nitrogen use.

Introduction

Many studies have concluded that in order to optimize herbage production per plot (BERANGER, 1985) and to increase economic results on the farm (JOURNET, 1985), the choice and mastery of stocking rates are primordial. Recommendations based on these assumptions per farming system and per agricultural subregion are of course needful to the definition of the general framework of a forage system, i.e. to define its major features. However, these criteria are no longer sufficient when production and consumption of forage resources need to be managed during the course of the year. In this case, the stocking rate is not so much a goal as the combined result, at any time, of herbage growth and the repercussions of former decisions (HODGSON, 1985).

For rotational grazing management, recommendations usually touch on turning out dates, nitrogenous fertilizer application, conditions for modification of plots earmarked for grazing, duration of grazing and rest periods for each plot. For forage stocks constitution, the recommended quantity per animal, bearing in mind the various types of forage in the feed ration and assumptions as to efficiency of utilization, provide a basis for calculating

the surface areas needed. In view of climatic variations, these criteria seem insufficient as management aids during the year. This is why it is important to improve on the information obtained from repeated surveys on animal husbandry operations (DURU et al, 1988a).

We are putting forward a yardstick that integrates variations in forage availability: the balance, at any given date, between forage production and consumption (either conserved or on pasture). This balance is expressed in Days' Consumption in Hand (DCH) and is a cash flow approach to the question. Detailed studies have been carried out previously (DURU et al, 1988a). Figure 1 gives an illustrative diagram.

This approach here applied to rotational grazing, is similar in its principle, to the one proposed by BRERETON (1987) about expected rotation length and by PARSONS and JOHNSON (1986), MAXWELL and WRIGHT (1987) about the management of continuous stocking. Rather than establishing standardized stocking rates, grazing trials should be managed in view of recommendations on the height of the sward.

We firstly describe some principles of methodology and then apply them to dairy farms.

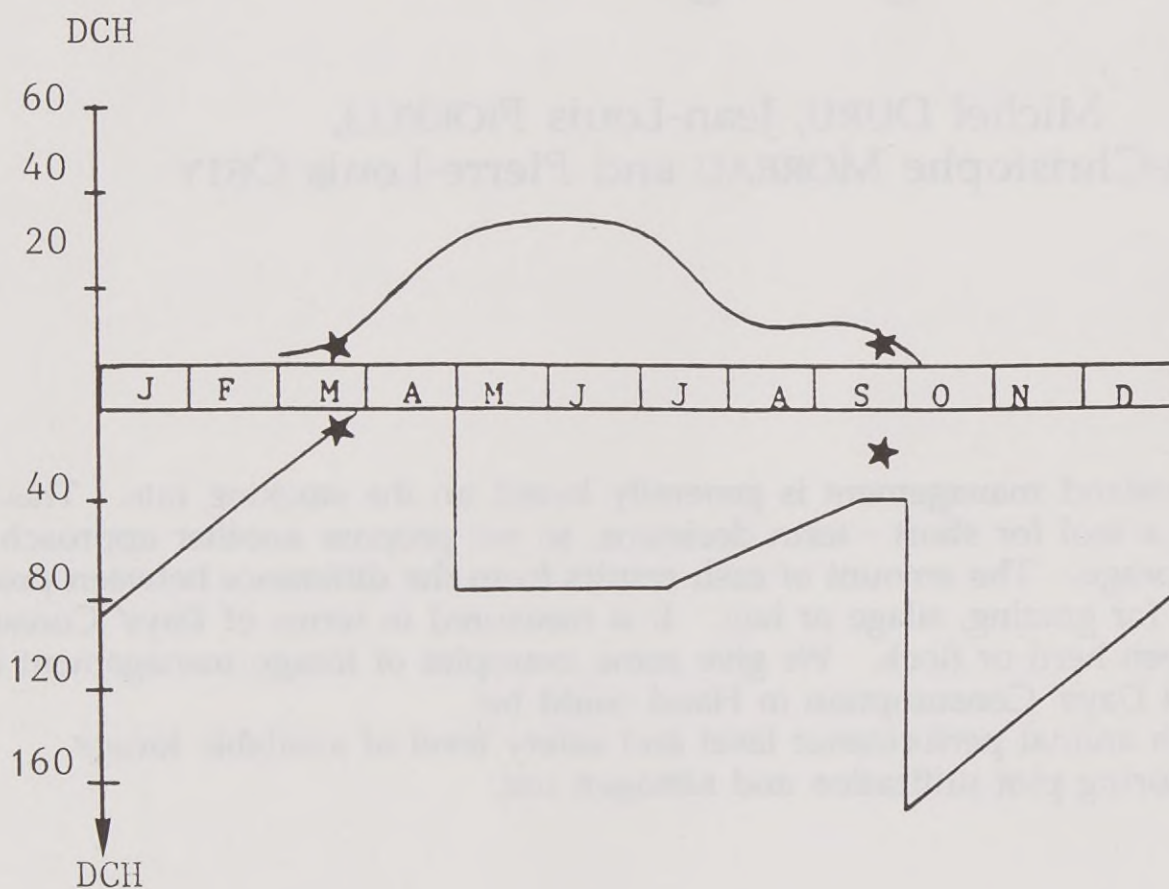


Figure 1 — Representation of the principle of forage cash balance and of its evolution during a season
Y+axis: Days' Consumption in Hand (DCH) for grazing — Y-axis: Days' Consumption in Hand (DCH) for stored feeds. * critical periods corresponding to the transitions between grazing and stored feeds consumption.

1. Method

1.1. Scope of the management study

For the organization of dairy cattle feeding objective observations concern the level of milk production particularly during the first months of lactation. The elaboration of

a forecast curve for milk production using calving dates and information on genetic potential gives a basis for the definition of a feeding programme. Any deviation during the year between the forecast and the actual situation can thus be easily detected.

Using data commonly recorded on grazing schedules, we suggest that particular attention be paid not only to conditions in which forage resources are mobilized and used, but also to how the system is made failsafe (CRISTOFINI and JEANNIN, 1979; DURU et al., 1988b6).

Once the herd production target is set, the forage system can be defined as (DURU et al. 1988c):

- a forecast schedule determining, for the period, a succession of targets for the herd and for forage production, particularly at key periods, as well as means of achieving them;
- a set of rules designed to cover a range of future events recognized as possible by the farmer, and describing the decisions to be taken at each stage in order to meet the aim set.

1.2. Definition of key periods

Decision-making processes are identified using occasional information drawn from stock farms and farmers' husbandry practices. From this knowledge of the production processes, a yearlong table of periods can then be drawn up to classify the information relevant to decisions of interest to us.

In herd and forage surface management, it is possible to identify periods when feeding targets are not met and when technical or economic performance or even the reproducibility of the system are therefore jeopardized or simply impossible. These we have entitled the key periods.

For dairy herds, control of production means easier work organization and better milk prices. Adequate feeding, especially in the first months of lactation, is decisive for developing the full milk production potential of the dairy herd. For forage production, key periods coincide with harvesting but also with sowing for farms where a high proportion of forage crops are annual. The risk of poor sprouting is often high, in fact, and this can affect availability of forage for the year ahead. To satisfy both qualitative and quantitative feedstuff requirements, harvesting for conserved forage and monitoring of grazing land should be carried out under optimum conditions, particularly in Spring.

1.3. Calculation of days' consumption in hand

We suggest that a useful management approach would be comparison of available resources at a given date (grazing, hay, silage...) to the daily consumption capacity of the herd. Whether green fodder, grazing or conserved forage is concerned, the "cash flow" at any time can be characterized by the number of days' consumption in hand. For a given farming system (type of animal production, parturition pattern...), the level and change in this balance on hand characterize the safety of supply of the forage system.

We suggest that, on a given farm, Days Consumption in Hand (DCH) of conserved forage and grazing can be a yardstick for in-season monitoring of the implementation of the herd feeding schedule. DCH can also be used as targets in the planning of the feeding practices. Those DCH will be, of course, specially fruitful in the key periods.

2. Applications

2.1. Diagnostic assessment for rotational grazing management: an experimental herd on permanent grassland (FIORELLI, unpublished)

This herd of dairy cows is raised intensively on rotational grazing in Lorraine (in the INRA Field Station, Mirecourt). For each week of the 1988 grazing season, sward height was measured on all plots allocated to the herd.

Despite the danger of over-simplification inherent in the linear shape of the growth curves for the herbage, and the supposedly close correlation between the grazing period duration on each plot and the amount of herbage there (DURU et al., 1988a), the link between the height of sward canopy (weighted for each plot) and the calculated value of Days in Hand seems satisfactory (Fig. 2a).

Milk production of the herd measured with reference to a currently-used theoretical lactation model shows initial sustained performance followed by a pronounced decline as from early August (Fig. 2b).

The comparison of available herbage upon entry on to each plot and the head of cattle and duration of grazing on each enables to calculate herbage allowance (Fig. 2c), and a relative scarcity of available forage over three periods: early June, early August and early September can be seen.

This tendency to the rather late increase in grazing pressure is in fact confirmed by continuing average sward height values (Fig. 2d), whilst repeated movement of the herd over the area usually leads to an increase in refused herbage in the high grass areas (NOLAN and CONNOLLY, 1988). We can reasonably infer that the amount of DCH maintained at the end of the period was in fact lower than our calculations led us to believe. Had this not been the case, the height value would have been higher than the DCH value if only due to the accumulation of refused herbage. It is possible therefore to assume that the herd had been underfed whilst on pasture given the value of the DCH compared to data on sward condition, its height in this case (MATHIEU and FIORELLI, 1985).

This description of conditions prevailing over rotational grazing management supplements the traditional reports carried out in experimental conditions or in on-farm follow-up. It is then possible to compare the situation under scrutiny with that of former years and/or with other locations. However, some degree of similarity in the deciders behaviour is required, particularly as regards the consumption rate of resources allocated to the herd. This means we can envisage correlating biological data on production and efficiency of utilization with recommendations for grazing management, as J. HODGSON suggested in 1985.

2.2 Diagnostic assessment for conserved forage management: two forage systems, based on maize silage in winter (AURICOSTE, DURU, unpublished)

Conserved forage stock control is addressed here for two dairy herds in the semi-arid areas of South-West France for the years 1986 (early start of herbage growth in Spring and early onset of Summer drought) and 1987 (earlier Spring and no Summer drought). The main key period is the Autumn insofar as consumption of stocks constituted in Summer can be adjusted and control of turning out dates in Spring will be affected by the size of the maize harvest. Moreover, the date and conditions of rye-grass seeding determine the productivity of pastures for grazing and silage production in the Spring.

Farmer A allowed 10 ares per cow for 3 or 4 months in Spring, and fed the herd on grass silage in the Summer. He irrigated his maize crop. Farmer B allowed about 20 ares grazing per cow, which provided about 50 % of her feed ration. He did not irrigate his maize crop.

We present below the forecasts and adjustments made by the two dairy farmers whilst adapting to two years' differing climatic conditions.

Farmer A: In May 1986, he was faced with an early shortfall of herbage accumulation for grazing and, exceptionally, watered his meadows, thus gaining a month before opening his grass silage tank and therefore not encroaching overmuch on his Summer provisions. He planned to offset the probable maize crop deficit by increasing the silage area (maize originally intended for cob harvesting) or proceeded to enrich straw silage with ammonia. In September, he finally chose the initial solution (Fig. 3a) and allocated 30 % more surface area to silage than planned at seed time. This adjustment meant he could build up a safety net and have a mixed ration available (grazing and silage) throughout the next grazing season in Spring.

In the Spring of 1987, strong herbage growth led to the farmer reducing his grazing area by 30 %. The surplus grass was made into silage. By the same token, strong maize growth meant that 10 % less surface area of maize would be made into silage.

Farmer B: The proportion of grazing in the Spring and Summer is higher than for Farmer A so that the level of conserved forage is much lower, particularly for maize silage.

In the Spring of 1986, the farmer sowed 30 % less maize than planned because of the drought. Against the risk of a shortage of pasture, the farmer preferred to harvest a second crop of rye-grass, but by then possible sowing dates for maize had gone by. This, plus the lower herbage growth, led the farmer to buy in maize up to 50 % of his conserved forage (Fig. 3b). In fact, despite everything, he enjoyed an early growth of rye-grass which allowed him to top the meadow earmarked for silage. Later in the year, the steady growth of herbage meant that he did not have to fertilize the grazing areas. Heavy Summer rains meant that 60% of the maize silage surfaces could be harvested whilst keeping a stock level well above that of the year before.

The level of forage security sought for the two commercial farms is different. Even in a favourable situation, such as the Spring of 1988, the number of Days in Hand is higher for Farmer A.

The management control aspect is better on Farm A. Weather conditions for the two years were very different, and yet the variations in the Days in Hand for each are slight (8 %), given the variations in surface area allocated to silage (35 %). The same applies to grazing management. It appears that Farmer A has a more finely adjusted technique than Farmer B and he manages to meet his targets better in variable environmental conditions.

2.3. The delicate spring period for grazing and conserved forage management on a farm (MOREAU, unpublished)

This dairy farm in the South-West Massif Central uses various types of forage cover (natural pasture, ray-grass, alfalfa, cocksfoot and maize).

Key periods here are the grazing season (when there are contradictory demands on grasslands: ploughing up leys for maize planting, limiting refused herbage and upholding the quality of the feed ration) and, on the other hand, initial grass silage production, since the regrowth of pasture available for grazing as from early June depends on the latter. This period is particularly delicate to manage since if there is surplus herbage, silage production from rye-grass plot must be feasible sufficiently early to allow subsequent planting of maize.

A major feature of the year in question (1985) was the heavy rainfall in March and June which delayed turning out and hay-making respectively. A marked period of drought from late July to late October meant there was neither hay nor silage available when the cattle were turned out the next Spring. Freak weather conditions (snow in early May) meant the farmer was forced to graze weight-resistant plots initially earmarked for silage. To offset this, the farmer planned to sow an extra plot of maize after ploughing in the rye-grass as soon as it was grazed. All these steps considerably delayed the end of the first cycle (See herbage age Fig. 4a7) and jeopardized herbage regrowth potential for the Summer. The situation got worse without any decision being taken by the farmer since the grass silage was made late. We then understand why conserved forage had to be added to feed rations as early as 20th July (Fig. 4c) although the degree of drought alone did not explain it. The drought in fact persisted and despite the increased silage maize surfaces sown, the farmer had to buy in the equivalent of 40 days of hay for the Winter.

This system has a low safety margin. The calculation of Days in Hand per grazing cycle (fig. 4b) adds detail to our analysis: the initial grazing cycle is too long, thus, the Days in Hand for the second cycle are insufficient despite a considerable increase in the grazing areas.

3. Conclusion

First calculations of DCH show that this approach could be used in experimental or commercial farms in two ways for help to decision making.

3.1. Elaboration of the yearplan: different Days in Hand targets for different systems

Initial calculations of this criterion for farms demonstrating good system control over a number of years show a certain level of constancy whatever the random factors. Various types of adjustments (conserved forage distribution, reduction of grazing areas) mean the Days in Hand remain within a certain range. It is as if the farmer had a previsional plan which he uses to decide on the implementation of techniques.

On pasture, we observe that the number of Days Consumption in Hand differs widely according to quality requirements for grazing: a high-performance dairy herd may work with 10 to 15 DCH, whereas in the same region, a herd of suckling cows might attain 30 to 50 DCH. Secondly, the number of Days Consumption in Hand, especially for conserved forage, depends on the level of security of supply required and the proportion of grazing in the feed ration.

3.2. Monitoring and follow-up of yearplan implementation: a prerequisite for forage system control

The Days in Hand yardstick is one the indicators that can be used for precipitating decision-making on forage stock control and grazing management in the Spring. To be operational, it must be easily correlated to the state of the vegetation on the plot, sward height, for example or other wider-based physiognomic state (MATHIEU, DE VAUBERNIER, 1988). Moreover, other indicators of quality must be considered. The latter are particularly important when stocking rates are high and the farmer is working in a variable environment.

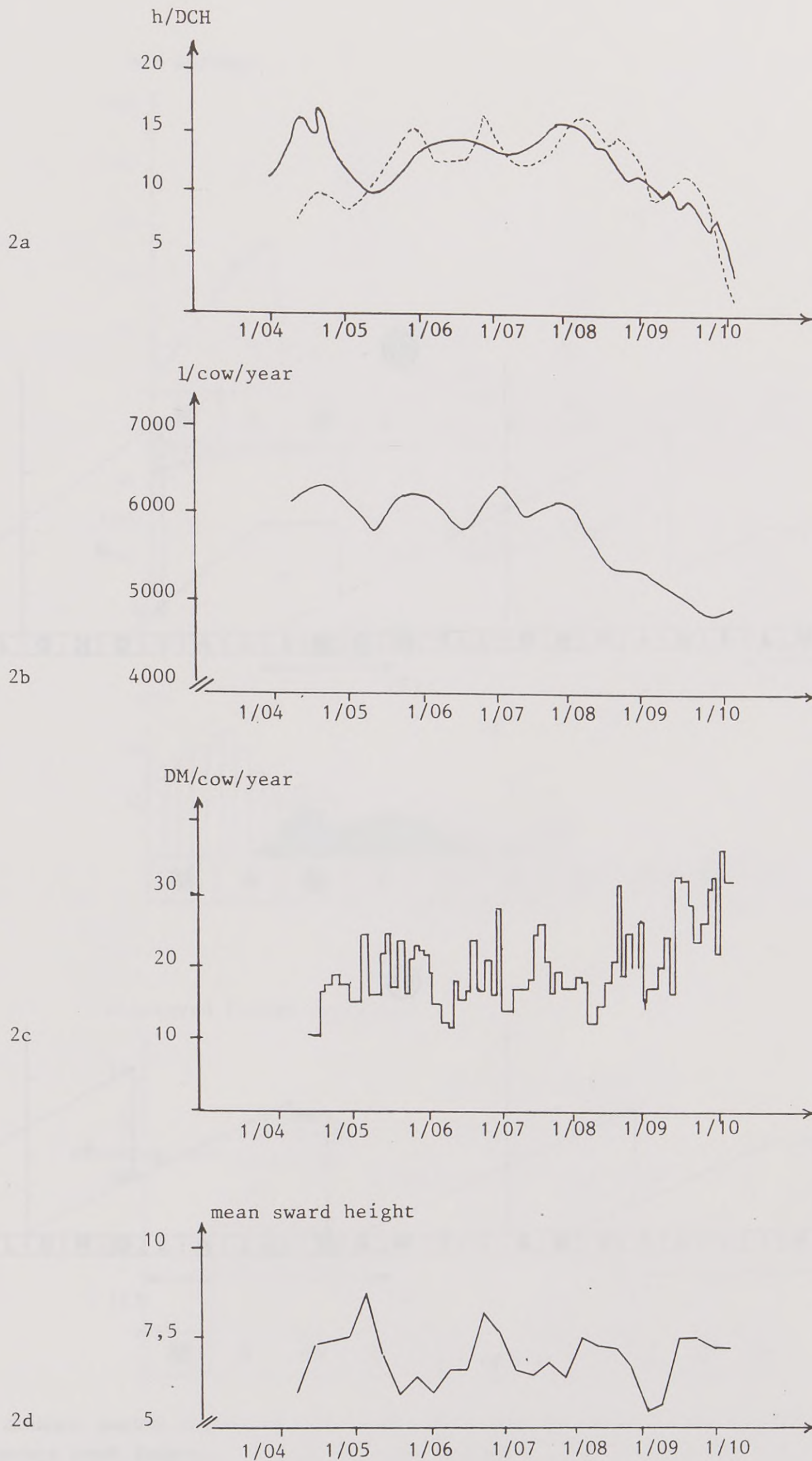


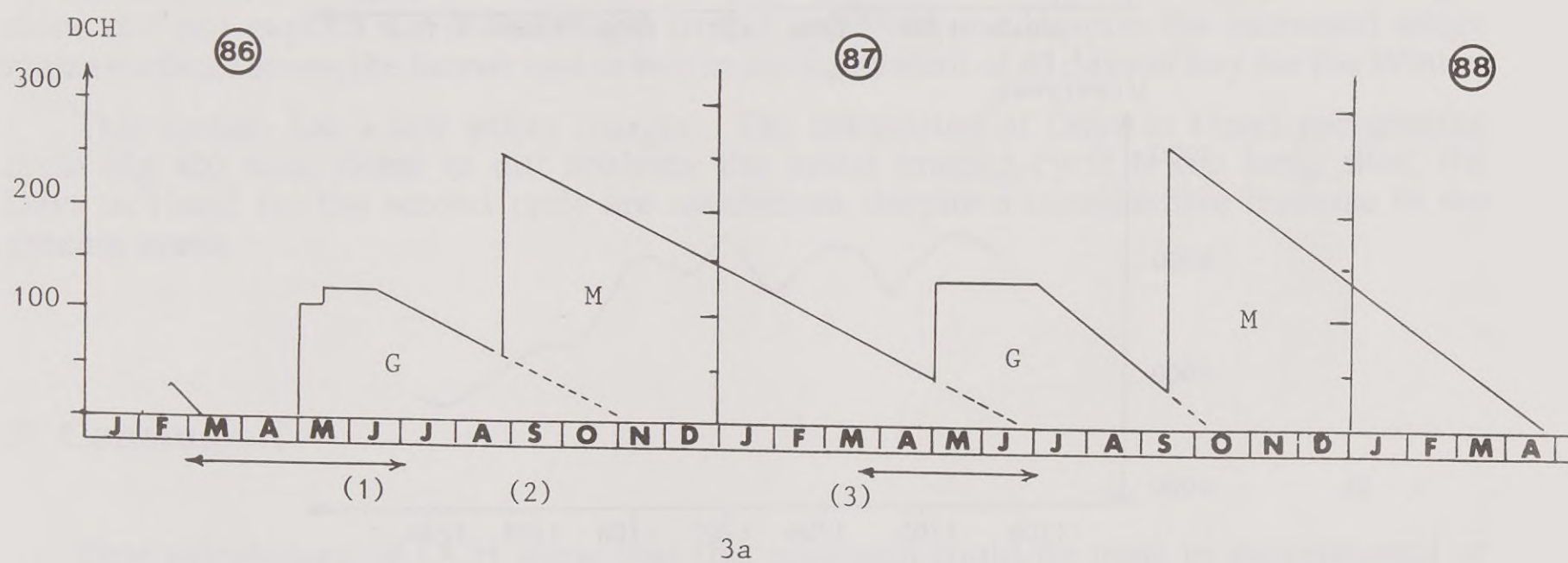
Figure 2 — A rotational grazing management for an experimental herd (1988):

Figure 2a — Sward height weighted for each plot and Days' Consumption in Hand (DCH)

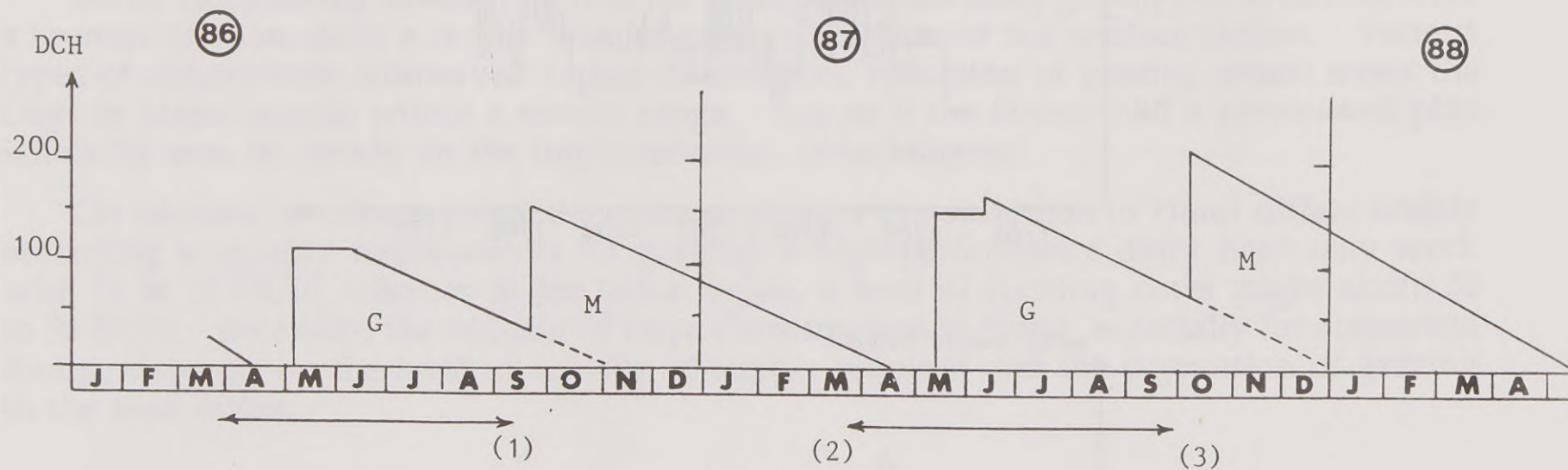
Figure 2b — Milk production (kg/cow)

Figure 2c — Herbage allowance (kg DM/cow/day)

Figure 2d — Mean sward height



3a



3b

Figure 3 — Conserved forage management for two commercial farms

Figure 3a — farm A: (1) irrigation of rye-grass; (2) increase of area for maize silage (+ 30 %); (3) decrease of grazing area comparing to 1986

Figure 3b — farm B: (1) purchase of maize silage (about 50 DCH); (2) early grazing of plots for grass silage; (3) decrease of maize silage area (5.5 ha instead of 9 ha expected)

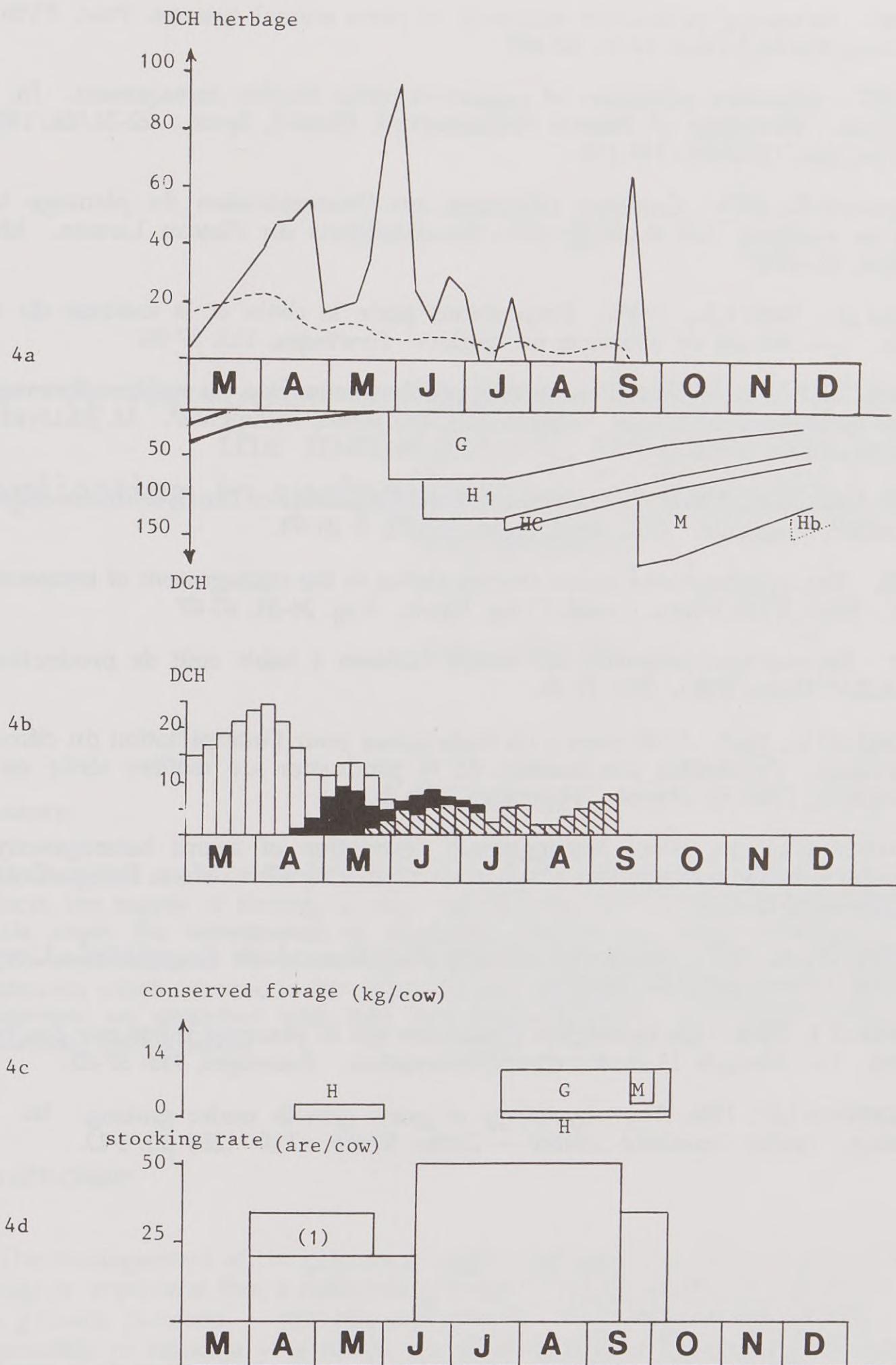


Figure 4 — A delicate period in grazing and conserved forage management on a commercial farm:

Figure 4a — forage cash balance. Y axis: DCH for grazing () and herbage age (); Y axis: DCH for conserved forage; G: grass silage; M: maize silage; H: hay (first and second cut); Hb: purchase of hay

Figure 4b — DCH according to grazing cycle first second third

Figure 4c — conserved forage distribution (hay per cow per day), (see figure 4a for legends)

Figure 4d — stocking rate (are/cow) along the grazing period (1: Spring grazing of hay area)

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Résumé :

Dans les exploitations d'élevage de ruminants, les prévisions et les évaluations de la conduite des surfaces fourragères sont généralement réalisées en termes de chargement.

Nous proposons de compléter cette méthode par un calcul de trésorerie fourragère. L'évaluation proposée concerne la résultante de la production et de la consommation des fourrages au pâturage et en stock. Elle est exprimée en nombre de « jours de consommation d'avance ».

Nous donnons quelques exemples de calcul pour des élevages bovins laitiers. Enfin, nous suggérons que cette approche permette d'aider au choix d'un système fourrager et au contrôle de sa mise en oeuvre.

A viewpoint on herbage systems in farms: the management programme Application to spring pasture management in the Jura Mountains

Anne MATHIEU

Summary:

The alimentation needs of dairy cattle herds in farms are not very variable between years. Facing this facts, the supply of herbage is very variable, due to the climate. Steady alimentation of the animals imply the introduction of regulation mechanisms. These regulations, linked with the farmer's objectives and the course of the season, are presented as a programme. The different programmes which are used in the second plateau of Jura Mountains (France) for the spring pasture management are described with their determining factors. The interest of such a typology of programmes are discussed.

Introduction

The management of the grazing of high yield dairy cows is a complex process. Indeed it is highly important that a sufficient quantity of good grass is available for the cattle. But grass growth patterns — quantity and quality — depend on the climate. Therefore it is not possible to forecast — a month or more ahead — either what quantity of grass will be available on a given area, or what area precisely will be grazed.

Moreover, GILLET et al (1980) showed that, if although consumption by animals follows grass growth, a grass excess or deficit at a given moment is only amplified later on. Then a rigid grazing plan, fixed in advance, cannot be followed.

Our aim is to provide better adapted tools to help managing this complex system.

The first step of the work presented here was to observe on commercial dairy farms what decisions are taken in spring for the adequate functioning of a pasture. This account is based on the systems theory.

1. Definition of a programme for a grazing plan

For Melese (1968), to pilot is "to choose an aim, to define the best trajectory, to launch the machine, then to permanently correct its variation with respect to the trajectory; possibly, it is to modify on the way the trajectory, or even the target when informations concerning the state of the outside world and the behaviour of the machine show that the original plan cannot be maintained".

We assumed that grazing is largely programmed in the farmer's mind before the start of the grazing season (SEBILLOTTE and SERVETTAZ, 1988; DURU et al, 1988). This is coherent with the fact that the organization of forage area management cannot be questioned each year. This programme includes three aspects: objectives, course of the grazing season and regulations.

1.1. The objectives

At our working level, the general objective is the predictive distribution of animal requirements over the year, which are linked with the farmer's objectives for animal production. Articulation between this cycle of the animal needs and the cycle of forage supply are strong; therefore farmers also have objectives regarding the distribution of forage supplies over the year. But needs as well as supplies are not greatly controllable.

For a day to day management, farmers need to have intermediate objectives for the state of their biological material. For instance a minimum nutritional state is necessary for adequate fecundity of the animals; a minimum growth must be reached before the first fecundation of heifers; a minimum leaf area index is required for good regrowth. These indicators permit to implement the regulations.

1.2. The predictive trajectories: the course of the grazing season

In a given region and for given production systems, rough adjustments between the predicted animal needs and the rhythms of resource production are forecast. The adjustments are independant of events in any given year. They are the back-bone of the grazing system.

For instance in the Jura massif, grass growth slows down in summer, requires an enlargement of the area grazed by the dairy cows in spring, on fields cut for hay in the first cycle. This extension occurs early (generally beginning in July) on some farms, later (beginning of August) on others.

1.3. Corrections readjustements with respect to the trajectory: fine regulations

Each year farmers use fine regulations to adjust to the particular events of that year. What we called the course of the grazing season is not questioned.

Thus in 1980, when rainfall prevented hay-making before July the 20th, no farmer could enlarge the grazing surface before the beginning of August. Therefore farmers who usually extend their grazing area early needed to introduce fine regulations.

These fine regulations occur because farmers have to offer their cattle, on each day of the grazing season, a parcel in a "grazeable" state.

The variables which define a "grazeable" state are at the minimum the quantity and quality of the grass and the accessibility (trafficability in particular) of the resource.

During rotational grazing, herbage quantity and quality depend:

— on the speed of regrowth, which is linked with the condition of the sward at the beginning of the regrowth preceding the stay of the cattle, as well as with available nitrogen, with the climate during regrowth and with the characteristics of the parcel.

— on the duration of regrowth.

The regulation which may be introduced to modify this quantity and this quality can be:

1.3.1. Regulations of regrowth speed

At the beginning of regrowth, grass sward state can be modified by mowing refused herbage, or by adding nitrogen fertilizers. These regulations do not remove the uncertainty concerning the quantity and quality of the grass in the next grazing. The direction of their action can however be predicted: mowing rejected tufts delay regrowth but give a more regular sward and application of nitrogen speeds up grass growth.

1.3.2. Regulation of regrowth duration

With rotational grazing, in case the surface is constant, the duration of regrowth in a parcel is equal to the sum of the stay durations on the others.

It is possible to modify the grass growth duration in a parcel:

— To alter the time the cattle remain on the other parcels. Other conditions being equal, to modify the duration of their stay in a parcel means to modify the consumption rate¹ of the herd. This regulation has an immediate effect on the regrowth duration in the other parcels and does not require to be prepared. Its consequences on regrowth in the modified parcel can be important. But such regulations tend to amplify the problem in the course of the next grazing (GILLET et al, 1980):

- If one wants to lengthen the growth duration because one fears a shortage of grass, one is led to lengthen the duration of the grazing on other parcels and therefore to increase consumption rates. The start of regrowth on these parcels will be delayed and the duration of regrowth will have to be lengthened during the next grazing.

- If one wants to shorten the regrowth duration, for instance during stem elongation because quality is deteriorating, the consumption rate must be decreased on the other parcels. This can induce rejected herbage, which will later on produce a quicker degradation of the quality of these parcels.

The consequences of these regulations depend on grass physiology and vary with the period of the year. Over-grazing in early spring can reduce growth at stem elongation, which is rather beneficial, but it may turn out to be disastrous at the beginning of summer in case of drought. Similarly, a lowering of the consumption rate will have lesser consequences in summer than during the reproduction phase of grass. These regulations can be introduced only if a compensation or another regulation in an opposite direction is brought in later on.

— Modifying the order of parcel utilisation. If the rotational grazing is based on parcels in various meadows, the order of the parcels can be changed in the course of the grazing. Some parcels may have a quality which deteriorates quicker than others or a higher sensitivity to dryness. But such modification of regrowth duration in a parcel always implies an other one in the opposite direction on an other parcel.

If two parcels can compensate one another, this regulation is quick to work out without any preparation or important consequences.

— Modifying the grazed surface by addition or subtraction of a parcel. In the first case this parcel must be in a "grazeable" condition.

To prepare this parcel requires an important anticipation of this regulation.

The withdrawal of a grazing parcel is easily done by mowing and stocking the resource when grass in pastures is abundant and when other animals are not available to graze this parcel.

Generally mowing, at the beginning of the following regrowth, leaves a state less favourable to pasture growth as leaf area index is lower. If a regrowth is needed to reinsert the parcel into the next grazing, mowing must take place before the date when grazing should have taken place. It cannot be much differed. At this time, there must be favourable weather for drying the hay or a silo has to be built to absorb this small volume of silage. The silage round-baler may perhaps provide an important element of adaptability.

— Modifying the number of grazing animals. This modification involves increasing or decreasing the length of stay on the parcels with a constant consumption rate. This means acting upon regrowth duration on the other parcels. In the case of dairy cows, modifying animal numbers is achieved in two ways:

- By drying some cows and withdrawing them from the herd. Technical advice recommends drying two months before calving. In fact this period can be shortened or lengthened to alter the duration of passage in the parcels. However the degree of freedom does not exceed a few weeks around the date of drying. This regulation is therefore limited in time and scope. It also requires that the surface allocated to dried cows is not limited.

- By modifying the dates when the cows ready for calving are introduced into the herd (heifers and dried cows). Here again the regulation is limited in time and fixed by the predicted calving dates.

— Modifying the addition of external food to the grazing. To add outside food reduces the amount of grass consumed on the pasture and therefore for an identical consumption rate increases the duration of the stay on the parcel.

A diet transition must be operated. The regulation cannot be immediately carried out. This can be overcome if outside food — in lesser quantity — is distributed all through the grazing period.

This regulation needs to be anticipated: stocks must be available. For zero-grazing the resources must be prepared. If they have not a double use (for instance zero-grazing and silage), the requirement to end with zero-grazing introduces rigidity. If silage is distributed, it must be consumed quickly enough to avoid mould and this also implies rigidity in grazing. Time when this regulation can be used is fixed by the possible opening dates of silos or by the availability of resources for zero-grazing.

1.3.3 On the production target

When it does not exist, or when one does not want to introduce a regulation which will bring back the resource of a parcel in a suitable state for grazing, a decrease in the dairy production can be accepted. This does not need any preparation.

If the depressed production is due to insufficient grass quantity, the overgrazing which may ensue may have consequences for future regrowth. As regards animals, there are only few references on the long term consequences of a production decrease. Certainly there is an interaction between the lactation phase when the decrease occurs and the amount of this decrease. The beginning of lactation is probably a phase sensitive particularly. Observations in farms show that, when a production decrease of about 10 % occurs

in mid-lactation, it has no effect on return to normal production when feeding conditions become more favourable.

1.4. The coherence of a programme

A regulation can be defined as a choice between several alternatives in a given period. Our study is based on the hypothesis that, in a farm, regulations used are few in number, and are determined, independently of the unfolding of the year. The state of animals or of meadows determine only the alternative, and the regulation intensity, but not the type of regulation.

Relations exist in a farm between regulations and the course of the grazing season and the objectives of the farmer. For instance, a regulation which is made of a more or less early drying of cows can only be used around the predicted period of drying. This period depends on the objectives on the animal production distribution over time. Conversely, the objectives and the course of the grazing season can be determined by the possible regulations. Some periods, during the year, are called "key-periods" (DURU et al, 1989). During these periods, an important gap between the target-state and the real state question the system functioning. For instance the female fecondations, the beginning of lactation, the sowing, take place at key-periods. Although it is very important that target-states are reached during these periods, they must occur at a moment where regulations can be well controlled. Then there is a coherence between the three elements of the programme which we have first described.

2. An application of the programme; the management of dairy-cow grazing in the Jura mountains (800 m. high)

2.1. Variability of grass growth

The spring season, that is to say the period between turn-out and the enlargement of the grazing area on hay regrowth paddock can be split into three parts:

- The beginning of grass growth, when growth rate is low². The lowering of temperature is frequent and leads to a slowing-down of grass growth. Then the risk is a shortage of grass.

- The stem elongation-spiking phase during which grass growth is very important. The risk is then to have more grass than the herd can graze.

- The following period, from June the 20th is marked by a physiological slowing-down of grass growth due to tillering crisis which occurs during stem elongation. It is a stage during which dryness can strongly affect growing rate.

This period ends with the enlargement of the grazed area on a surface previously mowed. Because milk is processed into cheese, feeding silage to cows is prohibited. The start of hay-making, depending on pluviometry, is quite variable from one year to the other. The variability of the possible surface enlarging date is high.

Therefore the risk of a grass shortage is very high in this period.

2.2. Typology of management of dairy-cow grazing in spring

An investigation carried out on 25 commercial dairy farms enabled us to detect several management plans during spring.

2.2.1. Type of programme n° 1 (37 % of farms)

The grazing area is rather small for this region and turn-out of the cows is carried out with a small quantity of grass. In May the grazed area can be enlarged with an area reserved for mowing. This buffer grazing occurs after a first graze on the grazing surface, at the end of May.

This grazing on a mowing parcel has another function than the grazing regulation in May: it also prepares the parcel for a new grazing at the end of June in case of shortage of grass. Indeed, at the end of June the other areas cannot be grazed; either they have just been mowed and have not yet regrown, or they have not been exploited and the grass is too high to allow grazing. A parcel which has been grazed at the end of May, can still be grazed a month later.

When grass growth is quick during stem elongation the grazing area—which is no very large — generally allows a good mastering of spiking.

This type of programme aims at managing a grass shortage.

2.2.2. Type of programme n° 2 (19 % of farms)

The pasture is far from the cowshed and milking takes place on the pasture. In order to achieve a good transition between winter period and grazing, the dairy cows are turned out on a mowing parcel around the shed. Therefore this parcel supports a very early grazing beginning of May. It will be used as a buffer surface for grazing at the end of June, only if it has been regrazed in between. The decision to regrazed the parcel must be taken at the beginning of June, at a time when grass is plentiful on pasture land and with a grass shortage end of June being not yet predictable.

Another difficulty of this type of programme is the mastering of grass growth on the pasture. Indeed the dairy cows enter the grazing surface only at a late date not much before stem elongation. In some cases, the heifers graze in the pasture of the dairy cows, before the arrival of the latter. For heifers the requirements in grass quality are less severe and the later entrance in their own pasture is tolerable.

2.2.3. Type of programme n° 2-1 (10 % of farms)

The pastures are far from the cowshed but they are clearly more late than the surfaces near the building, because of altitude differences.

The turnout of the cows and the transition between winter feed and grazing occur on the pastures near the cowshed. But the transition period is finished when the distant pastures have not yet a great amount of grass.

Among the parcels in which are the pastures, there are mowed surfaces. A type of programme n° 1 has been shifted in time. After a passage on the pastures, the cows are led to graze a parcel planned for mowing, parcel which can be used again as a buffer for grazing at the end of June, or beginning of July.

2.2.4. Type of programme n° 3 (24 % of farms)

These farms have only a low stocking rate. They are also characterized by calvings spread over the whole year, or starting very early in August. Consequently there are dried cows as early as the end of June or even earlier.

A nitrogen fertilizer is spread on the grazing surface before cows enter it. The grass available in the parcels is plentiful when the cows start grazing. The risk of lacking grass before stem elongation is slight. In case of shortage, hay, which is always available, can be distributed end of May.

This type of programme often leads to an excess of grass at the time of fast growth during stem elongation. The cows create quite a heterogeneous state of the sward, with well grazed parts and rejected tufts.

These heterogeneous grass is afterwards used by two herds, successively: in leader, the dairy cows consume the regrowth of well grazed parts. Just after, as follower, the dried cows eat the rejected tufts. Such two passages can be done in the grazing surface from the end of June.

End of June regulation is essentially carried out by means of the respective number of both herds, advancing or retarding the dates of drying according to the proportion of good quality grass with respect to rejects.

2.2.5. Type of programme n° 4 (10 % of farms)

The collective communal surfaces are at the disposal of farmers. As soon as there is a risk of lacking grass in pastures, they put a variable number of cows on the collective surfaces and they can put them back into their pastures as soon as the shortage is over. This regulation, which seems quite versatile, can be applied only in some cases. The quality even the quantity of grass on the communal surfaces is not very high and is able to feed only low yield animals. This type of animals — generally cows at the end of the producing period — has to be available at this very time.

Conclusion

This view-point on the grazing management, in terms of course during the season and regulations, provides other means to evaluate than the productivity balance. This allows to approach evaluation in terms of flexibility and sensitivity (DURU et al, 1987).

Table 1 shows the differences between the types of programme just described. The choice of the adoption of a programme in a farm is not very large: it is bound to by the major constraints or favorable factors for types 2, 2-1 and 4, and type 3 requires a special calving distribution over the year. Then, the clarification brought by the typology can be a guide for advisors in the choice of a programme.

An other aspect of the use of this typology is to provide a guide for a day to day aid for management. Important differences in crucial decisions (table 1) involve needs of advices of different kinds for each type of programme. Precise tools for decision making aid, as indicators for observation, have to be elaborate inside each programme.

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Résumé :

Les besoins des troupeaux dans des exploitations de vaches laitières sont peu variables d'une année sur l'autre. Face à cela, l'offre en herbe, qui dépend du climat, est très variable. L'alimentation régulière des animaux nécessite la mise en place de mécanismes de régulation. Ceux-ci en liaison avec les objectifs des exploitants et le déroulement de la campagne fourragère, sont présentés sous la forme d'un programme. Les différents programmes qui existent dans les exploitations agricoles du deuxième plateau du Jura pour la période de printemps sont décrits, ainsi que leurs déterminants. L'intérêt d'une telle typologie de programmes est discuté.

NOTES:

1. Consumption rate of a resource in a surface, during a given period is the ratio of consumed resource the period to the amount of the resource at the beginning of the period.
2. In mountains, this period (May), between the turn out and the beginning of stem elongation, is short : two weeks.

TABLE 1 : CHARACTERISTICS OF THE TYPES OF PROGRAMME

Programme of grazing management	Mean stocking-rate (equivalent-cow per ha)	Calving repartition over the year	Constraints	Favourable factors	Sensitivity grass shortage in spring	Flexibility	Crucial decisions periods
Type 1	1,2	Variable	/	Hay parcels near the grazing parcels	-	++	1 - End of May : duration of the "deprimage" before coming back to the grazily surface 2 - End of June : graze or mowe the deprived parcel
Type 2	1,0	Variable	Grazing parcels far from the cowshed		+	-	1 - Mid-May : date of entry in the grazing parcels 2 - Mid-June : decision about the use of the "deprimed" parcel
Type 2-1	0,9	Variable	Grazing parcels far from the cowshed	1 - Altitude difference between cowshed and grazing parcels 2 - Hay parcels near the grazing parcels	-	++	1 - Begining of June : cf 1 of type 1 2 - Begining of July : cf 2 of type 1
Type 3	0,9	Dried-cows at the end of june	/	/	-	+	End of June : number of cows to dry
Type 4	1,0	End-lactation cows in may and june	/	Possible use of communal parcels with dairy cows	-	+++	May and June : remove from or introduction of cows in the grazing parcels

Biotechnical indicators for practical herbage management

Jacques GILIBERT and Anne MATHIEU

Summary:

The farmers will have to improve their indicators for a better herbage system management. Those indicators must be simple and synthetic. Description or research of these indicators need studies in the farm themselves, with a close collaboration between farmers, advisers and researchers. As examples, some indicators are set out in this paper. At a given time, the "physiognomic elements" method describes the state of the grass in the meadows (percentage of elements in each parcel) and the "standard graphs" method allows to assess the state of animals (levels of milk, of protein rate and body score).

Introduction

All the year long, the owner of a herd has to organise the production of fodder, its use by animals, and possible fodder purchases in order to feed his animals with correct quantity and quality.

Economic and technical changes (as total production restrictions, increase of supplies prices higher than that of products, production potential of plants and animals higher and higher, importance of quality of products) will lead to the necessity of a more and more tied management.

The problematic here is the management of a complex unit in uncertain future. Our point of view on this management refers to the systemic theory (WALISER, 1977, LE MOIGNE, 1978). A system has a structure, an organisation and internal laws which determine its functioning. With the agronomic and zootechnic knowledge, we can set models which allow the understanding and prediction of the general framework of that system. But "a system cannot be entirely deduced from biotechnical references, even supposed comprehensive" (DURU et al, 1987). Indeed such a system is also subject to important random disturbances, as climate, pathology, prices variations of products and supplies..., making

the precise system state unforeseeable at a given moment. Frequent readjustements must be used to make the system go, and the more tied has to be the management, the more capital become the adjustments.

These adjustments are realized through technical decisions of the farmers when they note a gap between the wanted and the perceived reality. That to and fro motion is the one way to control the unknown and the uncertainty of the operating of a complex system. During the year unfolding there is a necessity of regular observations of the system state.

The state observation is made through the appreciation of variables. The choice of a variable expresses a point of view about the state. We call "indicators" these variables used for management. An important part of a good decision process consists of a choice of pertinent variables, with pertinent scales of time, in regard to the objective.

We present here two kinds of indicators for herbage system management. One is about evaluation of a pasture state, the other about animal performances.

1. Definition and characteristics of biotechnical indicators

1.1. Definition

We call "bio-technical" a variable, a phenomenon where both living materials and technics are involved. At a given time, the state of the farm living organisms or biological products will be the result of the implementation of technics (or practices..., know-how) and of the own dynamics of the biological material. The term "indicator" is, for us, a descriptive which measures, reflects, but mainly synthetizes a set of complex phenomena, hard to quantify, and only at a heavy cost. The sequence of the values of an indicator allows to evaluate the functioning. The evolution will appear as a serie of juxtaposed state values.

For management, indicators are used:

- to define, for a given system, target characteristics (MANICHON, 1982) by an acceptable value range or by a threshold to reach.

- to give a prognosis about the system evolution. References about previous situations permit to have hypothesis on the evolution of the system from the observed state, and the more probable unfolding of uncertain phenomena, and then, to take a decision which permit to reach the target-values of indicator.

- to have a diagnosis about the passed decisions, by comparison between target-values and real value of indicator. This diagnosis enriches references which permit prognosis, and permit a more and more precise definition of target-state.

The indicators must comply with the qualities of any measure: pertinency, objectivity, univocity, sensibility, fidelity.

Other more peculiar qualities are as well necessary, for their direct use for management:

- simplicity: it is an absolute necessity, since they are to be implemented on an extensive way.

- accessibility: the measuring must be cheap, quick, and must not disturb the usual running of the farm.

- direct link with technics and economy: an indicator will be readily used by a farmer if he gets from it instant informations about the past and future technics, as well as about the financial gains or losses. We may quote the following examples: if the actual

milk production is notably below the aim, the financial loss is obvious, the feeding has been improper and needs an improvement. A spicate meadow means a waste (financial loss), a bad grazing and a decision to make (to mow for instance).

The precision for a management indicator utilisation is a very important point. All biological phenomena are variable. The precision taken into account must be adapted to the usual variability, and reveal a change which require a management decision.

1.2. Origin of the indicators

The management indicators used by the practitioners (called "farmers'indicators") are, at a given time, a complex mixture of traditionnal ones and external ones. The so-called "external indicators" are set up in research stations, according with the agronomical theory, in controlled conditions and, generally, through an analytic way; they are numerous and detailed. The farmers have continually to integrate those external indicators (more or less distorted) in their own know-how, so that they become useful to manage the system in a synthetic way.

It is a fact that the transfer into farms of the technics set up in research stations is often very difficult. To make that transfer more effective, we propose that researchers study in farms the practical efficiency of the famers'indicators, the real purposes of the farmers, and then propose and test the new improved indicators. Such research on farms are not easy to perform because the way a pilot manages a complex unit is difficult to apprehend: "the cognitive system is too "expert" to reveal the problems it has solved" (ANDREEWSKY, 1986).

In short, we think that an easier integration of new technics requires a ternary way (station — on farm research — farm) rather than the usual binary way (station-farm) (figure 1).

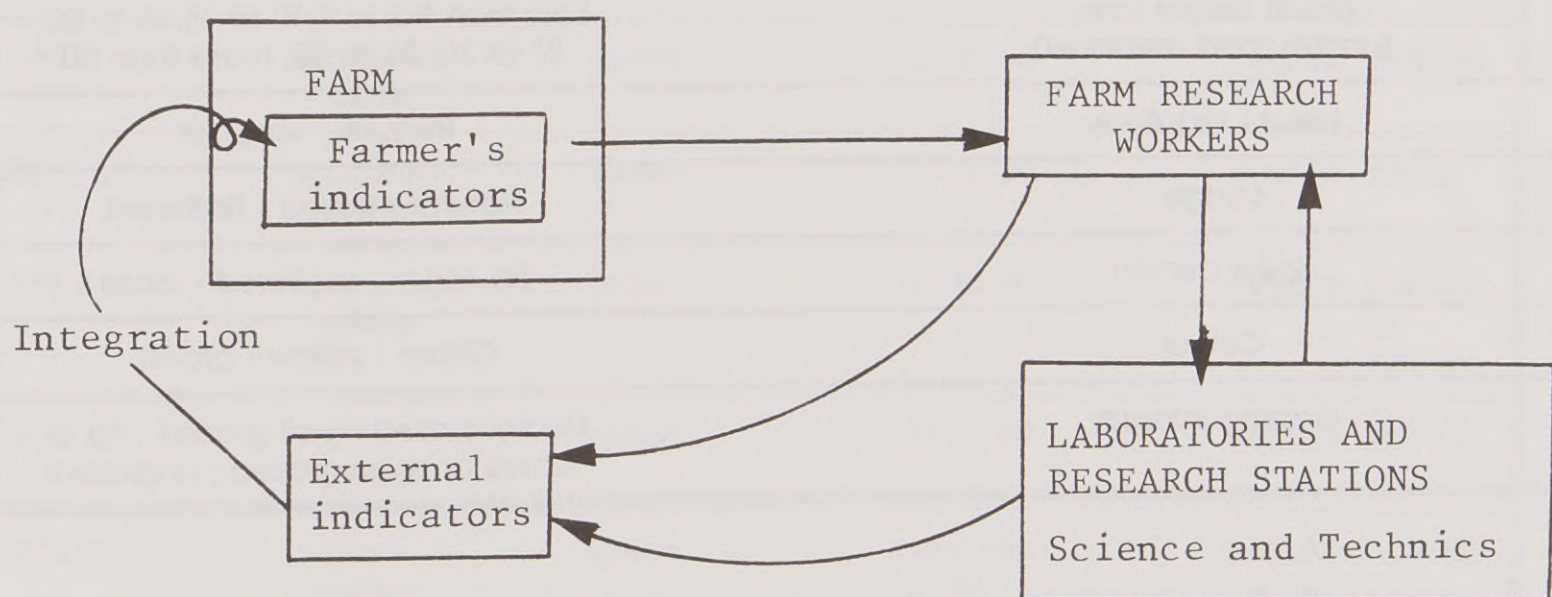


Figure 1 — Two ways of improvement of farmers'indicators

2. Indicators proposals

2.1. Description of the meadows of a grazing system: physiognomic elements

The state of a meadow at a given date depends on the state after the previous grazing, the preceding climatic sequence, animal behaviour and current management decisions; a well determined management programme predicting these states is unrealizable.

To be a good description of interaction between herbage and animals, an indicator must principally account for the further regrowth meadow possibilities and animal behaviour.

Several anglo-saxon authors propose different ways, none of them seeming suitable to our conditions of intra-parcel heterogeneity (permanent pastures, semi-continental climate, relatively low stocking rate). For instance, the analysis of tiller structure (TRATCHER and PARSONS, 1983) does not aim at management, the mean meadow height (HODGSON, 1985; PARKER, 1987) is suitable to relatively homogeneous parcels.

A visually heterogeneous meadow is made of vegetation spatial units. These elements have a size of at least some square decimeters (rejected tuft), but they can cover the totality of the plot. If there are spatial differences in nutritive value, or in the induced livestock grazing behaviour, or in regrowth potential, distinctions are made. These spatial units are called "physiognomic elements". Criteria selected to describe them are presented in table 1.

Table 1 — Criteria of description of physiognomic elements

Variable	Modality
Mean height (cm) (undisturbed meadow)	Less than 5; 5 to 9; 10 to 15; 16 to 20; 21 to 30; 31 to 50; more than 50
Height regularity	Regular - irregular
Lodge	Natural - Rayed - flattened
Spike density	No spike - scattered - close
Colour	Green - yellow - brown
Grazing intensity	Heavy grazed ; well grazed ; tip of leaves or spike grazed ; ungrazed

In a controlled grazing system, descriptions of physiognomic elements were recorded during five years. On the 530 elements described, we made a hierarchical cluster analysis after a correspondance analysis. 13 classes were obtained (Table 2).

Percentage of surface of each class is determined by notation of 50 to 100 randomly choosen points per parcel, of the physiognomic elements clusters present in each point.

It is the type of physiognomic elements, and their surface percentage in a parcel, which is proposed as management indicator.

We showed that such a characterization of the meadow allows a good understanding of variations of milk production curves according to grazing farmers' practices (MATHIEU and de VAUBERNIER, 1988).

Until then, that indicator is used "a posteriori" to assess the grazing management. First studies in farms show that different grazing strategies correspond to different successions of target states. Its use for actual management needs the establishment of target states references.

Table 2 — Physiognomic elements clusters

Cluster name	Structure	Colour	Height (cm)	Height regularity	Habit
GL 1	leafy	green	5 to 9	regular	natural
YL 1	leafy	yellow	5 to 9	regular	natural
GL 2	leafy	green	10 to 20	regular or irregular	natural
GL 3	leafy	green	21 to 30	irregular	natural or layed
GL 3, L	leafy	green	21 to 30	regular or irregular	layed
GSS 1	scattered spikes	green	less than 20	regular or irregular	natural
BSS 1	scattered spikes	brown	less than 20	regular or irregular	natural
GSS 2	scattered spikes	green	21 to 50	irregular	natural
GSS 2, L	scattered spikes	green	21 to 50	irregular	layed
BSS 2	scattered spikes	brown	21 to 50	irregular	natural or layed
GCS 1	close spikes	green	31 to 50	irregular	natural
GCS 2	close spikes	green	more than 51	irregular	natural
GCS 2, L	close spikes	green	more than 51	irregular	layed

2.2 Observations on animals

The meadows are used to feed animals. The most pragmatic way to control one's herbage gestion (quality and quantity) is probably to measure the results on animals. Here again, that is an old method, the modern improvement consists in regular measurements and their facing to norms and objectives.

2.2.1. Scales of time

The annual rhythm is not treated here; three scales of time are concerned: the season (quarter), the month and the week. To explain, we have to separate, but it is obvious that some indicators can be used with various scales of time, according to the required precision.

With a season scale, the animal measures, indicators of herbage management, are numerous.

The body condition of females may be applied to all species (milk-cows, beef-cows, ewes, goats). The energetical needs of the females widely vary according to the seasons; the need-supply adjustment is never perfectly performed, and the animal has to set in action an anabolism-catabolism process of its reserves, mainly fat, in order to realize an energetical complex pseudo-equilibrium between fluxes concerning the ingestion, the body reserves and the production. The knowledge of the average body condition of a herd, at the end of each season (chosen according to the production system) is an indicator of the feeding level of the ending period. It also is an objective for the farmer, for the body condition has a return effect on production (e.g. milk), health and reproduction (REMOND et al, 1988). Simplified methods of measurement are well linked with the actual state of reserves (RUSSEL et al, 1969 for ewes; CHILLIARD et al, 1984; WRIGHT and RUSSEL, 1984; BAZIN, 1984 for milk-cows; AGABRIEL, 1986 for beef-cows). Those measures are still very little used, even if research workers have shown their practical interest (GIBON et al, 1985 about ewes; MULVANY, 1977, GILIBERT, 1989 about milk-cows).

The weight (or score) of groups of young animals are widely used in beef and mutton production (e.g. average weaning weight...). Those seasonal weighings are even included in routine standardized controls of many countries. The average weight, or score, of a lot has the advantage, for the farmer, to be, at one and the same time, an indicator about the ending gestion and a technico-economical result.

For growing and fattening lots (grazing or confined) the average daily gain (ADG) is wordly used as a tool of management. The precision on the actual body weight given by the live-weight rather incites to seasonnal measures of the ADG for grazing animals and to monthly measures for confined ones.

The monthly rhythm is chiefly adapted to milk production. The routine milk control is worldly widespread with monthly measurements of quantities and monthly (or month average) measurements of the rates (FR and PR). However, the use of those results as management indicators remains insufficient with regards to possibilities.

The weekly indicators, on herbivorous animals, only concerns milk production. Indeed the milk production is very sensible to feeding variations, indeed, at certain periods, the herbage quickly varies in quantity and quality. But how the farmer can practically act? The one realistic way seems to us the statement of the gross collected volume, with an interval of one week (if some cows calved or has been dried during that week, we take away or add their approximative production).

2.2.2. For milk cows: 3 indicators, corrected through 3 standard graphs, used together

At a given month or day, the milk quantity, the protein rate and the note of body condition are unserviceable as so. They have to be referenced primarily to the average stage of lactation.

The "standard graphs of lactation" (figure 2) have been used for a long time. Obtained from the results of a great number of lactations, they enable to link the milk product at a given month, the stage of lactation and the corresponding total lactation production, called "level of lactation".

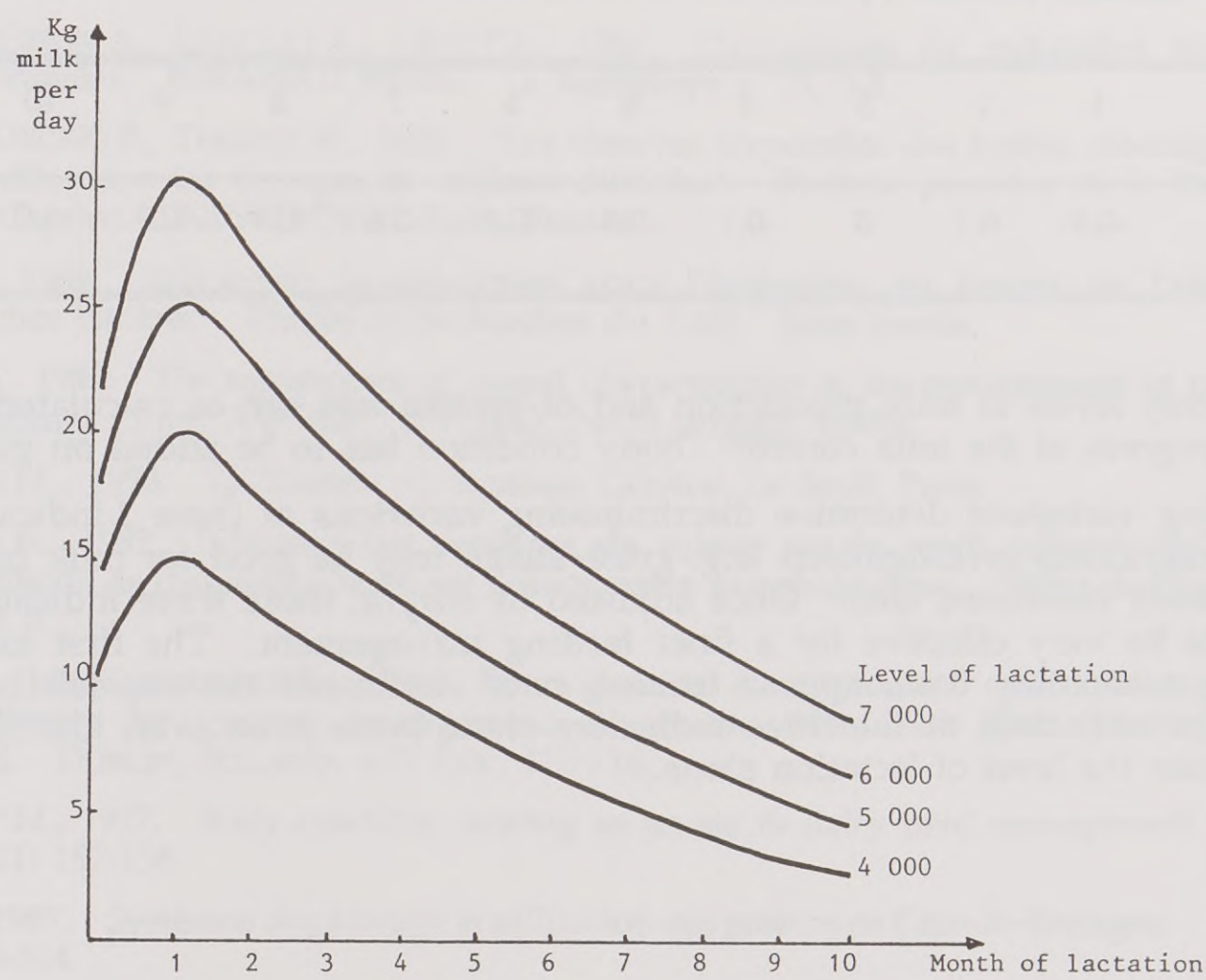


Figure 2 — Examples of “standard graphs of lactation”

First tries of protein rate and body condition “standard graphs” are now experienced in France (GILBERT, 1989) (Table 3).

Table 3 — Provisional standardized adjustments for protein rate and body condition according to month of lactation (and season for PR) (origin ITEB, INRA)

Protein rate (°/oo)

Month of lactation	1	2	3	4	5	6	7	8	9	10	11
P.R.adusjt-ment (°/oo)	-1,3	+2,6	+2,1	+1,3	+0,4	-0,4	-1,2	-2,0	-2,8	-3,5	-4,3

Month of measure	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
PR adjustment (°/oo)	-0,85	-0,5	0	+0,5	+0,85	+1,0	+0,85	-0,5	-0	-0,5	-0,85	-1,0

Table 3 — cont.

Body condition (score, 5 points)

Month of lactation	1	2	3	4	5	6	7	8	9	10	Dry
Score adjustment	-0,9	-0,1	0	-0,1	-0,2	-0,4	-0,6	-0,7	-0,9	-1,0	-1,2

The monthly levels of milk production and of protein rate can be calculated through the routine program of the milk control. Body condition has to be added on purpose.

The feeding variations determine discriminating variations of those 3 indicators as it is shown by numerous investigations (e.g. grass-silage may be good for milk production and bad for body condition, etc.). Once adjusted as *surpra*, those three indicators, used together, must be very effective for a finer feeding management. The first explorators trials, run on a monthly base, appear fruitful: once eliminated the non-feeding events (diseases...), the variations of the three indicators show better links with identified gaps of nutrition than the level of lactation alone.

Conclusion

The indicators proposed here, and the scale of time for observations are quite different of usual yearly indicators (as mean stocking rate, or milk production per cow per year). This kind of research about indicators can be assimilated to operational research. A particular interest of that work is the concomitant use of several indicators.

Two ways of research can be proposed:

— The indicators set out in this paper are still used essentially for diagnosis. Their use for prognosis and actual management needs further on farms surveys to state precisely the target values for the different types of farmers' strategies.

— Other indicators have to be brought to the fore for that specific purpose of actual management.

Two levels of indicators can be useful. At one level, the more sophisticated ones can be used to understand the herbage system functioning: others, simpler, for direct management. The farmers have to choose between all the proposed indicators, coming from a synthetic reasoning about experimental stations and on farms research.

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Résumé :

Les éleveurs auront à améliorer leurs indicateurs pour une meilleure gestion du système fourrager. Ces indicateurs doivent être simples et synthétiques. La description ou la recherche d'indicateurs nécessite des études dans les fermes elles-mêmes, avec une étroite collaboration entre les éleveurs, les conseillers et les chercheurs. A titre d'exemples, quelques indicateurs sont présentés dans cet article. A un instant donné, la méthode des « éléments physiognomiques » décrit l'état de l'herbe dans les prairies (pourcentage d'éléments dans chaque parcelle) et la méthode des « courbes standard » permet d'évaluer l'état des animaux (niveaux de lait, de taux protéique et d'état corporel).

Analysis of the functions of pastoral areas in forage systems in the mediterranean region

Gérard GUERIN and Stéphane BELLON

Summary:

The authors propose an analysis method of landuse for livestock farming in the Mediterranean region. The approach is based on identification of functions, that is to say the defining of the objective of utilisation of each piece of land.

Most of the functions concern feed and others deal with livestock or land use constraints. Their operation expresses relative adjustment between the supply of land available to the farmer and the requirements of his livestock. The grazing system integrates intensity of use by the livestock : intake patterns.

Technical support begins with representation of the land-use system expressed as a real planned pasture grazing sequence on which comments are made.

1. Why an investigation on forage systems functioning?

For the stock farmer, better adjustment between animal feed requirements and resources availabilities of his territory makes it possible:

- to reduce production costs, in particular as far as supplementary feed is concerned, through better use of available land resources.

- to ensure his raising system through relevant allocation and use of the variety of vegetation.

Both for extension and researchers, a common territory-related strategy aiming at improving this adjustment has been the increase in the productivity of cultivated areas. Part of production is then transfered from high vegetative growth periods to periods of shortage (winter, summer) in the form of forage stocks (hay, silage). Another solution was sought outside holdings using complementary land (mountain summer pastures or lowlands for winter).

Mechanizable areas are often limited in the Mediterranean zone. Furthermore, climatic conditions are very special with considerable seasonal differences and insignificant summer vegetative growth. A transferable excess through mowing rarely exists to periods showing a deficit, including for usual stocks (namely winter forage stock).

From our standpoint, it appears to be necessary to increase the ratio between grazed and supplementary feed but in that scope available references are very limited. Precisely, the aim of this paper is to contribute to a better understanding of what part non-mechanizable areas can play within animal fodder systems and to what extent they can satisfy economic objectives. Therefore, it calls for widening the range of known technics, so that the whole pastoral territory can be used (GUERIN and HUBERT, 1987).

When mechanizable areas exist on a farm, they actually depend on a "classical" intensification logic, namely bringing together grass production and its use (or harvesting).

On the opposite, the existing diversity in vegetation (grass, shrubs and woodlands) used by the livestock farmer allows him a different strategy taking into account differences between vegetal productions: various grass covers and other vegetation layers (shrubs and trees), are growing later and have a better maintenance during the year. Therefore, they can be grazed during critical period: summer, winter, inter-seasons.

2. How the use of such a diversity in vegetation can be considered for a more appropriate on farm advice

In a livestock farm, the extensionist often has to face very accurate questions, for instance, at the plot level how to choose between different species and varieties to sow. He also has to face more general questions, concerning the management of the whole farm territory (CERF and LENOIR, 1986): for example, a problem in feeding animals during summer or a settlement project for a new livestock operation.

In fact, concerning such diversified territories, associating both grasslands and rough grazings, available references are often irrelevant.

Reality is complex: the stock farmer manages his flock (feeding, stock events...) all the year round and over various years. He precisely has to deal with the management of his food resources and his animals, to renew them and to satisfy the stock requirements.

Most of the investigations on fodder systems depend on a single point of view: whether the flock alone or the forage production is used as the only way of analysis and diagnosis. But, for us it is necessary to link both of them because we have to deal with the adjustment among several dimensions. Then we have to represent and analyse the reality as a whole and therefore to re-formulate questions asked by farmers:

What problems: requirements supplying, resources management, climatic risks?

When: which season and which period and level of livestock requirements?

Where: what are the concerned areas or vegetations?

An appropriate on farm advice requires to:

(i) identify, specify and express each of the relevant questions.

(ii) be able to use and, if necessary, create adapted references otherwise pay attention to operation and practices versus structures and states.

3. The proposed approach: characterization of the various functions of grasslands and rough grazing areas

Taking into account the whole farm areas firstly consists in describing their utilization, i.e. determining what the concerned plot(s) is(are) used for. Otherwise, the aim is to affect functions within the livestock feeding system to the different parts of the farm territory.

Therefore, we take into account the coherence of the whole technical system, we integrate the actual on-plot decision making level.

The identification of functions for each piece of land enables to build up an explanatory representation of the farm territory use, expressed in the form of a pasture grazing sequence on which comments are made, generally each of the identified functions is achieved by several elementary plots.

In fact, to describe these functions, we have been tied up to stock farmers practices; thus we make a difference between the content of the practices and the aim of the farmer: i.e. how a plot is being utilized (technical itinerary) versus why it is being used during that period (feeding, buffer role...).

The analysis therefore examines both the resource utilization objective of each plot (the identification of the function of each area) and the way to mark it.

Most of the functions concern feeding (see 4.1.). Other ones relate with areas or animals themselves, even with the farmer's management practices (see 4.2. and 4.3.).

Functions are manifold because:

(i) Requirements are different along the year. According to the kind of animal production, the flock-or each batch-will be successively in a stage of late pregnancy, production (suckling or lactating), then maintenance. Additional information can be mentioned in that scope eg. flushing or restoring body reserves.

(ii) Grazing allowance is varied in nature (native or cultivated pastures, shrublands and woodlands) but mainly in its availability: vegetation period and maintenance capacity, related to climatic conditions (GUERIN and OSTERMANN, 1986). Seven seasons have been characterized according to grass, growth and development rhythms (early starting, vegetation peaks, ear emergence...) (see Table II).

(iii) For a given objective (i.e. a physiological state and a season), actual farmers practices can meet or not the flock requirements. The adjustment can be achieved with supplementary feeding or mobilizing body reserves.

Finally, the point which determines the level of use and management of the resource is the "exploitation pattern": i.e. the year round use sequence and the extent of the intake for each grazing period.

Three intake patterns are identified and described in Table I.

"Exploitation patterns" enable to operate both on animal requirements supplying and resource reproductibility. For instance, according to the intake pattern, producing animals by selecting the best in vegetation, can meet a sufficient ration both in amount and quality, although considering the resource condition a more complete grazing could not meet those high requirements. Therefore, goats can produce daily during spring (mid lactation) as much milk by grazing whether on a rationed grassland or on a more native pasture when selecting the best ! But it will be necessary for the perennality of this last resource to control it during other periods or else with other animals, i.e. allocate another function to this area.

Table 1 - Characterization of grazing intake patterns

INTAKE PATTERN	OBJECTIVE	MEANS	EVOLUTION AND MAINTENANCE	ON FIELD DECISION MAKING	ON FIELD INDICATORS	
					FOR ENTRANCE	FOR EXIT
I	Ensure both maximal amount and quality of the ingested grass	Grazing growing grass eg. : prevent grasses ear emergence	Depends on a strict grazing management (otherwise see II and/or III)	The area is being grazed at/during a period determined on the area itself	Grass stages of growth and development	Homogeneous reduction in the grass mat
II	Increase the quality of the intake allowing the animals to select in resource(s)	Sufficient area (low stocking density) or short grazing period (with a long daily grazing time)	Selection of some plants and thus possible flora drift. This intake pattern requires III (see below) or a technical operation during other periods	The area is being grazed when the use of the preceeding one is over	Enough resources to offer an opportunity of choice Indications mostly located on other areas (see I and III)	Decrease in the choice opportunity
III	Control invasion by shrubs and senescence in grassland	Total grazing of grassland and partial grazing of the shrub annual growth. Supplementary feeding is necessary	This intake pattern maintains the resources. It may improve it during particular periods	The area is being grazed when another one must be left. It is left when "completed"		Homogeneous reduction in the grass layer and intake of some shrubs

4. The various functions we have identified

Functions have been classified within three main groups: these directly connected with stock feeding (FEEDING FUNCTIONS) those bound to land use and climatic hazards (SECURITY FUNCTIONS) and COMPLEMENTARY FUNCTIONS.

4.1. Functions directly connected with livestock feeding

4.1.1. Forage stocks functions

Livestock farmers rarely mention forage stocks making as a major problem. It appears to be less important in Mediterranean area than elsewhere, for mechanizable lands are limited and stalling period is shorter.

When they exist, those problems are mostly dealt with an increase in spring grassland production through relatively well known techniques: rational fertilizer application, improvement in grasslands sowing and harvesting...

A better differentiation in forage stocks functions can lay upon the purpose of on-farm produced forage resources (fodder quality and physiological stage of the animals concerned, complementary feeding whether compulsory or only as security).

4.1.2. On pasture feeding functions

The characterization of a feeding functions integrates simultaneously:

- (i) A description of the pair "supply/requirements" i.e.
 - the period when vegetation is utilized
 - the requirement level of each group of animals.
- (ii) The degree of requirement coverage expected by grazing.
- (iii) A first appraisal of the utilization level of the resource: the grazing intake pattern.

Therefore, each function is defined by a period of "relative homogeneity" in the "supply/requirements" pair:

- same level of dietary requirements
- same context of vegetation allowance.

Precisely both aspects are used to build up a grazing systems: various periods where the adjustment is achieved or not. Table II points out how the system can be described.

The proposed list of feeding functions is important because it expresses simultaneously the season, requirements and their level of coverage with grazing. Therefore, the expression of those various functions enables to improve the approach of supplementary feeding and other adjustments (body reserves utilization) during particular periods.

4.1.3. Functions related to flexibility in the grazing system

Areas allocated to feeding functions cannot be grazed with the expected strictness. In fact apart of plant growth period or on less productive areas, it is often difficult to make compatible satisfaction of requirements with an impact on vegetation ensuring its control.

WAITING AREAS: Namely, the sequence of areas with a strict utilization (grazing intake pattern I in Table I, generally managed with rotational grazing) requires "waiting areas" to give some flexibility to the rotational system.

4.2. Security functions

In zones with irregular climate, as mediterranean hillside lands, it is necessary to guarantee animal feeding towards plant production changes as well as to enable the expectation of new production periods on the spot (transition winter/spring, summer/autumn...) or elsewhere (other grazing areas, including mountain summer pastures).

REGULATION AREAS: These "regulation areas" (grasslands, shrublands and woodlands) are usually larger than those used with the grazing intake pattern I. Most of them are being used with the intake pattern II by productive animals to compensate a lower resource quality than in grasslands.

Security areas: Some areas are forecasted for grazing in case of late winter cold, late spring growth in grasslands and insufficient winter feed supplies. Grazing these "security areas" is optional during a transition period (winter to spring — summer to autumn). Animals leave those areas as soon as herbage production is sufficient at turning out or during

autumn. Such a critical period can also be faced by increasing stall feed, i.e. producing or purchasing more forage stocks.

The winter/spring transition, for example, can be characterized by a grazing management different from the winter one. Some of these utilized areas are already grazed during winter and used more thoroughly in case of a longer winter; the intake pattern II becomes III and the security function is hardly noticeable. Other ones are kept for this period and solely grazed in case of a difficult year. Those vegetations with high maintenance capacity (shrublands and woodlands) are often hardly accessible and without improvement operations (compulsory shepherding). They are devoted to livestock maintenance where as forage stocks or areas located close to stock housing and with proper exposure are affected to productive animals.

Table II — Adjustment requirements supplies

The year is divided into main periods from both standpoints :

REQUIREMENTS

LATE PREGNANCY
YOUNG NURSING
MOTHER LACTATION
MOTHER MAINTENANCE
YOUNG ANIMAL GROWTH
MOTHER "RECOVERY"

SUPPLIES

EARLY SPRING
FULL SPRING
LATE SPRING
SUMMER
FULL AUTUMN
LATE AUTUMN
WINTER

Then, each of these periods is qualified by the coverage level of the requirements, three grades are recorded :

1/ The area ensures production requirements : the function is then directly qualified by their type (lactation, young animal growth...).

2/ The area only satisfies maintenance : the function is called "maintenance" (maintenance of suckling ewes during winter, summer maintenance of lactating ewes, winter flock maintenance...).

3/ Finally, when the feeding contribution of the area seems to be very limited, the function is being called "stroll" or "paddock" independently from the period and state.

4.3. Complementary functions, linked with livestock management

4.3.1. Turning out to grass

When animals start grazing, part of the feed ration must be dry in order to handle the transition (danger of bloat and diarrhoea). Grass progressively becomes the base of the ration.

Animals are generally turned out to grass in early spring and sometimes later in the year:

- in spring for animals with high requirements (beginning of lactation or suckling) and sensitive to difficult weather conditions;
- even later for replacement stock which has not reached minimum weight.

There are doubtless fairly similar procedures for other feed transitions (change to chestnuts, acorns, concentrates, etc.).

4.3.2. Complementary functions

Some areas of holdings are neither used to feed animals nor planned for any particular period. They are only used occasionally. The specific use of the land determines function denomination. The determinant features of these areas are comfort (water point, shade, shelter, ease of supervision and supplementary feed) and frequently the safety of the enclosure (permanent fencing). The vegetation is considered less as a grazing resource than as shade or shelter.

Three groups of functions are identified and the same area can fulfill several functions:

- **SAFEKEEPING** of livestock: the land is used when the farmer is away. In this case the animals are able to find at least part of their ration.
- **HOLDING** (exercise, breaking): the area is used at night or at midday, avoiding to move animals to stables or pens and makes supervision easier in remote places.
- **SUPERVISION**: the plot is used for lambing, weaning, prophylaxis and sick animals, and as a pen for young animals.

These functions are important: if no land is available for them, other areas (or covered installations) are used. Management of the latter is then disturbed and operating results may be affected.

4.3.3. Daily combination of several grazed resources

Sometimes, additional grazing on an artificial grassland is practiced in order to maintain the production level.

For the so called "AZERBADE" or "SOUPADE" in south east of France, a plot is grazed during a short time as a complement another area which provides most of the feed. On this plot (often a legume fodder crop), the animal intake is always of a better quality than this of the other vegetation grazed during the same day.

An almost opposite practice also exists: it consists in a rough grazing used during particular periods (feeding transition, concentrates supply). This is always sound to a rich(er) feeding grazed or based on artificial feed.

5. Use of the idea of function of areas in technical advice

5.1. Representation of the feed system: use of land/complementary feed

The first stage consists of dividing up time into homogeneous periods (combinations of supply and demand): the same seasonal use, similar physiological state of livestock. The purpose is to draw up a succession of functions for the schedule.

The second stage results in an ordered inventory of the land used for each of the preceding periods; the type, area, grazing equipment and common technical operations are specified for each land unit.

The degree of accuracy attained is very variable (depending on what is covered by discussion with the farmer, his conception of his holding and his practices) as regards land from pens to grazing areas; function periods vary in accuracy for livestock.

Graphic representation consists of:

- showing the functions and the intake pattern;
- recording feed functions and now integrating degree of coverage by grazing of the feed requirements of the livestock concerned. The degree and type of possible feed supplements are shown against each function.

At this stage, the other functions (transition, regulation, complementary function) are also sought and represented.

An example of graphic representation is given in the Figure 1.

5.2. Advice on landuse

Technical back-up concerns both diagnosis of the situation and proposals for the future in an accurate or rough representation. The procedure includes a talk with the livestock farmer based on three levels: "strategy", "tactics" and "plot".

STRATEGIC LEVEL: the production trends selected determine a weighted sequence of functions to be carried out. Discussion makes it possible to define the most important functions and the way they fit in with other functions. This leads to siting intervention priorities related to a particular function, their consequences for other functions and the pathway to be followed to handle them.

TACTICAL LEVEL: for each function, discussion covers the type of land area and the way to use them. Stress is laid on the role of each plot — in particular to start or finish a period — and also on feed complements. An essential factor in tactical choice is that of taking into account the past (participation in previous functions) and the future (more or less numerous or strict obligations for subsequent seasons).

PLOT LEVEL: This is the concrete level of technical procedures and decisions concerning land: size of pens, technical intervention on soil and vegetation, periods and duration of use of pens. Each technical procedure is discussed simultaneously on the base of real site conditions and the use to be made of the plot, i.e. in terms of adaptation of the technical procedure both from the creation or development point of view and that of simple renewal of certain resources.

Conclusion

Technical advice on land use involves references at each of the overlapping levels — plots (grazing and forage), tactics and strategy — backed up by livestock farmers' own practices and plans. This sometimes requires specific monitoring.

Analysis in terms of functions enables:

- identification of bottlenecks in the adjustment of supply and demand;

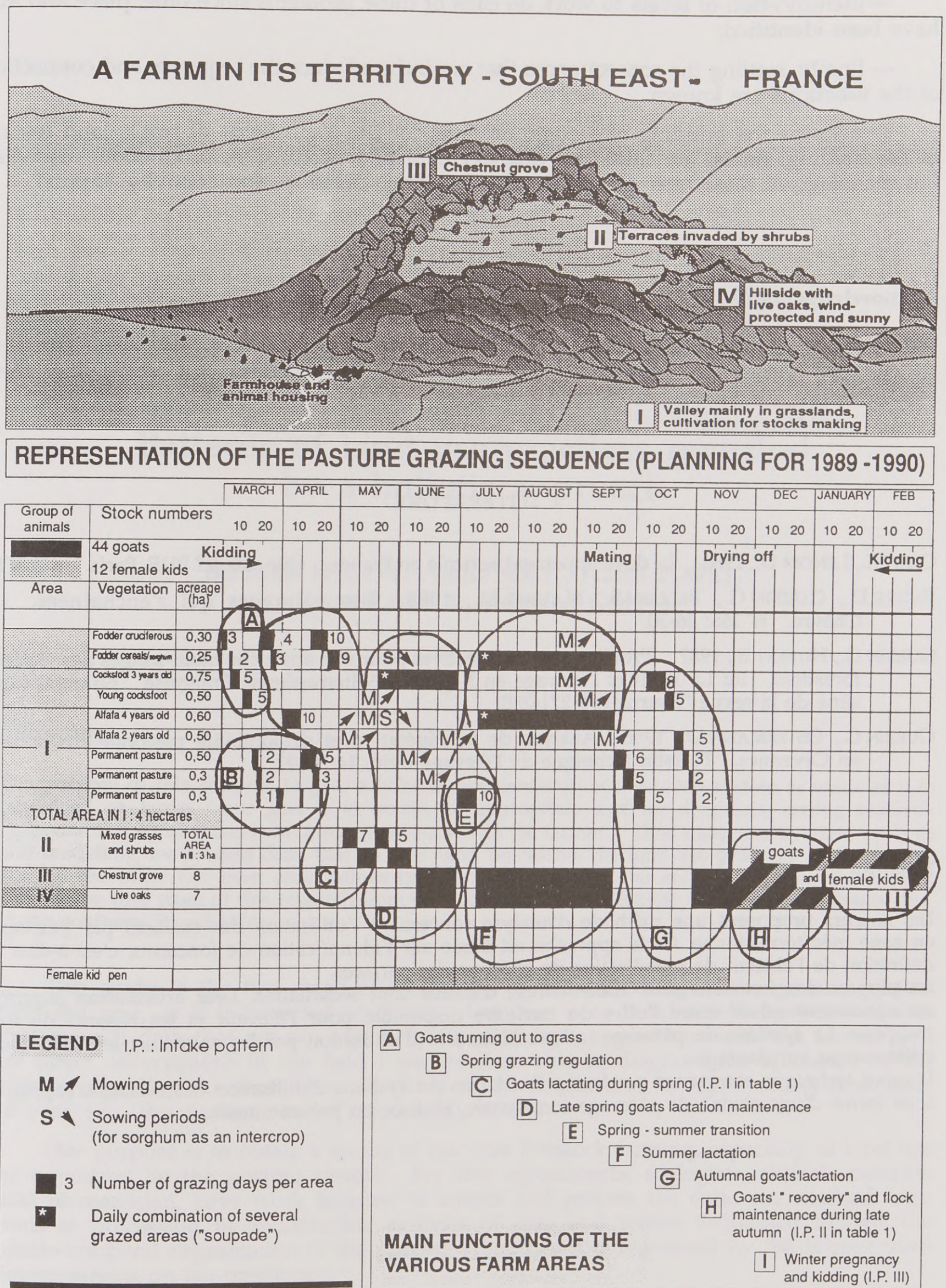


Figure 1 — An example of graphic representation of the pasture grazing sequence in a goat farm in southeastern France (from FAURE et al., 1988)

— identification of levels to work on each of these problems since time, place and aim have been identified;

— finally, settling the consequences that are induced since the sequence and connection of the functions are known.

This forms the building of a common level for the main fields of work: land (extent of the holding, fields) and livestock (management of reproduction, production, reserves), but matching all these factors requires also economic decisions (productivity, inputs).

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Résumé :

Les auteurs proposent une méthode d'analyse concernant l'utilisation des surfaces par l'élevage en zone méditerranéenne. Cette approche est basée sur l'identification de fonctions, c'est-à-dire la définition de l'objectif de mobilisation de chacune des surfaces.

La plupart des fonctions sont alimentaires ; d'autres sont sécuritaires. Leur articulation exprime un ajustement relatif entre l'offre du territoire disponible pour l'éleveur et les besoins de son troupeau. Le système de pâturage intègre l'intensité d'utilisation par les animaux : les modes de prélèvement au pâturage.

L'appui technique commence par la représentation du système d'utilisation des surfaces, exprimée sous forme d'une chaîne de pâturage commentée, réalisée ou prévisionnelle.

Grazing systems and flock management: Patterns of land use practices revealed by a holistic approach

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Summary:

The purpose of this study is to give a holistic representation of a grazing system at work as it is organized on farms ; our goal is to obtain an appropriate tool for diagnosis, setting research questions and simulations in an interactive work with the farmer. Thus using multivariate analysis and modelling we process data, that on one hand represents the land use practices of the farmer and on the other our own observations on the vegetation and the animals. In this report, we present the first stage of this research from data recorded in marshlands of the western France and in the southern French Alps.

This study is the first stage of a research on the modelling of the grazing system over the year, as it is recorded on farms. Our aim is to build a representation of this system with data that we can obtain by investigations carried out with the farmer and by direct observations in the field ; we are thus able to diagnose the efficiency of the system regarding the short term objectives of the farmer and its reproduction from year to year, i.e. the management of resource dynamics.

Our purpose is to obtain a model of real-size livestock farming, especially of land use as organized by the grazing system. For this agronomists, ecologists, animal scientists and biometrician, have work together to collect and process the data; our methodology aims at processing by multivariate analysis of data and matrix sequential models the spatio-temporal organization of the grazing system as it is expressed by the farmer from investigations on his practices.

This work has been carried out with data collected in three sites during three years: a sheep farm in the southern Alps and two suckler-cow systems in the Central Atlantic Marshlands of western France: a commercial farm and an INRA experimental station. These

examples were chosen because they deal with very different environmental constraints (marshlands versus dry hills), different kinds of livestock (suckler cows with two year old heifers and bull calves versus ewes and housed lambs); both these systems are now placed in a context of an extensive restructuring of land use due to the Government's Agricultural Policy.

The results given here deal with the use of multivariate analysis, preliminary to our modelling project. They relate mainly to:

- the general organization of the grazing system;
- the response of the different parcels regarding this general organization.

We consider the grazing system as a biological system operating through the transformation of the states of each grazed plot in relation to the decisions taken by the farmer to feed his flock and to manage his forage resources (mowing, allocating different animal groups for grazing, rhythms of grazing periods ...).

Our research attempts to answer the question "Is it relevant to look for a mathematical model allowing to retrace the vegetation changes of a land area submitted to grazing and to climatic hazard?" or closer to a functional hypothesis "Is there a "cycling" of the system after several seasons and how".

1. Data used

In order to study the evolutions of the plant resources on a grazed territory for the purpose of developing a mathematical model, we selected a number of informations which we believe to be relevant for characterizing the grazed plots and their use:

- (i) — to identify each plot with characteristics that are invariable over a short space of time (area, vegetation type);
- (ii) — to record the variations in the plant patterns occurring on the plot during the grazing period;
- (iii) — to record how these plots have been used;
- (iv) — to make a zootechnical survey of the flock in order to better understand the decisions observed and their effects on the pastures.

Thus, three great groups of variables have been elaborated (Table 1). The first aims at characterizing each plot in an "intrinsic" way. These variables are not supposed to change over time (area, botanical composition, soils, distance from the shed, trafficability...). The second group characterizes, by periods, the state of vegetation (especially quantity and quality of the resource) and the modes of use of each plot. Lastly, the third group deals with the changes over time of animal grouping and feed requirements.

The time scale chosen is a ten-day period ; this choice corresponds in fact to the maximum accuracy that can be expected for recording made directly on the farms, besides this type of period has been thought to be realistic if we take into account the evolution of the vegetation.

The plot is defined as a unit of use. If this seems obvious for fenced parcels, the same does not apply in case of a flock led by a shepherd. The allocation of the grazed territory has been in this case based on the farmer's own perception (identification of different grazing areas), recorded during the grazing period.

Table 1 — Main variables used in describing the grazing system

GROUP 1	GROUP 2	GROUP 3
"intrinsic" characterization of each plot	vegetation state and use changes for each plot	condition and feed requirement changes of the grazing animals
PLOT IDENTIFICATION		
	IDENTIFICATION OF THE PERIOD	
* Area * major types of plants * distance and location constraints * soil type * sensitivity to climatic change (trafficability...)	* state of the plot : - vegetation : resting or growth - resources : - quality - quantity - accessibility (trafficability...) * use of the plot - number of grazing days * harvesting (mowing, grazing) - grazing animals : - physiological condition - number - distribution of concentrate supplements (or not) * cultivation - operation : - types - dates	* groups of grazing animals (made by the farmer on physiological bases) * feed requirements - quality - quantity * number of animals

2. Data processing

From the tables retracing the variations, expressed in percentages, in the total area of the farm (excluding the arable land) taking this or that modality of this or that "vegetation" variable (quality, quantity, trafficability/accessibility) for all the ten-day period considered, we have used two descriptive approaches resulting from multivariate analysis: Centred Principal Component Analysis (CPCA) (LEBART et al., 1977), and Correspondance Analysis (CA) (for a review see GREENACRE, 1984). The principal properties of these methods together with the underlying theoretic Euclidean approach — when they are

applied to this particular type of table (juxtaposed percentage table as shown in Figure 1a) — are developed in LECLERC (1975). More details on our processing methods can be obtained by the authors, nevertheless they will be dealt with a further publication.

By projecting as supplementary points the data related to the changes in each plot (or unit of utilization) we were able to describe the transformations of the system as a whole, together with those of the plots taken separately (Figure 1b).

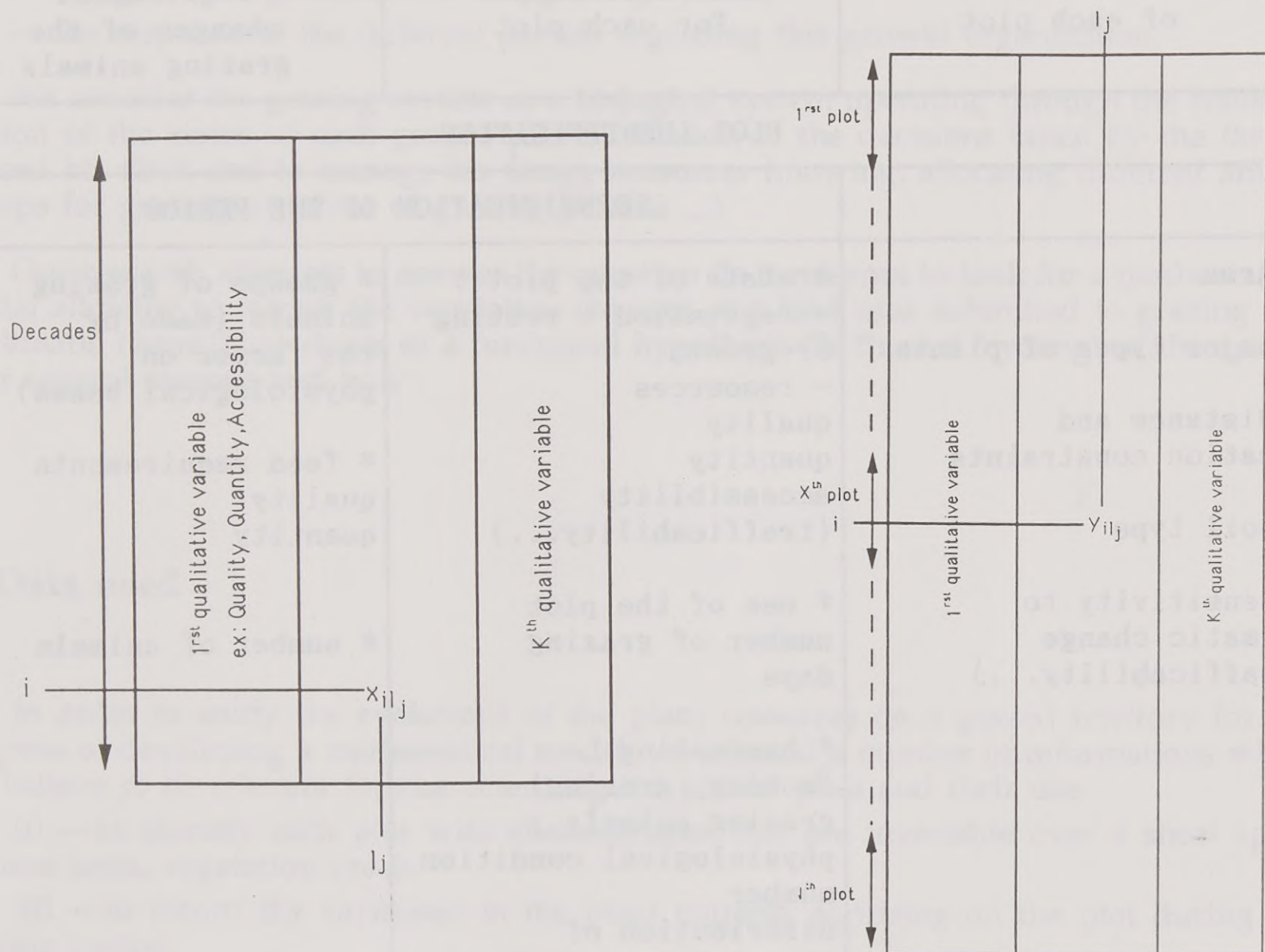


Figure 1a — Percentage X_{ilj} of surface of the farm at the i^{th} decade in the l^{th} modality of the j^{th} qualitative variable. (Table on which CPCA or CA are carried out)

Figure 1b — Percentage Y_{ilj} of the X^{th} unit of utilization (of the X^{th} plot) at the i^{th} decade in the l^{th} modality of the j^{th} qualitative variable. (Table constituting the supplementary points in the initial analysis)

This enabled us to determine different classes of operating for the plots and, at the same time, to give us the basis for our modelling project.

3. Sheep farms in southern Alps

The southern Alps are characterised by a harsh climate, marked simultaneously by mountain and Mediterranean influences: dry and hot summers, cold winters, short springs

and unstable autumns. The history of the rural communities must also be taken into consideration: land was very intensively used until the late XIXth century with extensive fertility transfers: it is now partly abandoned with the remaining activities concentrating on a part of the formally used land... The main consequences relate with soil quality, invasion by shrubs,... (de BONNEVAL et LACHAUX, 1987).

The grazing system of three farms have been monitored in 1985, 86 and 87 (HUBERT et al., 1985); the results given here are processed from data collected in 1986; the identification of "plots" on the farm territory was done with the farmer, according to his own representation and to his practices as a shepherd; each plot was then mapped and cover classes of grasses, shrubs and trees were defined; for each 10 day period from May to December, the state of the resources is given as regards available quantity (5 classes relating to the standing crop), the quality of the forage (3 classes according to the botanical composition, the phenological stage and the green matter proportion) and accessibility (3 classes for sward height, and shrub bulk). The flock is taken in account as different groups of animals, as managed by the farmer, and characterized by their feeding requirements expressed from a quality and quantity stand point (4 classes for each).

3.1. Data processing for the whole shows a strongly structured pattern: a double loop according to the seasons, with an overlap between spring and autumn related to the two growing periods of the year (Fig. 2)

This structure expresses a reorganization of the data according to the two main axes revealed by the multifactorial analysis: axis 1 is probably mainly related to the quality of the resources, increasing from left to right; forage quantity, but also accessibility, are the most important variables expressed by axis 2 increasing from bottom upwards. However, accessibility is partly taken into account by axis 1.

3.2. The position of each parcel with regard to this global structure, for each 10 day period is also represented on Figure 2 (periphery), in relation to the use by the flock. It shows:

— a dispersal of the flock, divided into groups on a great number of plots during spring and early summer;

— the grouping of the flock in summer on the higher part of the territory (except for 40 ewes brought in near the farm for lambing in late July) and in autumn to graze grass regrowth.

Thus most of the flock lactate during spring and the remaining ewes, which lamb in summer, are able to join the whole flock in October for mating.

3.3. By projecting the supplementary points on the initial analysis we can discriminate the different "trajectories", over the year, of plots submitted to different uses (Fig. 3)

- plots showing different patterns of use related to their position in the calendar:
 - plot A is a grassland intensely grazed during short periods in spring and autumn;
 - plot B is a rough grazing, that is grazed more frequently but slightly;
 - the range (C) located in altitude (plots 35, 36, 37) is used in summer only.

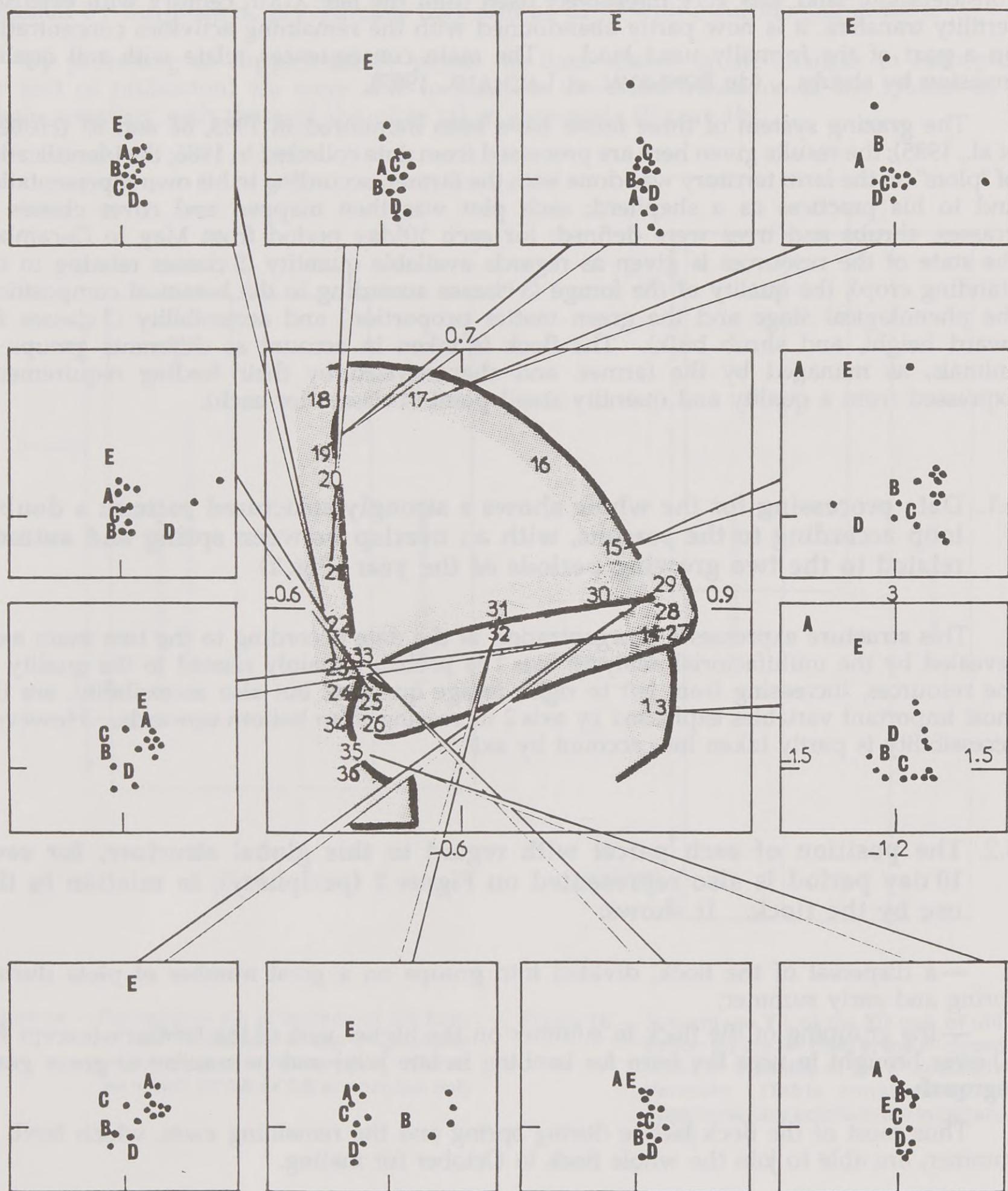


Figure 2 — Center: Projection of the table [(system x ten day periods) x plots] on the axes 1 and 2 of the CA. The figures indicate the number of each ten day period (from 13 to 36); it shows the temporal "trajectory" of the whole territory situated on the plane by the location of the number of each concerned period.

— Periphery: Projection of the table [variables x plot] for each uneven ten day period on the axes 1 and 2 of the multivariate analysis. It shows the projection of all the plots of the grazing system for each ten day period. The positions of 5 plots (A-E) are represented, see their own "trajectory" in Figure 3 (southern Alps farm).

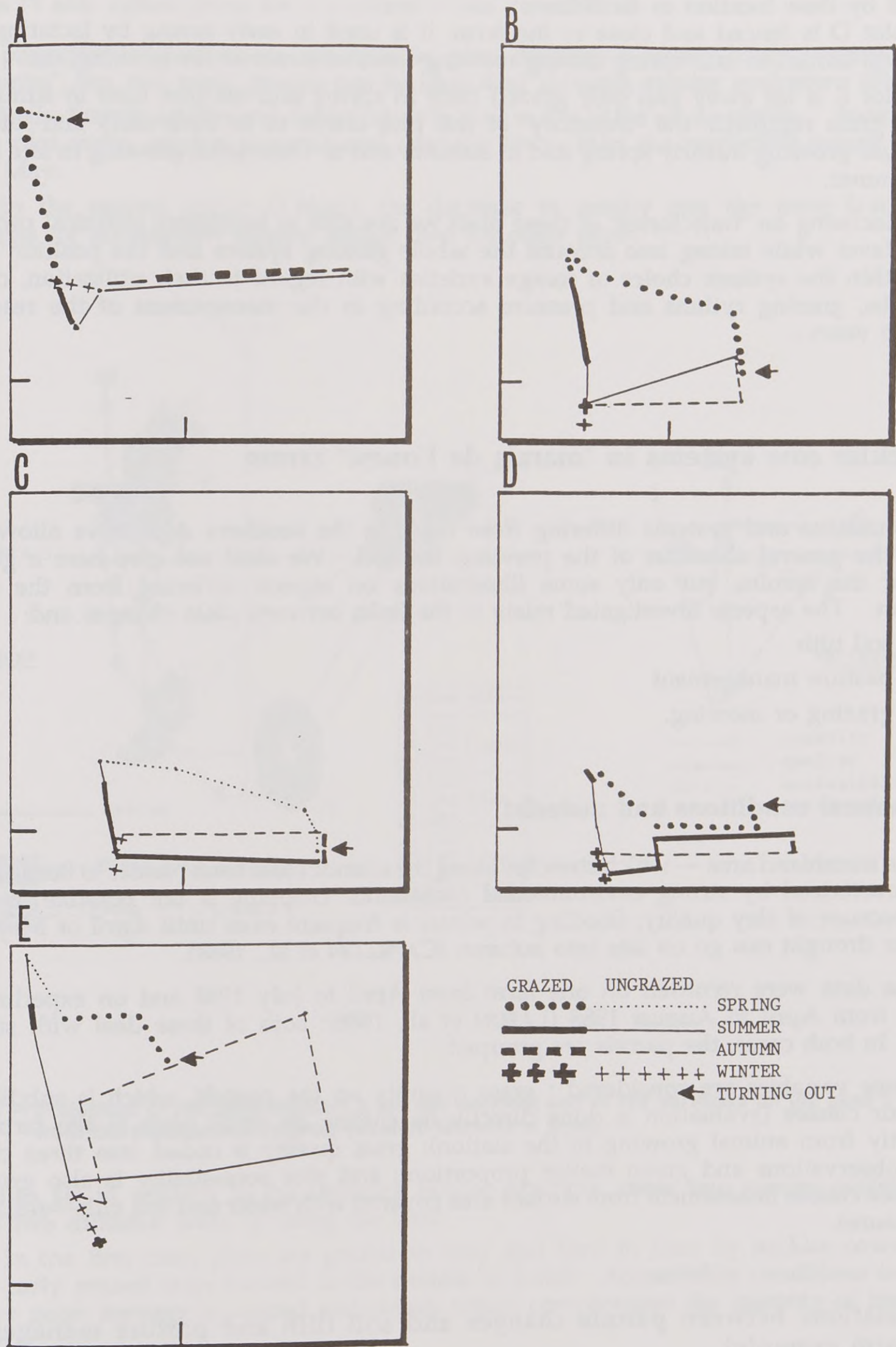


Figure 3 — Projection in supplementary points of the plot changes; each diagram represents the temporal "trajectory" (ten day periods n° 13 to 36) in the plane 1-2 of CA. Grazed periods are underlined (southern Alps farm)

— particular plots: their use is related to their distance from the farm, to opportunities allowed by their location or facilities:

- plot D is fenced and close to the farm: it is used in early spring by lactating ewes with twin lambs, in late spring during mowing-time, in summer for lambing, etc.

- plot E is far away and only grazed once in spring and another time in summer to control grass regrowth; the "trajectory" of this plot seems to be both early and late, due to *Dactylis* growing in early spring and in autumn and to *Onobrychis* growing in late spring and summer.

In focusing on "trajectories" of these plots we are able to highlight technical problems at this level while taking into account the whole grazing system and the position of the plot within the system: choice of forage varieties with regard to their utilization, control of shrubs, grazing rhythms and pressure according to the management of the resources over the years...

4. Suckler cow systems in "marais de l'ouest" farms

Conditions and systems differing from those in the southern Alps have allowed us to test the general character of the previous method. We shall not give here a general view of the results, but only some illustrations on aspects differing from the above situation. The aspects investigated relate to the links between plots changes and:

- soil tilth
- pasture management
- grazing or mowing.

4.1. General conditions and material

The marshland area — which stretches along the atlantic coast from Nantes to Bordeaux — is characterized by strong environmental constraints: cropping is not possible in some areas because of clay quality; flooding in winter is frequent even until April or May, and summer drought can go on late into autumn (CAPILLON et al., 1988).

The data were recorded on one farm from April to July 1988 and on experimental station from April to August 1985 (LAFON et al., 1988): both of these deal with suckler cows. In both cases, the parcels are grouped.

Three variables are considered : grass quantity on the parcels, which is subdivided into four classes (evaluation is done directly by cutting on small plots in the farm and indirectly from animal growing in the station); grass quality is coded into three classes (from observations and green matter proportion); and plot accessibility is also grouped into three classes (assessment from surface area covered with water and soil tilth —resistance to pressure).

4.2. Relations between parcels changes and soil tilth and pasture management (farm example)

A multivariate analysis shows the structure where the three variables are interwoven (Fig. 4). Values decrease on the first axis as time goes on, with a low ordinate point at the beginning of May. The evolution of the whole system to that date is characterized by a pronounced increase in quantity but a deterioration of quality: the most favourable

accessibility is reached at that time. Afterwards, quality goes on decreasing and quantity declines (Y axis values grow for a constant X axis value).

A projection of parcels on the factorial plan displays a strong heterogeneity in the "trajectories", but two main groups can be identified showing similar evolutions (Fig. 4):

— in the first group (5 plots), the trajectory is close to that of the whole system. Accessibility follows plot mean, quality is better and quantity lower than the respective means by the end of May;

— in the second group (2 plots), the decrease in quality and the most favourable conditions for accessibility appear earlier than for other plots.

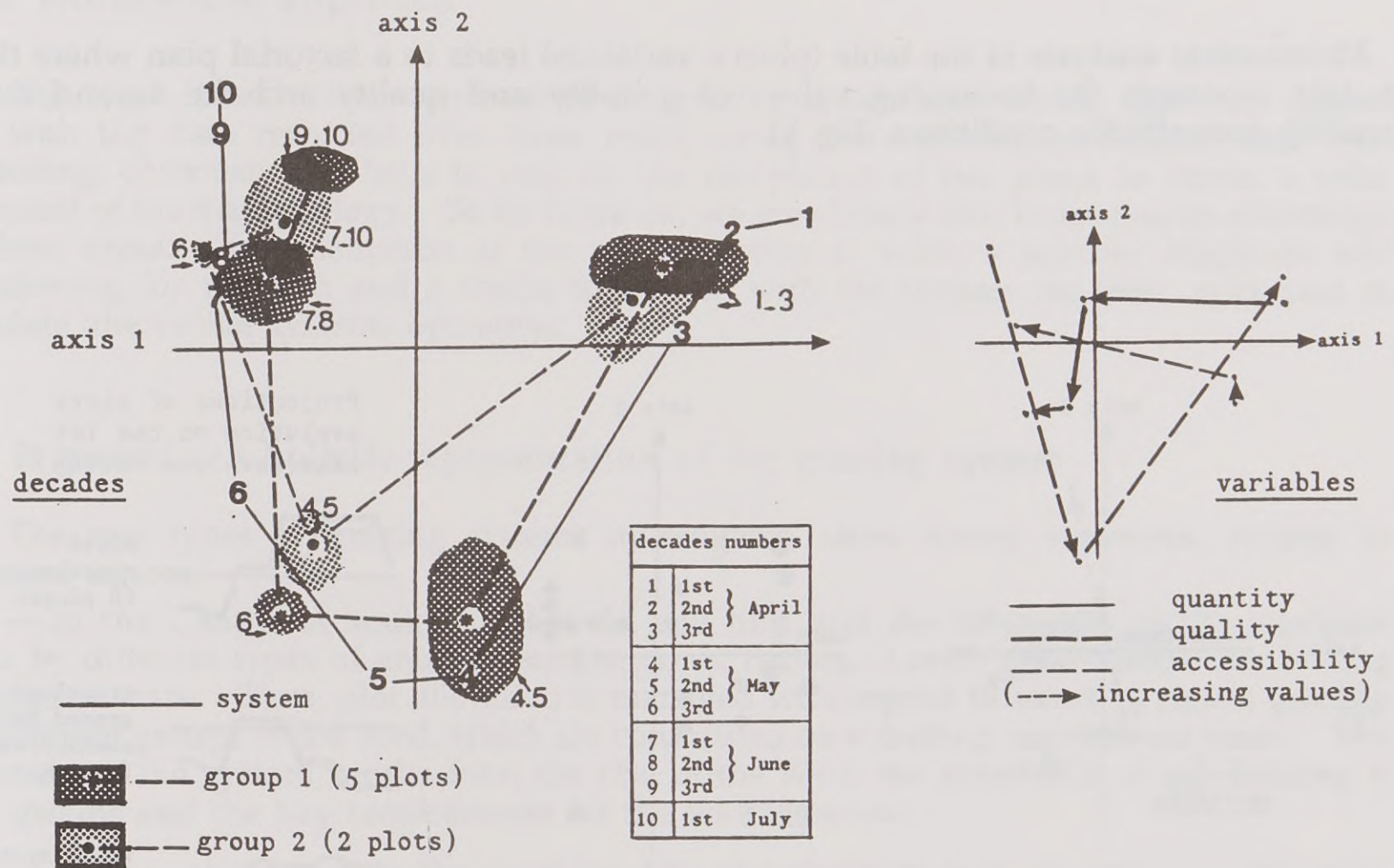


Figure 4 — Projection of the table [system x ten day periods] and of the variables on the axes 1 and 2 from the multivariate analysis (western Marshland farm)

When set in relation to the livestock farmer practices, these two groups correspond well to two different ways of using the land:

— in the first case, plots are grazed in May and then in June by suckler cows (one plot is early grazed then mowed in the middle of June). Accessibility conditions in May are very poor: herbage is wasted and soiled, which compromises the quantity of the next regrowth;

— in the second case, plots are briefly grazed in mid-April, and for longer at the end of May-beginning of June. In April, accessibility conditions are so bad that cows are rotated more quickly than in the above first cycle, and an extra plot is added; this leads to delaying this second grazing cycle. Herbage is then too high and quality becomes very bad. In fact, even though accessibility conditions are bad in April, these plots are

the best at that time and the first grazing is allocated to cows with lower requirements: because of this decision, grass management will not be possible later on these plots.

Globally, the aspect of the curves seems to be linked with farmer practices. The relationship between the curves and the biological cycle of grass, which is very strong in the southern Alps farm, is toned down here by an attempt to manage grass quantity and quality, taking accessibility conditions into account.

4.3. The relation between plot changes and the choice of grazing or mowing (case of the experimental station)

Multivariate analysis of the table (plots x variables) leads to a factorial plan where the first axis expresses the increasing values of quantity and quality and the second axis increasing accessibility conditions (Fig. 5).

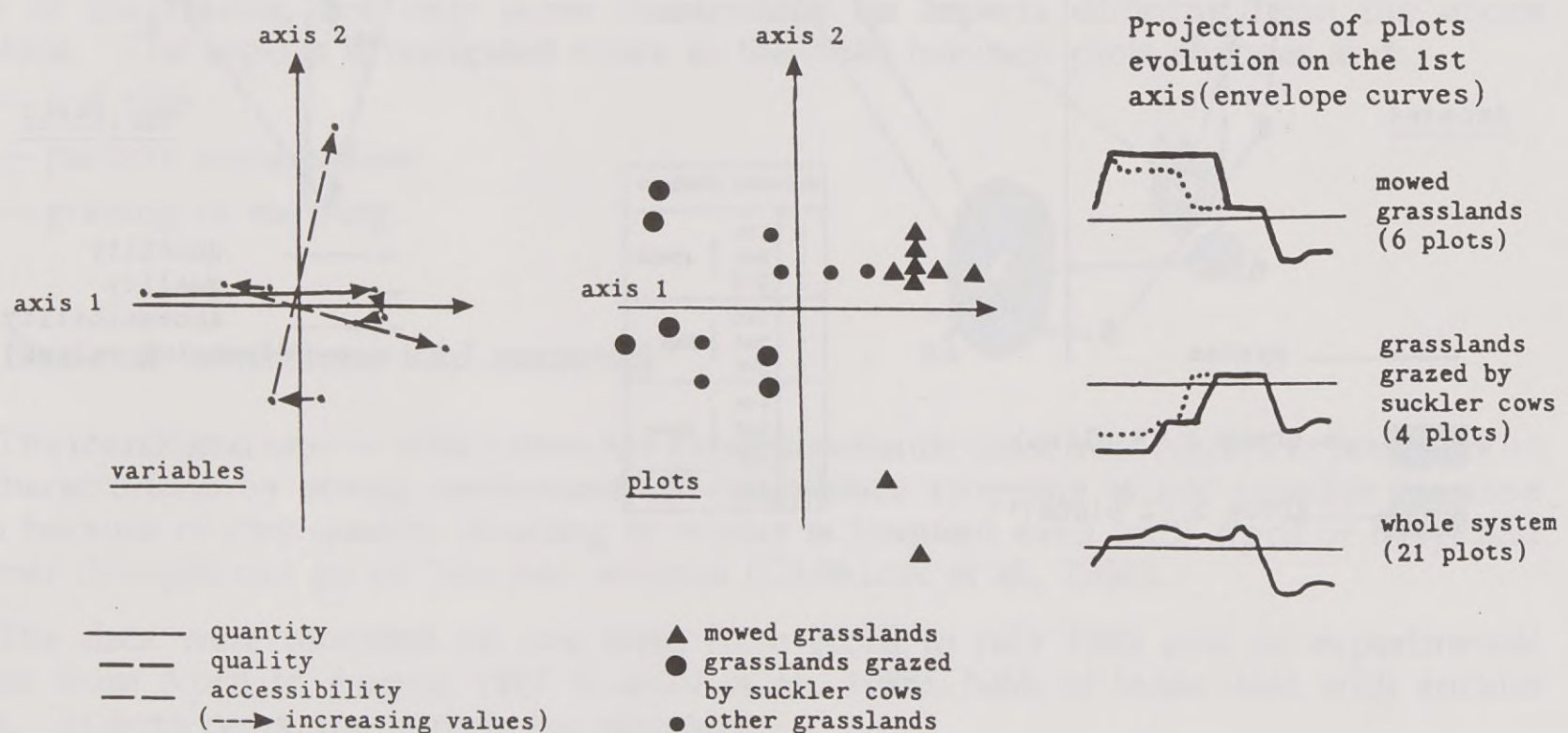


Figure 5 — Projection of the table [plots x variables] on the axes 1 and 2 from the multivariate analysis (western Marshlands experimental station)

Two plots groups may be distinguished according to their values on the first axis:

- mowed grasslands, which are temporary grasslands, are situated on the positive values of the axis;
- permanent grasslands, grazed by suckler cows, are located on the negative values.

Evolution of these two groups over time shows that there are no differences during summer when drought is the main factor affecting pasture management. But in spring, several evolutions can be shown (Fig. 5):

— for mowed pastures, grass quantity and quality are higher than in the whole system at the beginning of the season;

— for grazed pastures, the peak of herbage production is reached in the middle of spring, and the herbage quantity is lower than in the previous group.

In the system, which is probably the more intensive of the two, pasture management is strongly linked to quantity management: grazed or mowed pastures do not have the same dynamics.

5. A worthwhile approach

This work, based on an approach of the grazing system as a whole, has to be carried out with the data recorded over three years, using the multivariate analysis and then modelling; obviously, we have to wait for the completion of this phase to obtain a valid appraisal of the methodology. So far however, we are already able to assume its advantage in three areas: a representation of the whole system at work, a tool for diagnosis and questioning for research and a media to discuss with the farmers on their work and to simulate alternative systems operation.

5.1. It provides a holistic representation of the grazing system

The two types of grazing systems investigated show strong structures, related to different factors:

— in the Central Atlantic Marshlands, soil tilth and the utilization of the available grass by different types of animals (suckler cows, heifers,...) seem to be the factors leading to this structure. Thus, plot allocation is managed with regard to mowing versus grazing by different groups in the herd, which are constituted on a feeding requirement basis. The structure of the system results from the size of the herd, the possibility of subdividing it into groups and the hay requirements for the winter period.

— on the other hand, in the southern Alps the structure rests on resources diversity (sown or spontaneous grasses, altitude, aspects of slope, distances,...); the breeding period of the flock is managed to obtain the best fit with the climatic constraints. The grazing system shows a yearly cycle organized from two loops leading it to different states. In some seasons (spring and autumn), the diversity of these states is exploited by dividing the flock into several groups. During summer and winter, the system achieve more stable and homogeneous state; then the dietary behavior of the animals gathered in one flock dictate the utilization of the resources.

5.2. It provides a purposeful tool for research

This leads us to highlight different questions at different levels of this organization:

— will this system recover a steady state at the beginning of each year? If not, does the observed drift affect its reproduction ? through which technical interventions can one sustain its balance? What are the effects of climatic hazards? How does the farmer take this hazard into account through spatio-temporal organization of his land?

— the "trajectory" of each plot efficient to the stand point of its place in the system? What kind of improvements can be proposed: improved productivity, a different grazing period, another organization of plots allocation... keeping in mind the working of the whole system.

5.3. It is a useful help for diagnosis and simulation

This work is being continued, with a three years survey in each case, and the modelling stage is just at its beginning. However, we believe that with this approach, we have a good representation of the whole grazing system as well as the "trajectories" of the different plots involved. Therefore it could provide us with a useful tool for system diagnosis, alternative forecasting and interactive conversation with the farmer on the effectiveness of his practices in regard to his goals.

It is obvious, that in the future we have to look for a simplified method which can be currently used for research as well as for advising. For this purpose we intend to build the model from these cases on the basis of a three years survey with this set of data, and then to apply it on other farms in which we have recorded data on the grazing system. We will then check whether this leads to relevant diagnosis and questioning.

Acknowledgments:

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Résumé :

Le propos de ce travail est de rechercher une représentation globale du fonctionnement d'un système de pâturage tel qu'il est mis en oeuvre par un éleveur sur le territoire de son exploitation. Notre objectif est d'obtenir un outil de diagnostic, d'interrogation pour la recherche et de simulation qui puisse être utilisé en dialogue avec l'éleveur. La méthodologie choisie consiste à traiter par analyse

de données et par modélisation à la fois la représentation des pratiques d'organisation du territoire pâturé par l'éleveur et les observations que nous avons pu pratiquer sur l'état de la végétation et des animaux. Cette communication présente la première étape de ce travail réalisé à partir de données provenant des Marais de l'Ouest et des Alpes du Sud.

3. Further viewpoints on farmer practices on land use and on development

Introducing livestock farmers' ways of thinking in the study of existing systems

John R. French

3. Further viewpoints on farmer practices on land use and on development

Summary

Livestock farmers are producing a significant amount of food and fiber in the United States. They are also producing a significant amount of environmental problems. The purpose of this study is to understand the ways of thinking of livestock farmers and to use this understanding to develop a more effective approach to the study of existing systems. The study is based on a series of interviews with livestock farmers and on a review of the literature. The results of the study are presented in this paper.

Livestock farmers are producing a significant amount of food and fiber in the United States. They are also producing a significant amount of environmental problems. The purpose of this study is to understand the ways of thinking of livestock farmers and to use this understanding to develop a more effective approach to the study of existing systems.

One of the major problems in the study of existing systems is the lack of understanding of the ways of thinking of the people who are involved in the system. This lack of understanding can lead to a number of problems, including a lack of effective communication and a lack of effective problem solving.

The purpose of this study is to understand the ways of thinking of livestock farmers and to use this understanding to develop a more effective approach to the study of existing systems. The study is based on a series of interviews with livestock farmers and on a review of the literature.

—after the first interview and the second interview, the farmer's understanding of the system can be better understood, and the approach of the study can be improved.

—the farmer's understanding of the system can be improved by using the farmer's own language and by using the farmer's own examples of the system. This approach can be used to develop a more effective approach to the study of existing systems.

The study also shows that the farmer's understanding of the system is not only a matter of knowledge, but also a matter of attitude. The farmer's attitude towards the system can be improved by using the farmer's own language and by using the farmer's own examples of the system. This approach can be used to develop a more effective approach to the study of existing systems.

Introducing livestock farmer's ways of thinking in the study of grazing systems

Jean Pierre DARRE

Summary:

Livestock farmers act according to what they observe or the information in their possession, and to the previous states or events they know. One may consider that some aspects at least of the system — all the forage crops of a farm — are only intelligible if the livestock farmer and his choices, his ways of conceiving things, are included in the description. After briefly justifying our position, we demonstrate that an analysis of the farmer's ways of thinking which guide his material acts and justify them can operate on two levels, that of the decision process and that of the forms of knowledge of reality. We shall thus demonstrate that an analysis carried out on the first level cannot ignore or neglect the second level without running the risk of misinterpretation.

Livestock farmers act according to what they observe or to the information in their possession, and to the previous states or events they know.

Can a researcher analyse, in the same way, how "a particular field" or the forage system of which it is a part operate setting himself in a way in the farmer's shoes, and considering only that he does better, in a more systematic and more informed manner?

This question does not call for an answer, since this is what happens anyway. However, the choice of keeping strictly to the "observation of material facts" implies that one at least of the following hypotheses is assumed:

— either the ways of thinking and the reasons for the farmer's choices are transparent, i.e. can be fully known from the analysis of material facts,

— or one considers that they are normally an echo of the techno-economic logics of the material system, and that any act deviating from this logic is a parasite, a "noise", an accident exterior to the system, the result of the farmer's ignorance or of other failings.

One may also consider that these hypotheses are defensible only in a limited way; in this case, some aspects at least of the system — a field or all the forage crops of farm — are only intelligible if the livestock farmer and his choices, his ways of conceiving things, are included in the description.

Our paper follows this second course. After briefly justifying our position we demonstrate that an analysis of the farmer's ways of thinking which guide his material acts and justify them can operate on two levels, that of the decision process and that of the forms of knowledge of reality. We shall thus demonstrate that an analysis carried out on the first level cannot ignore or neglect the second level without running the risk of misinterpretation.

Can one read the farmer's motives in his grass.

The build-up and processing of data to understand the reasons for the choices and ways of doing of a livestock farmer apart from what material observations allow to infer, may be achieved with relatively sophisticated means and begins at the simplest level with the question: "Why do you do this" or "Did you do like that?" The usefulness of this investigation appears precisely when we are not sure to understand from the material observations "why he did like that" and we presume that this choice is not absurd. The need to resort to more elaborate and more complex means than the question "Why..." results more particularly from the fact that we cannot always be certain of the value of the answers to this question. Conversely, we can verify that a particular form of knowledge, revealed by listening to and analysing the farmer's remarks may bring additional information, after observing that this form of knowledge cannot be read in material practices. Some farmers in the Garonne valleys, (southwestern France; interviews by Caroline Auricoste and Michel Duru, 1988) hold the view and is both a means of defining the object and norm of action — that "maize (silage) is for the milk, is favourable to milk production". An analysis of the way the forage system functions in this area allows to understand how this view originated (the same analysis carried out the Ternois, northern France (Darré; 1985) shows up opposite views: "maize is for maintenance, not for milk"), but this analysis would not have revealed the farmers views themselves.

Observing the dissymetry of the two approaches provides another reason for ensuring that they are used in a complementary way. This reason proceeds from a logical criticism. By showing that the growth and reproduction cycles of a herd, and the variations in plant maturation explain the way grazing is managed over the year (Méot, Hubert et al, 1989), we have indeed shown the reason "why" the farmer chose this particular management, but we have not demonstrated that this was the sole feasible solution. Nothing allows us to assert that other farmers, in similar circumstances, would not have found a different solution. The farmer cannot therefore be considered as an automaton expressing in terms of solution — the particular type of management — logic of the system.

We see that, even though the farmer's choices may seem clear, as analysed from his material practices, nothing allow us to assume that he has only solved a riddle, the solution of which is written in the facts, independently of any human conscious presence. (There remains, of course, that the system can be inherited and mechanically reproduced by the farmer or that we may consider that in such and such cases knowing the way the solution evolved would not be of much profit to us.)

1. Decision theories and embeddedness

We now place ourselves in a perspective where it is admitted that farmers adopt solutions and make choices that are not entirely in keeping with the logics of their production systems, and that are not sufficiently apparent in material practices and states.

Some researchers, agronomists or economists, specify that farmers "make decisions" and that it is therefore necessary beyond "reading" from material practices, to analyse the "cognitive process", the "decision process" (Sebillotte and Soler, 1988, Cerf and Sebillotte, 1988).

The very notion of decision and even more the extension of its use have been the subject of abundant criticism (see for instance, Sfez, 1973), but we shall not discuss this here.

We only want to show that in any case, studies analysing the "decision process" as a cognitive process cannot, without risk of misinterpretation, pass over other aspects of knowledge processes. These cognitive processes are individual processes they happen "in the head" of individuals — they are an aspect of psychology, of the field of psychology called "cognitive psychology". Unquestionably, knowledge operations relate to individual symbolic activities and some aspects at least of the "decision processes" come under this same field of investigation.

With the reservation that these processes may take more or less elaborate or even aberrant forms according to individuals, they are analysed and described as independent, in their principles, from the characteristics of the subject having reached maturity.

It is useless arguing here whether the subject of these processes is Man in general, or Man in our societies. In any case, the processes are designated whether right by or wrong by, this does not matter here — as independent of the subject's characteristics, of his activities, his cultural environment etc.

These processes are both individual and universal. They may be analysed and described leaving out the fact that, as any person, a livestock farmer carries out a specific activity, under certain conditions, and that his thinking activities, as well as his material activities, fit into a background of social relations.

Can one admit, would decision theorist admit that these processes are independent of the social class and of the positions held within them by individuals? Probably not. But in this case, the question to be raised is "How do we reintroduce the social dimension in the analysis?" Mark Granovetter has done it by showing how the "rational actor's theories" could not avoid taking into account the "embeddedness" of the actor in a system of social relations (Granovetter, 1985).

Granovetter however restricts his analysis to the subject's preoccupations on the regulation and reproduction of his system of relations and of the position he holds in it. There is yet another, in our opinion, more important dimension to "embeddedness": this concerns cognitive processes and in particular the forms of social insertion of the farmers: we mean the socially constructed forms of knowledge of reality.

2. Universal processes and local objects

Opposing the methodological individualism implied in psychological or psychosociological decision theories, we can quote the statement of the anthropologist Clifford Geertz: "Human thought is consummately social: social in its origins, social in its functions, social in its forms, social in its application. Basically thinking is a public activity — its natural habitat is the houseyard, the market place and the town square". (Geertz, 1973: 360).

This statement may seem a little excessive, and later Geertz himself tempered it. Referring to Herbert Simon's work, he notes the existence of two "approaches of human thinking": "a unific one, which conceives of it as a psychological process, person-bounded and law-governed, and a pluralistic one, which conceives of it as a collective product, culturally coded and historically constructed — thinking in the head, thought in the world". (Geertz, 1983: 14).

We are led in this way to identify two levels in the way individuals carry out choices, decide to act one way or the other.

The first level is constituted by the cognitive processes, assimilated or not with decision processes. The second consists in the **ways of knowing** reality, of describing it. These forms of knowledge constitute, as expressed by S.G. March and H.A. Simon (March and Simon, 1958), the "limits to rationality" of the subjects.

The second level constitutes the social side of action thinking. It results from daily dialogues between livestock farmers in which each one of them seeks all at once to be informed, to influence the others, to build up and adjust his references. (Darré, 1985). What is thus constructed and transformed, day after day, is a **convergence** on the meaning of words, on the way of saying things — a convergence that does necessarily imply agreement.

The common view, in a village, that grass silage is a modern feed, for high milk yields versus traditional hay, which gives medium yields, but requires less cash outflow of silage as that of hay. (Darré, 1985).

In other words, assuming the independance of cognitive and decisional processes with regard to social systems, there remains that the **objects** and the norms of action associated with their definitions, on which these processes or these operations act, are not the same among all subjects. The farmer's grass, beyond its mere designation, is not the same as that of the researcher's, because it is constructed both from different activities and within different inter-influence systems.

That which can cause a discrepancy between the researcher's or the adviser's discourse and that of the former, is not therefore to be sought in a different way of arguing choices, but in a different way of "constructing reality".

3. The example of a dialogue between researcher and farmer

To illustrate how this discrepancy may evolve and to show clearly the distinction between the two levels, let us take an example from an interview between researchers and a farmer of the Garonne valley, mentioned earlier.

Livestock farmer — (after saying he'd run short of hay for his cows) — So this winter they've eaten straw with "Minerol" (...) We took "Minerol" just for palatability, to make them eat the straw.

Researcher — Was it straw you'd bought?

F. — No, we'd stocked it last year.

R. — Why did you buy "Minerol" rather than hay?

F. — Because we had good straw, barley straw that hadn't got wet, and besides for hay we don't rely on it. Well, we rely on it a bit for feeding, but not so very much... They get it in self service and mainly for bulk...

R. — So, how did this 1st experience work out this winter?

F. — Well... with the straw... Of course! They did eat very well with the "Minerol", but I didn't bother to calculate the value of what it can yield, they got it as an extra, for additional maintenance.

The researcher's question, probably resulting from a misunderstanding about the preceding question and implying that the straw also had been bought in ("Why did you buy "Minerol" rather than hay") reflects a decisional calculation that can possibly be decomposed as follows:

— the necessary supplies must be secured to cover the animal's requirements and hay does that;

— expenses for hay are assured to be covered by milk production;

— is the cost difference between "Minerol" (+ straw) and hay worth this assurance? (in any case we're winners with hay; why then quibble and run a risk with straw?).

The decisional calculation which starts from an "objective" (the animal's production potential) to estimate the necessary inputs, considering that in doing so a positive economic output is assured, leading thus to a solution ensuring a maximum result with no risk, certainly constitutes a chain of operations that any sane adult can not only accept, but produce.

However the farmer's answer does not relate to this calculation. Had it been so, he would have argued about the relation between the assumed risk increase (lower palatability of the improved straw) and the cutting down of costs. He does it, incidentally, in connection with the risk (...straw ...of course! They did eat it very well with the "Minerol"), but it is not upon this that the main point of his argumentation rests.

It bears on two points:

— A reasoning that starts, not from an aim, but from "what is available, following a chronological order of operations: the cow gives as it is given, that is to say essentially — the basal ration — according to what the farmer could offer her or knew to offer her". This winter we ran short of hay and we replaced it with what we had, not as good though, straw "because we had good straw...".

And this year, the farmer has made sure this won't happen again. The interview goes on along these lines.

F. — This year, they'll certainly eat fodder

R. — You won't do it again?

F. — Well, no. Because the fodder stock is appropriate.

— The construction of a feed category that does not belong to the researcher's sphere of thinking — feeds that do not go into the calculation of the ration, to which no value is attributed either for maintenance and production, or in relation to other elements of the "menu", that have no real defined function, at least in this interview. They are "what is given extra", for "additional maintenance", that which isn't worth bothering about calculating the value of what it can yield, that which "is not counted", which is "for the bulk": a feed category which includes the hay, as well as the straw that replaced it.

This kind of "extra that is not counted" does count though, since the farmer congratulates himself on being able to assure the needed quantity for the following winter. This category is rather like bread on the table in France: it is in "self service", it is not counted, unlike the dishes composing the menu and it does not come in at any particular moment in the meal: it is there for when we want it during or outside the meals.

The decision to buy "Minerol" to make the cows eat the straw result of course from a cognitive process just as normal and universal as that which led to the researcher's questions. It is on the second level, that at which things and actions are constructed, that one can analyse the difference between the two and possible misunderstanding

Conclusion

The study of a parcel of a forage system may involve three levels, that should clearly be distinguished:

— material phenomena and practices,

- decision processes,
- forms of knowledge.

We have particularly insisted upon the distinction between levels 2 and 3, which is often not made in research on decision processes.

Our aim was not to prove that all these levels of analysis are indispensable at all times and in all cases: this depends on the objectives of the research. However there remains a need to look more thoroughly into the way complementarities between these levels may be ensured, and first of all to assess their usefulness.

First level research, such as that of A. Méot and B. Hubert mentioned earlier, to have achieved good results. But nothing allows to foresee that investigations at other levels might not bring up other disturbing elements in this coupling of action logics with the logic of things.

Studies and research on decision processes may, within certain limits, keep to the analysis of cognitive process. These limits are defined in particular by the educational and social background of the farmers, who are the objects of empirical studies or of advisory back-up actions. This background ensures that the ways farmers conceive things, describe and evaluate them, are close to those of researchers.

As for research on forms of knowledge, this can be carried out independantly but it will only acquire its full meaning when related to material phenomena and practices.

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Résumé :

L'éleveur agit en fonction de ce qu'il constate ou des informations dont il dispose et des états ou événements antérieurs qu'il connaît. On considère que certains aspects au moins du système — ensemble des cultures fourragères d'une exploitation — ne sont intelligibles que si l'on introduit dans la description l'éleveur et ses choix, ses façons de concevoir les choses. Après avoir rapidement justifié cette position, nous montrerons que l'analyse des façons de penser qui conduisent les actes matériels et les justifient peut s'opérer à deux niveaux, celui des processus de décision et celui des formes de connaissance de la réalité. Nous montrerons ainsi que l'analyse au premier niveau ne peut ignorer ou négliger le second sans risques d'erreurs d'interprétation.

Groups of stock farmers are mobilized to produce references for their farming systems. An account of the Aveyron département

Jean-Louis ROUQUETTE

Summary:

Located in the south-west of the French Massif Central, the département of the Aveyron has only a mosaic of difficult environments for its livelihood. Yet, the professional agricultural organizations, since 1981, operate an original service for drawing up farming system references. It is here presented by one of the creators and formerly leader.

Volunteer farmers, as properly representative of the various local capabilities, set up small groups of 12 to 15 farmers, who, within about 5 years long, elaborate references from the concrete and personalized support of their own farms. Systems considered attainable and sustainable are derived and then described as "typical cases". A diversified range is sought and the really efficient practices are emphasized. Outlines for cooperative work with Research are suggested.

As far as forage production is concerned, references derived from experimental stations or even test fields on a farm, are necessary but insufficient, if not dangerous, as a basis for a decision tool for production techniques in stock farming operations.

On the one hand, the production of a field, localized and dated, should enter into the process of feeding a herd or flock; the risks affecting this production should be taken into account at the level of a strategic choice for a harvesting chain, and all the more so, for a production system. On the other hand the results, even in the form of very detailed reports with figures, should be combined with a description of the corresponding practices and, as far as possible, with possible alternatives, in particular at the forage system level.

Such considerations led one département, the Aveyron, to create an original service for producing references which it considers necessary for its agriculture and which are not available elsewhere. Without going into the aspects concerning development conceptions and institutional and financial problems, the present account will give an outline of this production of references in relation to the forage systems.

1. A department which depends on stock farming for its livelihood: a mosaic of difficult environments

Located in the foothills south-west of the Massif Central, the department of the Aveyron rises in levels of from 140 to 1400 meters in altitude in successive terraces cut into the deep valleys: Lot, Aveyron and Tarn, all turned towards the Garonne basin. Characterized by broken mountain terrain, dependent on unfavourable climatic influences, removed from large communication arteries and industrial centers, it accumulates a lot of physical and socio-economic handicaps. In spite of the slopes, the long winter and summer drought, there are still many deep-rooted men attached to their native soil, who want to exploit the only true natural resource of the region: forage production and in particular grass. In fact, all forms of stock farming, (mainly cattle, sheep, goats and pigs) are practised, as well as scattered rural tourism. The department has always and will always look for the best possible combinations in animal production.

In the department as a whole, the large professional agricultural organizations always wish to maintain the largest possible number of agricultural and rural activities. In order to achieve this, they have suggested that any stock farmer, no matter what his situation, should benefit from suitable "decision making help" for his objectives, his advantages and his restrictions. This means first of all correctly choosing and then running a satisfactory farming system. This of course means producing "good references".

With this objective in mind, an original program for drawing up farming system references was first designed and then implemented in 1981 by the department's agricultural organizations.

These references are developed in a specific framework of 6 areas, corresponding in particular to very contrasting natural environments in the department.

- the granitic and schistose hills, very often with steep slopes, of the Ségalas and comparable areas.

- the small valleys of Rougier and the narrow and steep-sided valleys of the Lot and the Tarn.

- the low altitude and very quick-drying plateaux of Bas-Quercy.

- the high altitude limestone plateaux of the Grands Causses.

- the granitic and schistose mountains of the Haut des Monts near Lacaune and of Levézou.

- the basalt mountains of Aubrac.

2. The defined objectives and the action program used

The implementation of the program which was to produce the "Systems" references was based on two main elements:

- Concrete and personnalized aid of farmers mobilized as working "pilots", and who accepted to discuss their own conception of the system and their achievements with their colleagues and with researchers and technicians.

- An in-depth study of forage systems considered as crucial for farming systems from the space management angle. The permanent preoccupation is that of an easy-to-manage organization to ensure a balance between creating of forage resources on the usable space and covering the needs of the animals.

2.1. Essential involvement of farmers

For each of the 6 areas and for different family situations, the "Farming Systems References" service should identify and gradually perfect, a range of farming systems. These systems should be consistent, simple where possible, dependable, viable but also liveable, in other words, able to be reproduced in time and space.

The program implemented is based on a carefully considered choice of volunteer farmers, corresponding to a typology defined by the local Development professionals and retaining for the moment, in addition to geographical and family situations, combinations of productions and activities, different degrees of capital invested, different operational phases of the farming system (installation, starting, transition, full operation).

For each system studied, the practices used are described and evaluated, in particular with respect to forage systems. The package of systems, with descriptions of the practices, is made available to all of the distribution circuits (initial and ongoing training, information, technical and economic support).

The farmers concerned therefore accept to devote a lot of time and reflection to perfecting the regional package. They are actual agents doing research into the systems with the free assistance of a "system-engineer", one per region.

2.2. A few elements concerning the working methodology of the research groups

The volunteer farmers are organized into small groups of from 12 to 15 members. Each group involves its activity for five years, on the basis of the following progression:

- in-depth knowledge, from all angles, of the farms of the group members: land (in particular grasslands), herds or flocks, equipment, work, capital, market relation mode, etc.
- analysis of farming projects: representation and discussion of operations planned for 4, 5 or even 6 years (creation, extension, transformation of such and such an activity, etc.)
- development of campaign plans (land use, herd or flock management, cash availability). Discussion of operations planned for the near future lead to specifying certain technical itineraries.
- follow-up of successive campaigns: comparison of results with the tactics and technical itineraries chosen (description and evaluation of practices), work surveys, etc.
- editing of the results (reports with figures and practices used).

2.3. Definition of typical cases

The program implemented in the Aveyron was, from the first year, to supply concrete results of the farming systems, in other words it was to describe:

- farming situations and production means,
- strategic and tactical projects undertaken by the farmers,
- significant practices used.

From the third or fourth year of operation on, according to the groups of farmers, these results were developed into local "typical-cases" so as to create the desired range of farming systems for diffusion.

A typical case is a proposition for a balanced and accessible farming system. It is constructed using one or two farms chosen by the group of farmers to validate and illustrate the described balance. The main elements in this description concern:

- the geographical situation and the structural characteristics of the system;
- a description of the project describing in particular the technico-economic results of the system at full operation and the monetary flows which might describe it;
- a description of the main practices necessary for obtaining the announced results (land, grassland system, herds or flocks);
- reflection on one or several possible strategies for installing the system using a frequently encountered starting structure.

A typical case is not a set of average statistics, since it comes from one or several farms with regular operations. Neither is it an objective which is only accessible to an elite (maximum figures): since its validation by a local group means that the equipment and practices used are not exceptional and that its efficiency in the context of the chosen project can be easily checked.

At the beginning of 1989, 60 typical cases, of which some had been brought up to date since their definition, were proposed in the Aveyron.

3. Program evaluation elements

3.1. Typical cases described and advice to farmers

— For all of the project studies: with respect to structural characteristics and installation conditions, it is possible to draw inspiration from local typical cases to answer the following questions: which production goals ? And for setting up a farm ? For finding a better balance? Or for adapting to new constraints?

— For drawing up plans or programs with respect to land (forage system), herds or flocks, cash availability: different productions and corresponding practices are progressively described in the typical cases and concretely visible on farms. Answers are therefore proposed to questions dealing with technical choices and cash availability, with possible adaptation to different hazards, with indicators for correct decision-making from day to day.

— For achieving diagnoses and technical and economic prescriptions both with respect to the general balance of the farm and to the particular activities: which particular points should be treated to stabilize, improve, adapt the operation? The typical cases demonstrate the possible progress margins, for a given typological case, and may suggest efficient changes in practice in relation to the desired result.

When using the described typical cases, certain questions are raised. How to deal with the problem of comparing the personal situation of the moment with the typical case? How to manage the degrees of "similarity" and the degrees of "interest in" the different typical cases available? How should the typical cases be presented and used in training activities, project studies, technical support?

3.2. Operation of farmer groups

Each group deliberately brings together very different farms. From experience this diversity has been shown to be very positive. Certain practices observed by farmers who do not have the same farming system as that being studied, may be the subject of criticisms leading to very interesting possibilities. For example, with respect to practices combining grazing in the height of spring and concentrate feeding, the discussion between farmers

of dairy cattle — slaughter cattle — dairy sheep — slaughter sheep and goats resulted in very positive changes being undertaken.

We will only mention in passing the importance of the quality of inter-personal relationships.

The group work between "pilot-farmers" leads to three important observations:

— farmers emphasized tactical choices enabling flexibility, safety, management simplicity as responses to climatic and economic hazards.

— the rather "well-minced" references from experimental stations or test fields are sometimes severely criticized by these "pilots".

Too much advice on strategic choices is still given without sufficiently taking into account the importance of risks and possible tactical responses, considering the main characteristics of the physical environment (climatic tendency, nature of soils, slopes, etc.) and of economic and human environment (sales and purchasing facilities, possible group work).

— the necessity when expressing and diffusing results to go beyond reports with figures and to insist firmly on detailed description of the practices used (with alternatives) in particular with respect to the forage system.

4. Perspectives

The operation of groups producing references on farming systems and development of local typical cases integrating forage systems which are well described as to their design and running, is undeniably worthwhile for helping farmers with decision making. But in order for this option to be fully exploited, it necessarily leads to an in-depth redefining of Development organization and practices.

This collective investment implies paying continual attention to the evolution of the situation and the needs of farmers, in order for the range of farming systems to remain pertinent and properly representative of the diversity characteristic of agriculture in the department.

A procedure for redefining the typology and consequently for completely renewing the networks, is and will be undertaken in the Aveyron every five years.

Another original aspect of these groups should be noted: on the local level they take an active part in the program for circulating acquired references (reception of youth in training, "Open House Days". etc.) Progress should however be made with the achievement of collective diffusion-communication programs. How should a technical or economic norm be linked with a personalized project? Technical or economic messages and variety in typical cases? Technical references and necessary diversity for forage systems?

Significant questions are again brought up, in particular relating to indicators and criteria to be favoured in the management tools.

— Which indicators should be chosen for decision making aids for the long or middle term? Which combinations of monetary flows are pertinent in the short term (campaign predictions and adaptation to climatic hazards)?

— How should we represent a strategy for balance between dry forage areas and pastures? etc.

So many of the problems posed today call for a permanent and organized discussion between Farmers, Technicians and Researchers: better identifying of management indicators for a given farming system, better choosing of pertinent evaluation criteria for diagnoses,

taking into account of the diversity of farming systems chosen or to be chosen in a given area, improving of the way in which the production of references by groups of farmers is related to technical and economic innovations. We may say that similarities and even extensions (BONNAL et al, 1988) to the experiment referred to here, are to be found in other Research and Development programs.

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Résumé :

Au Sud-Ouest du Massif Central, le Département de l'Aveyron ne dispose, pour vivre de l'élevage, que d'une mosaïque de milieux difficiles. Cependant, les organisations professionnelles agricoles font fonctionner, depuis 1981, un service original d'élaboration de références sur les systèmes d'exploitation. Un de ses créateurs et ancien animateur la présente ici. De petits groupes — 12 à 15 — d'éleveurs volontaires et jugés représentatifs des diverses possibilités locales élaborent, en 5 ans, des références à partir du support concret et personnalisé de leurs exploitations. Des systèmes jugés équilibrés et accessibles en sont tirés, décrits comme « cas-types ». L'accent est mis sur une panoplie diversifiée et sur les pratiques permettant d'atteindre effectivement les résultats. Des pistes de travail commun avec la Recherche sont indiquées.

Hierarchical analysis of spatial patterns in pastoral systems

Gérard BALENT

Summary:

The structure, function and evolution of the pastoral territory in the Pyrenees depend upon geographical, ecological and historical factors. They contribute to cut up the territory into a set of spatial units differing in scale and corresponding to different present or past levels of organization of agro-pastoral activities. These levels constitute a nested hierarchy. Because of the duality of both individualistic and collective management on the same part of the territory, agricultural practices conduct to the definition of more complex entities e.g. the distribution of the grazing pressure on the territory. The overlapping of both structural and functional entities defines spatial units interacting in a complex non-nested hierarchies. Correspondence Analysis is a useful tool to modelize these interactions.

Introduction

A pastoral system can be defined as a set of interactions between physical environment, plants, animals and men in a hierarchy of temporal and spatial scales (BALENT, 1987). It works like a complex ecological system where spatial patterns of grazing activities are particularly important. The analysis of these patterns reveals the nature of the relations between a rural society and its environment. It accounts for the distribution and the management of primary production (DIGARD, 1982), and for the social relationships between the farmers too. It constitutes a useful way to understand the structure, the function and the evolution the pastoral system (CARATINI, 1983).

Spatial organization in pastoral systems is generally rather complex. In the pastoral system of the Central Pyrenees Mountains (GIBON, 1981; BALENT & BARRUE-PASTOR, 1986; BALENT, 1987), one can distinguish between different geographical, political, historical, agronomical entities. The valleys include communes with different types of land each with a variety of fields differing in use (cropping, haying, grazing). Boundaries of these spatial units are generally clearly established. But because of the common grazing of the

territory during winter, the free-ranging animals contribute to superpose upon this partition another set of spatial units differing only in grazing pressure, the boundaries of which are fuzzy, changing with time and do not correspond to any other spatial unit.

Facing the complexity of actual space organization resulting from both past and present utilizations it is difficult to study the effects of grazing practices on the ecological dynamic of the vegetation specially at the level of spatial units differing only in grazing pressure. The main problem is in the choice of suitable levels of organization within the system (DALE, 1970). Differently scaled investigations define entities differently and so are most related to different phenomena (ALLEN & STARR, 1982). The choice is between structural and functional entities and closely dependent upon the nature of the interactions within the system. A bounden stage is to focus on the spatial level of organization common to the different spatial cut off i.e. the field level.

I propose in this paper to consider spatial patterns in the pastoral system of the Central Pyrenees at the light of the new concepts issued from hierarchy theory (ALLEN & STARR, 1982; O'NEILL et al., 1986; URBAN et al., 1987). "Hierarchy theory offers three important principles...: (1) Levels of organization are populated by entities whose attendant processes behave at characteristic frequencies (i.e. different rates of time)... (2) Big is not just more, it is different, because there can be change in observational criteria and phenomena across levels... (3) Complexity in ecological systems comes from the interaction of several levels of organization." (ALLEN, 1987). As pointed out by FRESCO & WESTPHAL (1988), by analogy with ecology, agriculture can be described as a hierarchy of system, ranging from the cell to complex systems such as the village commune or parish.

On these bases I first propose to distinguish in pastoral system between several hierarchical sets of spatial levels of organisation depending within each set on different structural or functional approaches. Then to analyze the interactions between these levels.

1. The structural units: Geographical, historical and agronomical spaces nested hierarchies

1.1. The valley

It is usual to consider the Pyrenees mountains territory to be divided firstly into valleys. Each one having specific geographical and ecological features. For a long time the valleys constituted the framework of the summer grazing activities in the different villages (Valley Syndicates to manage the summer ranges and the common pastures: Barousse and Barèges for instance). They have been and still remain the places of important social and cultural differentiation.

1.2. The parish

Each valley is divided in several parishes. The parish is the primary spatial unit to study the pastoral system in the Pyrenees. In fact, this system is characterized by the coexistence of both collective and individual rules of grazing management closely related to common and private land holding. The parish council is the main decision-making unit dealing with land use: Common grazing on crop-fields and hay-meadow during winter and more generally schedule of the grazing activities within the whole village territory. With the current trends of mountain agriculture, the underlying principles of farm systems and the cohesion of farmer community are changing but the village remains the main spatial unit for grazing management (BALENT & BARRUE-PASTOR, 1986).

1.3. The others subunits

The parish territory can be subdivided in different sub-units depending upon structural factors (Figure 1). Some such as land characteristics, land holding and land use are continuous; other such as the spatial structure of each individual farms are discontinuous.

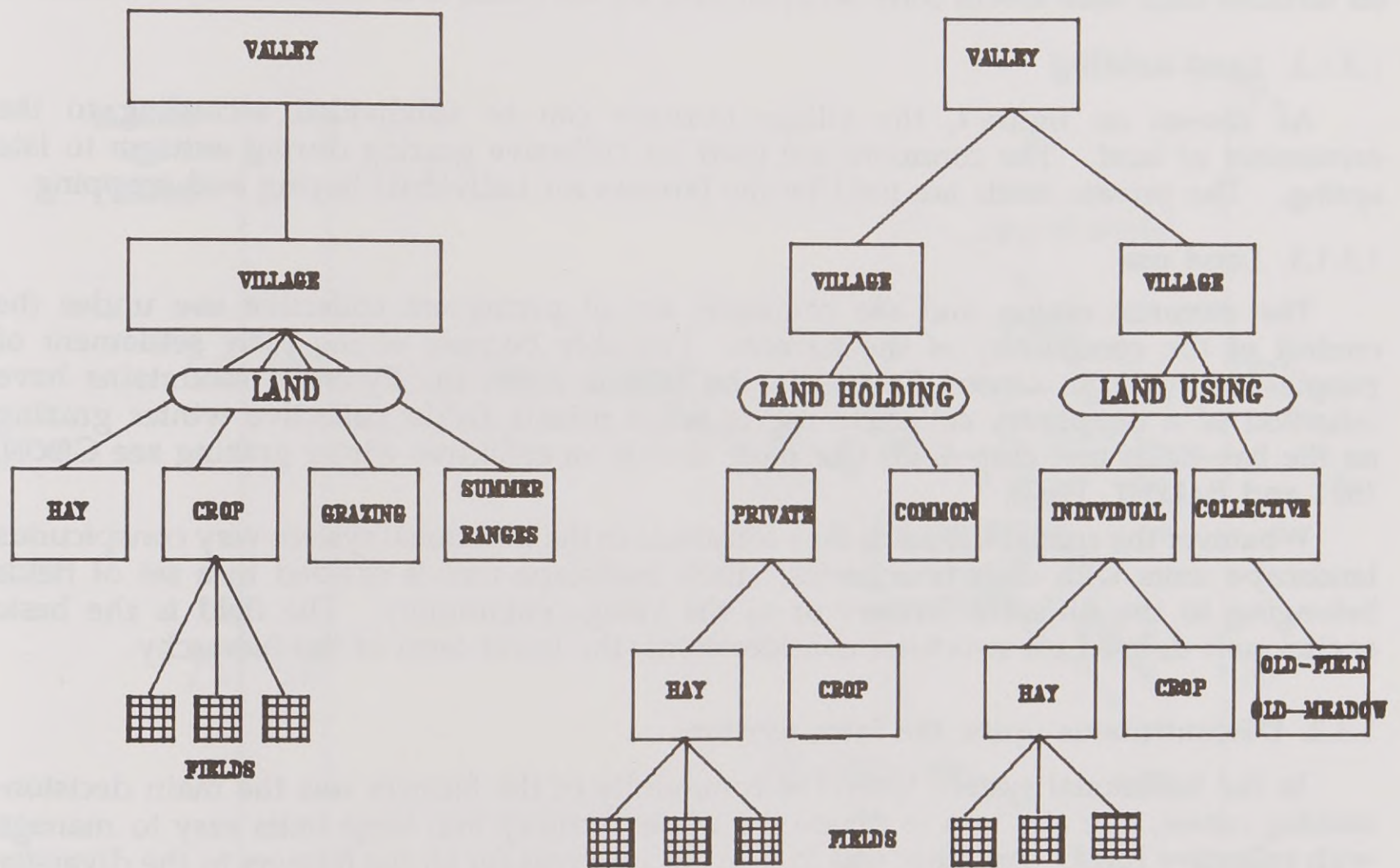


Figure 1 — The different types of spatial hierarchy

1.3.1. Continuous units

1.3.1.1. Land characteristics

Till the beginning of the century land use in the Pyrenean villages was constrained by land characteristics (i.e. soil characteristics, slope, altitude):

— The summer ranges (between 1500 and 2800 m) are collectively owned by one village, by a group of villages or by the state. In the central part of the Pyrenees they are generally undergrazed. They present a very slow ecological dynamic and do not

constitute a limiting factor to animal feeding. Further on I shall only focus on pastoral resources of valleys.

— The commons are located between 1000 and 1500 m on heavy slopes with a shallow stony soil unsuitable for cropping. They are grazed during summer and mainly in autumn and late spring. Overgrazed and burnt for hundred years, undergrazed now they are invaded by both pyrophytic species like *Brachypodium pinnatum* and woody species like *Juniperus communis*, *Corylus avellana* and *Betula pendula*. Range conditions are poor now.

— The best parts of the village territory are devoted to haying and cropping. Landscapes are typical: large hay-fields surrounded by hedgerows of a fodder tree (*Fraxinus excelsior*) in the valley along river used for irrigation; near the village hundred of small crop-fields on terraces built with stones form an open-field on the sunny side of the valley ("soulane").

1.3.1.2. Land holding

As shown on figure 1, the village territory can be subdivided according to the ownership of land. The commons are used for collective grazing during autumn to late spring. The private fields are hold by the farmers for individual haying and cropping.

1.3.1.3. Land use

The summer ranges and the commons are of permanent collective use under the control of the community of the farmers. Probably because of the early settlement of people coming from central Europe in the Middle Ages, the Pyrenees mountains have inherited of a temporary collective use of some private fields: collective winter grazing on the hay-fields and crop-fields (for more details on collective winter grazing see GIBON, 1981 and BALENT, 1987).

Whatever the spatial subunits, they constitute in the traditional system very conspicuous landscape units with clear boundaries. Each landscape unit is divided in a set of fields belonging to the different farmers or to the village community. The field is the basic spatial unit defined on structural considerations, the lower level of the hierarchy.

1.3.2. Discontinuous units: the farm territory

In the traditional system when the community of the farmers was the main decision-making centre, one aim was to divide the whole territory into large units easy to manage with collective rules. An other was to provide an access for all the farmers to the diversity of the ecological and agronomical resources necessary to the farm household and the cropping and livestock systems. Therefore the farm territory was split in a great amount of small fields spread within the whole village territory.

This kind of management was accurate in a pastoral system steadily conducted by the farmers community for purpose of auto-consumption. Changes in the main aim of the system (e.g. meat production instead of auto-consumption) and this spatial organization become obsolete.

2. Functional units: Agricultural practices space A non-nested hierarchy

2.1. The decline of agriculture and the evolution of agricultural practices

2.1.1. Changes in land use: Towards a field mosaic

As mentioned above, the village territory is made up three large units: The commons on the slope of the valley, the hay-fields in the bottom near the river and the crop-fields near the village on the slope facing south.

The dramatic fall of human population at the end of the 19th century and the new trend in agricultural system (i.e. meat production instead of auto-consumption) led to important changes in the use of territory. Figure 2 gives some quantitative values for the private fields of the village of Oô (BALENT & BARRUE-PASTOR, 1986). Two points are of primary importance: the drastic fall of the crop-fields and to smaller extend of the hay-fields actually representing no more than 45 % of the private land and the correlative appearance of a new kind of pastoral area, the intermediate zone (BALENT, 1987) resulting of the abandonment of cropping and haying.

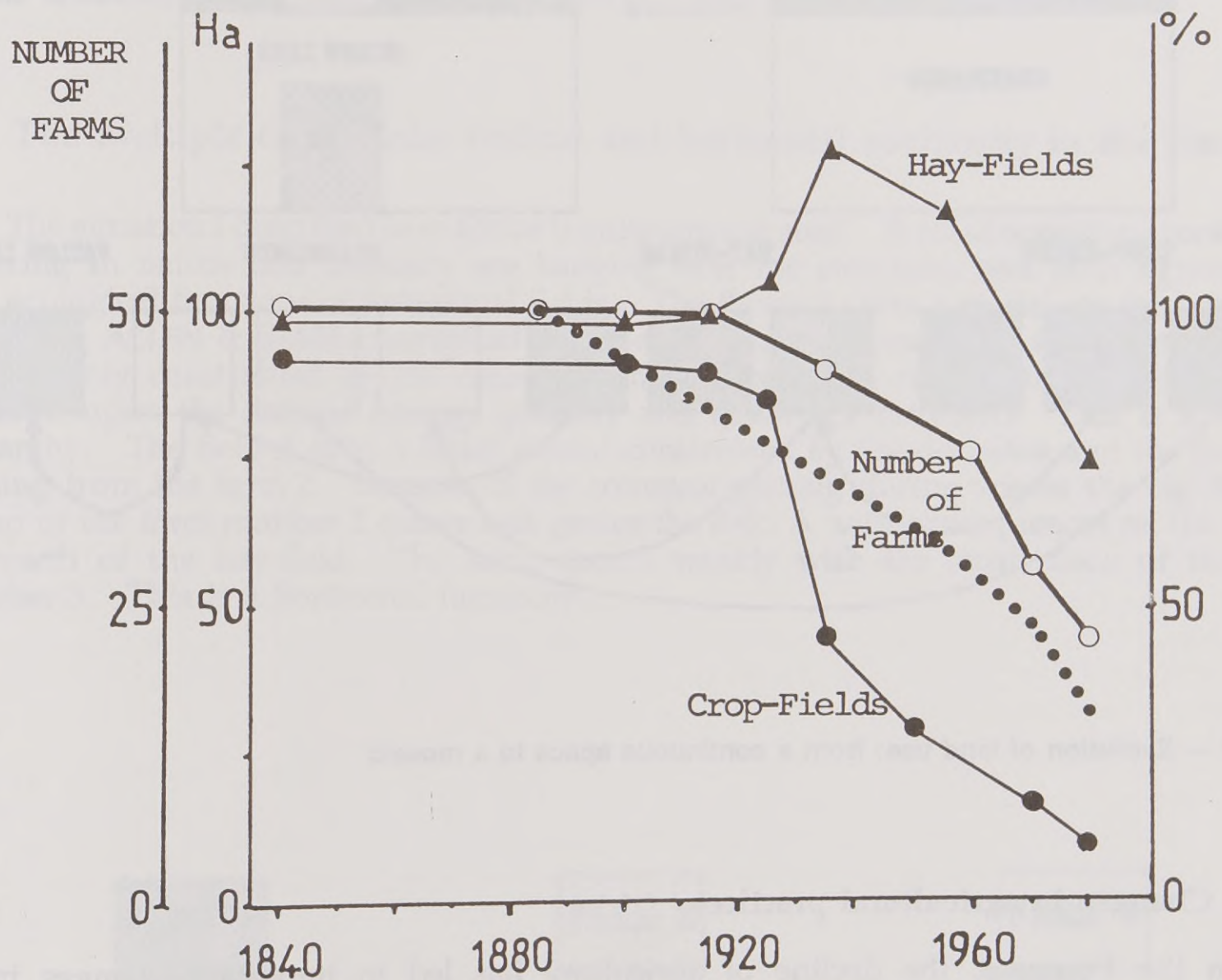


Figure 2 — Evolution of land use in the village of Oô (from BALENT & BARRUE-PASTOR, 1986)

The abandoned crop-fields were transformed into hay-fields or rightly into grasslands depending upon their slope. Some evolve into nitrophytic fallows. The hay-fields were transformed either into grasslands either into fallows. This set of abandoned private fields is now use for collective grazing from autumn to late spring as the Commons used to be, or evolving into fallow depending upon their accessibility and location in the village territory. Figure 3 shows the mechanism of the transformation in the use of the village territory and its main result i.e. the transition from a territory divided in large zones of homogeneous use closely related to ecological characteristics towards a mosaic of fields differing in use and management history (BALENT & DURU, 1984).

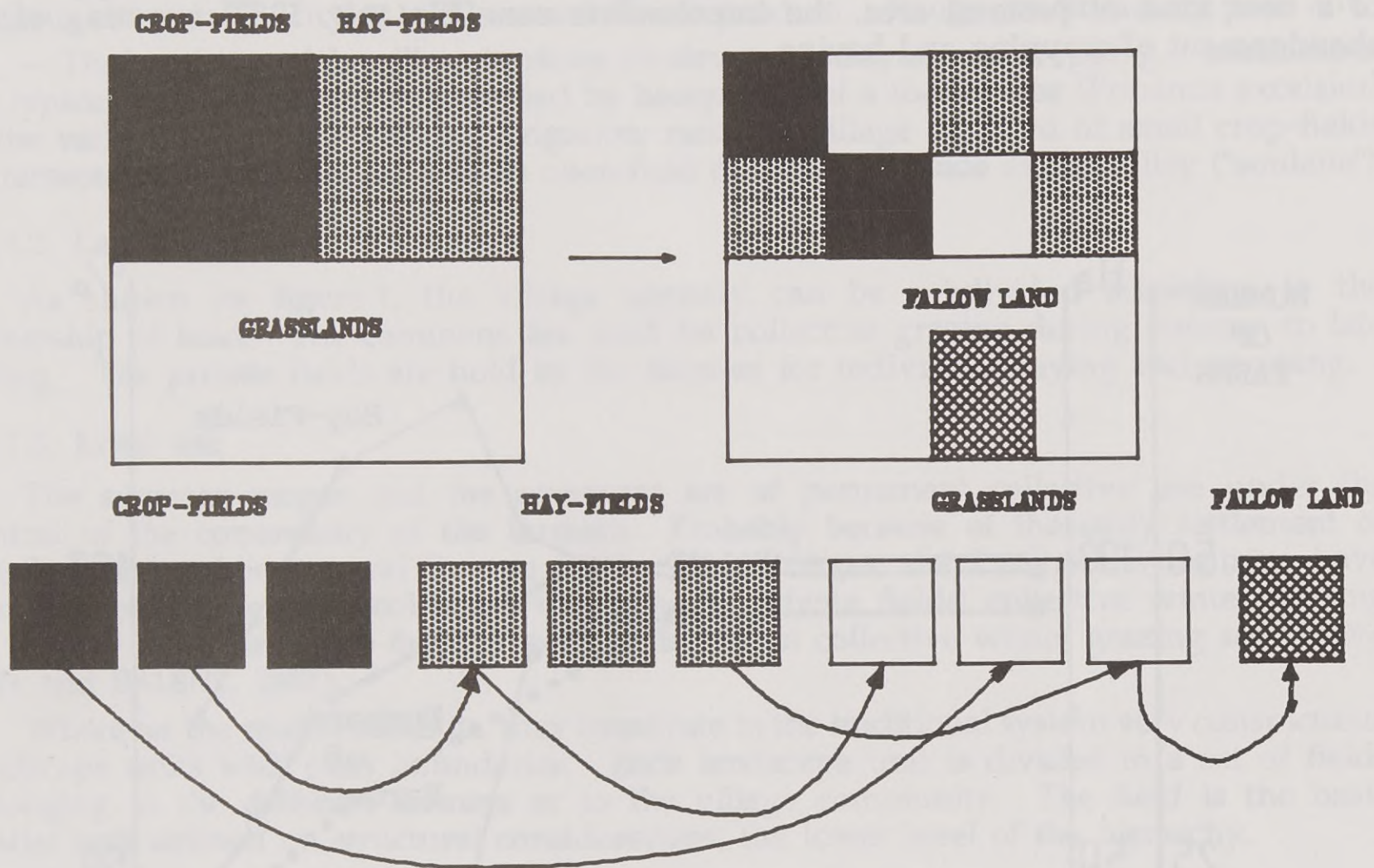


Figure 3 — Evolution of land use: from a continuous space to a mosaic

2.1.2. Changes in agricultural practices

In the Pyrenees, the decline of agriculture has led to important changes in the management of soil fertility and the utilization of grazing resources (BALENT & DURU, 1984; BALENT & BARRUE-PASTOR, 1986).

2.1.2.1. Management of soil fertility

Nowadays the soil fertility of all the pastoral resources i.e. hay-fields and grasslands, is regularly decreasing. The commons, the old-fields and the old-meadows receive any kind of mineral or organic fertilizers. The returns of the grazing animals are only 35 % of the output. The level of fertility of the grazed areas is a residual fertility strictly related to the management history of the fields. The same occurs for the hay-fields where the amount of organic fertilizer is not sufficient enough to overcome the losses due to haying, winter grazing and leaching.

2.1.2.2. Management of grazing activities

The falling of the collective rules of management of the grazed territory have two apparent consequences

— The decision-making about grazing management are more and more individualistic. They depend upon the proper constraints of each farmer within his farming system rather than on any sustainable project dealing with the management of the whole territory.

— The animals are sent to graze freely on the territory. The distribution of grazing pressure on the territory depends mainly upon the grazing behaviour of the animals (BALENT & GIBON, 1986). Heavy grazing occurs on the most palatable resources i.e. hay-fields and old-fields, while under-grazing makes the commons and the old-meadows evolve into fallow.

Because of these practices and of the mixed grazing of all the flocks and herds of the village, the boundaries between spatial units differing in grazing pressure are changing and fuzzy (BALENT & CHARPENTEAU, 1986; BALENT, 1987). The overlap between the structural and functional boundaries is quite difficult to establish as well as the hierarchy of the constraints weighting on each individual field is.

2.2. The multiple constraints: vertical and horizontal continuity in the hierarchy

The situation I described here above is quite complicated. A set of numerous constraints differing in nature and intensity are hanging over the structure, and both agronomical and ecological functions of individual fields. The figure 4 gives a model for the hay-fields according ALLEN & STARR conceptual framework: From a hierarchical viewpoint the field A is mainly constrained by the decisions and the practices of the farm number 1 (e.g. decision upon the date of haying, quantity and quality of fertilizer). This is a vertical hierarchy. The field A is to a lesser extend constrained by the decisions and the practices coming from the farm 2. Because of the common grazing during winter the big flock of sheep of the farm number 2 comes and grazes the field A with consequences on the spring regrowth of the hay-field. The same occurs weakly with the small flock of the farm number 3. This is a horizontal hierarchy.

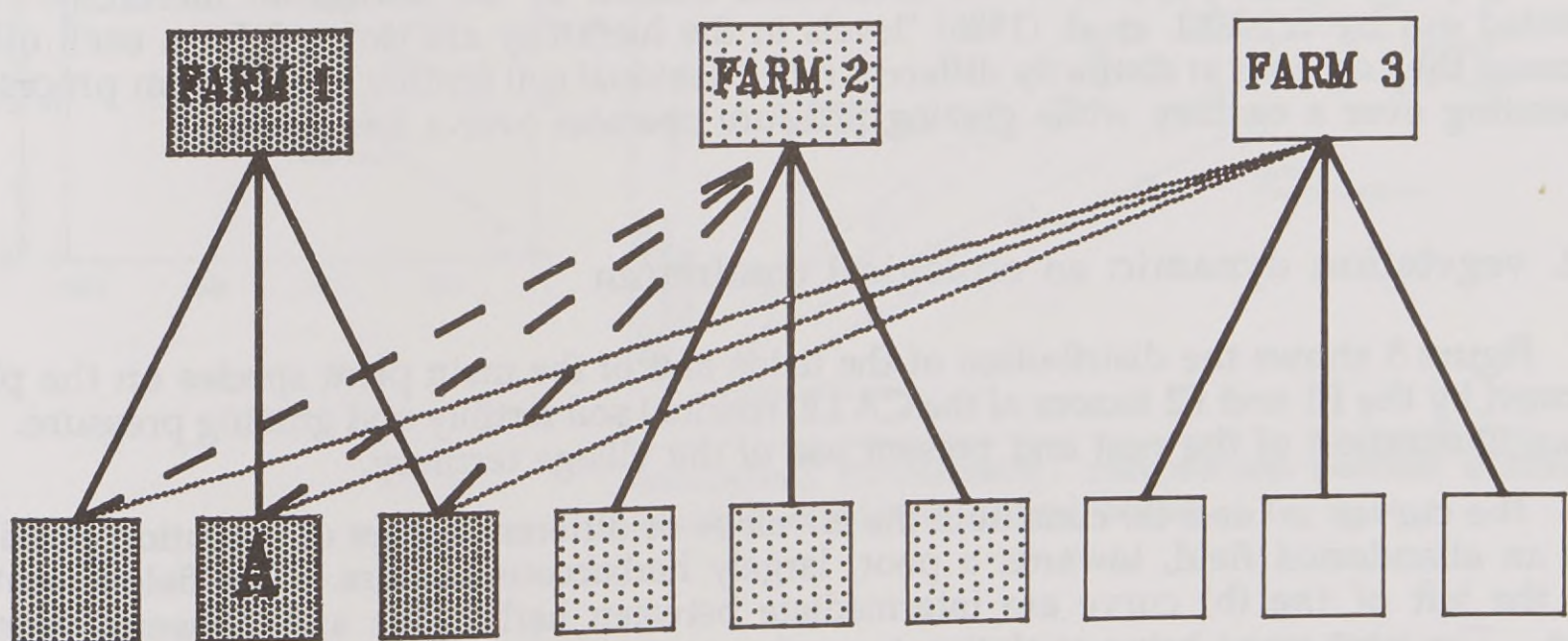


Figure 4 — The non-nested hierarchy of constraints hanging over the hay-fields

The vertical hierarchy mainly drives the fertility of the field, the horizontal hierarchy mainly drives grazing pressure. The resulting mosaic of fields is of primary importance. The surroundings the A field are likewise of importance. Propagules coming from the closest fields may modify the botanical composition.

3. Ecological functioning a link between continuous and discontinuous spaces

A stratified sampling was carried out according to the management history of the fields, present use and grazing pressure. The use of each of the 70 selected fields is known for 1935-1954-1980 and the grazing pressure from observation of the grazing patterns of the animals. For each field the botanical composition is collected by the point quadrat method. Data were processed using Correspondence Analysis (CA: BENZECRI et coll., 1973) program of the Biomeco Software.

3.1. Hierarchy of ecological factors

The significance of the four main ecological factors extracted by CA is based on the informations on field use and on the ecological value of plant species (see BALENT, 1986; 1987).

The first factor F1 ordines the fields and the plant species according to a gradient of residual soil fertility; the second factor F2 according to the intensity of management mainly grazing pressure of the animals. The botanical composition reflects the influence of man on the grassland ecosystem, the two first factors being directly related to past and present agricultural practices. The third factor points out two different dynamics of evolution of field vegetation into fallow i.e. wooded nitrophytic fallow land and herbaceous oligotrophic fallow land. The fourth factor ordines the fields and the plant species according to soil moisture.

The first factor i.e. residual soil fertility, corresponds to the main constraints exerted by the upper levels of the vertical hierarchy on the field level. The second factor i.e. grazing pressure corresponds to the constraints exerted by the horizontal hierarchy. As pointed out by O'NEILL et al. (1986) "levels in the hierarchy are isolated from each other because they operate at distinctly different rates": residual soil fertility results from processes operating over a century while grazing pressure operates over a few years.

3.2. vegetation dynamic: an ecological continuum

Figure 5 shows the distribution of the fields and of the main plant species on the plan formed by the F1 and F2 factors of the CA i.e. residual soil fertility and grazing pressure. It is an illustration of the past and present use of the village territory.

The curves (a) and (b) constitute the envelope of different curves of evolution possible for an abandoned field, towards a poor, largely herbaceous pasture. The fields located on the left of the (b) curve are intermediate between herbaceous and ligneous vegetation. The next stage being evolution towards coppice and forest.

As pointed out here above the fertility of the fields tends constantly to decrease. Therefore the field A, recently abandoned exhibits a set of nitrophytic annual and biannual species; Without grazing the field is transformed into thicket with *Prunus spinosa*, *Crataegus monogyna*, *Fraxinus excelsior*. On grazed fields the trampling and the defoliation lead

to the disappearance of the annuals and their replacement by the perennial species of permanent grassland. *Lolium perenne*, *Poa trivialis* are dominant where there is heavy grazing, and *Dactylis glomerata*, *Poa pratensis*, *Trifolium repens* where there is light grazing, the importance of the species turn-over depending on grazing pressure. Because of the grazing behaviour of the animals, the increasing number of palatable species increase the grazing pressure, the maximum in grazing pressure occurring simultaneously to the maximum of the palatability. This is the stage of improvement of the pastoral value of the fields.

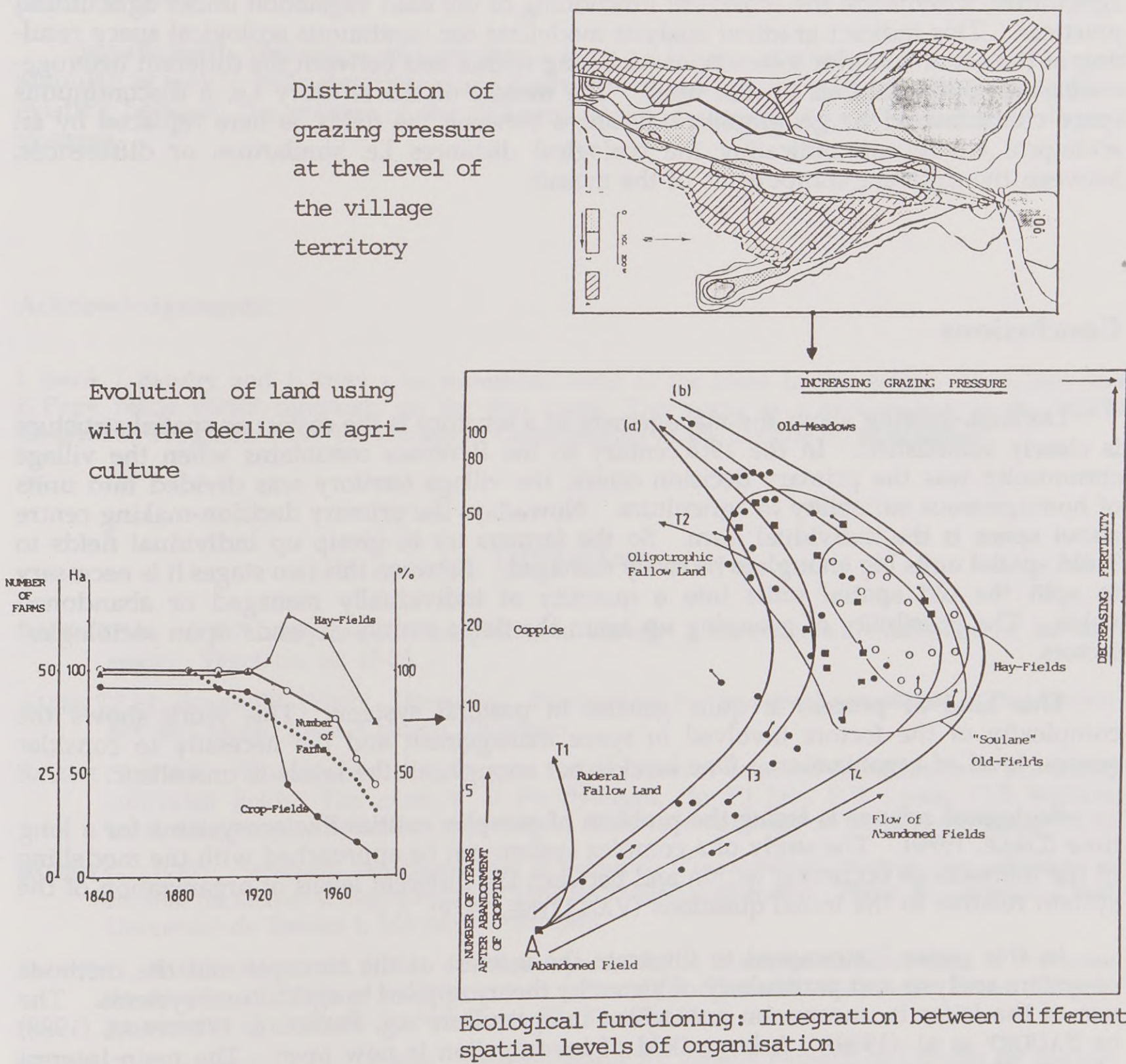


Figure 5 — Modelling the functioning of the ecological space

The second stage starts when the decline of the fertility on the heavily grazed fields induces the disappearance of the best fodder species. The vegetation is less and less palatable and the grazing pressure is decreasing. The botanical composition is gently evolving toward a state of equilibrium. Under-grazing and fire controlled vegetation lead to the settlement of *Brachypodium pinnatum*.

The overall dynamic of the pastoral resources of the valleys works like a continuous flow of fields evolving from a starting point i.e. cropping to a final point i.e. oligotrophic pasture. The sustainability is only ensured as long as new crop-fields to abandon exist. Figure 2 shows that we are now close to the end of the process.

This ecological modelling of the old-field succession that starts with the decline of agriculture, summarize the ecological functioning of the field vegetation under agricultural practices. This indirect gradient analysis modelizes the continuous ecological space resulting of the set of complex interactions occurring within and between the different heterogeneous and discontinuous spatial units. The mosaic of the territory i.e. a discontinuous space characterized by geographical distances between the fields, is here replaced by an ecological continuum indicating the ecological distances i.e. similarities or differences, between the different components of the mosaic.

Conclusions

Decision-making about the management of a territory is the easiest as spatial structure is clearly established. In the 19th century in the Pyrenees mountains when the village community was the primary decision centre, the village territory was divided into units of homogeneous suitability to agriculture. Nowadays the primary decision-making centre about space is the individual farm. So the farmers try to group up individual fields to build spatial units big enough to be easily managed. Between this two stages it is necessary to split the old spatial units into a quantity of individually managed or abandoned fields. The possibility of grouping up again the fields mainly depends upon sociological factors.

This kind of process is quite general in pastoral systems. This work shows the complexity of the factors involved in space management and the necessity to consider several level of organization. One level is not enough, all the levels is unrealistic.

Ecological science is facing the problem of complex entities like ecosystems for a long time (DALE, 1970). The study of a complex system can be approached with the modelling of the interactions occurring within and between the different levels of organization of the system relative to the initial questions (VAN DYNE, 1979).

In this paper I attempted to illustrate the interest of the concepts and the methods of system analysis and particularly of hierarchy theory applied to agricultural systems. The use of the latter is uncommon and recent in agriculture e.g. FRESCO & WESTPHAL (1988) or BAUDRY et al. (1989). A large field of investigation is now open. The main interest of hierarchical analysis of a complex phenomena is in the double nature of the hierarchy i.e. vertical and horizontal. It allows to give for example an account of the constraints hanging over the individually managed fields because of the common winter grazing of crop- and hay-fields.

Another interest in the Pyrenean case is the definition of the smaller level of organization common to the different spatial hierarchies e.g. field level. This is the spatial unit suitable for comparative analysis.

If hierarchical analysis offers a set of useful concepts and methods to scale up and down across the structure and the levels of organization of very complex systems, factorial analysis are their natural complement to modelize ecological processes. Correspondence Analysis (see the basic paper of PRODON & LEBRETON, 1981) allows us:

— to establish a hierarchy between the different factors structuring the data e.g. residual fertility > grazing pressure;

— to analyse at the same time several levels of organization differing in scale and rate e.g. field level as a function of informations coming from upper levels of the spatial hierarchy (grazing pressure);

— to calculate functional distances between the different spatial units along ecological gradients e.g. similarity between hay-fields and old-fields versus old-meadows and nitrophytic fallows.

Simultaneous utilization of both hierarchical and factorial analysis is one of the most stimulating way to build descriptive and functional models giving account of the connections existing between the entities of the different levels of organization of complex biological systems.

Acknowledgements:

I thank J. Baudry and F. Burel who stimulated some of the ideas in this paper. B. Hubert and F. Papy made useful comments on the first draft. This paper is a contribution to the EGPNC Committee Programme on "the Ecological Consequences of the Decline of Agriculture".

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Résumé :

La structure, le fonctionnement et l'évolution du territoire pastoral dans les Pyrénées centrales dépend de nombreux facteurs écologiques, géographiques et historiques qui contribuent à découper le territoire en de nombreuses entités de taille et de nature différentes. Ces découpages structuraux aux frontières bien marquées peuvent être représentés dans un schéma hiérarchique emboîté. La coexistence de pratiques collectives et individuelles sur le même espace conduit à des découpages fonctionnels plus complexes aux limites souvent floues. La superposition de ces deux ensembles définit une hiérarchie de découpages spatiaux verticale mais aussi horizontale (non-emboîtée). L'Analyse des Correspondances constitue un bon outil pour l'étude des interactions existantes entre les différents niveaux de cette hiérarchie.

Analysing the management of a pastoral territory The study of the practices of a shepherd in the Southern French Alps

Etienne LANDAIS and Jean-Pierre DEFFONTAINES

Summary:

For two years the authors investigated the practices of a shepherd summering a meat producing flock of 1,000 sheep in the southern French Alps. The study focused on the articulation between daily management practices of the flock and the overall management of the pastoral system during the summer. The method adopted, consisted of progressively developing a working relationship between the shepherd and the researchers, in which the statements and thinking of the shepherd were continuously reported back to him from a scientific viewpoint, and these statements compared with observations made in the field. Visual aids were used as a major means of expression (diagrams, maps, photographs, films).

The results include information about:

- flock management practices which determine the control the shepherd has over flock movement and feeding activities;
- the practices which concern the management of the pastoral unit as a whole are based on the subdivision of the area into a series of 'quartiers' and 'secteurs', in which a continuous assessment of available herbage resources and of the choice of the daily grazing 'circuits' is made.

Introduction

This study is part of a new approach to agronomic research which has been developed over the past 15 years by the department of "Systèmes agraires et Développement" of the Institut National de la Recherche Agronomique (INRA, France); it is based on the idea that understanding the methods used by farmers is a necessary forerunner to proposing any technical innovation. A synthesis of these works has recently been written (Landais et Deffontaines, 1988).

For two years, the practices of a shepherd managing a flock of about a thousand head of sheep over the summer season were studied. These sheep are destined for the meat market and spend the summer on alpine pastures in the Reallon valley, in the Alps. The principal aim of the work was to identify the objectives and the strategies of the shepherd in his management of the pastoral unit over the summer period (about 110 days, from the end of June to the beginning of October), and the type of indicators that he uses throughout the summer grazing period and the reference points which enable him to judge a situation and take the necessary decisions.

1. Materiels and methods

The flock which was studied consisted principally of animals belonging to local breeders and which are related to the sheep population called "Commune des Alpes", a wool sheep well-adapted to the mountainous conditions of the "Préalpes du Sud" breed. The average weight of ewes is about 50 kg.

The production system involves a long winter period indoors (5 months) with lambs raised and sold at an average age of 4 months. Autumn lambing, justified by the seasonal variation in prices entails out-of-season mating in springtime and a second mating season in autumn. This autumn mating produces "tardons" (late lambs) which account for half of the lambs; these were traditionally fattened on the alpine pastures. Now, only the tardons born too late in the season to be weaned before the ewes go to the summer pastures, and the lambs which do not fatten well inside, are fattened on the mountain pastures.

The summering flock is made up of the following categories of animals:

- ewes and pregnant gimmers (about 45 % of the flock)
- ewes which have recently weaned their spring-born lambs (30 %).
- a few lactating ewes with their "tardons" (7 %)
- non-pregnant gimmer ewes (10 %).

Physiologically speaking, the critical phases of the reproductive cycle take place in the valley and not on the alpine pastures. However, mountain summer pasture is important for the whole equilibrium and the reproductive strategies of this system of raising sheep. From an economic point of view, the fodder units eaten on the mountain pastures are considered cheaper than what can be produced or bought by the sheep farmers in the valley (winter forage is produced in the valley whilst the sheep are in the mountains). From a technical viewpoint, this period in the mountains is very important for the overall regulation of the reproductive cycle, the rams are left in the valley for the summer and the ewes return in autumn from their summer pastures in good body condition. From a health viewpoint, this period is also very profitable.

The pastures used by the sheep lie between 1600-2600 m and are characterised from the phyto-ecological point of view, by their aspect and their situation in the altitudinal gradient which covers subalpine and alpine vegetation (alpine pastures begin at 2300 m).

The study area is in the Parc National des Ecrins. The Park has contributed financially to this work as their aim is to maintain traditional pastoral activities at the same time as conserving the mountain ecosystems. Concrete suggestions for the pastoral management are expected in the medium term.

The first phase of the work consisted of constructing a means of exchanging information, either orally or written, between the shepherd and the researchers. The progressive structuring of the shepherd's description of his own practices was obtained by a iterative

procedure which consisted of the researchers writing down the shepherd's description then returning him the document, pointing out its contradictions and inadequacies; this led him to deepen his analysis, to speak more precisely and to better define his concepts. The contradictions and inadequacies were exposed by systematic comparisons of:

- the observed practices (which were noted down, located on maps, and filmed), and the description of these practices by the shepherd;

- the events which mark the real functioning of the pastoral system, and the predictions or intentions of the shepherd.

The results of this research were published (Landais et Deffontaines, 1988) as a report which followed as closely as possible the comments of the shepherd, literally and in their internal logic. The passages quoted below are extracts from this document. It is important to note at this stage that we have not used observation or measurement that would allow evaluation of the shepherd's practices in terms of animal production or of the effect on the pastures.

2. Results

2.1. The practices of flock management

The quality of management of the grazing system is based on the control the shepherd has on the movements and the feeding of the flock at the level of the daily grazing 'circuits'¹. This control depends on:

- the quality of the continuous observations made by the shepherd, which determine the accuracy and the relevance of his analysis of the situation. These observations involve:

- the flock. Most important are the often visual indicators (picked up by binoculars): position, configuration and movements of the flock (noting the position of the 'bêtes de remarque' — easily identifiable animals); feeding behaviour and the spatial distribution of the animals. The shepherd also uses auditory information, such as bells and bleating.

- the different factors which will influence the spontaneous movement of the flock ('biais'), include the characteristics of the terrain, as well as the nature and state of the vegetation; the meteorological conditions; the time of day and the position in the daily grazing circuit (what has preceded this position, particularly what the animals have already eaten, and what will happen next, in so far as the animals can anticipate it).

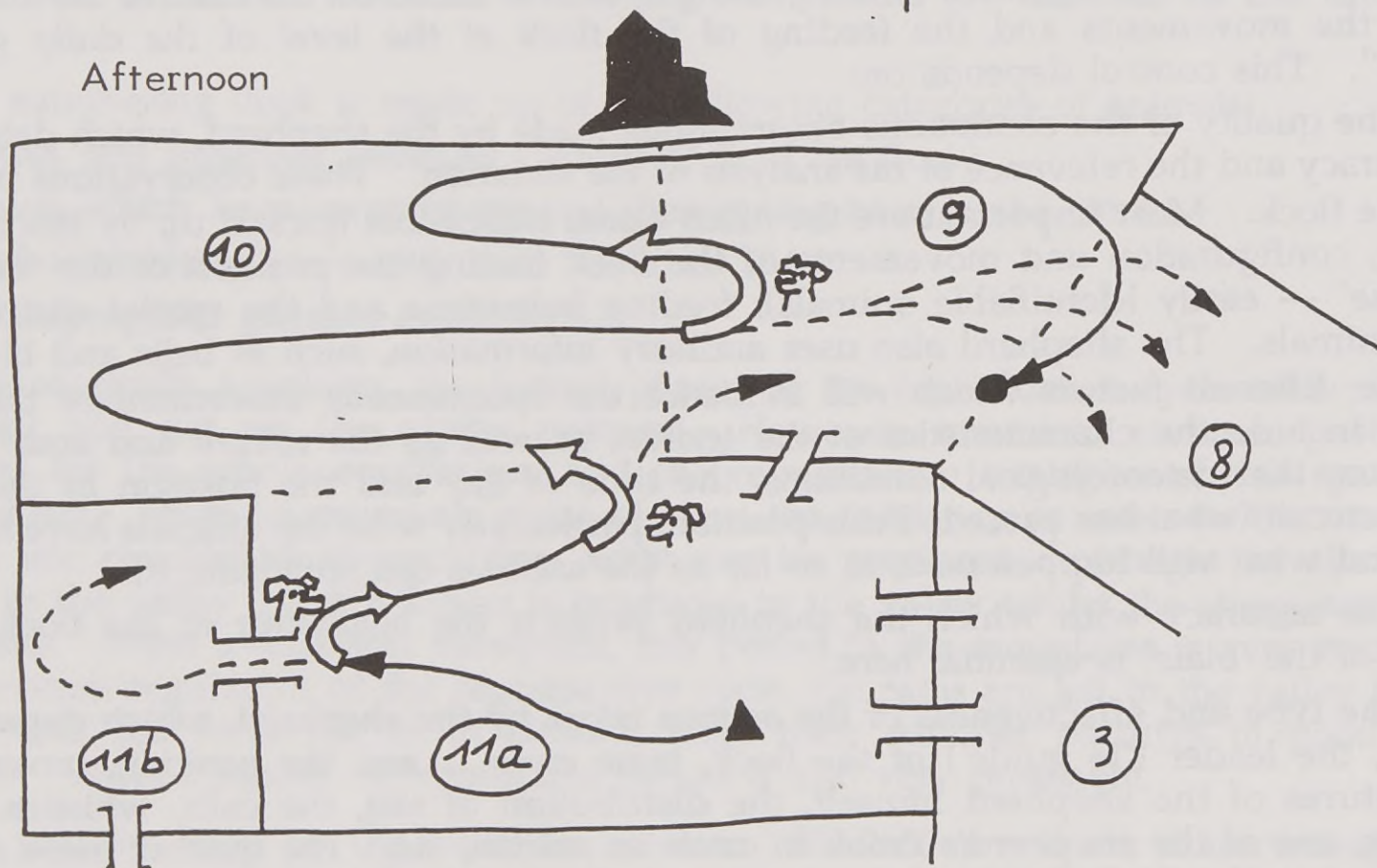
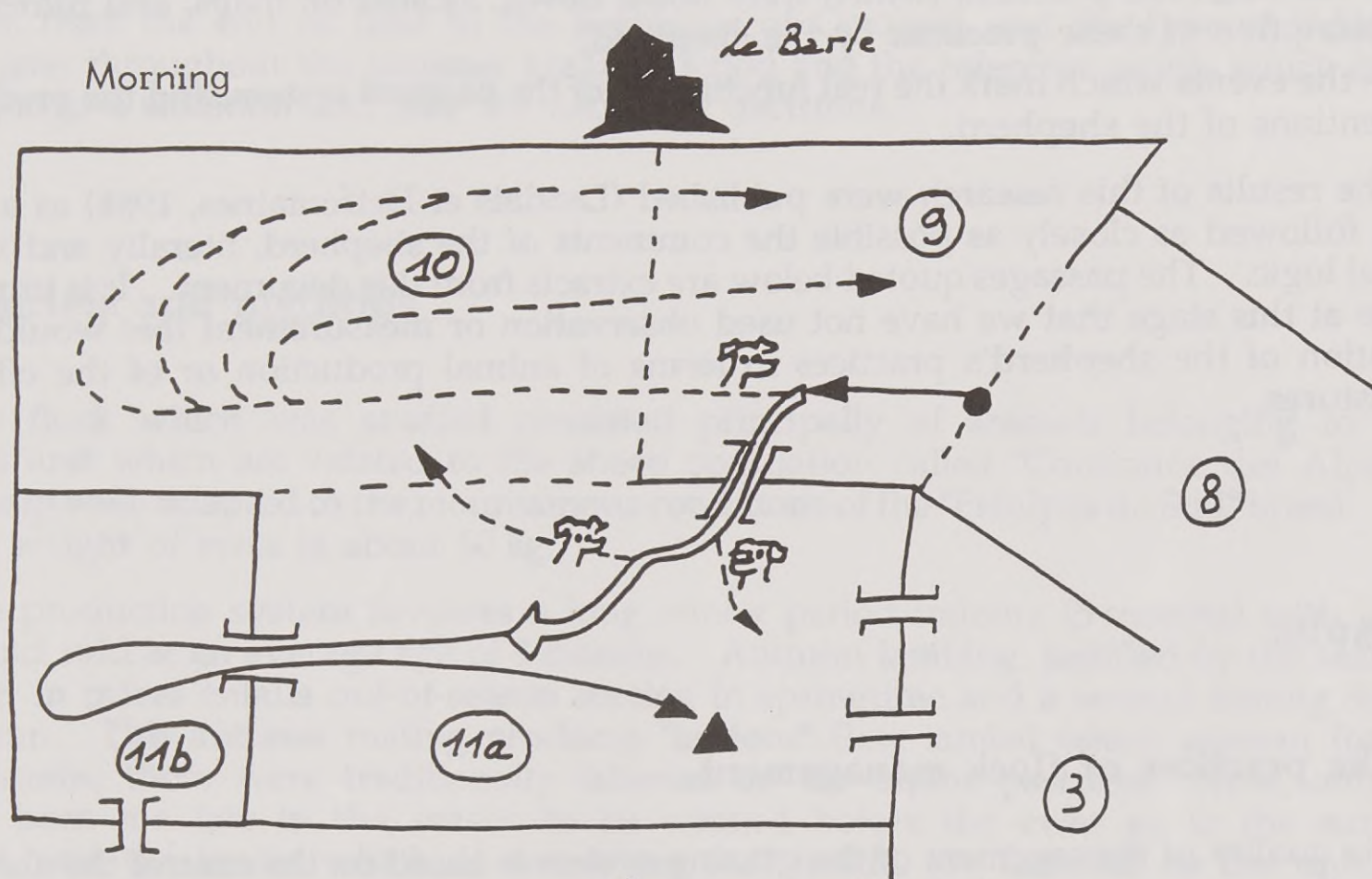
- the accuracy with which the shepherd predicts the behaviour of the flock. The concept of the 'biais' is essential here.

- the type and effectiveness of the actions taken by the shepherd, which depend on: the dog, the leader ('le guide') of the flock, tame ewes and the position, movements and postures of the shepherd himself, the distribution of salt, the calls, whistles, stone throwing, use of the shepherd's crook to catch an animal, etc. The quicker these actions are applied to the flock the more rapid is the response of the flock (cf. see above).

The actions by which the shepherd achieves control over the movement of the flock so that it follows the chosen circuit fall into five broad categories:

- maintaining the flock as one unit: "the shepherd should maintain his flock as one unit, rounding up the animals which hang back or wander off from the flock either by calling; them, going to collect them himself or sending his dog after them. If the flock breaks up, it is no longer possible to control it."

- herding the flock: "the shepherd guides the flock which moves as a unit without grazing. The shepherd is either behind and pushes the flock with the help of his dog,



- Spontaneous course followed by the flock
- Course followed by the herded flock
- - - Course that the flock would have taken in the absence of the shepherd

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or in front leading the flock with the "leader" sheep and the tame sheep around him. It is the shepherd who indicates the direction to be taken and chooses the speed of movement."

— "the shepherd slows down the grazing flock, to allow it to spread out fully which prolongs the grazing time in the place where they are."

— blocking the way: "the shepherd stops the sheep from moving to another 'secteur' or to another part of the 'secteur' in which they are already. This is done either by blocking a specific path or by using a natural barrier e.g. a road, a ravine, a ridge."

— the shepherd turns the flock around: "the shepherd, with or without the help of his dog, interrupts the movement of the flock and turns it about, to send it back the way it came, so that the animals continue to eat in roughly the same area."

"The job of shepherd is to know when and how to act effectively. A good shepherd obtains what he wants from his flock with a minimum of actions. The best criterion by which to judge a shepherd is the calmness of his flock. Everything is done in confidence and with ease, spontaneously to the point that one has the impression that the shepherd is doing nothing. To reach this stage one has to be very attentive and aware, and to have had a lot of experience."

2.2. The management of the grazing area

The management of the mountain pastures is organised on the basis of specific grazing units which take into account:

— the morphological and pedological characteristics of the different spatial sub-units within each grazing unit: relief, slope, stoniness, altitude, aspect... as well as their respective positions within the alpine pasture and the routes of access for the flock.

— the growth stage and the abundance of the vegetation; the quality of which is evaluated through the feeding behaviour of the animals.

— the spatial behaviour of the flock on the individual sub-units. The number of sheep is very important and it influences the way in which the animals will use each part of the pasture (a particular section may not be grazed being too small for the flock as a whole).

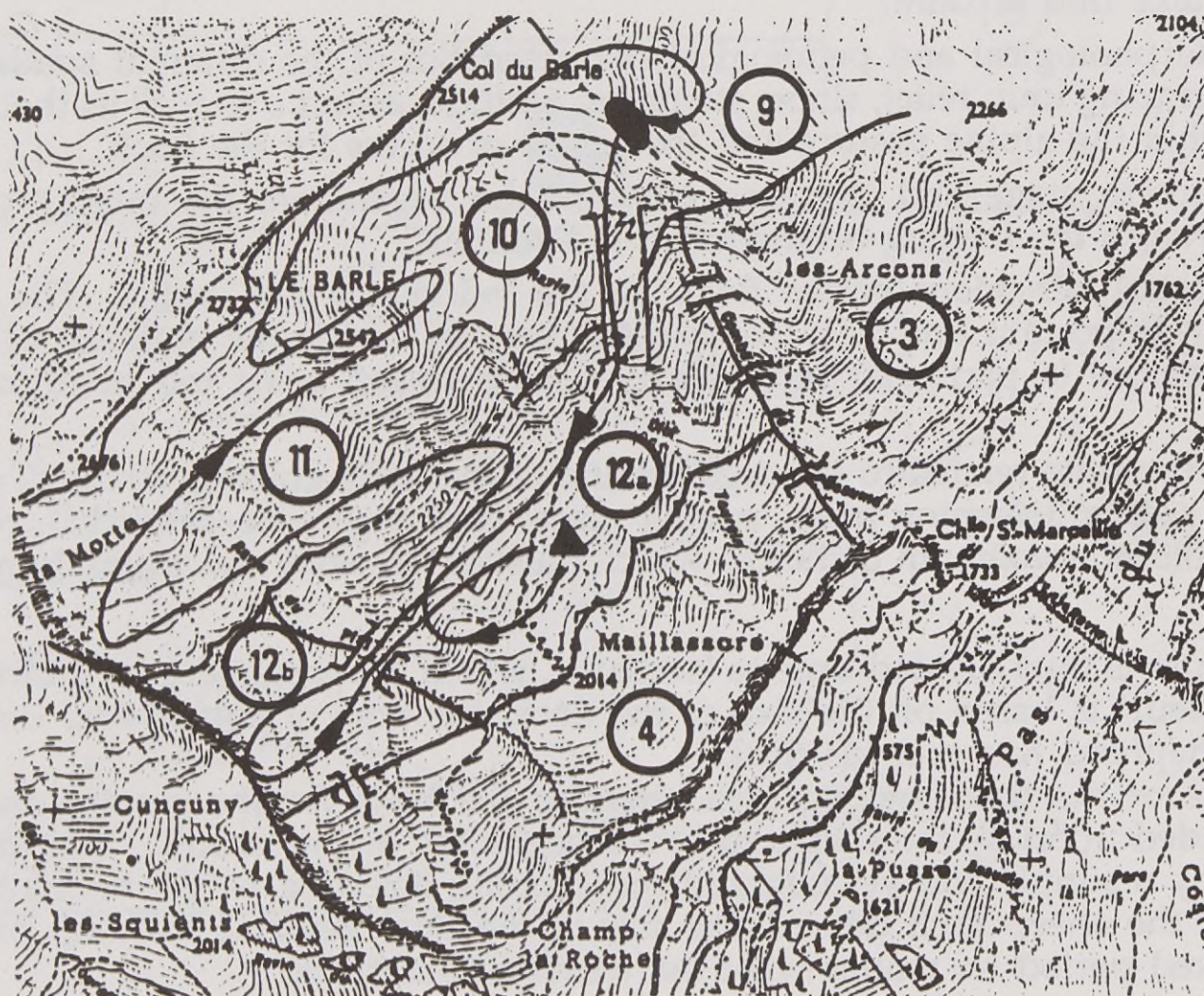
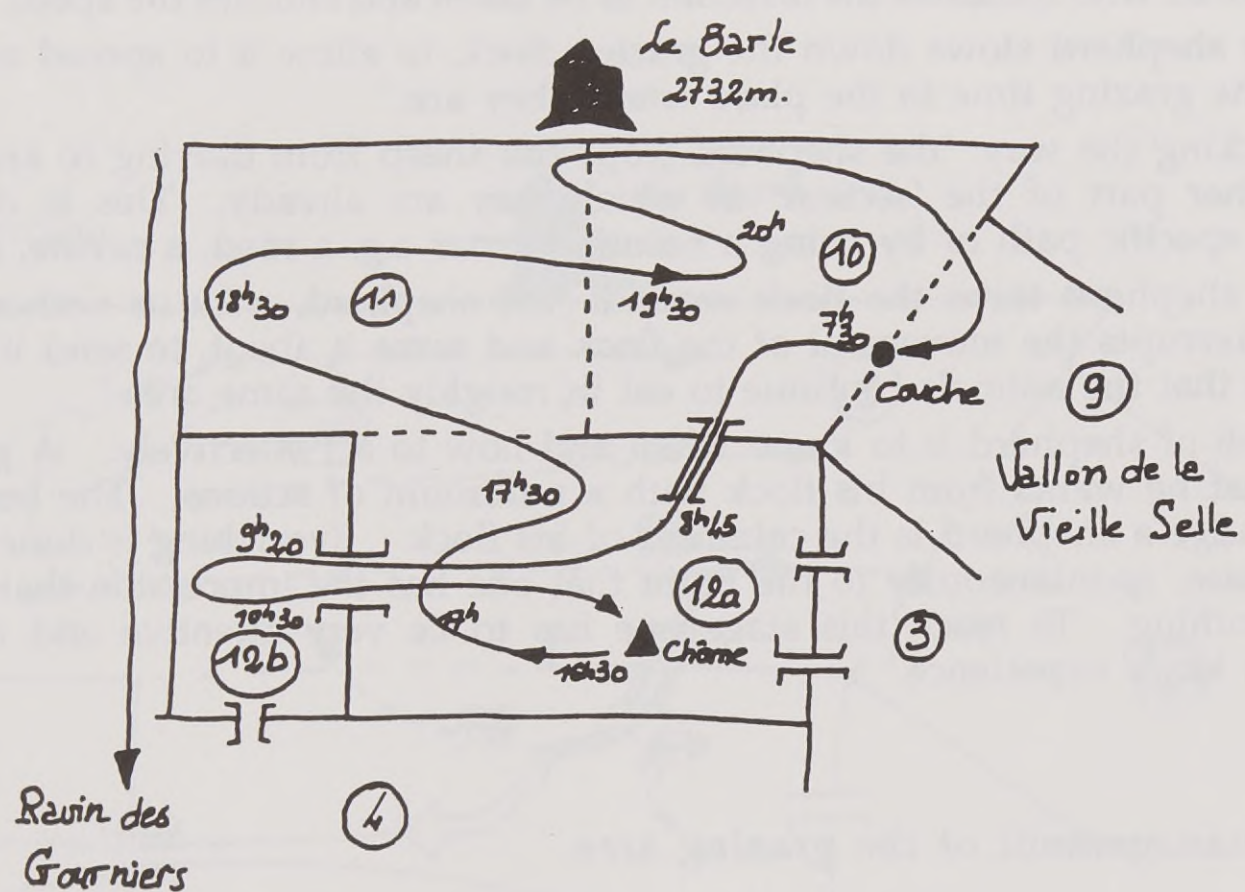
— the constraints related to the organisation of the daily grazing 'circuits': positioning of the "fixed points" (sleeping place, resting place, watering point, salt-licks), paths which cannot be avoided, maximum distances which must be covered and maintaining the flock as one unit.

The pasture is thus divided up into 'secteurs', which are grouped into 'quartiers'. The size of a 'secteur' is based on the size of the flock, the type of animal and the degree of control the shepherd has over his flock.

This structure of the total grazing area provides the basis for the grazing management which is decided upon by the shepherd at the beginning of the season. The management is governed by a simple and yet mightily constraining objective — "the necessity of filling the bellies of the sheep each day —" the size of the flock remains constant on a limited area, for a fixed period no matter what the weather conditions.

The principal degree of liberty the shepherd has is in deciding the daily grazing circuits. These take into account the spatial relationships between the different secteurs, and also the complementarity as far as their contribution to the available forage is concerned. The shepherd again uses his observations of the feeding behaviour of the animals to understand this complementarity. The objective as always is to get the animals to eat the maximum quantity from the variety of plant resources available.

Moreover the best management of plants occurs when they are used optimally, that is grazed when the plants are providing the maximum amount of green matter without



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Altitude : 2 100-2 500 m

any wastage by the animals. To achieve this the shepherd gives the flock only a limited area to graze over; his aim is to preserve until the end of the grazing season "new and clean" areas which the animals most prefer.

Therefore the aim of the Parc des Ecrins, to preserve and improve the pastures coincides with the aims of the shepherd, although he recognises that there is a lack of precise and practical indicators by which his performance can be evaluated.

The organisation and management of the daily grazing circuits are just part of the overall strategy of the management within the alpine pastures in the summer. At this level, the objectives are to exploit as best as possible the alpine pastures (to graze everywhere; to overgraze nowhere) in an overall perspective of gradual improvement of the value of the grazing and of its use; this is expressively summarised by the shepherd's saying: "the good shepherd increases his pasture, the bad shepherd sees his pasture disappearing".

The principal indicators that the shepherd has to govern his programme of management are:

- The dates and lengths of periods of use of each 'quartier' and each 'secteur'. This information is gathered over the previous years, and allows a general estimation of the available standing crop at any point in time, so that the shepherd can vary his management of the pasture as he wishes (the shepherd's freedom of action depends principally on the abundance of the herbage available).

- The estimation of the amount of available grazing that remains is done 'secteur' by 'secteur' based on the visible state of the vegetation (the unit used is the grazing time of the flock expressed in hours) which is then converted into the circuits and thus into the days of grazing left. The estimation of the number of days of grazing left allows the shepherd to adjust his management in relation to the summering period that remains, varying the pressure of grazing in the different 'secteurs' that are left to be exploited. This estimation obviously becomes more precise as the season progresses and as the balance between the shepherd's assessment of the available herbage (number of grazing days available in advance: *jours d'avance*²) and the requirements (number of remaining days to the end of the season) becomes tighter. For this estimation the shepherd cumulates separately the days of grazing that are possible under bad weather conditions (certain 'secteurs' provide more shelter than others, others are dangerous, or even unusable in bad weather). Sheltered 'secteurs' need to be preserved for the end of the season because snowfall is not rare in September. All in all the shepherd comes out as a master of compromise between multiple imperatives.

3. Discussion

This study has shown a number of factors of general interest which allow a rational analysis of the management by shepherds of the alpine pastures. It has highlighted the richness of the indicators drawn by the shepherd from the animals' behaviour; these allow the shepherd to manage the pastoral system in the absence of direct and precise indicators in the form of animal performance on the different pastures or the development of the grazed vegetation.

The results are being used in relation with the Parc National des Ecrins and the CERPAM³ to: contribute to the development of new methods of evaluation of the alpine pastures, calculating the possible grazing pressure and types of exploitation; helping in the decisions on grazing management. These results will also be used to train shepherds and other people involved.

This research has provided an important contribution to the understanding of farming practices. The results confirm that the method adopted does allow the possibility of finding out by means of observation the objectives, the strategies and the indicators which are used by the shepherd. It is only when the researcher goes beyond the descriptive framework that he reaches references, decision rules, thought processes and concepts of general validity.

Acknowledgements:

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GLOSSARY

SECTEUR: a 'secteur' is a subdivision of the pastoral unit. This physical division of the pasture is described using six criteria: altitude, aspect, area, position and accessibility, landform, vegetation.

QUARTIER: a 'quartier' is a group of 'secteurs' grazed at the same period in the summer when the sheep use the same sleeping place. There are essentially three 'quartiers': the July 'quartier', the August 'quartier' and the Autumn 'quartier'.

CIRCUIT: the 'circuit' is the route followed during a day by the flock which covers a certain number of 'secteurs' within a particular 'quartier'. The 'circuit' begins and ends at the sleeping place within this 'quartier'.

COUCHE: this is the place where the flock groups for the night. Each 'quartier' is defined around its sleeping place.

CHOME: the 'chôme' is the resting place where the animals spend the hottest time of the day ruminating. Like the sleeping place the location of the "chôme" is usually fixed. Its position is determined by the physical nature of the mountain.

BIAIS: the 'biais' is the movement which the flock spontaneously makes in a given situation. This behaviour can be anticipated as it depends on different factors which the shepherd is able to perceive.

BETES DE REMARQUE: these animals have some distinctive marking which allow them to be identified easily at a distance. Being distinctive they break the homogeneity of the flock and enable the shepherd to follow its spatial structure.

GUIDE: the leader is the wether which belongs to the shepherd and is trained to lead the flock.

Résumé :

Les auteurs ont étudié durant deux années les pratiques d'un berger d'estive conduisant un troupeau de 1 000 têtes d'ovins-viande dans les Alpes du Sud. La recherche portait essentiellement sur l'articulation entre les pratiques quotidiennes de conduite du troupeau et la gestion du système pastoral à l'échelle de la saison d'estive. La méthode adoptée repose sur la construction progressive d'une relation de travail particulière entre l'auteur concerné et les chercheurs, la restitution permanente de son discours au berger et la confrontation de ce discours aux observations sur le terrain. Les supports visuels ont été privilégiés (schémas, cartes, photographies, films).

Les résultats concernent:

- les pratiques de conduite du troupeau, qui conditionnent la maîtrise exercée par le berger sur les déplacements et l'alimentation des animaux ;
- les pratiques de gestion de l'espace pastoral, qui reposent sur un découpage fonctionnel de cet espace en « quartiers », l'évaluation continue des ressources disponibles et le choix des « circuits » de pâturage quotidiens.

NOTES:

1. The terms in 'inverted' commas' are defined in the glossary.
2. This shepherd's spontaneous expression evokes the concept of "jours d'avance" used by M. DURU et al. for studying forage systems (see paper n° 2.4).
3. Centre d'Études et de Réalisations Pastorales Alpes-Méditerranée.



Résumé :

Le présent rapport a été établi en vue de donner une idée de l'état de la situation économique de la région de la vallée de la Loire, en ce qui concerne la production et la consommation de l'énergie électrique. Les données sont basées sur les statistiques officielles de la région, et sur les renseignements fournis par les entreprises électriques de la région. Les conclusions sont que la production d'énergie électrique dans la région de la vallée de la Loire est en constante augmentation, et que la consommation est également en constante augmentation. Les perspectives sont donc très optimistes pour l'avenir de la région.

— Les entreprises de production d'énergie électrique de la région de la vallée de la Loire ont réalisé de très importants progrès dans la production et la consommation de l'énergie électrique. Les perspectives sont donc très optimistes pour l'avenir de la région.

ANNEXES

1012

1. Les entreprises de production d'énergie électrique de la région de la vallée de la Loire ont réalisé de très importants progrès dans la production et la consommation de l'énergie électrique. Les perspectives sont donc très optimistes pour l'avenir de la région.

2. Les entreprises de production d'énergie électrique de la région de la vallée de la Loire ont réalisé de très importants progrès dans la production et la consommation de l'énergie électrique. Les perspectives sont donc très optimistes pour l'avenir de la région.

3. Les entreprises de production d'énergie électrique de la région de la vallée de la Loire ont réalisé de très importants progrès dans la production et la consommation de l'énergie électrique. Les perspectives sont donc très optimistes pour l'avenir de la région.

4. Les entreprises de production d'énergie électrique de la région de la vallée de la Loire ont réalisé de très importants progrès dans la production et la consommation de l'énergie électrique. Les perspectives sont donc très optimistes pour l'avenir de la région.

5. Les entreprises de production d'énergie électrique de la région de la vallée de la Loire ont réalisé de très importants progrès dans la production et la consommation de l'énergie électrique. Les perspectives sont donc très optimistes pour l'avenir de la région.

6. Les entreprises de production d'énergie électrique de la région de la vallée de la Loire ont réalisé de très importants progrès dans la production et la consommation de l'énergie électrique. Les perspectives sont donc très optimistes pour l'avenir de la région.

7. Les entreprises de production d'énergie électrique de la région de la vallée de la Loire ont réalisé de très importants progrès dans la production et la consommation de l'énergie électrique. Les perspectives sont donc très optimistes pour l'avenir de la région.

8. Les entreprises de production d'énergie électrique de la région de la vallée de la Loire ont réalisé de très importants progrès dans la production et la consommation de l'énergie électrique. Les perspectives sont donc très optimistes pour l'avenir de la région.

9. Les entreprises de production d'énergie électrique de la région de la vallée de la Loire ont réalisé de très importants progrès dans la production et la consommation de l'énergie électrique. Les perspectives sont donc très optimistes pour l'avenir de la région.

Grasslands and agrarian systems Methodological considerations on SPACE in the management of grasslands

Jean-Pierre DEFFONTAINES, Sylvie LARDON

Summary:

In order to help to take into account the space in the study of the management of grasslands, the authors first of all developed a theoretical reflection.

They suggest a first model, that of the agrarian system, linking space to agricultural actors and activities. A second model defines the different statuses of space: space-resource, space-product and space-factor in relation to this agricultural activity.

These models are associated with the idea of spatial structure in order to highlight types of questions relating to the management of grasslands. The authors then illustrate their reflection with the concrete case of management of high mountain grasslands in the Alps.

Introduction

The present paper attempts to apply the concept of agrarian system to the study of grassland management. The agrarian system is taken to be the set of relationships which are established between a rural society and a given area when it is exploited. The idea thus defined is very general and can refer to different scales of activity, from the local level to enormous regional complexes. (MAZOYER M., 1987, DEFFONTAINES J.P., OSTY P. L., 1977, JOUVE P., 1988, PEPIN-LEHALLEUR M., SAUTTER G., 1989).

When used in research work dealing with agricultural and rural improvement and development, especially that which tries to describe, evaluate, compare and understand the practices of farmers (LANDAIS E., DEFFONTAINES J.P., 1988 a, SEBILLOTTE M., 1987) the concept of the agrarian system has proven useful and well adapted, since it avoids the dissociation of spatial dimensions from technical and socio-economic dimensions (INRA/ENSAA, 1977).

Thus when tackling a problem of grasslands management within an agrarian system it is necessary, in a general way, to relate the problem to a model linking three inseparable elements, namely the actors (especially farmers), the activities (especially agricultural production) and space. We suggest the following representation of this model.

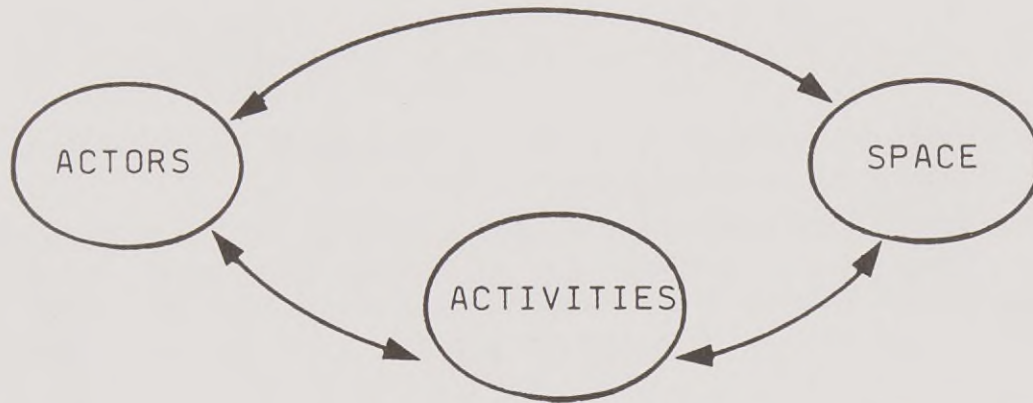


Figure 1 — Model of an agrarian system

References to space are frequent in questions relating to the management of grasslands and appear according to different modalities. Thus space becomes relevant when dealing with the localization and distribution of different herbaceous populations and with the mechanisms at the basis of their spatial heterogeneity and their evolution (HENTGEN A., 1984, HENTGEN A., 1989, BALENT G., DURU M., 1984). Space also intervenes when dealing with the use of forage resources in terms of the advantages or constraints which they present or through the users' perception of them which influences their technical choices (BENOIT M., 1985). Similarly, animal behaviour, their drifting, the organization of work sites take place in space (BENOIT M., 1986).

Faced with this diversity in references to space it is necessary, when dealing with grasslands, to define what is meant by the term space and to propose analytical tools.

1. Concepts of space

Space is not here a subject of study in itself. It is defined with respect to agricultural activity. We suggest defining the different statuses of space in relation to agricultural activity and to demonstrate the use of concepts of spatial structure and spatial process (LARDON S., 1988).

1.1. Different statuses of space

In the perspective of an approach within an agrarian system, we have retained three statuses for space: space-resource, space-product and space-factor. It is one or another status which is considered, depending on the point of view holding.

The space-resource is defined by the characteristics of space which enable agricultural activity. A fairly complete inventory could be made; but for us, these characteristics are meaningful only when seen as advantages or constraints for a possible action.

Thus, concerning the technical harvesting operations on grasslands in a farm, the spatial characteristics chosen are, for example, the depth of the ground, the geological

substratum, the altitude, the accessibility, the distance from the farmhouse, the surface area of the grasslands (AURICOSTE C. et al. 1983).

The space-product is defined by space characteristics arising from the implement of agricultural activity. It is the result of an action applied to a space-resource which creates the space-product.

Thus, the landscape, which may be described using visual indicators for the environment, for ground occupation, for agricultural practices and agrarian structures, is the product of human activity. It keeps the traces of past installations such as terraces, drains, hedges and shows present use such as the nature of the cover and the way in which the parcels are managed (DEFFONTAINES J. P., 1986).

The space-factor is defined by space variables which act on the developing agricultural activity. It intervenes directly in the action which transforms the space-resource into a space-product.

Thus, the position of the parcels between themselves and with respect to the farmhouse acts on the organization of the pastures in a farm (BENOIT M., LARDON S., 1984).

1.2. Spatial structure and spatial process

We consider that space is made up of a set of objects which may be represented by a few basic figures, namely: the point, the line and the surface area (BRUNET R., 1980). These components of space have properties of shape, size and position.

Thus, the farm space consists of a set of parcels (surface area), roads for getting to them (line) and specific elements (point) such as silos, barns, watering points. We may speak of the surface area of a plot, the length of a road or the position of a watering point.

For DELATTRE P. (1985), the word structure describes "the arrangement of the elements of a system within the framework of the theoretical model chosen for studying this system". We shall refer to the arrangement of the spatial objects belonging to the system studied as the spatial structure.

Thus, in the framework of research into the ground occupation of agrarian landscapes, the spatial structure consists of elements such as environmental units, installations, hedges (BAUDRY J., 1985).

A spatial structure corresponds to a situation at a given moment. It is a state of space which may be represented by means of a combination of three basic figures (BRUNET R., 1987) (figure 2). It may be observed in the physical space (for example the mosaic of parcels in a municipality) or by projection on a geographical space (for instance the administrative mesh of municipalities in a region). It has different properties of diversity and density.

Thus, the grasslands structure of the Causse farms is characterized by the overlapping of grasslands and grazed area which are more or less scattered, distant, heterogeneous. The contiguous relationships which link the parcels together also intervenes in flock driving (LANGLET A., 1985).

For LEMOIGNE J.L. (1977), the word process describes any action which changes identifiable objects in time, space and shape. We refer to the action which transforms the spatial structure of the system studied from one state to another as spatial process.

Thus, concerning the driving of animals on grasslands, the spatial process of the pasture corresponds to the drifting and feeding behaviour of the flocks.

A spatial process has a certain duration. It may be analyzed by discrete sequences (for example successive use of parcel ground) or by continuous functions (for example the growth of grass on a parcel). A spatial process may not be directly observed in the physical space nor represented by projection on the geographical space. Only the changes in the spatial structure, induced by the spatial process, may be observed. It has properties of transforming speed and differences between successive states.

Thus, pasturing on grasslands may be viewed as consecutive visits of the flock to different parcels or as a flow of animals on a heterogeneous substratum.

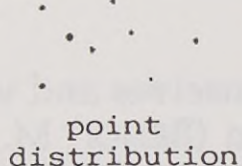
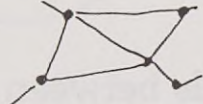
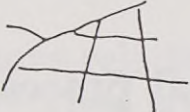
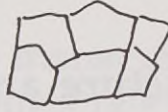
	point	line	surface
point	 point distribution	 network	 mesh-point combination
line		 grid	 meshing
surface			 paving

Figure 2 — Elementary space structures constructed from basic figures

1.3. Space model

Defining a spatial structure of a phenomenon requires characterizing the space-resource and also describing the space-product. The analysis of the spatial structure enables grasping the elements of the system and their interactions.

Defining a spatial process means specifying the space-factor of the phenomenon being studied: which in turn means studying the transformation of a space-resource into a space-product. This formalization helps to understand the functioning of the system being studied by discerning the active elements.

We suggest a model which incorporates these different concepts:

This model serves as a useful theoretical reference when attempting to integrate space into a study of grasslands management within an agrarian system. We shall show how this model is used when dealing with problems of grassland management.

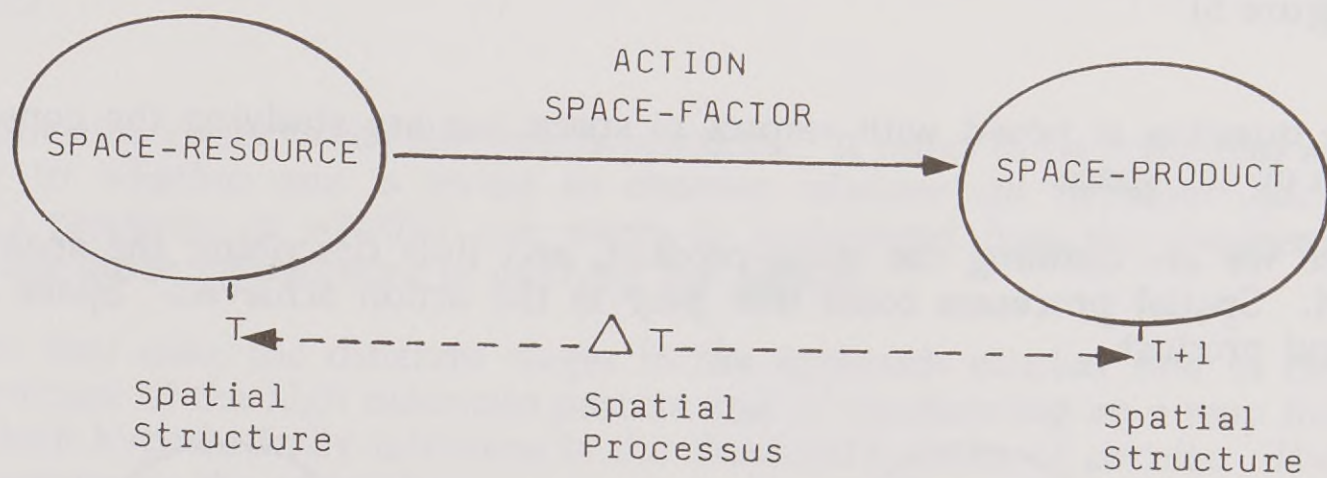


Figure 3 — Space model

2. Two types of questions concerning space in grassland management

We have seen that an approach within the agrarian system consists of taking into account the relationships between space, the activities and the actors. In the study of grasslands management, the activities are the farmers' practices.

2.1. How does spatial structure intervene in grasslands management? (Figure 4)

The question is clearly posed at the level of farm practices: we are studying the influence of space on grassland management practices.

Here, space is considered as a resource. It is therefore necessary to specify the spatial structure judged to be significant with respect to the practices. Space is also a factor because spatial processes affect the modalities and efficiency of the practices.

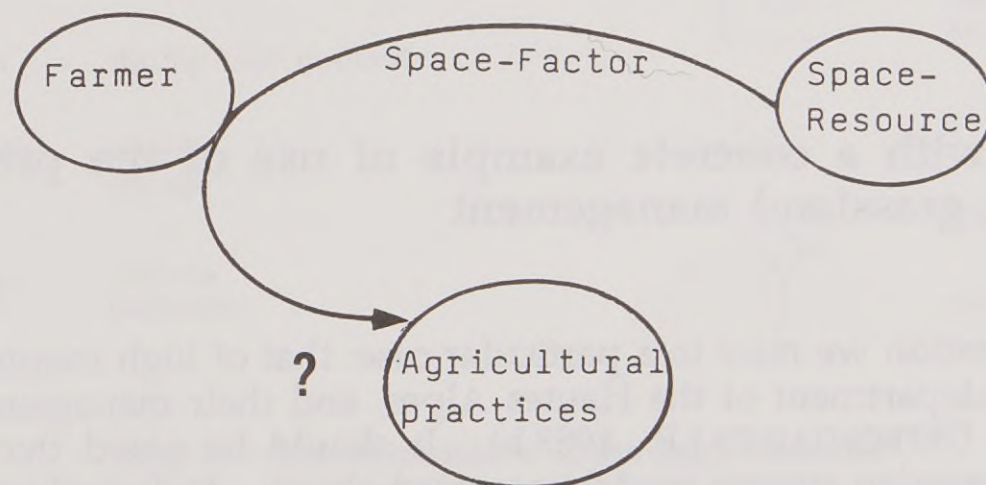


Figure 4 — Effect of space on agricultural activity

Thus, what are the consequences, on the management of grasslands in a region, of a proposed autoroute or the draining of a catchment area? Where should a milking station be located to reduce to a minimum the movements of a flock for a dairy farm?

2.2. How does the management of grasslands transform the spatial structure? (Figure 5)

The question is posed with respect to space: we are studying the consequences of practices on the space.

Here we are defining the space-product, and thus describing the spatial structure obtained. Spatial processes come into play in the action achieved. Space is therefore factor and product.

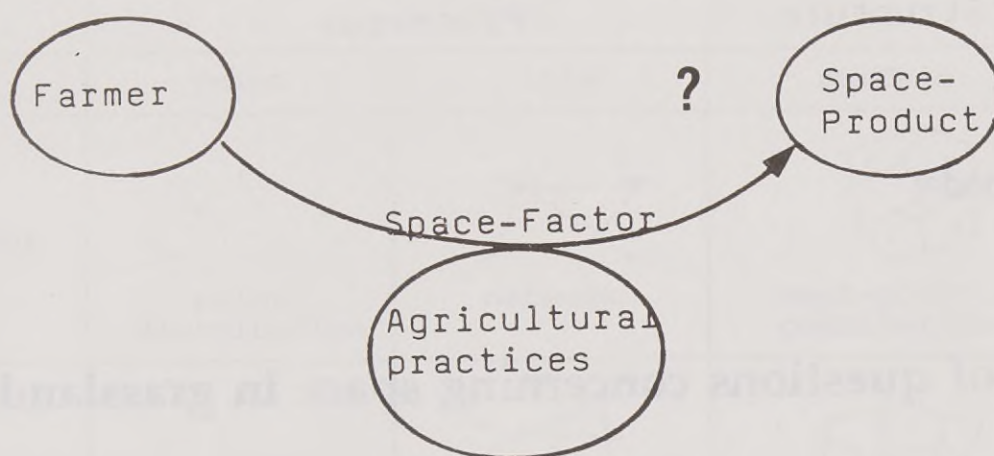


Figure 5 — Effect of agricultural activity on space

Thus, what will happen to certain grasslands of dairy farms whose total production of milk is limited by a quota and who intensify forage production on part of their surface? How can we prevent fallow land from turning into little pieces of "postage stamp" pastures following dairy quota measures?

The approach is different for each of these types of question, because it is not always the same elements and the same relationships of the system which are favoured. Our formalization has the advantage of defining for each of them the way in which space is considered, how it is structured and which processes are brought into play. This method seems to be useful for understanding the system studied in all its complexity.

3. Illustration with a concrete example of use of the proposed concepts for studying grassland management

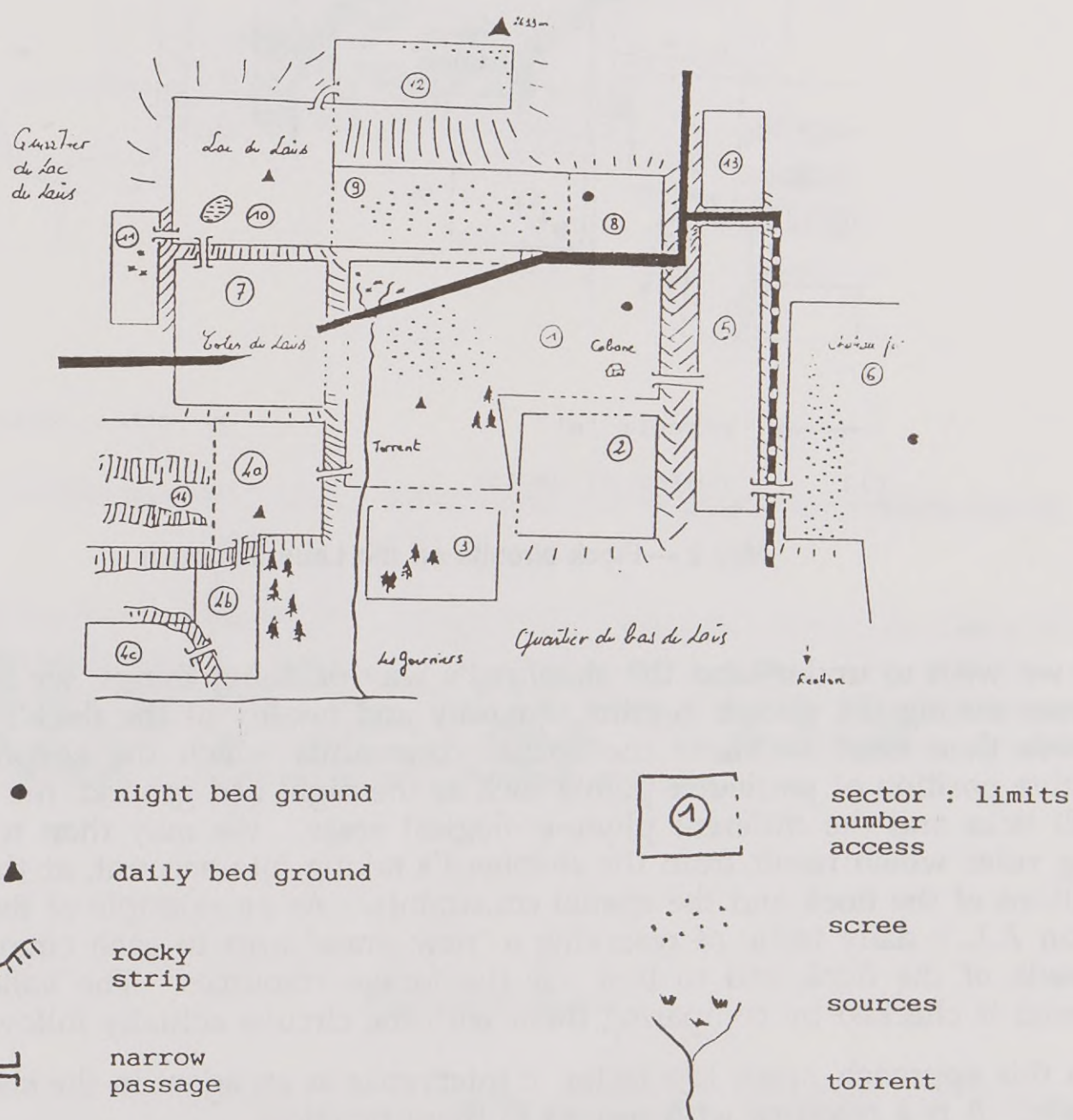
For this illustration we refer to a particular case: that of high mountain pastures (Laus Mountain) in the department of the Hautes Alpes, and their management by a shepherd: A.L. (LANDAIS E., DEFFONTAINES J.P., 1988 b). It should be noted that this example is a reduction of the agrarian system model presented above. In fact, there is only one actor, the shepherd, and we are only dealing with his pastoral practices. This simplification of the model does not however seem to us to change the illustrative nature of the example.

The study within an agrarian system of the A.L.'s management of the high mountain pastures in Laus, involves considering the unit formed by the shepherd, the high mountain pastures and the driving of the flock of sheep. We shall deal successively with each of the two types of questions mentioned earlier.

3.1. How does space intervene in the shepherd's choice of daily circuits for the flock?

The question refers to the shepherd's practices. It refers to two different approaches, according to whether one is trying to observe relationships between space and the shepherd's practices, or whether one wants to understand how the shepherd proceeds when taking space into account in defining the circuits.

In the first case, the different stages in the approach consists first of defining the spatial structure of the high mountain pasture and of representing on a map those spatial objects which hypothetically intervene in the shepherd's choice of circuits. These objects which characterize the space-resource are in particular the night bed ground, the daily bed ground, obstacles in the the flock's way, watering points (Map 1).

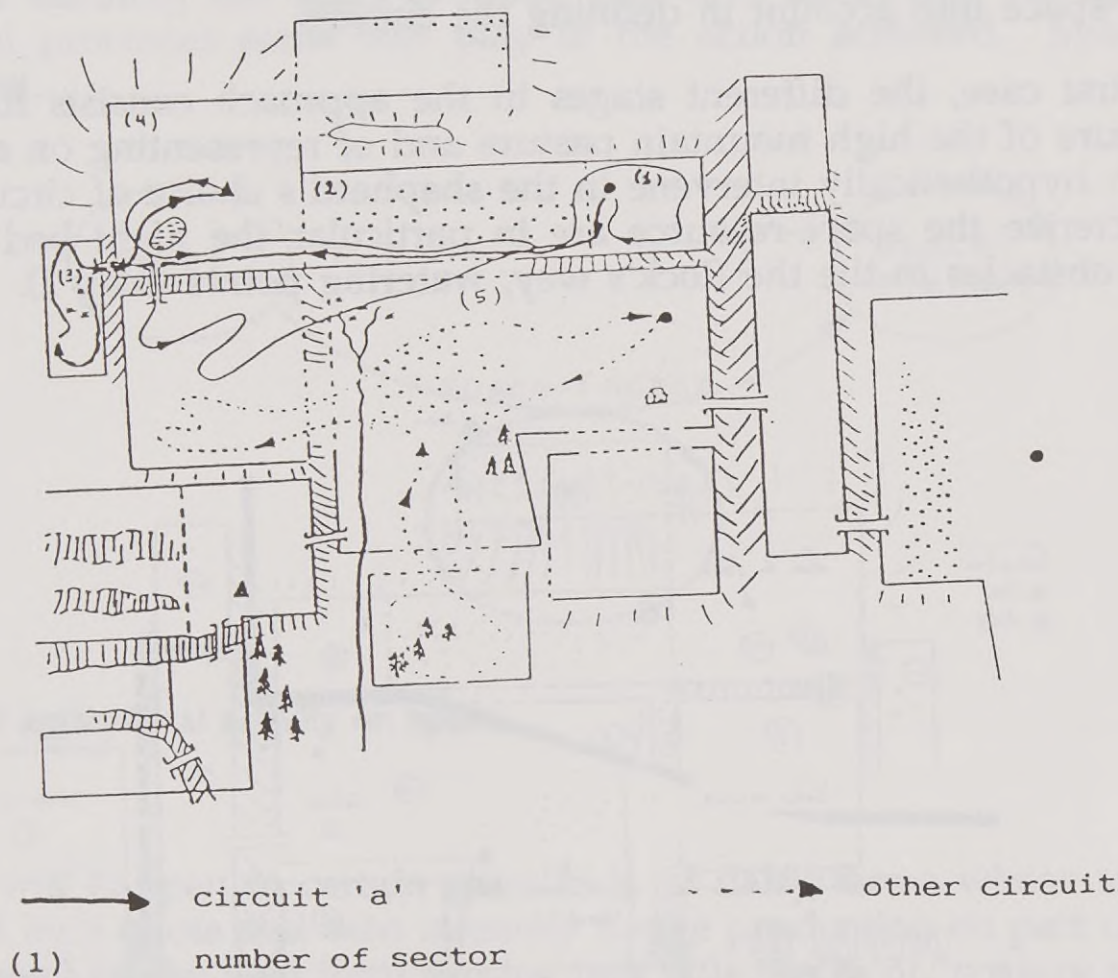


Map 1 — Spatial structure of the Laus mountain

In a second phase, the path of the circuit is drawn on the same cartographic background. Finally the relationships between the spatial structure and the circuit are identified by systematic study of the different circuits used.

Thus, on map 2, the circuit 'a' leaves from the night bed ground in the upper area (1), crosses a long scree (2) and reaches a distant sector (3) through a narrow passage in order

to graze new grass. It returns to the edges of the lake for the animals to drink and stops for them to rest at the daily bed ground (4). The return path either joins the scree (2) and stay in the night bed ground sector (1), or crosses a rocky strip in order to graze another sector (5). Thus the animals will even graze a sector which is distant and difficult to reach (3). The rapid crossing of the scree (2) in the morning and the variation of the circuit when returning, which require the crossing of a rocky strip is used to avoid overgrazing.



Map 2 — Flock circuits on the Laus Mountain

If we wish to understand the shepherd's way of doing things, we need to know his objectives during the circuit: rhythm, quantity and quality of the flock's food during the day. We then need to know the spatial constraints which the shepherd accepts: the respective position of particular points such as the night bed ground, the day bed ground, the salt licks and the different phyto-ecological areas. We may then try to identify the driving rules which result from the shepherd's taking into account, at the same time, the restrictions of the flock and the spatial constraints. As an example of the rules we might mention A.L.'s daily tactic of reserving a "new grass" area in each circuit to satisfy both the needs of the flock and to best use the forage resources. The validity of the rules expressed is checked by comparing them with the circuits actually followed.

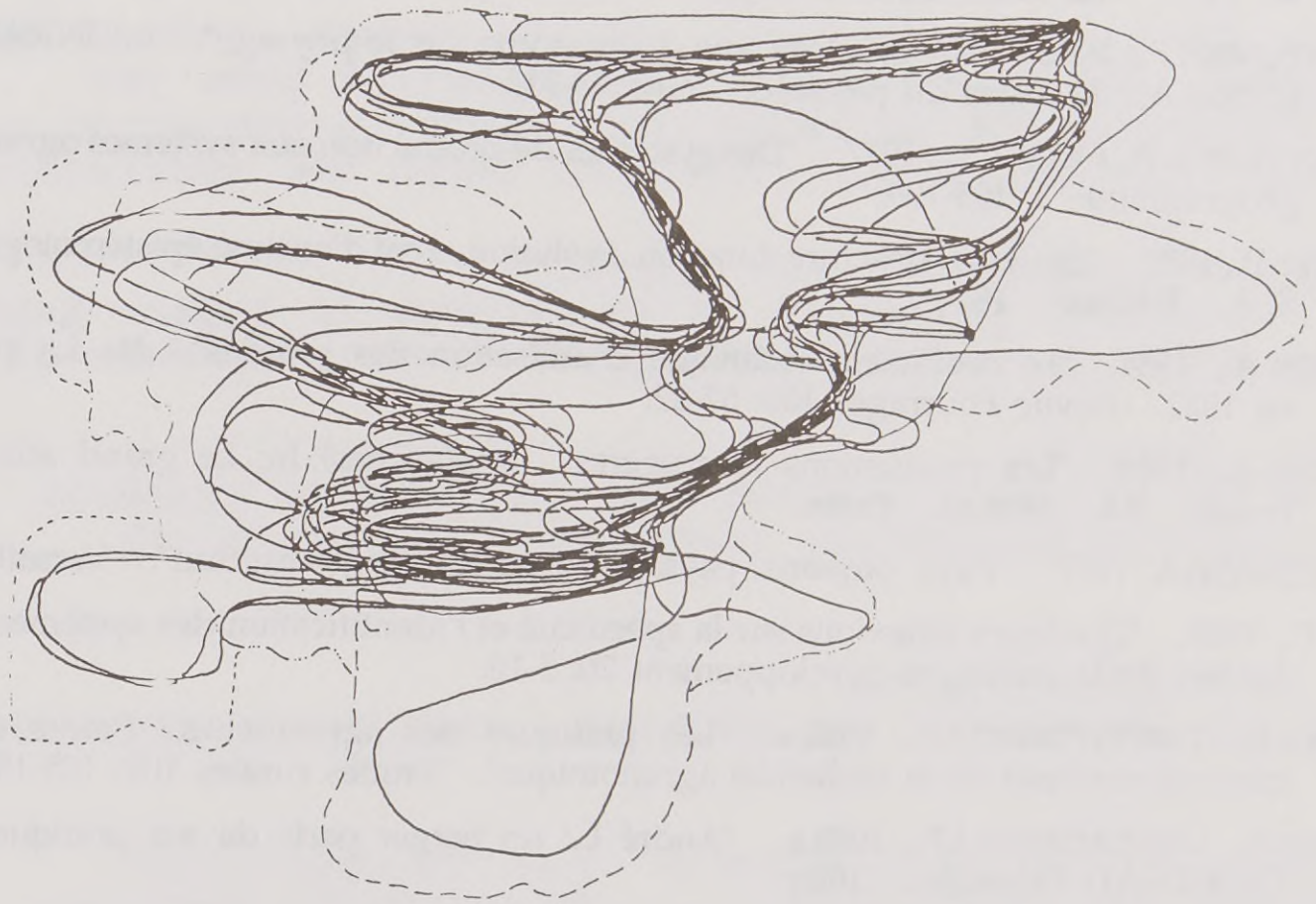
In this approach, space is a factor: it intervenes as an agent in the shepherd's pastoral methods. It is a resource with respect to these practices.

3.2. How do the daily circuits transform the space?

This question centers on the spatial objects which may be changed by the flock's intervention. Environmental preoccupations are dominant. We are concerned with the space produced by A.L.'s practices.

The approach consists of representing the daily circuits on a map of the high mountain grasslands and of distinguishing areas according to the visits made by and the behaviour

of the flock. The analysis is continued by comparing the state of the vegetation in space and time (different phyto-ecological areas) and that of the environment (gulleys, erosion). Map 3 shows areas which are infrequently or frequently visited.



Map 3 — Superposing of daily circuits on an area (Adapted from Isabelle Savini)

In this approach we observe the consequences of the driving of the flock in the space characterized mainly by the mosaic of phyto-ecological areas. The position of spatial objects such as the night bed ground and obligatory crossing points intervene in the shepherd's use of space for feeding the animals. The phenomenon observed is the differentiating of space as affected by the animals' grazing.

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Résumé :

Pour aider à la prise en compte de l'espace dans l'étude de la gestion des surfaces en herbe, les auteurs développent d'abord une réflexion théorique. Ils proposent un premier modèle, celui du système agraire, qui relie l'espace aux acteurs et aux activités agricoles. Un second modèle définit les différents statuts de l'espace: l'espace-ressource, l'espace-produit et l'espace-facteur en rapport avec cette activité agricole. Ces modèles sont associés à la notion de structure spatiale pour mettre en lumière des types de questions relatives à la gestion des surfaces en herbe. Les auteurs présentent ensuite une illustration de leur réflexion sur le cas concret de la gestion d'un alpage dans les Alpes.

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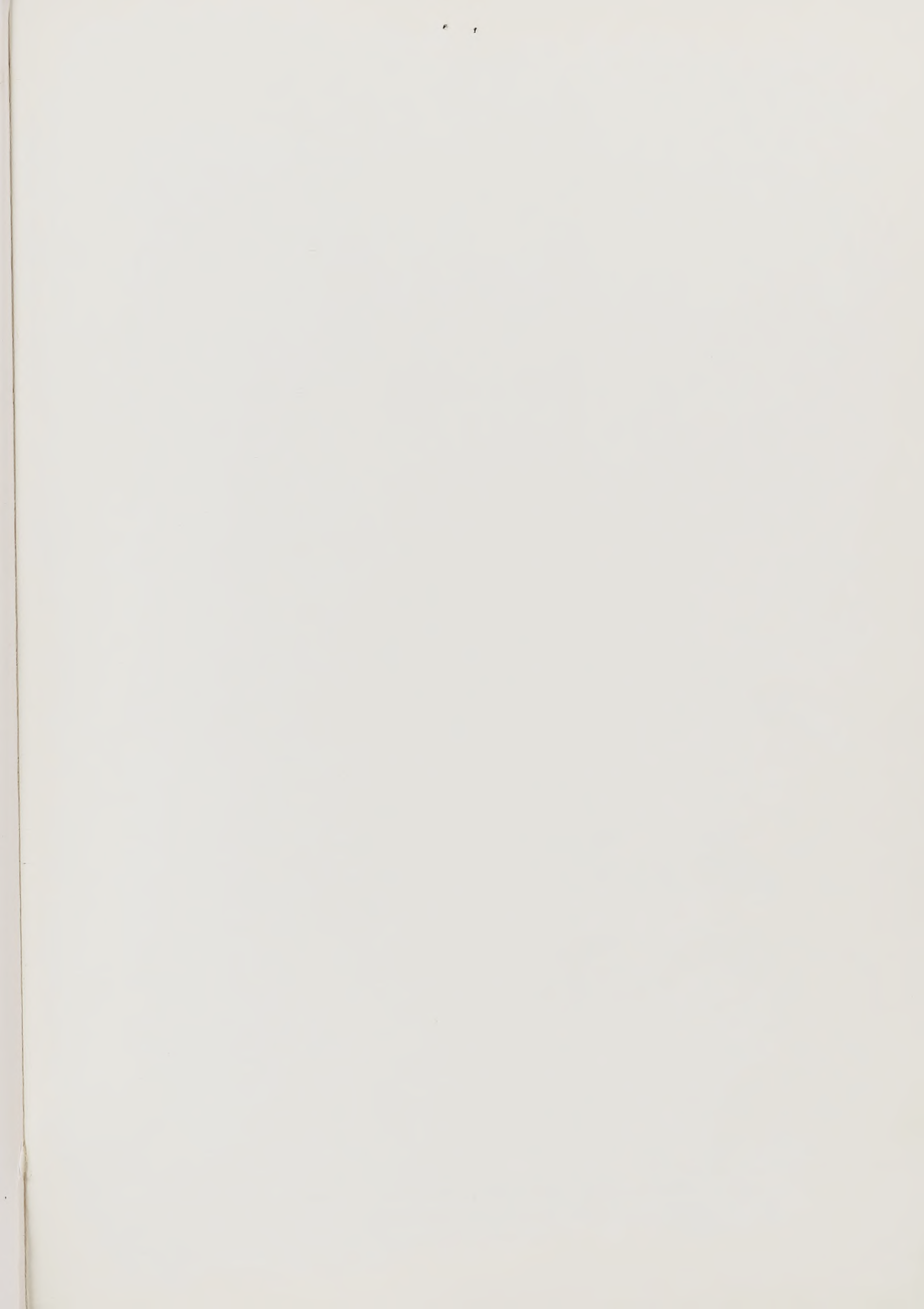
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ETUDES ET RECHERCHES

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